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END-OF-LIFE MANAGEMENT

Solar Photovoltaic Panels

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ABOUT IRENA

IRENA is an intergovernmental organisation that supports countries in their transition to a sustainable energy future and serves as the principal platform for international co-operation, a centre of excellence and a repository of policy, technology, resource and financial knowledge on renewable energy. IRENA promotes the widespread adoption and sustainable use of all forms of renewable energy, including bioenergy, geothermal, hydropower, ocean, solar and wind energy, in the pursuit of sustainable development, energy access, energy security and low-carbon economic growth and prosperity.

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ABOUT IEA-PVPS

The IEA, founded in November 1974, is an autonomous body within the framework of the Organisation for Economic Co-operation and Development (OECD) that carries out a comprehensive programme of energy co-operation among its member countries. The European Commission also participates in the work of the IEA. The IEA-PVPS is one of the collaborative research and development (R&D) agreements established within the IEA. Since 1993, participants in the PVPS have been conducting a variety of joint projects in the applications of PV conversion of solar energy into electricity.

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AUTHORS

IRENA: Stephanie Weckend
IEA-PVPS: Andreas Wade, Garvin Heath

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GLOSSARY

Amorphous silicon	Non-crystalline form of silicon formed using silicon vapour which is quickly cooled.
Electrical and electronic equipment	The term electrical and electronic equipment (EEE) is defined as equipment designed for use with a voltage rating not exceeding 1,000 Volts (V) for alternating current and 1,500 V for direct current, or equipment dependent on electric currents or electromagnetic fields in order to work properly, or equipment for the generation of such currents, or equipment for the transfer of such currents, or equipment for the measurement of such currents.
Extended Producer Responsibility	Extended Producer Responsibility (EPR) is an environmental policy approach in which a producer's responsibility for a product is extended to the post-consumer stage of a product's life cycle. An EPR policy is characterised by (1) shifting responsibility (physically and/or economically; fully or partially) upstream towards the producers and away from governments and (2) the provision of incentives to producers to take into account environmental considerations when designing their products.
Monocrystalline silicon	Silicon manufactured in such a way that if forms a continuous single crystal without grain boundaries.
Raw material	Basic material which has not been processed, or only minimally, and is used to produce goods, finished products, energy or intermediate products which will be used to produce other goods.
Pay-as-you-go and pay-as-you-put	In a pay-as-you-go (PAYG) approach, the cost of collection and recycling is covered by market participants when waste occurs. By contrast, a pay-as-you-put (PAYP) approach involves setting aside an upfront payment of estimated collection and recycling costs when a product is placed on the market. Last-man-standing-insurance is an insurance product that covers a producer compliance scheme based on a PAYG approach if all producers disappear from the market. In that situation, the insurance covers the costs of collection and recycling. In a joint-and-several liability scheme, producers of a certain product or product group agree to jointly accept the liabilities for waste collection and recycling for a specific product or product group.
Poly- or multicrystalline silicon	Silicon manufactured in such a way that it consists of a number of small crystals, forming grains.
Thin-film	Technology used to produce solar cells based on very thin layers of PV materials deposited over an inexpensive material (glass, stainless steel, plastic).

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FIGURES

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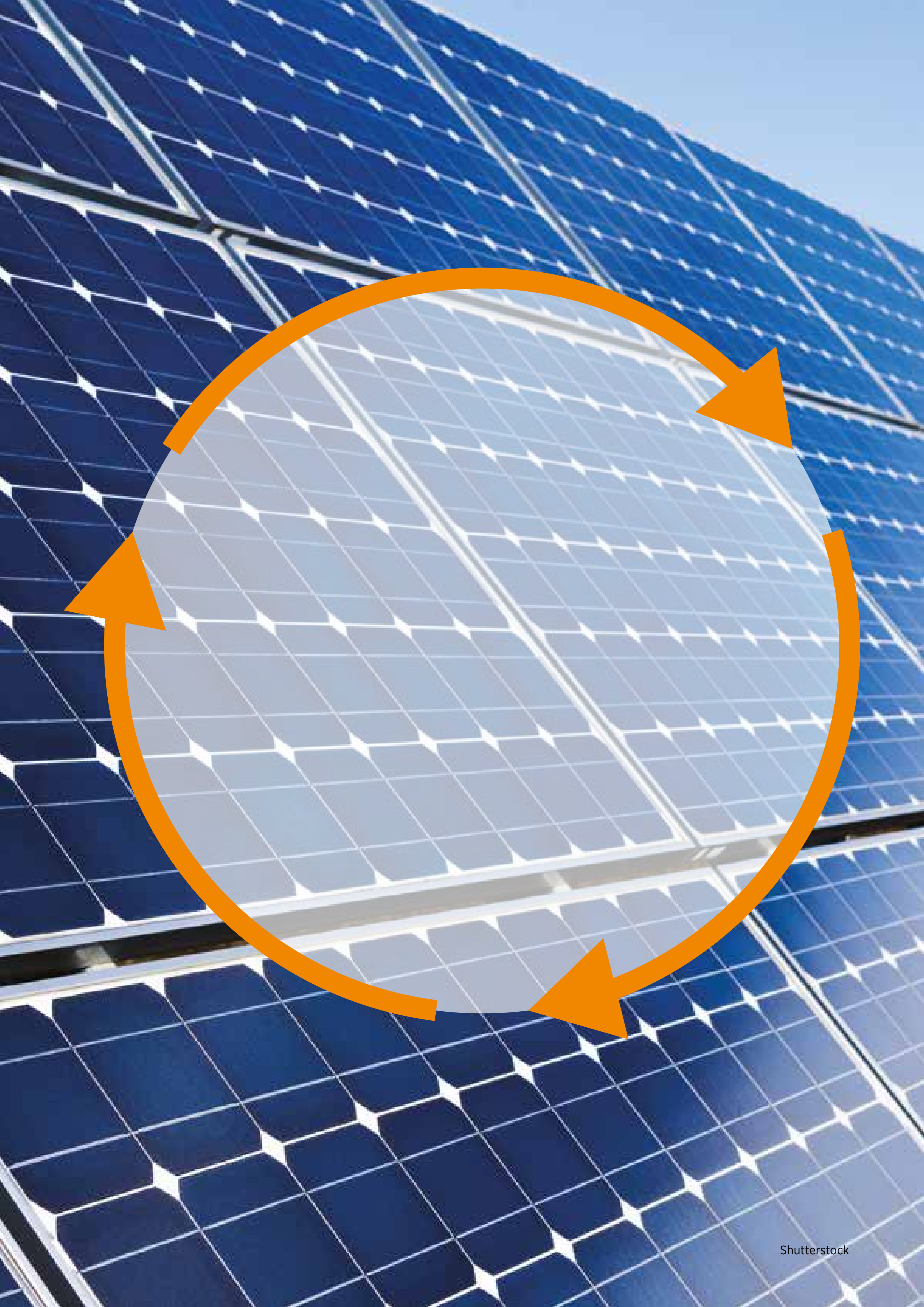
ABBREVIATIONS

a-Si	amorphous silicon
B2B	business-to-business
B2C	business-to-consumer
BIPV	building-integrated PV
c-Si	crystalline silicon
CIGS	copper indium gallium (di)selenide
CdTe	cadmium telluride
CIS	copper indium selenide
CO2	carbon dioxide
CU-PV	Energy Research Centre of the Netherlands and PV CYCLE
EEE	electrical and electronic equipment
EPR	extended producer responsibility
EVA	ethylene vinyl acetate
GW	gigawatts
IEA	International Energy Agency
IEA PVPS	International Energy Agency Photovoltaic Power System Programme
IEE	Institute for Electrical Engineering of the National Academy of Sciences, China
IRENA	International Renewable Energy Agency
ISE	(Fraunhofer) Institute for Solar Energy Systems, Germany
ITRPV	International Technology Roadmap for Photovoltaic
JNNSM	Jawaharlal Nehru National Solar Mission, India
kg	kilogramme
kW	kilowatt
L	litre
METI	Ministry of Economy, Trade and Industry, Japan
mg	milligramme
MOE	Ministry of Environment, Japan
MW	megawatt
NEDO	New Energy and Industrial Technology Development Organization, Japan
NREL	National Renewable Energy Laboratory, US
PAYG	pay-as-you-go
PAYP	pay-as-you-put
PV	photovoltaic
R&D	research and development
t	metric tonne
W	watt
Wp	watt-peak
WEEE	waste electrical and electronic equipment



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EXECUTIVE SUMMARY

Solar photovoltaic (PV) deployment has grown at unprecedented rates since the early 2000s. Global installed PV capacity reached 222 gigawatts (GW) at the end of 2015 and is expected to rise further to 4,500 GW by 2050. Particularly high cumulative deployment rates are expected by that time in China (1,731 GW), India (600 GW), the United States (US) (600 GW), Japan (350 GW) and Germany (110 GW).

As the global PV market increases, so will the volume of decommissioned PV panels. At the end of 2016, cumulative global PV waste streams are expected to have reached 43,500-250,000 metric tonnes. This is 0.1%-0.6% of the cumulative mass of all installed panels (4 million metric tonnes). Meanwhile, PV waste streams are bound to only increase further. Given an average panel lifetime of 30 years, large amounts of annual waste are anticipated by the early 2030s. These are equivalent to 4% of installed PV panels in that year, with waste amounts by the 2050s (5.5-6 million tonnes) almost matching the mass contained in new installations (6.7 million tonnes).

Growing PV panel waste presents a new environmental challenge, but also unprecedented opportunities to create value and pursue new economic avenues. These include recovery of raw material and the emergence of new solar PV end-of-life industries. Sectors like PV recycling will be essential in the world's transition to a sustainable, economically viable and increasingly renewables-based energy future. To unlock the benefits of such industries, the institutional groundwork must be laid in time to meet the expected surge in panel waste.

PV panel waste and global e-waste

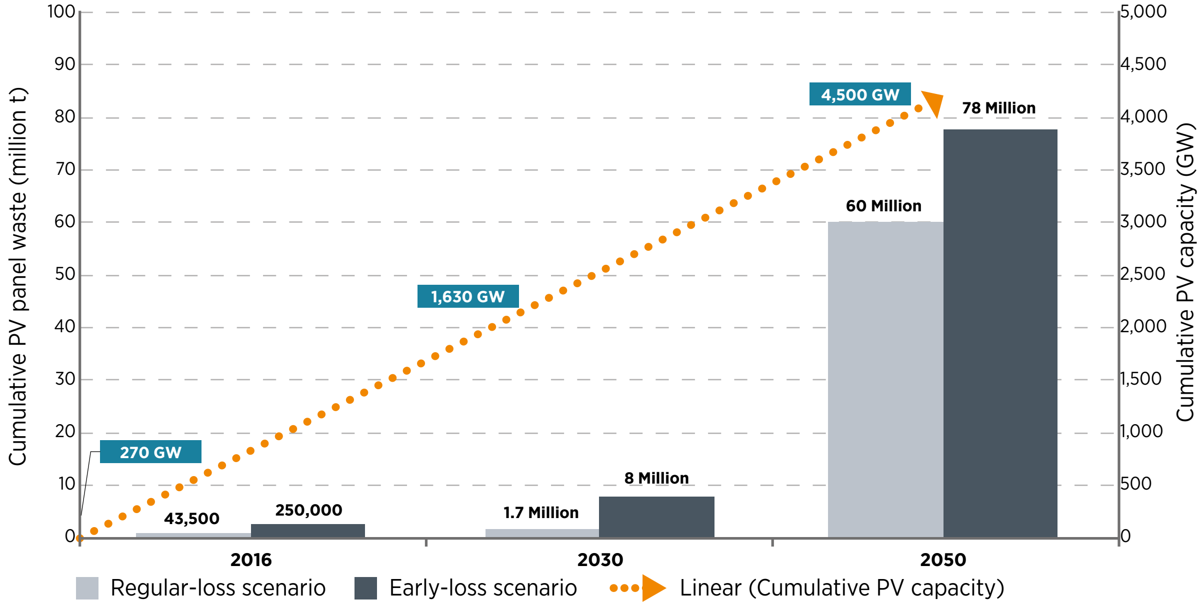
The world's total annual electrical and electronic waste (e-waste) reached a record of 41.8 million metric tonnes in 2014. Annual global PV panel waste was 1,000 times less in the same year. Yet by 2050, the PV panel waste added annually could exceed 10% of the record global e-waste added in 2014.

As the analysis contained in this report shows, the challenges and experiences with e-waste management can be turned into opportunities for PV panel waste management in the future.

This report presents the first global projections for future PV panel waste volumes to 2050. It investigates and compares two scenarios for global PV panel waste volumes until 2050.

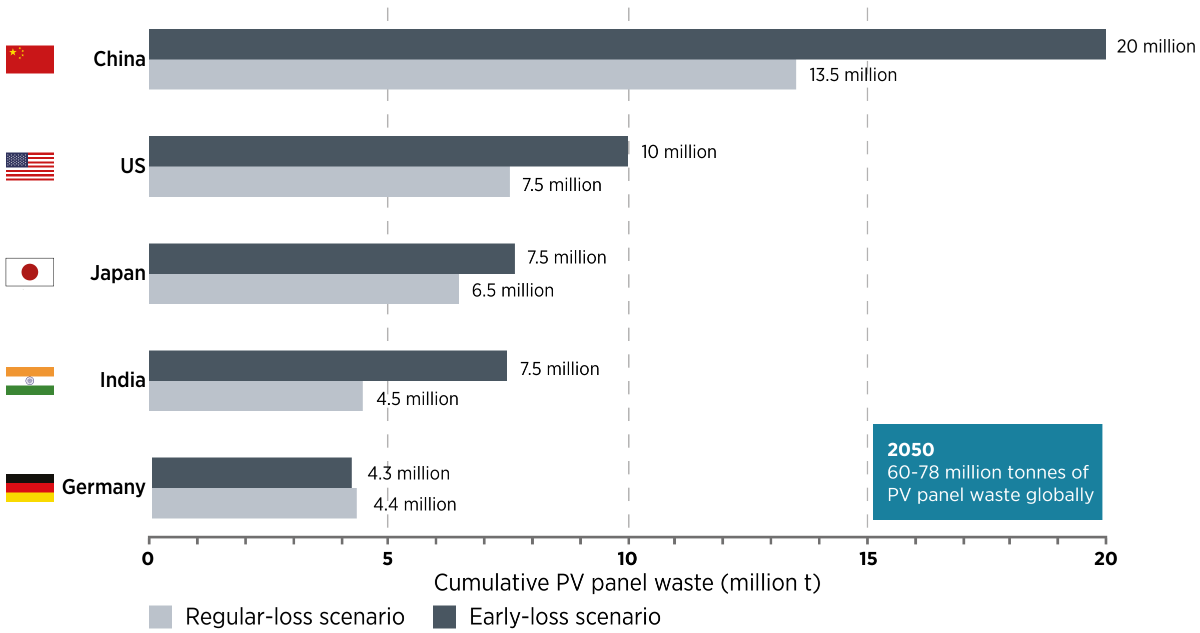
- Regular-loss: Assumes a 30-year lifetime for solar panels, with no early attrition;
- Early-loss: Takes account of "infant", "mid-life" and "wear-out" failures before the 30-year lifespan.

Overview of global PV panel waste projections, 2016-2050



Policy action is needed to address the challenges ahead, with enabling frameworks being adapted to the needs and circumstances of each region or country. Countries with the most ambitious PV targets are expected to account for the largest shares of global PV waste in the future, as outlined by case studies in this report. By 2030 the top three countries for cumulative projected PV waste are projected to include China, Germany and Japan. At the end of 2050 China is still forecast to have accumulated the greatest amount of waste but Germany is overtaken by the United States of America (US). Japan comes next followed by India.

Cumulative waste volumes of top five countries for of end-of-life PV panels in 2050

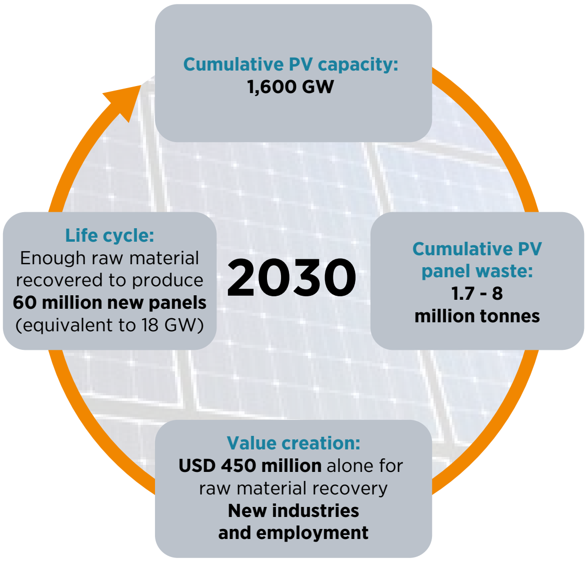


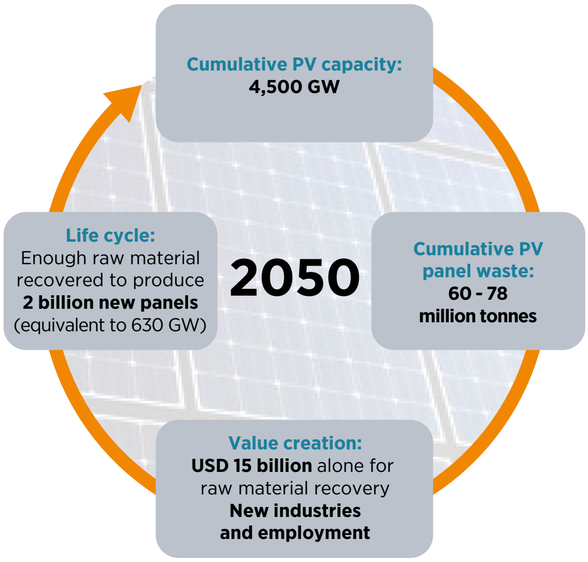
At present, only the European Union (EU) has adopted PV-specific waste regulations. Most countries around the world classify PV panels as general or industrial waste. In limited cases, such as in Japan or the US, general waste regulations may include panel testing for hazardous material content as well as prescription or prohibition of specific shipment, treatment, recycling and disposal pathways. The EU, however, has pioneered PV electronic waste (e-waste) regulations, which cover PV-specific collection, recovery and recycling targets. Based on the extended-producer-responsibility principle, the EU Waste Electrical and Electronic Equipment (WEEE) Directive requires all producers supplying PV panels to the EU market (wherever they may be based) to finance the costs of collecting and recycling end-of-life PV panels put on the market in Europe. Lessons can be learned from the experience of the EU in creating its regulatory framework to help other countries develop locally appropriate approaches.

End-of-life management could become a significant component of the PV value chain.[1] As the findings of the report underline, recycling PV panels at their end-of-life can unlock a large stock of raw materials and other valuable components. The recovered material injected back into the economy can serve for the production of new PV panels or be sold into global commodity markets, thus increasing the security of future raw material supply. Preliminary estimates suggest that the raw materials technically recoverable from PV panels could cumulatively yield a value of up to USD 450 million (in 2016 terms) by 2030. This is equivalent to the amount of raw materials currently needed to produce approximately 60 million new panels, or 18 GW of power-generation capacity. By 2050, the recoverable value could cumulatively exceed USD 15 billion, equivalent to 2 billion panels, or 630 GW.

1. *The value creation in different segments of the solar value chain has been studied in IRENA's publications "The Socio-economic Benefits of Solar and Wind" (2014) and "Renewable Energy Benefits: Leveraging Local Industries" (2016 forthcoming).*

Potential value creation through PV end-of-life management





End-of-life management for PV panels will spawn new industries, can support considerable economic value creation, and is consistent with a global shift to sustainable long-term development. New industries arising from global PV recycling can yield employment opportunities in the public and private sectors. In the public sector, jobs may be created in local governments responsible for waste management, such as municipalities and public waste utilities, but also public research institutes. Solar PV producers and specialised waste management companies may become the main employment beneficiaries in the private sector. Opportunities could also emerge in developing or transitioning economies, where waste collection and recycling services are often dominated by informal sectors. Here, PV waste management systems could generate additional employment, especially in the repair/reuse and recycling/treatment industries, while encouraging better overall PV waste management practices.

PV end-of-life management also offers opportunities relating to each of the 'three Rs' of sustainable waste management:

- **Reduce**

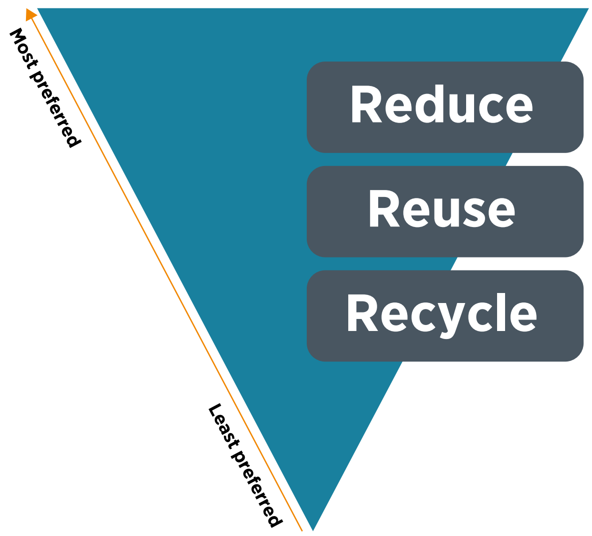
As research and development (R&D) and technological advances continue with a maturing industry, the composition of panels is expected to require less raw material. Today, two-thirds of globally manufactured PV panels are crystalline silicon (c-Si). These are typically composed of more than 90% glass, polymer and aluminium, which are classified as non-hazardous waste. However, the same panels also include such hazardous materials as silver, tin and lead traces. Thin-film panels, by comparison, are over 98% non-hazardous glass, polymer and aluminium, combined with around 2% copper and zinc (potentially hazardous) and semiconductor or other hazardous materials. These include indium, gallium, selenium, cadmium, tellurium and lead. Hazardous materials are typically subject to rigorous treatment requirements with specific classifications depending on the jurisdiction.

By 2030, given current trends in R&D and panel efficiency, the raw material inputs for c-Si and thin-film technologies could be reduced significantly. This would decrease the use of hazardous and rare materials in the production process and consequently improve the recyclability and resource recovery potential of end-of-life panels.

- **Reuse**

Rapid global PV growth is expected to generate a robust secondary market for panel components and materials. Early failures in the lifetime of a panel present repair and reuse opportunities. Repaired PV panels can be resold on the world market at a reduced market price. Even partly repaired panels or components might find willing buyers in a second-hand market. This secondary market presents an important opportunity for buyers in countries with limited financial resources which still want to engage in the solar PV sector.

Preferred options for PV waste management



- **Recycle**

As current PV installations reach the final decommissioning stage, recycling and material recovery will be preferable to panel disposal. The nascent PV recycling industry typically treats end-of-life PV panels through separate batch runs within existing general recycling plants. This allows for material recovery of major components. Examples include glass, aluminium and copper for c-Si panels that can be recovered at cumulative yields greater than 85% of total panel mass. In the long term, dedicated panel recycling plants can increase treatment capacities and maximise revenues owing to better output quality and the ability to recover a greater fraction of embodied materials. PV-specific panel recycling technologies have been researched and implemented to some extent for the past decade. Learning from past, ongoing and future research is important to enable the development of specialised, cost- and material recovery-efficient recycling plants. Technical and regulatory systems, however, need to be established to guarantee that PV panel waste streams are sufficiently large for profitable operation.

THE WAY FORWARD

Industry, governments and other stakeholders need to prepare for the anticipated waste volumes of solar PV panels in the following three main ways:

- **Adopt PV-specific waste regulations**

Sustainable end-of-life management policies for PV panels can be achieved through an enabling regulatory framework, along with the institutions needed to implement it. Addressing the growth of PV waste and enabling related value creation will not be easy in the absence of legally binding end-of-life standards specific to PV panels. The development of PV-specific collection and recycling regulations, including recycling and treatment standards for PV panels, will be crucial to consistently, efficiently and profitably deal with increasing waste volumes. Furthermore, waste regulations or policies can promote more sustainable life cycle practices and improve resource efficiency. Lessons learned from the experiences summarised in this report can help guide the development of regulatory approaches.

More data and analyses are needed at the national level to support the establishment of suitable regulatory and investment conditions. As a first step, accurate assessments of waste panel markets will require better statistical data than is currently available. This should include regular reporting and monitoring of PV panel waste systems, with amounts of waste produced by country and technology; composition of this waste stream; and other aspects of PV waste management. In addition, installed system performance and, in particular, the causes and frequency of system failures should be reported to provide clearer estimates of future end-of-life panel waste. The resulting country-level waste and system performance data would improve the viability of how PV panel waste management is organised, expand knowledge of material recovery potential and provide a foundation for sound regulatory frameworks. Further data to assess the full range of value creation, including socio-economic benefits, will also help to stimulate end-of-life market growth for solar PV.

- **Expand waste management infrastructure**

Management schemes for PV waste should be adapted to the unique conditions of each country or region. As case studies on Germany and the United Kingdom show, different waste management frameworks have emerged from the national implementation of the EU WEEE Directive. These experiences can provide a variety of lessons and best practices from which other PV markets can benefit. Rapidly expanding PV markets such as Japan, India and China still lack specific regulations

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covering PV panel waste. However, they have started preparing for future waste streams through R&D and the establishment of long-term policy goals. In the absence of sufficient waste volumes or country-specific technical know-how, regional markets for waste management and recycling facilities also help to maximise value creation from PV waste.

Co-ordination mechanisms between the energy and waste sectors are essential to supporting PV end-of-life management. A wide array of energy stakeholders is usually involved in the decommissioning stage of a PV project, which includes dismantling, recycling and disposal. These stakeholders include project developers, construction companies, panel producers and others. Traditionally, the waste sector has only been involved in a limited way (e.g. disposal of PV panel waste at landfill sites and/or with general waste treatment). However, with increasing waste volumes and related recycling opportunities, waste management companies will become an important player in PV end-of-life activities. This is already the case in several EU countries. In accordance with the extended-producer-responsibility principle, producers in these countries provide the financing for waste management and delegate the treatment and recycling of PV panels to the waste sector. The development of industrial clusters that promote co-operation across energy and waste sector stakeholders can be effective in stimulating innovation and contributing to spillover effects.

- **Promote ongoing innovation**

R&D and skills development are needed to support additional value creation from PV end-of-life panels. Considerable technological and operational knowledge about PV panel end-of-life management already exists in many countries. This can guide the development of effective waste management solutions, helping to address the projected large increase in PV panel waste. Pressure to reduce PV panel prices is already driving more efficient mass production and material use, material substitutions, and the introduction of new, higher-efficiency technologies. To improve even further, additional skills development is needed. Research and education programmes are critical to not only achieve the technical goals but also train the next generation of scientists, engineers, technicians, managers etc. Such jobs will be required to develop the technical, regulatory, logistics and management systems necessary to maximise value extracted from growing PV waste streams. In addition, specific education and training on PV panel repairs can help to extend the lifetime of PV panels that show early failures. Material recycling for PV panels faces another barrier: recovered raw materials often lack the quality needed to achieve maximum potential value because recycling processes are not fully developed. Increased R&D for PV panel end-of-life treatment technologies and techniques could help close this gap and enable improved and efficient recovery of raw materials and components. Just as importantly, technological R&D must be coupled with prospective techno-economic and environmental analyses to maximise societal returns, minimise detrimental outcomes and avoid unintended consequences.

In the years ahead, policy-makers and PV stakeholders must prepare for the rise of panel waste and design systems to capitalise on the resulting opportunities. Unlocking end-of-life value from PV panels calls for targeted actions like those described above and, most importantly, appropriately designed frameworks and regulations. With the right conditions in place, end-of-life industries for solar PV can thrive as an important pillar of the infrastructure for a sustainable energy future.

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INTRODUCTION

The deployment of PV technology has grown dramatically in recent years, reaching a cumulative global installed capacity of 222 GW at the end of 2015 (IRENA, 2016b). PV offers economic and environmentally friendly electricity production but like any technology it ages and ultimately requires decommissioning (which includes dismantling, recycling and disposal). As PV increasingly becomes a global commodity, and to ensure its sustainable future, stakeholders involved with each step of the product life cycle must implement sound environmental processes and policies, including responsible end-of-life treatment. Regulatory frameworks that support the early development of life cycle management techniques and technologies will foster such processes and policies.

This report aims to look ahead of the curve, projecting future PV panel waste volumes in leading solar markets and distilling lessons from current PV waste management approaches. The intention is that other countries can then move faster up the learning curve with technological and regulatory systems dealing with PV panel waste.

In mature and saturated markets for products like automobiles in Europe or the US, the ratio of waste to new products is more or less constant. By contrast, the ratio of waste panels to new installed panels is currently very low at 0.1% (around 43,500 metric tonnes of waste, and 4 million metric tonnes of new installations estimated by end of 2016).[2] This is because the global PV market is still young, and PV systems typically last 30 years. Findings in this report show that a large increase in PV waste is projected to emerge globally around 2030. Some regions, like the EU, will start generating important waste volumes earlier because of their larger-scale adoption of PV since the 1990s. The proportion of global PV panel waste to new installations is estimated to increase steadily over time, reaching 4%-14% in 2030 and climbing to over 80% in 2050.

End-of-life management with material recovery is preferable to disposal in terms of environmental impacts and resource efficiency as a way to manage end-of-life PV systems. When recycling processes themselves are efficient, recycling not only reduces waste and waste-related emissions but also offers the potential for reducing the energy use and emissions related to virgin-material production. This could be particularly significant for raw materials with high levels of impurities (e.g. semiconductor precursor material), which often require energy-intensive pre-treatment to achieve required purity levels. Recycling is also important for long-term management of resource-constrained metals used in PV.

2. Assuming 80-100 metric tonnes (t) per megawatt (MW). See Chapter 2.

The PV recycling industry is expected to expand significantly over the next 10-15 years. Annual end-of-life PV panel waste is projected to increase to more than 60-78 million metric tonnes cumulatively by 2050 according to this report's model. This increasing scale should improve the cost-effectiveness and energy/resource efficiency of recycling while stimulating the technical innovations needed to handle the wide variety of materials used in fast-evolving PV technologies.

This report highlights and demonstrates the importance and benefit of developing flexible regulatory frameworks. They ensure sustainable PV end-of-life management, and enable economically and environmentally efficient processes and technologies for product and material recovery processes. They stimulate associated socio-economic benefits like recovery of valuable materials, and foster new industries and employment.

As the first region witnessing large-scale PV deployment, the EU started to promote sustainable PV life cycle management in the early 2000s. The voluntary extended-producer-responsibility (EPR)[3] initiative PV CYCLE (PV CYCLE, 2016) was one example. This has led to the development of pilot and industrial-scale recycling facilities as well as the first comprehensive legal framework on PV panels: the Waste Electrical and Electronic Equipment (WEEE) Directive of 2012 (European Parliament and Council, 2012).[4] In other parts of the world, little specific legislation for handling end-of-life PV panels yet exists, and waste is handled under each country's legislative and regulatory framework for general waste treatment and disposal.

3. The OECD defines EPR as an environmental policy approach in which a producer's responsibility for a product is extended to the post-consumer stage of a product's life cycle. An EPR policy is characterised by (1) shifting responsibility (physically and/or economically; fully or partially) upstream towards the producers and away from governments and (2) the provision of incentives to producers to take into account environmental considerations when designing their products (OECD, 2015).

4. In the context of the WEEE Directive, PV panels have been clearly defined as pieces of electrical equipment designed with the sole purpose of generating electricity from sunlight for public, commercial, industrial, rural, and residential applications—the definition excludes balance-of-system components (such as inverters, mounting structures, and

The purpose of this joint IRENA and IEA-PVPS Task 12 report is to communicate existing technological and regulatory knowledge and experience, including best practice related to PV panel end-of-life waste management. The report also identifies opportunities for value creation from end-of-life PV by analysing potential environmental and socio-economic benefits based on novel projections of PV panel waste to 2050. The report consists of five main chapters.

Chapter 2 provides predictions of global PV growth which act as the baseline for quantifying future PV panel waste streams (globally and for specific countries). These results provide the context and motivation for the waste management policies and recycling technologies described in the remainder of the report.

Chapter 3 characterises the materials embodied in the different types of PV panels along with corresponding regulatory waste classification considerations that determine required treatment and disposal pathways for PV panels.

Chapter 4 describes general PV waste management options, explaining general waste management principles and the difference between voluntary and legal approaches. This is followed by summaries of country-specific current approaches to waste management in **Chapter 5**, including case studies of major current and future PV markets. These are Germany, the UK, the US, Japan, China and India.

Chapter 6 covers value creation from end-of-life PV by analysing opportunities to reduce, reuse and recycle, as well as resulting socio-economic benefits.

Finally, **Chapter 7** outlines the conclusions and way forward.


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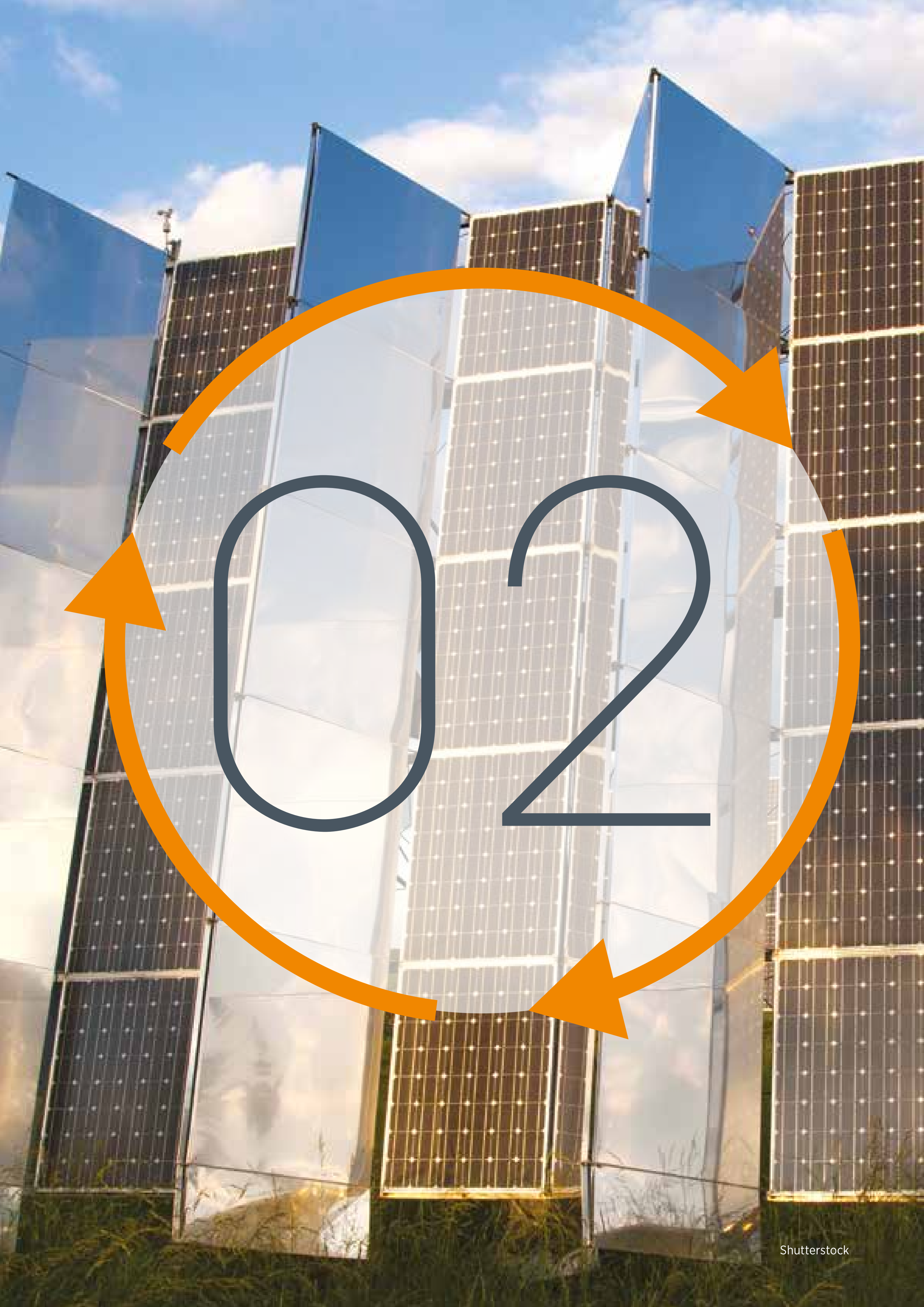

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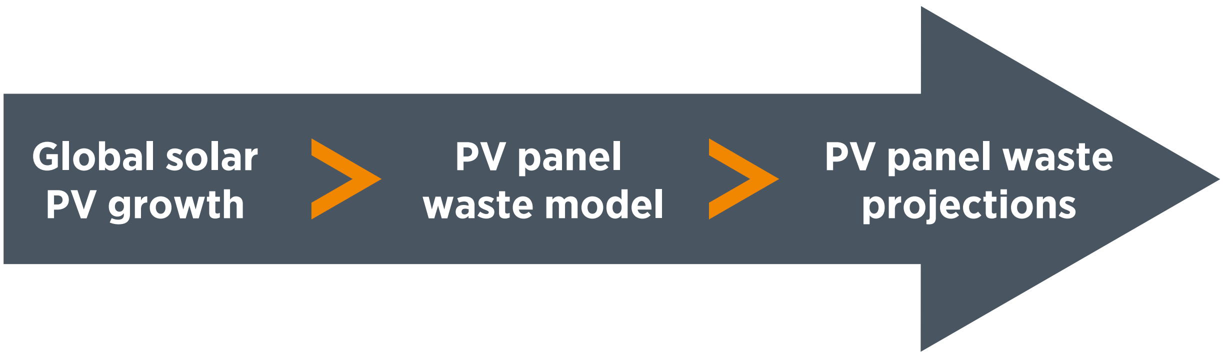
SOLAR PV PANEL WASTE PROJECTIONS

PV panel waste streams will increase alongside worldwide PV deployment. This publication is the first to quantify potential PV panel waste streams in the period until 2050.

As outlined in Figure 1, a three-step approach is used to quantify PV panel waste over time. First, this chapter analyses trends and future global solar PV growth rates from 2010 to 2050, which is a main input to waste volume estimation. Next, the PV panel waste model and main methodology used in this report are explained. The last section summarises the findings and provides PV panel waste predictions globally and by country.

Figure 1 Approach to estimating PV panel waste



2.1 GLOBAL SOLAR PV GROWTH

In 2015 capacity to generate renewable energy increased by 8.3% or 152 GW, the highest annual growth rate on record (IRENA, 2016b). Global solar PV capacity added in 2015 made up 47 GW of this increase, cumulatively reaching 222 GW at the end of 2015, up from 175 GW in 2014 (IRENA, 2016b). The bulk of these new installations was in non-traditional PV markets, consolidating the shift in major PV players. Traditional PV markets such as Europe and North America grew 5.2% and 6.3% in 2015 respectively. By contrast, Latin America and the Caribbean grew at a rate of 14.5%, and Asia at a rate of 12.4%. Asia alone thereby witnessed a 50% increase in solar PV capacity in 2015, with 15 GW of new PV capacity installed in China and another 10 GW in Japan. Main global PV leaders today include China (43 GW of cumulative installed capacity), Germany (40 GW), Japan (33 GW) and the US (25 GW).

To account for current and future waste streams for solar PV, global PV growth rates were projected until 2050. These rely on results from previous work on PV forecasts by both IRENA and the IEA. For projections to 2030, *REmap* (see Box 1), IRENA's roadmap for doubling the global share of renewables, was used (IRENA, 2016a). For 2030-2050, the projections are based on IEA's *Technology Roadmap on Solar Photovoltaic Energy* (see Box 2) (IEA, 2014).

Box 1 An overview of IRENA's REmap – a global renewable energy roadmap

IRENA's roadmap shows feasible, cost-effective ways to double renewables from 18% to 36% in the world's total final energy consumption by 2030. This is based on an in-depth analysis of the energy transition in 40 economies, representing 80% of global energy use. For each technology, including solar PV, power capacity deployment is calculated from the reference year 2010 in five-year increments to 2030. This takes into consideration existing technologies, their costs and the available timeframe.

The REmap analysis finds that doubling the renewables share is not only feasible but cheaper than not doing so once health and environmental factors are taken into account. The accelerated energy transition can boost economic growth, save millions of lives and combined with energy efficiency helps limit the global temperature increase to 2° Celsius in line with the Paris Agreement. To meet that goal, however, renewable energy deployment needs to happen six times faster. For decision-makers in the public and private sectors alike, this roadmap sends out an alert on the opportunities at hand and the costs of not taking them (IRENA, 2016a).

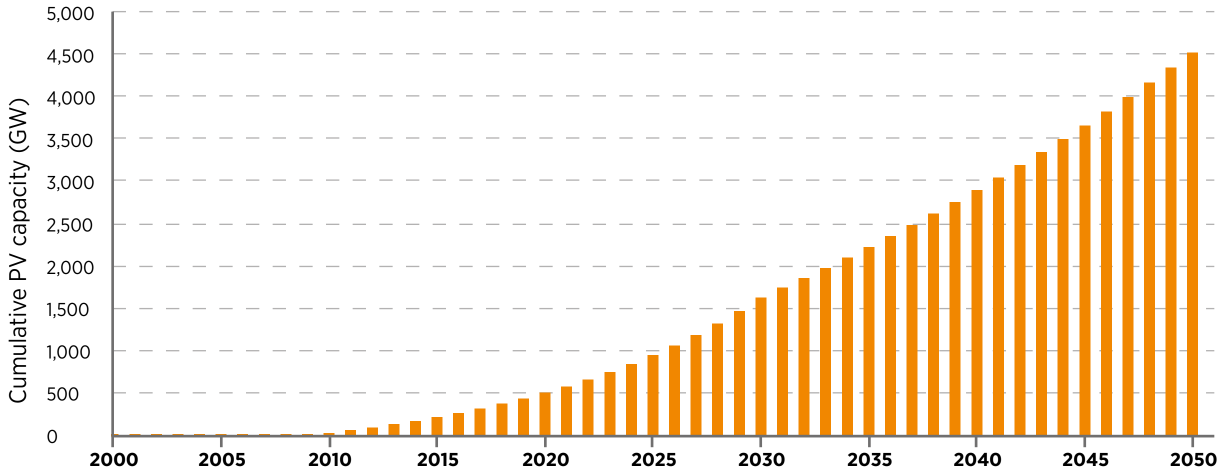
Box 2 An overview of the IEA's PV Technology Roadmap to 2050

To achieve the necessary reductions in energy-related CO_2 emissions, the IEA has developed a series of global technology roadmaps under international guidance and in close consultation with industry. The overall aim is to advance global development and uptake of key technologies to limit the global mean temperature increase to 2° Celsius in the long term. The roadmaps are not forecasts. Instead, they detail the expected technology improvement targets and the policy actions required to achieve that vision by 2050.

The PV Technology Roadmap is one of 21 low-carbon technology roadmaps and one of nine for electricity generation technologies. Based on the IEA's *Energy Technology Perspectives* (2014), this roadmap envisages the PV contribution to global electricity reaching 16% by 2050. This is an increase from 135 GW in 2013 to a maximum of 4,674 GW installed PV capacity in 2050. The roadmap assumes that the costs of electricity from PV in different parts of the world will converge as markets develop. This implies an average cost reduction of 25% by 2020, 45% by 2030 and 65% by 2050, leading to USD 40-160 per megawatt-hour, assuming a cost of capital of 8%. To achieve the vision in this roadmap, the total PV capacity installed each year needs to rise rapidly from 36 GW in 2013 to 124 GW per year on average. It would peak to 200 GW per year between 2025 and 2040. The vision is consistent with global CO_2 prices of USD 46/t CO_2 in 2020, USD 115/t CO_2 in 2030 and USD 152/t CO_2 in 2040 (IEA, 2014).

As shown in Figure 2, global cumulative PV deployment accelerated after 2010 and is expected to grow exponentially, reaching 1,632 GW in 2030 and about 4,512 GW in 2050.

Figure 2 Projected cumulative global PV capacity



Based on IRENA (2016) and IEA (2014)

To develop annual estimates of PV capacity between 2016 and 2030, an interpolation was made between IRENA's *REmap* estimates for 2015, 2020 and 2030. To achieve this, an average annual growth rate was calculated between each five-year period, amounting to 8.92%. In some selected countries, the individual growth rates may be adjusted higher or lower due to political and economic uncertainties foreseen. To extend the model projection to 2050, more conservative growth projections were assumed for 2030-2050 with annual growth rate of about 2.5%. This extrapolation was matched with the forecast of the IEA's PV Technology Roadmap.

The final projections of global PV growth to 2050 are shown in Table 1 and were used to model global waste streams in the next chapter.

Table 1 Projected cumulative PV capacity, 2015-2050, based on IRENA (2016) and IEA (2014)

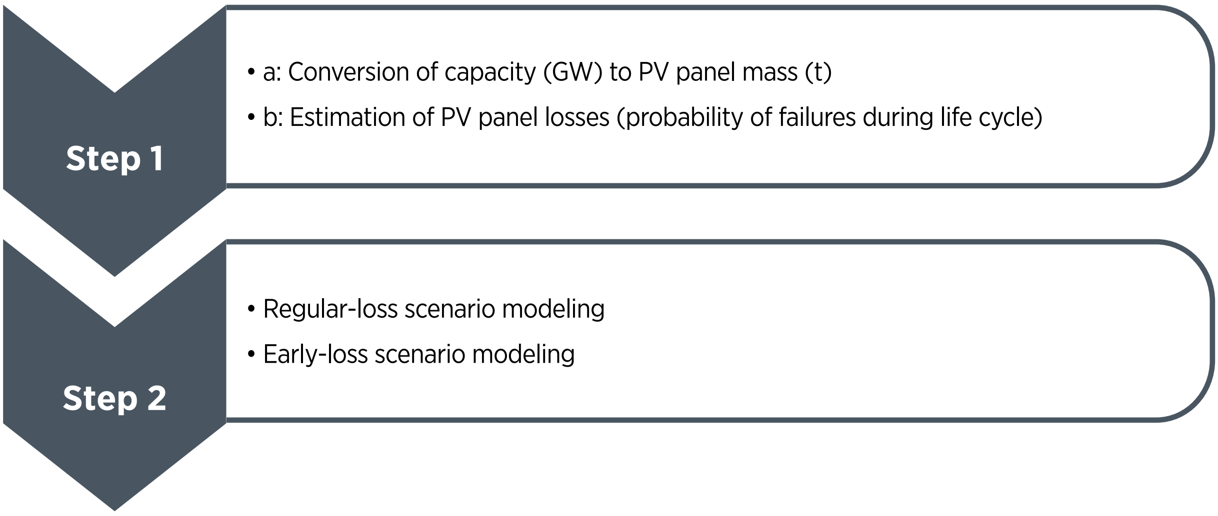
Year	2015	2020	2025	2030	2035	2040	2045	2050
Cumulative installed PV capacity (GW)	222	511	954	1,632	2,225	2,895	3,654	4,512

2.2 PV PANEL WASTE MODEL

The objective of this report is to quantify future PV panel waste streams. Most waste is typically generated during four primary life cycle phases of any given PV panel. These are 1) panel production 2) panel transportation 3) panel installation and use, and 4) end-of-life disposal of the panel. The following waste forecast model covers all life cycle stages except production. This is because it is assumed that production waste is easily managed, collected and treated by waste treatment contractors or manufacturers themselves and thus not a societal waste management issue.

Future PV panel waste streams can be quantified according to the model described in Figure 3. The two main input factors are the conversion and probability of losses during the PV panel life cycle (step 1a and 1b). They are employed to model two waste stream scenarios using the Weibull function, the regular-loss and the early- loss scenario (step 2).

Figure 3 Two-step PV panel waste model



The next section provides a step-by-step guide showing details of the methodology and underlying assumptions.

Step 1a: Conversion of capacity to PV panel mass (from gigawatts to metric tonnes)

Table 2 PV panel loss model methodology for step 1a

Model	Data input and references
• The model's exponential regression function converts gigawatts of PV capacity to metric tonnes of panel mass. • For each year, the annual conversion factor is calculated.	• Standard panel 1990-2013 data sheets (Photon, 2015) are used to extract supporting data for the exponential fit. Typical panel data were used in five-year periods from the biggest producers (Arco Solar, BP Solar, Kyocera, Shell Solar, Sharp, Siemens Solar, Solarex, Solarworld, Trina and Yingli). • Standard panel data are predicted using the 2014 International Technology Roadmap for Photovoltaic (ITRPV) as a baseline (Raithel, 2014) as well as other literature (Berry, 2014; IEA, 2014; IRENA, 2014; Marini *et al.*, 2014; Lux Research, 2013 and Schubert, Beaucarne and Hoornstra, 2013).

To estimate PV panel waste volumes,[5] installed and projected future PV capacity (megawatts or gigawatts-MW or GW) was converted to mass (metric tonnes-t), as illustrated in Table 2. An average ratio of mass of PV per unit capacity (t/MW) was calculated by averaging available data on panel weight and nominal power. For past PV panel production, the nominal power and weight of representative standard PV panel types was averaged from leading producers over five-year intervals (Photon, 2015). The panel data sheets of Arco, Siemens, BP, Solarex, Shell, Kyocera, Sharp, Solarworld and Trina were considered.

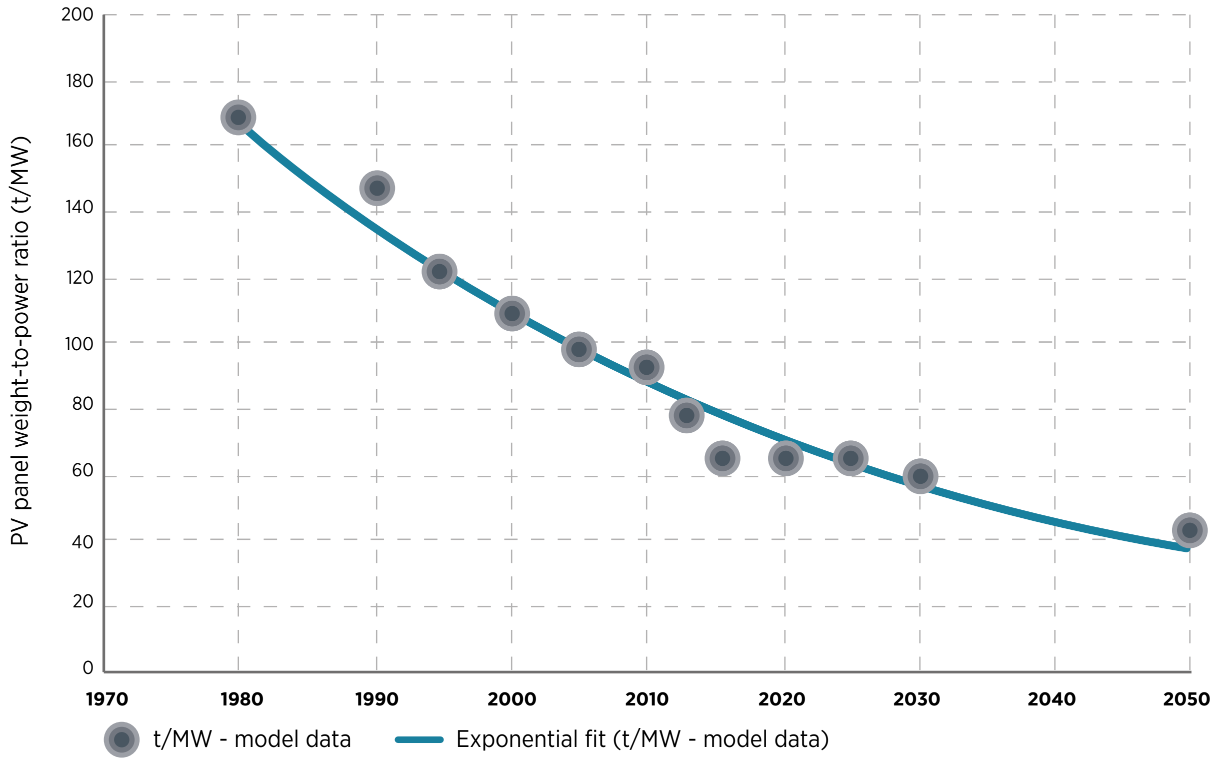
5. Note that 'volume' is used interchangeably in this report with the more accurate metric 'mass' despite the incongruence of units.

For future PV panel production, the data are based on recent publications (Berry, 2014; IEA, 2014; IRENA, 2014; Marini, 2014; Raithel, 2014; Lux Research, 2013 and Schubert, Beaucarne and Hoornstra, 2013).

This report's model includes a correction factor to account for panels becoming more powerful and lighter over time. This is due to optimisation of cell and panel designs as well as weight reductions from thinner frames, glass layers and wafers. The correction factor is based on an exponential least-square fit of weight-to-power ratio for historic and projected future panels.[6] Figure 4 shows how the weight-to-power ratio is continuously reduced over time due to further developments in PV technologies such as material savings and improved solar cell efficiencies.

6. In previous studies a constant factor of 100 t/MW was used as a first approximation (Sander et al., 2007). This report's approach is thus more reflective of expected panel weight per capacity change.

Figure 4 Exponential curve fit of projection of PV panel weight-to-power ratio (t/MW)



Step 1b: Probability of PV panel losses

Table 3 PV panel loss model methodology for step 1b

Model	Data input and references
• Infant failure • Midlife failure • Wear-out failure	• Assumptions on early losses were based on reports by TÜV, Dupont, SGS and others (IEA-PVPS, 2014a; Padlewski, 2014; Vodermeyer, 2013; DeGraaff, 2011).

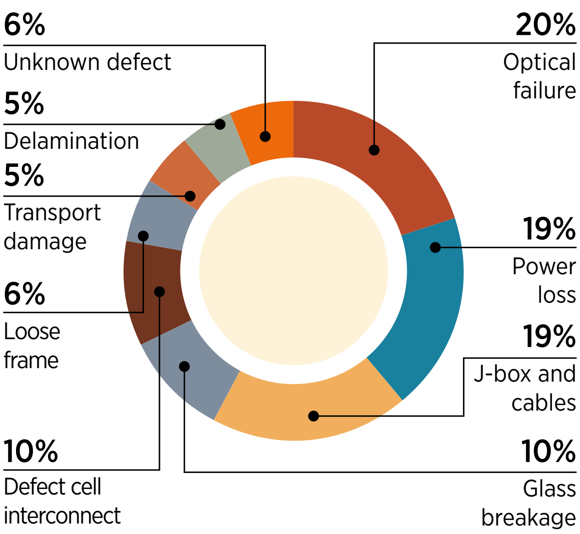
The potential origin of failures for rooftop and ground-mounted PV panels was analysed independently from PV technology and application field to estimate the probability of PV panels becoming waste before reaching their estimated end-of-life targets. The three main panel failure phases detected are shown in Table 3 (IEA-PVPS, 2014a):

- Infant failures defined as occurring up to four years after installation (average two years);
- Midlife failures defined as occurring about five to eleven years after installation;
- Wear-out failures defined as occurring about 12 years after installation until the assumed end-of-life at 30 years.

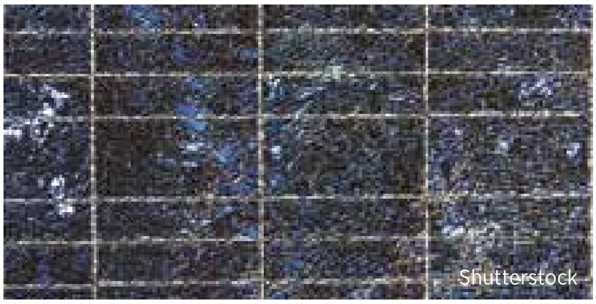
Empirical data on causes and frequency of failures during each of the phases defined above were obtained from different literature (IEA-PVPS, 2014a; Padlewski, 2014; Vodermayer, 2013 and DeGraaff, 2011). Independent of those phases, Figure 5 provides an overview of the main causes of PV panel failure.

7. C-Si panels constituted the largest share of surveyed technologies. The weight-to-power ratio was continuously reduced during the development of the PV technology by material savings and improved solar cell efficiencies (Photon, 2015).

Figure 5 Failure rates according to customer complaints



Based on IEA-PVPS (2014a)



The main infant failure causes include light-induced degradation (observed in 0.5%-5% of cases), poor planning, incompetent mounting work and bad support constructions. Many infant failures have been reported within the electrical systems such as junction boxes, string boxes, charge controllers, cabling and grounding.

Causes of midlife failures are mostly related to the degradation of the anti-reflective coating of the glass, discoloration of the ethylene vinyl acetate, delamination and cracked cell isolation.

Causes of frequently observed failures within all phases in the first 12 years - after exposure to mechanical load cycles (e.g. wind and snow loads) and temperatures changes - include potential induced degradation, contact failures in the junction box, glass breakage, loose frames, cell interconnect breakages and diode defects.

In the wear-out phase, failures like those reported in the midlife phase increase exponentially in addition to the severe corrosion of cells and interconnectors. Previous studies with statistical data on PV panel failures additionally observe that 40% of PV panels inspected suffered from at least one cell with microcracks. This defect is more commonly reported with newer panels manufactured after 2008 due to the thinner cells used in production.

These failures and probability of loss findings, alongside data from step 1a (conversion factors) are used to estimate PV panel waste streams (step 2).

On the basis of step 1a and 1b, two PV waste scenarios were defined (see Table 4) – the regular-loss scenario and early-loss scenario.

Step 2: Scenarios for annual waste stream estimation (regular-loss and early-loss scenarios)

Table 4 PV panel loss model methodology for step 2

Model	Data input and references

Regular-loss scenario input assumptions
• 30-year average panel lifetime
• 99.99% probability of loss after 40 years
• extraction of Weibull model parameters from literature data (see Table 5)
Early-loss scenario input assumptions
• 30-year average panel lifetime
• 99.99% probability of loss after 40 years
• Inclusion of supporting points for calculating non-linear regression:
  • Installation/transport damages: 0.5%
  • within first 2 years: 0.5%
  • After 10 years: 2%
  • After 15 years: 4%
• Calculation of Weibull parameters (see Table 5)
	• The 30-year average panel lifetime assumption was taken from literature (Frischknecht *et al.*, 2016).
	• A 99.99% probability of loss was assumed as an approximation to 100% for numerical reasons using the Weibull function. The 40-year technical lifetime assumption is based on depreciation times and durability data from the construction industry (Greenspec, 2016).
	• The early-loss input assumptions were derived from different literature sources (IEA-PVPS, 2014a; Padlewski, 2014; Vodermeyer, 2013; DeGraaff, 2011).

Both scenarios are modelled using the Weibull function as indicated in the formula below. The probability of losses during the PV panel life cycle is thereby determined by the shape factor α that differs for the regular-loss and early-loss scenario.

The formula is:

$$F(t) = 1 - e^{-(t/T)^{\alpha}}$$

where
t = time in years
T = average lifetime
α = shape factor, which controls the typical S shape of the Weibull curve

Both scenarios assume a 30-year average panel lifetime and a 99.99% probability of loss after 40 years. A 30-year panel lifetime is a common assumption in PV lifetime environmental impact analysis (e.g. in life cycle assessments) and is recommended by the IEA-PVPS (Frischknecht *et al.*, 2016). The model assumes that at 40 years at the latest PV panels are dismantled for refurbishment and modernisation. The durability of PV panels is thus assumed to be in line with average building and construction product experiences such as façade elements or roof tiles. These also traditionally have a lifetime of 30-40 years.

Neither initial losses nor early losses were included in the **regular-loss scenario.** The results from Kuitsche (2010) are used directly, assuming an **alpha shape factor in this scenario of 5.3759** (see Table 5).

In the **early-loss scenario**, the following loss assumptions are made based on an analysis of the literature and expert judgement (IEA-PVPS, 2014a; Padlewski, 2014; Vodermayer, 2013 and DeGraaff, 2011):

- 0.5% of PV panels (by installed PV capacity in MW) is assumed to reach end-of-life because of damage during transport and installation phases[8];
- 0.5% of PV panels will become waste within two years due to bad installation;
- 2% will become waste after ten years;
- 4% will become waste after 15 years due to technical failures.

The early-loss scenario includes failures requiring panel replacement such as broken glass, broken cells or ribbons and cracked backsheet with isolation defects. However, only panels with serious functional or safety defects requiring entire replacement are included, while other defects that, for example, reduce power output or create panel discoloration are ignored.

In the early-loss scenario, the shape factor was calculated by a regression analysis between data points from literature and also considered early failures (see Table 5). The resulting **alpha shape factor of 2.4928 for the early-loss scenario** is lower than literature values presented. This is because it includes early defects that yield higher losses in the first 30 years and lower losses in later life should a panel last longer.

For each scenario (regular-loss and early-loss), the probability of failure value (alpha) is multiplied according to the Weibull function by the weight of panels installed in a given year. Since a bigger alpha value is used in the regular-loss scenario, the curve ascends smoothly and intersects with the early-loss scenario curve at the nominal lifetime point of 30 years. In line with the Weibull function and due to the different assigned alpha parameters, regular-loss and early-loss scenarios have the opposite effect after 30 years. Hence, the regular-loss scenario indicates a higher probability of loss from 30 years on (see Figure 6).

8. Most PV system installers might have to purchase excess panels to compensate for potential losses during transport and installation, which was accounted for in this model. The model assumes that 0.5% of panels are lost in the initial period and is lower than the rate assumed in Sander's model (2007).

Table 5 Overview of Weibull shape factors reported in the literature for modelling PV panel loss probability alongside baseline values selected for use in this study

Weibull shape factors	Kumar & Sarkan (Kumar, 2013)	Kuitsche (2010)	Zimmermann (2013)	Marwede (2013)	This study
Lower	9.982	3.3		8.2	
Upper	14.41	8.7484		12.8	
Baseline		5.3759 (represents regular-loss scenario)	5.3759		2.4928 (represents early-loss scenario)

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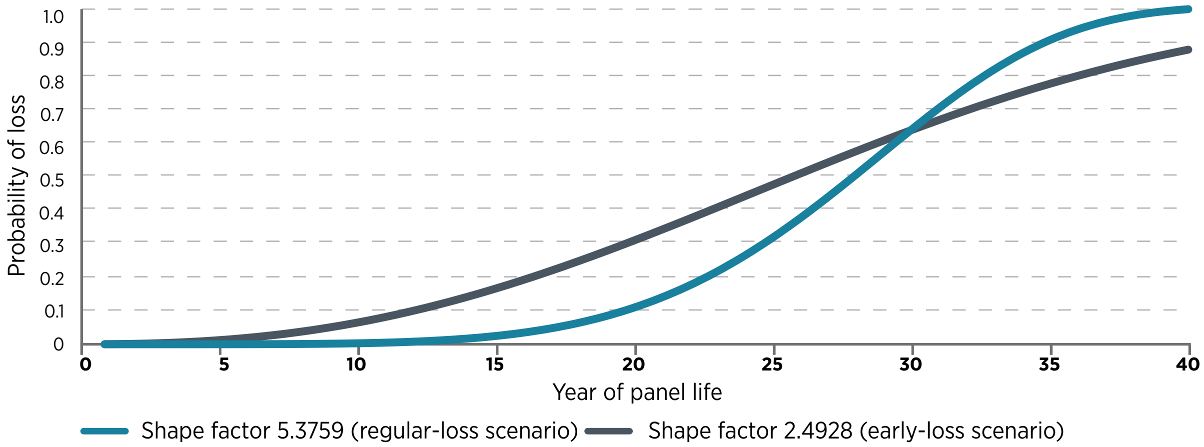
Figure 6 Example of Weibull curve with two different shape factors from Table 5



Box 3 Uncertainty analysis

This study is the first to quantify PV panel waste at a global scale and across different PV technologies. This means the scenarios portrayed here should be considered order of magnitude estimates and directional rather than highly accurate or precise, owing to the simple assumptions and lack of statistical data. Further, they stimulate the need for more assessments. This box gives a short overview of the three main areas of uncertainty that could affect the results and conclusions of the study. The uncertainty related to the cumulative installed PV capacity to 2050 is an input factor for the model and therefore not further considered here.

First and foremost, the data available on PV panel failure modes and mechanisms is only a small fraction of the full number of panels installed worldwide. This means the baseline assumptions bear some uncertainties and will need to be refined as more data become available. The rapid evolution of PV materials and designs adds another level of complexity and uncertainty to estimates.

Moreover, failure does not necessarily mean that a panel will enter the waste stream at the given year of failure. This is because some failures might not be detected right away or may be tolerated for years. For example, if a PV panel still produces some output, even if lower than when initially commissioned, replacement may not be financially justified. Hence, data available on the different determinants of the end of a PV panel's lifetime are often interlinked with non-technical and system aspects that are very difficult to predict.

The last major uncertainty relates to key assumptions used to model the probability of PV panel losses versus the life cycle of the panels using the Weibull function. To calculate the Weibull shape factors for this study's regular-loss and early-loss scenarios, existing literature was reviewed. The results of the analysis are presented in Table 5. It is assumed that the early losses in the early-loss scenario are constant into the future. In other words, no learning to reduce premature losses is taken into account. The model also excludes repowering PV plants.

In summary, this study develops two scenarios – regular-loss and early-loss – to account for the above uncertainties about the mechanisms and predicted timing of panel failures. To better estimate potential PV panel waste streams in the future, national and regional decisions on PV waste stream regulation must include a monitoring and reporting system. This will yield improved statistical data to strengthen waste stream forecasts and enable a coherent framework for policy regulations.

The above modelling produces PV panel waste projections by country up to 2050. The next section summarises the findings of the model.

2.3 PV PANEL WASTE PROJECTIONS

Global PV panel waste outlook

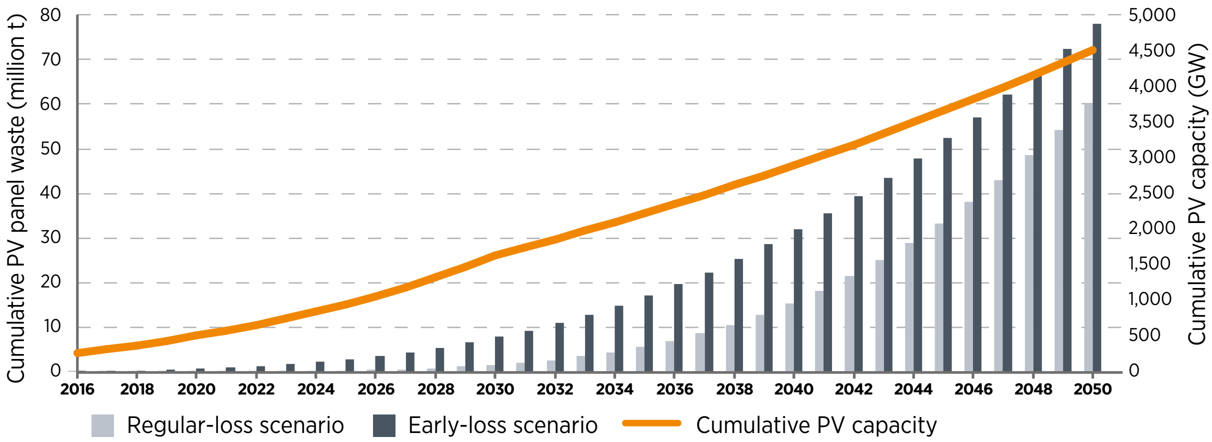
Total annual e-waste in the world today accounts for 41.8 million t (Baldé, 2015). By comparison, cummulative PV panel waste will account for no more than 250,000 t by the end of 2016 according to the early-loss scenario modelled in this report. This represents only 0.6% of total e-waste today but the amount of global waste from PV panels will rise significantly over the next years.

Figure 7 displays **cumulative PV panel waste results** up to 2050.

- In the regular-loss scenario, the PV panel waste accounts for 43,500 t by end 2016 with an increase projected to 1.7 million t in 2030. An even more drastic rise to approximately 60 million t could be expected by 2050.
- The early-loss scenario projection estimates much higher total PV waste streams, with 250,000 t alone by the end of 2016. This estimate would rise to 8 million t in 2030 and total 78 million t in 2050. This is because the early-loss scenario assumes a higher percentage of early PV panel failure than the regular-loss scenario.

Based on the best available information today, this report suggests the actual future PV panel waste volumes will most likely fall somewhere between the regular-loss and early-loss values.

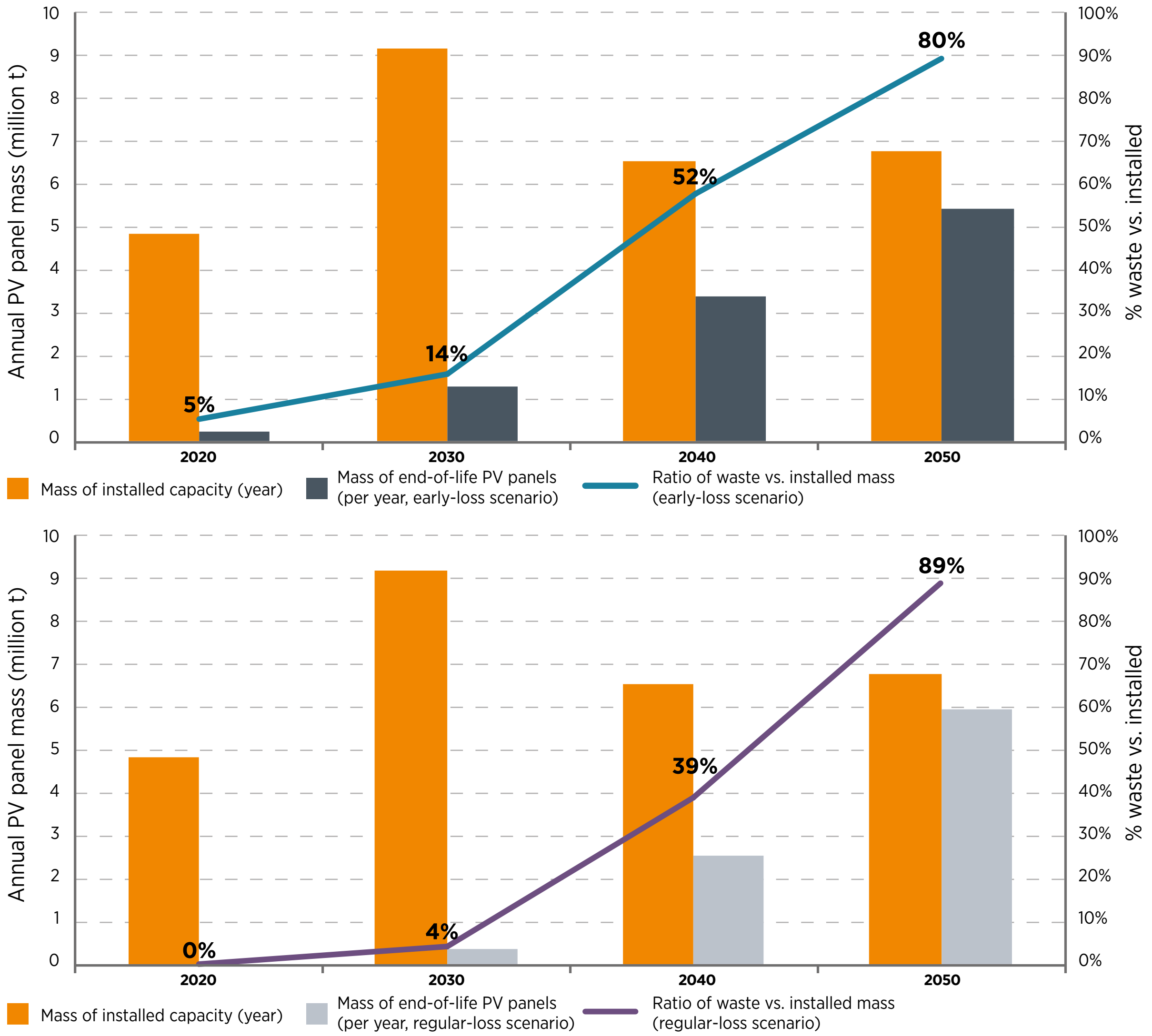
Figure 7 Estimated cumulative global waste volumes (million t) of end-of-life PV panels



Annual PV panel waste up to 2050 is modelled in Figure 8 by illustrating the evolution of PV panel end-of-life and new PV panel installations as a ratio of the two estimates. This ratio starts out low at 5% at the end of 2020, for instance (i.e. in the early-loss scenario, annual waste of 220,000 t compared to 5 million t in new installations). However, it increases over time to 4%-14% in 2030 and 80%-89% in 2050. At that point, 5.5-6 million t of PV panel waste (depending on scenario) is predicted in comparison to 7 million t in new PV panel installations.

A feature of the Weibull curve shape factors for the two modelled scenarios is that the estimated waste of both scenarios intersects. The scenario predicting greater waste panels in a given year then switches. The intersection is projected to take place in 2046. This modelling feature can be observed in Figure 8 which shows the volume of PV panel waste amounting to over 80% of the volume of new installations as a result of the early-loss scenario in 2050. The comparable figure for the regular-loss scenario exceeds 88% in the same year.

Figure 8 Annually installed and end-of-life PV panels 2020-2050 (in % waste vs. t installed) by early-loss scenario (top) and regular-loss scenario (bottom)



Waste projections by country

Detailed PV panel waste estimates by selected countries are displayed in Table 6 from 2016 up to 2050. The countries were chosen according to their regional leadership when it comes to PV deployment and expected growth.

The projections are modelled using the same Weibull function parameters as the global estimates of the previous section. Projected waste volumes of PV panels in individual countries are based on existing and future annual installations and rely on input data available for each country. The historic cumulative installed PV capacity was used as benchmark in each country alongside future projections to 2030 using IRENA's *REmap* and for 2030 to 2050 IEA's *PV Technology Roadmap*, with a simple interpolation.

Table 6 Modelled results of estimated cumulative waste volumes of end-of-life PV panels by country (t)

Year	2016		2020		2030		2040		2050	
Scenario (regular-loss/early-loss)	**regular loss**	**early loss**	**regular loss**	**early loss**	**regular loss**	**early loss**	**regular loss**	**early loss**	**regular loss**	**early loss**
Asia										
China	5,000	15,000	8,000	100,000	200,000	1,500,000	2,800,000	7,000,000	13,500,000	19,900,000
Japan	7,000	35,000	15,000	100,000	200,000	1,000,000	1,800,000	3,500,000	6,500,000	7,600,000
India	1,000	2,500	2,000	15,000	50,000	325,000	620,000	2,300,000	4,400,000	7,500,000
Republic of Korea	600	3,000	1,500	10,000	25,000	150,000	300,000	820,000	1,500,000	2,300,000
Indonesia	5	10	45	100	5,000	15,000	30,000	325,000	600,000	1,700,000
Malaysia	20	100	100	650	2,000	15,000	30,000	100,000	190,000	300,000
Europe										
Germany	3,500	70,000	20,000	200,000	400,000	1,000,000	2,200,000	2,600,000	4,300,000	4,300,000
Italy	850	20,000	5,000	80,000	140,000	500,000	1,000,000	1,200,000	2,100,000	2,200,000
France	650	6,000	1,500	25,000	45,000	200,000	400,000	800,000	1,500,000	1,800,000
United Kingdom	250	2,500	650	15,000	30,000	200,000	350,000	600,000	1,000,000	1,500,000
Turkey	30	70	100	350	1,500	11,000	20,000	100,000	200,000	400,000
Ukraine	40	450	150	2,500	5,000	25,000	50,000	100,000	210,000	300,000
Denmark	80	400	100	2,000	4,000	22,000	40,000	70,000	130,000	125,000
Russian Federation	65	65	100	350	1,000	12,000	20,000	70,000	150,000	200,000
North America										
United States of America	6,500	24,000	13,000	85,000	170,000	1,000,000	1,700,000	4,000,000	7,500,000	10,000,000
Mexico	350	800	850	1,500	6,500	30,000	55,000	340,000	630,000	1,500,000
Canada	350	1,600	700	7,000	13,000	80,000	150,000	300,000	650,000	800,000
Middle East										
United Arab Emirates	0	10	50	100	3,000	9,000	20,000	205,000	350,000	1,000,000
Saudi Arabia	200	250	300	1,000	3,500	40,000	70,000	220,000	450,000	600,000
Africa										
South Africa	350	550	450	3,500	8,500	80,000	150,000	400,000	750,000	1,000,000
Nigeria	150	200	250	650	2,500	30,000	50,000	200,000	400,000	550,000
Morocco	0	25	10	100	600	2,000	4,000	32,000	50,000	165,000
Oceania										
Australia	900	4,500	2,000	17,000	30,000	145,000	300,000	450,000	900,000	950,000
Latin America and Caribbean										
Brazil	10	10	40	100	2,500	8,500	18,000	160,000	300,000	750,000
Chile	150	200	250	1,500	4,000	40,000	70,000	200,000	400,000	500,000
Ecuador	10	15	15	100	250	3,000	5,000	13,000	25,000	35,000
Total World	**43,500**	**250,000**	**100,000**	**850,000**	**1,700,000**	**8,000,000**	**15,000,000**	**32,000,000**	**60,000,000**	**78,000,000**
Sum of Leading Countries	**28,060**	**187,255**	**72,160**	**668,500**	**1,352,850**	**6,442,500**	**12,252,000**	**26,105,000**	**48,685,000**	**67,975,000**
Rest of the World	**15,440**	**62,745**	**27,840**	**181,500**	**347,150**	**1,557,500**	**2,748,000**	**5,895,000**	**11,315,000**	**10,025,000**

PV panel waste projections until 2030

The results modelled indicate that the highest expected PV panel waste streams by 2030 are in Asia with up to 3.5 million t accumulated, depending on the scenario. Regional Asian champions in renewable energy deployment will therefore also experience the highest waste streams. For example, China will have an estimated installed PV capacity of 420 GW in 2030 and could accumulate between 200,000 t and 1.5 million t in waste by the same year. Japan and India follow, with projections of between 200,000 t and 1 million t, and 50,000-325,000 t in cumulative PV-waste by 2030 respectively.

Europe is predicted to present the second largest PV waste market with projected waste of up to 3 million t by 2030. Germany, with an anticipated 75 GW of PV capacity, is forecasted to face between 400,000 and 1 million t of PV panel waste by 2030. Other future significant PV waste markets are projected to include Italy and France.

With an expected cumulative 240 GW in deployed PV by 2030, the US will lead in terms of total installed PV capacity in North America. It is projected to generate waste between 170,000 and 1 million t by then. Countries such as Canada (up to 80,000 t) and Mexico (up to 30,000 t) will also experience rising PV waste streams by 2030.

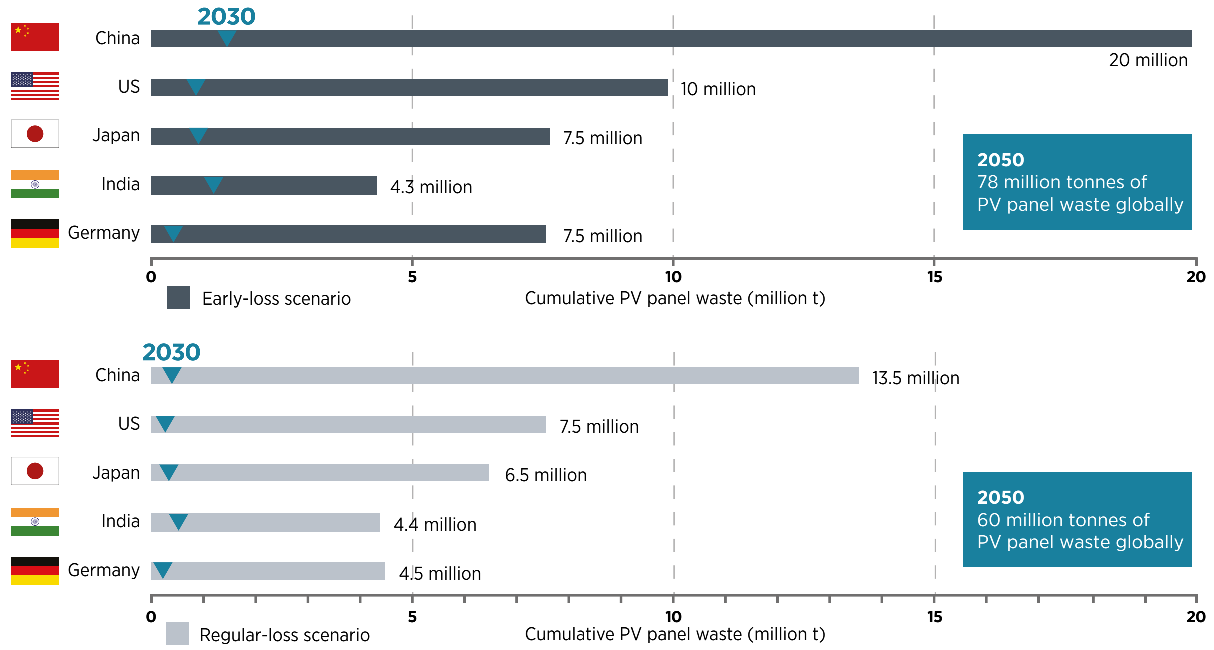
By 2030 Africa and Latin America are predicted to also see expanding PV-waste volumes. South Africa (8,500-80,000 t by 2030) and Brazil (2,500-8,500 t by 2030) will be regional leaders in this respect. Other significant PV-waste markets by 2030 will include the Republic of Korea with cumulative waste of 25,000-150,000 t and Australia with 30.000-145,000 t.

Waste volume surge in 2030-2050

Given the worldwide surge in PV deployment since 2010 and average lifetime and failure rates for panels, waste volumes are certain to increase more rapidly after 2030. Whereas in 2030 the top three PV panel waste countries are expected to include China, Germany and Japan, the picture slightly changes by 2050. By then, China is still predicted to have accumulated the greatest amount of waste (13.5-20 million t). However, Germany is overtaken by the US (7.5-10 million t), Japan is next (6.5-7.5 million t) and India follows (4.4-7.5 million t). The regular-loss and early-loss waste estimates by top five countries in 2030 and 2050 are displayed in Figure 9.

The analysis presented in this chapter develops quantitative estimates for PV panel waste streams until 2050 by country and region as well as on a global scale. At the same time, PV panels and consequently their waste differ in composition and regulatory classification, which will be discussed in the next chapter.

Figure 9 Estimated cumulative waste volumes of end-of-life PV panels by top five countries in 2050 by early-loss scenario (top) and regular-loss scenario (bottom)



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PV PANEL COMPOSITION AND WASTE CLASSIFICATION

PV panels create unique waste-management challenges along with the increasing waste streams forecast in Chapter 2. Apart from in the EU, end-of-life treatment requirements across the world for PV panels are set by waste regulations applying generically to any waste rather than dedicated to PV.

Waste regulations are based on the classification of waste. This classification is shaped according to the waste composition, particularly concerning any component deemed hazardous.

Waste classification tests determine permitted and prohibited shipment, treatment, recycling and disposal pathways. A comprehensive overview of the widely varying global PV waste classification is beyond the scope of this report. Instead, this chapter characterises the materials contained in PV panels and corresponding waste-classification considerations. These determine the required treatment and disposal pathways for PV panels when other more specific waste classifications and regulations are not applicable.

Table 7 Market share of PV panels by technology groups (2014-2030)

<table>
<tr><th>Technology</th><th></th><th>2014</th><th>2020</th><th>2030</th></tr>
<tr><td rowspan="4">Silicon-based (c-Si)</td><td>Monocrystalline</td><td rowspan="4">92%</td><td rowspan="4">73.3%</td><td rowspan="4">44.8%</td></tr>
<tr><td>Poly- or multicrystalline</td></tr>
<tr><td>Ribbon</td></tr>
<tr><td>a-Si (amorph/micromorph)</td></tr>
<tr><td rowspan="2">Thin-film based</td><td>Copper indium gallium (di)selenide (CIGS)</td><td>2%</td><td>5.2%</td><td>6.4%</td></tr>
<tr><td>Cadmium telluride (CdTe)</td><td>5%</td><td>5.2%</td><td>4.7%</td></tr>
<tr><td rowspan="4">Other</td><td>Concentrating solar PV (CPV)</td><td rowspan="4">1%</td><td>1.2%</td><td>0.6%</td></tr>
<tr><td>Organic PV/dye-sensitised cells (OPV)</td><td>5.8%</td><td>8.7%</td></tr>
<tr><td>Crystalline silicon (advanced c-Si)</td><td>8.7%</td><td>25.6%</td></tr>
<tr><td>CIGS alternatives, heavy metals (e.g. perovskite), advanced III-V</td><td>0.6%</td><td>9.3%</td></tr>
</table>

Based on Fraunhofer Institute for Solar Energy Systems (ISE) (2014), Lux Research (2013) and author research

3.1 PANEL COMPOSITION

Technology trends

To achieve optimal waste treatment for the distinct PV product categories, the composition of PV panels needs to be taken into consideration. PV panels can be broken down according to the technology categories shown in Table 7. The different technology types typically differ in terms of materials used in their manufacturing and can contain varying levels of hazardous substances that must be considered during handling and processing.

C-Si PV is the oldest PV technology and currently dominates the market with around 92% of market share (ISE, 2014). Multicrystalline silicon panels have a 55% and monocrystalline silicon panels a 45% share of c-Si technology respectively. Due to low efficiency ratios, a-Si products have been discontinued in recent years, and the market share nowadays is negligible.

The two thin-film PV panel technologies make up 7% of the PV market, 2% for CIGS panels, and 5% for CdTe panels. The following analysis will not pay any more attention to CPV and other technologies because it only has a low market share at less than 1%.

Although the market share of novel devices is predicted to grow, mainstream products are expected to retain market dominance up to 2030, especially c-Si panels (Lux Research, 2013). As shown in Table 7, silicon technology has great potential for improvement at moderate cost if new process steps are implemented into existing lines. For example, an increase in usage of hetero-junction cells is predicted, providing higher efficiencies and performance ratios. According to Lux Research (2013 and 2014), CIGS technology has great potential for better efficiencies and may gain market share while CdTe is not expected to grow. In the long term, CIGS alternatives (e.g. replacing indium and gallium with zinc and tin), heavy metal cells including perovskite structures, and advanced III-V cells, might take nearly 10% of market share. The same can be said of OPV and dye-sensitised cells (Lux Research, 2014). Recent reports indicate OPV has reached efficiencies of 11% and dye-sensitised cells 12% (IEA, 2014).

In line with a PV market heavily dominated by c-Si PV, all the main panel manufacturers except for First Solar rely on silicon-based PV panel technologies. In 2015, the top ten manufacturers for PV panels represented 32 GW per year of manufacturing capacity, which is around two-thirds of the global PV market, estimated at 47 GW (see Table 8).

Table 8 Top ten PV panel manufacturers in 2015

	Thin-film	Silicon-based	Annual manufacturing capacity (MW)
Trina Solar		x	≤5,500
Canadian Solar		x	≤4,500
Jinko Solar		x	≤4,500
JA Solar		x	≤3,500
Hanwha Q CELLS		x	≤3,000
First Solar	x		≤3,000
Yingli		x	≤2,500
GCL System			≤2,000
Suntech Power		x	≤2,000
Renesola		x	≤1,500
Sum of top 10 PV panel manufacturers			**≥32,000**

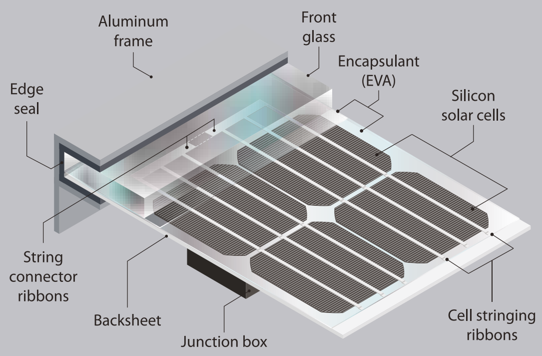
IRENA/IEA-PVPS estimates, 2016[9]

9. Uncertainty is a core characteristic of PV manufacturing capacity data due to inaccurate or incomplete manufacturing and export data on manufactuers discussed.

Component trends

The various components of major PV panel technologies will influence material and waste characterisation as well as the economics of treatment pathways. As shown in Boxes 4 and 5, the design of silicon-based and thin-film panels differs, affecting their composition accordingly.

Box 4 c-Si PV panel components



c-Si (monocrystalline) panel, National Renewable Energy Laboratory (NREL), 2016

c-Si technology consists of slices of solar-grade silicon, also known as wafers, made into cells and then assembled into panels and electrically connected.

The standard cell consists of a p-doped wafer with a highly doped pn-junction. The surface is usually textured and may show pyramid structures (monocrystalline silicon) or random structures (polycrystalline silicon) and an anti-reflective layer to minimise the reflection of light.

c-Si (monocrystalline) panel, National Renewable Energy Laboratory (NREL), 2016

To form an electric field, the front and back of the cell are contacted using grid-pattern printed silver and aluminium pastes. During a thermal process known as firing, the aluminium diffuses into the silicon and forms the back surface field. Advanced cell concepts add further layers to the wafer and utilise laser structuring and contacting to optimise the efficiencies of the cell (Raithel, 2014).

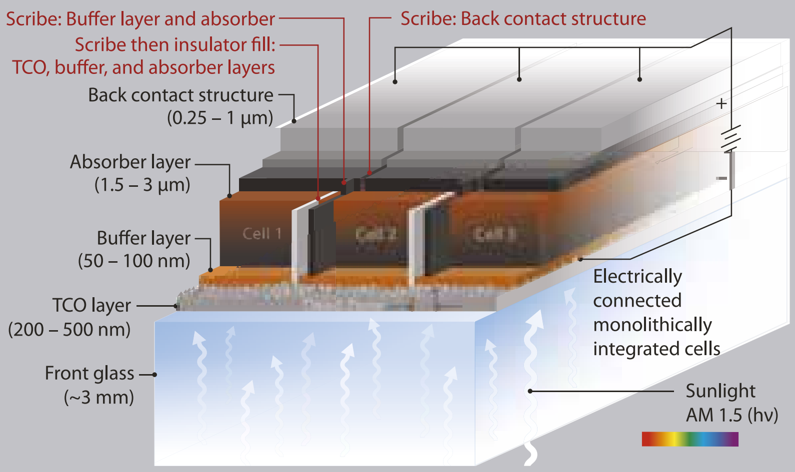
PV CYCLE

PV CYCLE

Box 5 Thin-film PV panel components

Thin-film panels consist of thin layers of semiconducting material deposited onto large substrates such as glass, polymer or metal.

Thin-film PV panel technologies can be broken down to two main categories, CIGS and CdTE.



Thin-film (monolithic integration) panel, NREL, 2016

CIGS panels use high light absorption as a direct semiconductor. Adjustment to the light spectrum is made by varying the ratios of the different elements in the compound semiconductor (e.g. indium, gallium and selenium). The compound has very good light absorption properties so much thinner semiconductor layers are needed to achieve similar efficiencies with C-Si panels (hence the term thin-film). CIGS cells are deposited on a metal back-contact (which can be composed of different metals and alloys) on glass substrates. Deposits on a steel carrier or polymer foil are also possible, producing flexible designs and high throughputs in roll-to-roll productions.

To form the junction needed for the PV effect, thin layers of cadmium sulfide usually form the hetero-transfer layers. Zinc oxide or other transparent conducting oxides are used as a transparent front contact, which may contain traces of other elements for better conductivity. Owing to the deposition of the cell layers on the substrate, the surface requires an encapsulation layer and front glass layer usually made of solar glass. This mainly protects the layers from long-term oxidation and degradation through water ingress, for example. Cadmium sulfide is needed as a buffer layer but it can be replaced by cadmium-free materials like zinc, zinc oxide, zinc selenide, zinc indium selenide or a chemical dependent of indium selenide (Bekkelund, 2013).

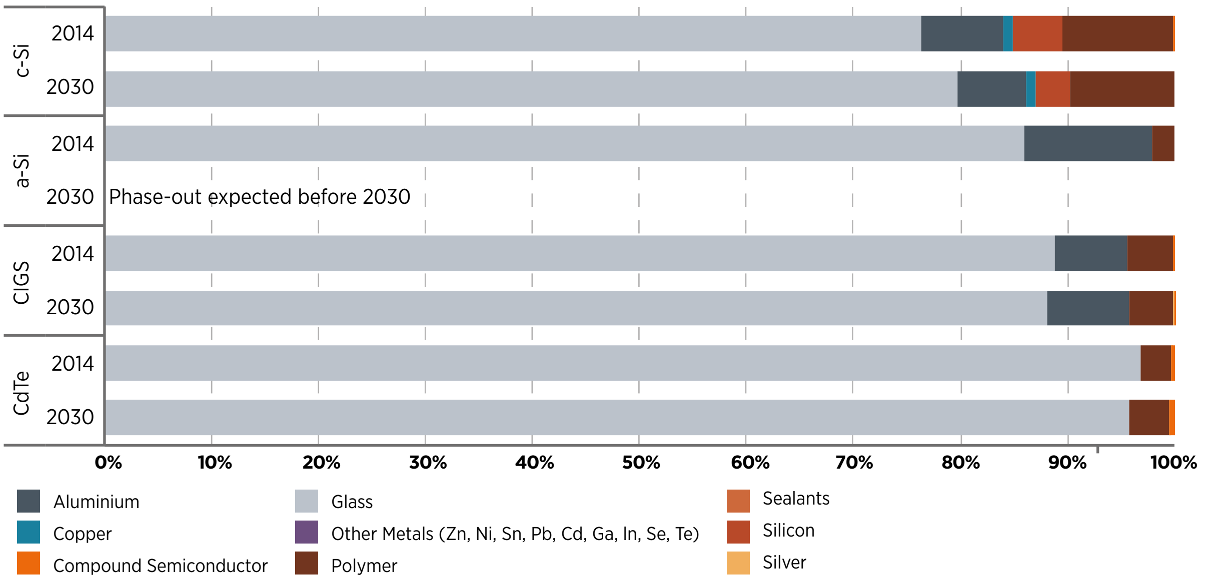
Furthermore, CIGS panels contain cell absorbers made of 'chalcopyrite,' a crystalline structure, with the general formula $Cu(In,Ga)(S,Se)_2$. Most frequently, a mixed crystal compound copper indium diselenide with various additions of gallium (either copper indium selenide or CIGS) is used in the manufacturing process. The substitution of other materials such as aluminium for indium, or silver for copper is currently under investigation. However, these variations will not be commercialised for several years (Pearce, 2014).

Though **CdTe panels** may be grown both in substrate and superstrate configurations, the superstrate configuration is preferred for better efficiencies (up to more than 17%). The transparent conductive oxide, intermediate cadmium sulphide (CdS) and CdTe layers, are deposited on the glass superstrate. The typical thickness of the CdTe layer today is 3 microns, which has the potential to be reduced to one micron in the future. The back layer can consist of copper/aluminium, copper/graphite or graphite doped with copper. An encapsulation layer laminates the back glass to the cell.

A typical crystalline PV panel with aluminium frame and 60 cells has a capacity of 270 watt-peak (Wp) and weighs 18.6 kilogrammes (kg) (e.g. Trina Solar TSM-DC05A.08). For a standard CdTe panel, 110 Wp can be assumed on average for 12 kg weight (e.g. First Solar FS-4100). A CIGS panel usually holds a capacity of 160 Wp and 20 kg (e.g. Solar Frontier SF160-S).

Research on the PV components concludes that progress in material savings and panel efficiencies will drive a reduction in materials use per unit of power and the use of potentially hazardous substances (Marini *et al.* (2014); Pearce (2014); Raithel (2014); Bekkelund (2013); NREL (2011) and Sander *et al.*, (2007)). On this basis, Figure 10 compares the materials employed for the main PV panel technologies between 2014 and 2030.

Figure 10 Evolution to 2030 of materials used for different PV panel technologies as a percentage of total panel mass



Based on Marini et al., (2014); Pearce (2014); Raithel (2014); Bekkelund (2013); NREL (2011) and Sander et al., (2007)

● Crystalline silicon PV panels

By weight, typical **c-Si PV panels** today contain about 76% glass (panel surface), 10% polymer (encapsulant and backsheet foil), 8% aluminium (mostly the frame), 5% silicon (solar cells), 1% copper (interconnectors) and less than 0.1% silver (contact lines) and other metals (mostly tin and lead) (Sander *et al.*, 2007 and Wambach and Schlenker, 2006).

Industry trend studies such as the International Technology Roadmap for Photovoltaic (ITRPV) suggest new process technologies will prevail, encouraging thinner and more flexible wafers as well as more complex and manifold cell structures. These will require new interconnection and encapsulation techniques. For example, bifacial cell concepts offer high efficiencies in double glass panels made of two glass panes each two millimetres thick. An encapsulant layer reduction of up to 20% is possible owing to thinner wafers. Cells with back-contacts and metal wrap-through technologies that reduce shadow and electrical losses (known as hetero-junction concept cells) are equally expected to gain significant market share (Raithel, 2014).

By 2030 the glass content of c-Si panels is predicted to increase by 4% to a total of 80% of the weight's panel. The main material savings will include a reduction in silicon from 5% down to 3%, a 1% decrease in aluminium and a very slight reduction of 0.01% in other metals. Specific silver consumption is expected to be further decreased by better metallisation processes and replacements with copper or nickel/copper layers (Raithel, 2014).

In today's market, the most efficient panels with back junction-interdigitated back-contacts have shown efficiencies of about 21%. Hetero-junction technologies have achieved 19%. The average efficiency of a c-Si panel has grown by about 0.3% per year in the last ten years (Raithel, 2014).

a-Si PV panels have lost significant market share in recent years and do not contain significant amounts of valuable or hazardous materials (see Figure 10). Thus, they will most likely not require special waste treatment in the future. This section and the rest of the report therefore does not cover a-Si panels.

In **multi-junction cell design**, two (tandem) or more cells are arranged in a stack. In all cases the upper cell(s) have to be transparent in a certain spectrum to enable the lower cells to be active. By tailoring the spectrum sensitivity of the individually stacked cells, a broader range of sunlight can be absorbed, and the total efficiency maximised. Such cell types are used in a-Si, c-Si and concentrator cells. The low cost of c-Si today allows cost-efficient mass production of high-efficiency multi-junction cells. This can be combined, for example, with III-V alloys, chalcogenides and perovskites expected to perform extremely well even in non-concentrating tracker applications (Johnson, 2014).

Thin-film panels

Thin-film panels are technologically more complex than silicon-based PV panels. Glass content for c-Si panels is likely to increase by 2030. By contrast, it is likely to decrease for thin-film panels by using thinner and more stable glass materials. This in turn will encourage a higher proportion of compound semiconductors and other metals (Marini *et al.*, 2014 and Woodhouse *et al.*, 2013).

CIGS panels are today composed of 89% of glass, falling 1% to 88% in 2030. They contain 7% aluminium, rising 1% in 2030, and 4% polymer remaining stable. They will experience a slight reduction of 0.02% in other metals but a 0.2% increase in semiconductors. Other metals include 10% copper, 28% indium, 10% gallium and 52% selenium (Pearce, 2014; Bekkelund, 2013 and NREL, 2011).

CIGS panel efficiency is currently 15% and targeted at 20% and above in the long term (Raithel, 2014).

By 2030 the proportion of glass as total panel mass in **CdTe panels** is expected to decrease by 1% from 97% to 96%. However, their polymer mass is expected to increase by 1% from 3% to 4% compared to today. In comparison to CIGS panels, material usage for semiconductors as a proportion of panel usage will decline almost by half from 0.13% to 0.07%. However, the share of other metals (e.g. nickel, zinc and tin) will grow from 0.26% to 0.41% (Marini *et al.*, 2014; Bekkelund, 2013 and NREL, 2011). The main reason for this increase in other metals is the further reduction in CdTe layer thickness (which brings down the semiconductor content of the base semiconductor). However, the efficiency improvements of the past couple of years were also related to 'bandgap' grading effects, which can be achieved by doping the semiconductor layer with other components. The addition of other components to the mix is reflected in the rise in other metals. Another reason for the increase in the proportion of other metals is the addition of a layer between back-contact metals and the semiconductor package. This reduces copper diffusion into the semiconductor and thus long-term degradation and leads to the thickening of the back-stack of metals (Strevel *et al.*, 2013).

The PV industry is aiming for 25% efficiency for CdTe panel research cells and over 20% for commercial panels in the next three years. This is substantially higher than the 15.4% achieved in 2015. New technologies are also expected to reduce the performance degradation rate to 0.5%/year (Strevel *et al.*, 2013).

Chapter 6 provides additional details on panel composition, the function of various materials and potential future changes in panel design and composition.

3.2 WASTE CLASSIFICATION

Background

PV panel waste classification follows the basic principles of waste classification. This also considers material composition by mass or volume and properties of the components and materials used (e.g. solubility, flammability, toxicity). It accounts for potential mobilisation pathways of components and materials for different reuse, recovery, recycling and disposal scenarios (e.g. materials leaching to groundwater, admission of particulate matter into the soil). The overall goal of these classification principles is to identify risks to the environment and human health that a product could cause during end-of-life management. The aim is to prescribe disposal and treatment pathways to minimise these threats. The risk that materials will leach out of the end-of-life product or its components to the environment is very significant, and assessment of this threat helps define necessary containment measures. However, this is just one possible risk. Other examples assessed through waste characterisation include flammability, human exposure hazards through skin contact or inhalation. Risks assessed may differ by country and jurisdiction.

Depending on national and international regulations such as the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal (UN, 2016), waste can be classified into various categories such as inert waste, non-hazardous waste and hazardous waste. To some extent, the origin of the waste is also taken into consideration, defining subcategories such as industrial waste, domestic waste and specific product-related categories such as e-waste, construction waste and mixed solid wastes. The different categories of classified waste then determine permitted and prohibited shipment, treatment, recycling and disposal pathways.

In 2015 two-thirds of PV panels installed across the world were c-Si panels. Typically, more than 90% of their mass is composed of glass, polymer and aluminium, which can be classified as non-hazardous waste. However, smaller constituents of c-Si panels can present recycling difficulties since they contain silicon, silver and traces of elements such as tin and lead (together accounting for around 4% of the mass). Thin-film panels (9% of global annual production) consist of more than 98% glass, polymer and aluminium (non-hazardous waste) but also modest amounts of copper and zinc (together around 2% of the mass), which is potentially environmentally hazardous waste. They also contain semiconductor or hazardous materials such as indium, gallium, selenium, cadmium tellurium and lead. Hazardous materials need particular treatment and may fall under a specific waste classification depending on the jurisdiction.

Key criterion for PV panel waste classification: Leaching tests

Table 9 summarises typical waste characterisation leaching test methods in the US, Germany and Japan. The overview provides one of the most important characterisation metrics used in PV waste classification across the world at this time.

Table 9 PV waste characterisation: Leaching test methods in the US, Germany and Japan

	US	Germany	Japan
Leaching test	US Environment Protection Agency method 1311 (TCLP)	DIN EN German Institute for Standardization standard 12457-4:01-03	Ministry of Environment Notice 13/JIS K 0102:2013 method (JLT-13)
Sample size (centimetres)	1	1	0.5
Solvent	Sodium acetate/ acetic acid (pH 2.88 for alkaline waste; pH 4.93 for neutral to acidic waste)	Distilled water	Distilled water
Liquid:solid ratio for leaching test (*e.g.* amount of liquid used in relation to the solid material)	20:1	10:1	10:1
Treatment method	End-over-end agitation (30±2 rotations per minute)	End-over-end agitation (5 rotations per minute)	End-over-end agitation (200 rotations per minute)
Test temperature	23±2˚C	20˚C	20˚C
Test duration	18±2 hr	24 hr	6 hr

Based on Sinha and Wade (2015)

The key criterion for determining the waste classification is the concentration of certain substances in a liquid which has been exposed to fragments of the broken PV panels for a defined period of time in a particular ratio. This leachate typically dissolves some of the materials present in the solid sample and hence can be analysed for the mass concentration of certain hazardous substances. Different jurisdictions, such as Germany, the US or Japan provide different threshold values for the allowable leachate concentrations for a waste material to be characterised as non-hazardous waste. For instance, the threshold for leachate concentration for lead allowing a panel to be classified as hazardous is 5 milligrammes per litre (mg/l) in the US and 0.3 mg/l in Japan. For cadmium, the hazardous threshold is 1 mg/l in the US, 0.3 mg/l in Japan and 0.1 mg/l in Germany. These compare to publicly available leaching test results in the literature (summarised in Sinha and Wade, 2015) for c-Si and CdTe PV panels. They range from non-detect to 0.22 mg/l for cadmium and non-detect to 11 mg/l for lead. Thus, in different jurisdictions, CdTe and c-Si panels could be considered either non-hazardous or hazardous waste on the basis of these test results.

Regulatory classification of PV panel waste

From a regulatory point of view, PV panel waste still largely falls under the general waste classification.

An exception exists in the EU where PV panels are defined as e-waste in the WEEE Directive. The term ‘electrical and electronic equipment’ or EEE is defined as equipment designed for use with a voltage rating not exceeding 1,000 V for alternating current and 1,500 V for direct current, or equipment dependent on electric currents or electromagnetic fields in order to work properly, or equipment for the generation of such currents, or equipment for the transfer of such currents, or equipment for the measurement of such currents (EU, 2012).

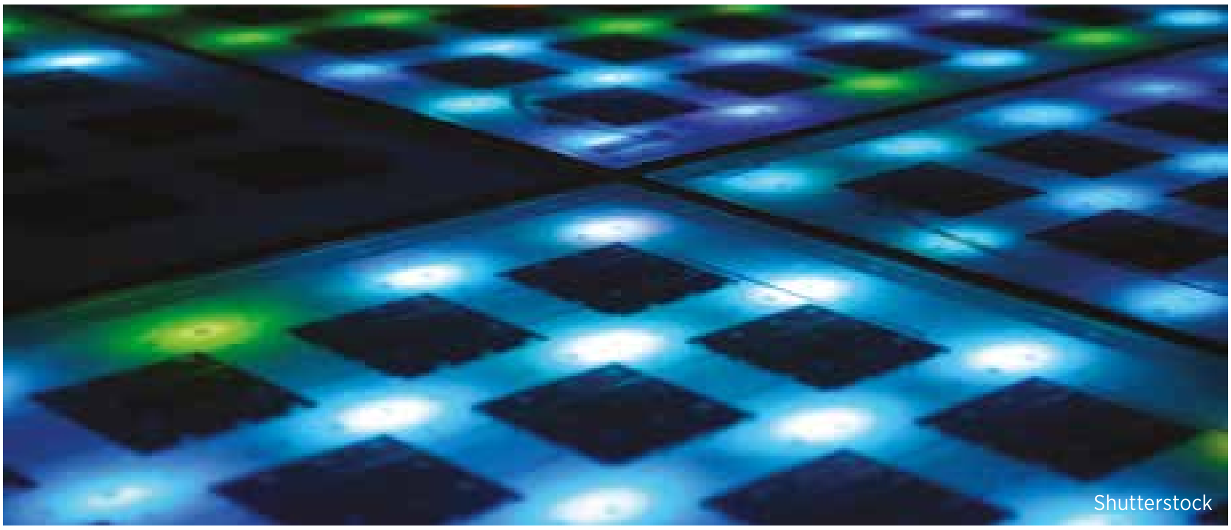
Hence, the waste management and classification for PV panels is regulated in the EU by the WEEE Directive in addition to other related waste legislation (e.g. Waste Framework Directive 2008/98/EC). This comprehensive legal framework also ensures that potential environmental and human health risks associated with the management and treatment of waste are dealt with appropriately. By establishing a List of Wastes (European Commission, 2000), the EU has further created a reference nomenclature providing a common terminology throughout the EU to improve the efficiency of waste management activities. It provides common coding of waste characteristics for classifying hazardous versus non-hazardous waste, transport of waste, installation permits and decisions about waste recyclability as well as supplying a basis for waste statistics.

Some codes from the EU's List of Wastes applicable to PV panels are given in Table 10.

Table 10 Examples of waste codes relevant to PV panels from the EU List of Wastes

Type	Waste code	Remark
All types	160214	Industrial waste from electrical and electronic equipment
	160213*	Discarded equipment containing hazardous components
	200136	Municipal waste, used electrical and electronic equipment
	200135*	Discarded electrical and electronic equipment containing hazardous components
In special cases also: *e.g.* amorphous-silicon (a-Si) panels	170202	Construction and demolition waste – glass

** Classified as hazardous waste, depending on the concentration of hazardous substances. Table 10 portrays leaching test methods commonly used for hazardous waste characterisation.*
Based on European Commission, (2000)



Shutterstock

PV PANEL WASTE MANAGEMENT OPTIONS

Beyond general waste regulations, various approaches have been developed specifically for managing end-of-life PV panel waste. The following sections summarise the general principles of panel waste management as well as examples portraying voluntary, public-private-partnership and regulated approaches.

4.1. WASTE MANAGEMENT PRINCIPLES FOR PV PANELS

Life cycle methodology

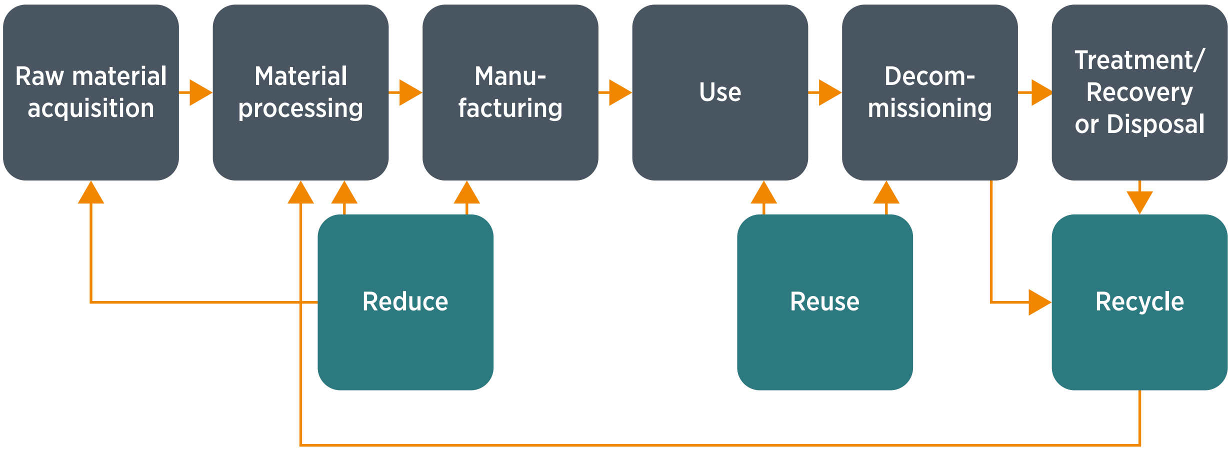
All waste management approaches follow the life cycle stages of a given product.

Figure 11 displays how for PV panels the life cycle starts with the extraction of raw materials (cradle) and ends with the disposal (grave) or reuse, recycling and recovery (cradle).

Chapter 6 will provide more information on the cradle-to-cradle and recovery opportunities to:

- Reduce;
- Reuse;
- Recycle.

Figure 11 Process flow diagram of the life cycle stages for PV panels and resulting opportunities for reducing, reusing or recycling



Adapted from Fthenakis (2000)

Stakeholders and responsibilities

The responsibility for end-of-life waste-management activities downstream (waste generation, collection, transport, treatment and disposal) are typically covered by the following three main stakeholders:

- **Society.** End-of-life management is supported by society, with government organisations controlling and managing operations, financed by taxation. This could create revenue for municipalities and eliminate the fixed costs of building a new collection infrastructure while providing economies-of-scale benefits. Drawbacks could include a lack of competition and slower cost optimisation.

- **Consumers.** The consumer that produces panel waste is responsible for end-of-life management, including the proper treatment and disposal of the panel. The consumer may try to minimise costs, which can have a negative effect on the development of sound waste collection and treatment. Since the producer is not involved, there may be less motivation to produce recyclable and 'green' products. This approach currently remains the dominant framework in most countries for end-of-life PV panel management.

- **Producers.** End-of-life management is based on the extended-producer-responsibility (EPR) principle. This holds producers physically and financially responsible for the environmental impact of their products through to end-of-life and provides incentives for the development of greener products with lower environmental impacts. This principle can also be used to create funds to finance proper collection, treatment, recycling and disposal systems. Although producers finance the waste management system, the added cost can be passed through to consumers in the form of higher prices.

Costs and financing

A decision needs to be made on which of the three stakeholders mentioned (society, consumers and producers) is to take financial responsibility for end-of-life management. All waste management approaches, including e-waste, involve incurring costs. That is equally true for end-of-life PV panel management. The costs can be broken down into three interconnected systems outlined below:

1. **A physical system of collection, storage/aggregation, treatment, recovery, recycling and disposal.** This system collects PV panels, for instance, from separate waste generation points and transfers them to a more central location where first-level treatment can start. After this first treatment step, which usually separates the waste product into material groups (e.g. metals, mixed plastics, glass etc.), further processing of the different material streams is required for recovery and recycling. This step removes potentially hazardous materials and impurities from recycling materials because they prevent recycling. Finally, the disposal of non-recoverable, non-recyclable fractions also needs to be taken care of in the physical system. The costs of operating these physical system are a function of several factors. These include the geographical and economic context, the chosen number of collection and processing points and the complexity of dismantling and separation processes (first-level treatment). A final factor is the value/costs associated with final processing of the different material streams for recycling or disposal.

2. **A financial processing system.** This system counts the amounts of various materials recovered from the recycling process and the associated revenues and costs to the system.

3. **A management and financing system.** This system accounts for the overhead costs of operating an e-waste system for PV panels, for example.

To provide the financial basis for recycling end-of-life products, several fee models have been developed and implemented worldwide. Part of these fees is set aside to finance the waste treatment system when end-of-life products are dropped off at collection points operated by municipalities, dealers, wholesalers, producers or their service providers. The fees are typically structured to follow several principles to ensure they are fair, reasonable, based on actual programme costs and include regular revisions:

- The funds generated from the fees collected should cover the system costs and achieve clear environmental goals.
- The fees should be a function of the return on investment, technical and administrative costs. The revenues generated from the collection, recycling and treatment fees should be sufficient to cover the costs of implementation.
- The fee structure should be implemented without rendering the PV sector uncompetitive with international markets. Special care should be taken to avoid free riders.
- The fee structure should be simple to implement.
- The fee structure should be viable for the PV products covered by the regulation.

Box 6 Financing models for collection, treatment, recovery, recycling and disposal of PV panels

Producer-financed compliance cost

Under this model, the producer finances the activities of the waste management system by joining a compliance scheme and paying for its takeback system or stewardship programme. It covers two types of wastes. The first is orphan waste (from products placed on the market after implementation of the waste management system by producers that no longer exist and cannot be held liable). The second is historic waste (waste from products placed on the market before the waste management system was established). The costs are usually shared between producers. All costs are revised regularly and charged per panel or weight based on the actual recycling costs and estimates of future costs.

Consumer-financed upfront recycling fee

This fee is paid to collect funds for the future end-of-life treatment of the product. Consumers pay the fee at the time of the purchase of the panel. The fee is set according to estimates for future recycling costs but may also be used to offset current recycling costs.

Consumer-financed end-of-life fee (disposal fee)

The last owner pays a fee for the collection and recycling costs to the entity in charge of the recycling of the end-of-life product.

The implementation of these different financial approaches can vary considerably from country to country owing to different legal frameworks, waste streams, levels of infrastructure maturity, and logistical and financial capabilities. In most countries with e-waste management systems, a combination of the consumer-based and producer-based approaches is incorporated into the compliance scheme (e.g. in the EU). However, each such scheme should be adapted to the unique conditions of each country or region.

Enabling framework

Adjusting or developing an end-of-life management scheme for PV panel waste requires the balancing of a number of factors such as collection, recovery and recycling targets. These three targets become the main driver of waste management policies.

Waste management approaches or schemes need to take into account different options for collection systems (e.g. pick-up versus bring-in systems). They also need to consider the nature and design of products to manage end-of-life and recycling processes adequately (e.g. PV panels are often classified as e-waste). Hence, waste management leads naturally also to a motivation to change the design of products themselves in favour of easier waste treatment, for instance (Atasu, 2011).

- **Voluntary approach.** Producers often rely on their internal environmental management systems to manage all their company's environmental responsibilities, including the end-of-life of their products or services. One example is found in the International Standards Organisation ISO 14000 family of international standards on environmental management. ISO 14040: 2006 specifically deals with the principles and framework for life cycle assessment of a company's products and operations (ISO, 2006). Within this or other frameworks, some PV panel manufacturers have established individual voluntary takeback or product stewardship programmes that allow defective panels to be returned for recycling on request. The management of such programmes can be borne directly by the company or indirectly through a recycling service agreement outlined in more detail below:

1. **Direct management:** the manufacturer operates its own recycling infrastructure and refurbishment or recycling programmes to process its own panels, enabling it to control the entire process (e.g. First Solar, 2015b).

2. **Indirect management:** the manufacturer contracts service providers to collect and treat its panels. Different levels of manufacturer involvement are possible depending on the contract details.[10]

10. *For example, manufacturers could decide to operate part of the collection and recycling infrastructure. They could contract out the other parts, as in a business-to-business (B2B) environment in which the panel owner is contractually required to bring the panel to a centralised logistic hub. At that point the manufacturer takes over the bulk logistics and treatment processes.*

In the option on indirect programmes, producers could outsource part or the entire management and operation of their recycling programmes to a third party. The members of such an organisation may be entirely producers or may also include a network of government entities, recyclers or collectors. Alternatively, it may be a single entity created by the government to manage the system. The activities carried out by third-party organisations and other compliance schemes can vary from country to country and depend on specific legislative requirements and the services offered to members.

- **Public-private approach.** Set up in 2007, PV CYCLE is an example of a voluntary scheme that includes both a 'bring-in' and 'pick-up' system based on the principle of a public-private-partnership between industry and European regulators. The association was established by leading PV manufacturers and is fully financed by its member companies so that end-users can return member companies' defective panels at over 300 collection points around Europe. PV CYCLE covers the operation of the collection points with its own receptacles, collection, transport, recycling and reporting. Large quantities of panels (currently more than 40) can be picked up by PV CYCLE on request. In some countries, PV CYCLE has established co-operatives and it encourages research on panel recycling. PV CYCLE is being restructured to comply with the emerging new regulations for end-of-life PV in the different EU member states (see next chapter on the EU) (PV CYCLE, 2016).

- **Regulatory approach.** The EU is the only jurisdiction that has developed specific regulations and policies addressing the end-of-life management of PV. The next section examines in more detail the regulatory approach taken by the EU.

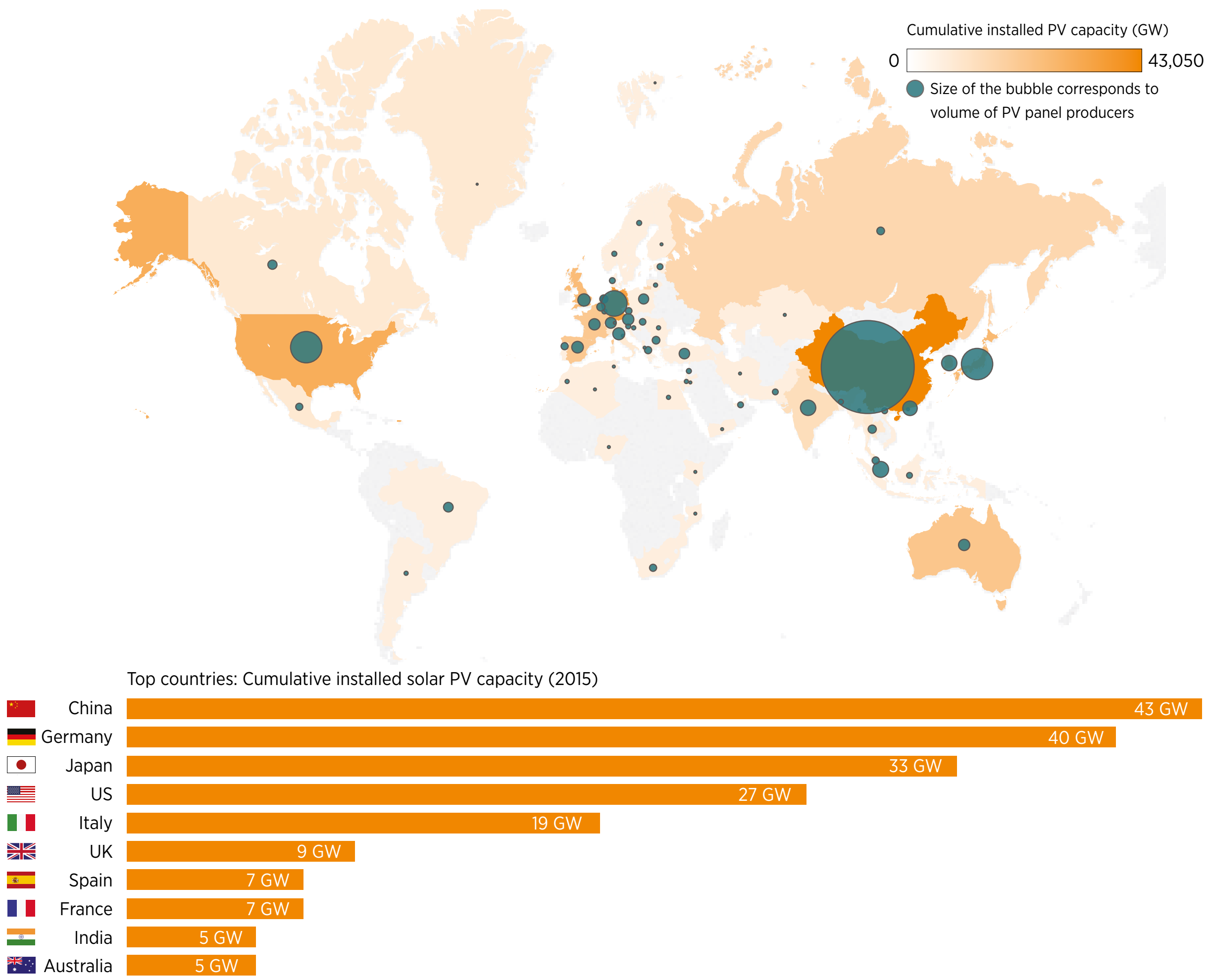
4.2. REGULATORY APPROACH: EUROPEAN UNION

Background

Since the late 1990s, the EU has led PV deployment with significant volumes installed between 2005 and 2011, prompting an increase from 2.3 GW to 52 GW over that period (IRENA, 2016b). Manufacturers selling into the EU thus also started to devise early PV life cycle management concepts, the most prominent example being the previously mentioned pan-European PV CYCLE initiative (PV CYCLE, 2015). The resulting increases in PV production triggered PV recycling technology development since production scrap recycling offered direct economic benefits and justified investments in such technologies in the short term.

High deployment rates, growing manufacturing capacities and increasing demand for PV globally led to a rapid internationalisation and commoditisation of supply chains. This made it very difficult to implement pan-European voluntary initiatives for long-term producer responsibility (see Figure 12 for global overview of PV panel producers and cumulative installed PV capacity). This resulted in the need for regulation to ensure a level playing field for all market participants and secure the long-term end-of-life collection and recycling for PV waste (European Commission, 2014).

Figure 12 World overview of PV panel producers and cumulative installed PV capacity



WEEE Directive

Balancing the advantages and disadvantages of different approaches to addressing e-waste management – including waste PV panels - is at the core of the EU regulatory framework set up through the WEEE Directive. This framework effectively addresses the complex EEE waste stream[11] in the 28 EU member states and the wider economic area, placing the **extended-producer-responsibility principle** at its core. The directive has a global impact, since producers which want to place products on the EU market are legally responsible for end-of-life management, no matter where their manufacturing sites are located (European Commission, 2013).

This combination of producer legal liability for product end-of-life, EEE dedicated collection, recovery and recycling targets, and minimum treatment requirements ensuring environment and human health protection may be a reference point for PV waste management regulation development globally.

The original WEEE Directive (Directive 2002/96/EC) entered into force in February 2003 but proved to be insufficient to tackle the quickly increasing and diverse waste stream (European Parliament and Council, 2002). In 2012, following a proposal by the EU Commission, the directive was revised (2012/19/EU). For the first time it included specifics on end-of-life management of PV panels. The revised WEEE Directive entered into force on 13 August 2012, was to be implemented by the EU member states by 14 February 2014 and thus introduced a new legal framework for PV panel waste. Each one of the 28 EU member states is now responsible for establishing the regime for PV panel collection and treatment in accordance with the directive (European Parliament and Council, 2012).

As the revised WEEE Directive is based on the extended-producer-responsibility principle, producers (see Box 7) are liable for the costs of collection, treatment and monitoring. They must fulfil a certain number of requirements and responsibilities (European Commission, 2015; European Commission, 2014; European Commission 2013; European Parliament and Council, 2008 and 2008b).

- **Financing responsibility.** Producers are liable through a financial guarantee to cover the cost of collection and recycling of products likely to be used by private households. They are responsible for financing public collection points and first-level treatment facilities. They also need to become a member of a collective compliance scheme or may develop an individual scheme.

- **Reporting responsibility.** Producers are obliged to report monthly or annually on panels sold, taken back (through individual or collective compliance schemes) and forwarded for treatment. Within this reporting scheme, producers equally need to present the results from the waste treatment of products (tonnes treated, tonnes recovered, tonnes recycled, tonnes disposed by fraction e.g. glass, mixed plastic waste, metals).

- **Information responsibility.** Producers are accountable for labelling panels in compliance with the WEEE Directive. They must inform buyers that the panels have to be disposed of in dedicated collection facilities and should not be mixed with general waste, and that takeback and recycling are free (European Parliament and Council, 2008b). They are also responsible for informing the buyer of their PV panel end-of-life procedures. Specific collection schemes might go beyond legal requirements, with the producer offering pick-up at the doorstep, for example. Lastly, producers are required to give information to waste treatment companies on how to handle PV panels during collection, storage, dismantling and treatment. This information contains specifics on hazardous material content and potential occupational risks. In the case of PV panels, this includes information on electrocution risks when handling panels exposed to light.

Box 7 Definition of producers under the WEEE Directive

'Producers' include a range of parties involved in bringing a product to market — not just the original equipment manufacturer. The WEEE Directive defines the producer in Article 3:

'Producer' means any natural or legal person who, irrespective of the selling technique used, including distance communication within the meaning of Directive 97/7/EC (European Commission, 1997) of the European Parliament and of the Council of 20 May 1997 on the protection of consumers in respect of distance contracts (19):

i. is established in a Member State and manufactures EEE under his own name or trademark, or has EEE designed or manufactured and markets it under his name or trademark within the territory of that Member State;

ii. is established in a Member State and resells within the territory of that Member State, under his own name or trademark, equipment produced by other suppliers, a reseller not being regarded as the 'producer' if the brand of the producer appears on the equipment, as provided for in point (i);

iii. is established in a Member State and places on the market of that Member State, on a professional basis, EEE from a third country or from another Member State; or

iv. sells EEE by means of distance communication directly to private households or to users other than private households in a Member State, and is established in another Member State or in a third country.

Whoever exclusively provides financing under or pursuant to any finance agreement shall not be deemed to be a 'producer' unless he also acts as a producer within the meaning of points (i) to (iv).

WEEE Directive targets

The WEEE Directive follows the staggered approach to collection and recovery targets outlined in Table 11. Collection targets rise from 45% (by mass) of equipment 'put on the market'[12] in 2016 to 65% of equipment 'put on the market' or 85% of waste generated as from 2018. Recovery targets rise from 75% recovery/65% recycling to 85% recovery/80% recycling in the same time frame. Recovery is to be understood as the physical operation leading to the reclamation of a specific material stream or fraction from the general stream. Recycling, on the other hand, should be understood in the context of preparing that reclaimed stream for treatment and reuse (European Commission, 2015).

The e-waste recovery quotas are specified in a separate directive detailing minimum treatment requirements and technical treatment standards and specifications for specific equipment such as PV panels (European Commission, 2008). This two-pronged approach enables the implementation of 'high-value recycling' processes (see Box 8 for definition). The European Commission has also committed to further developing methodologies establishing individual collection and recycling targets for PV panels. They will take into consideration recovery of material that is rare or has high embedded energy as well as containing potentially harmful substances (European Commission, 2013).

11. *EEE is defined as equipment designed for use with a voltage rating not exceeding 1,000 V for alternating current and 1,500 V for direct current, or equipment dependent on electric currents or electromagnetic fields in order to work properly, or equipment for the generation of such currents, or equipment for the transfer of such currents, or equipment for the measurement of such currents (EU, 2012).*

12. *'Put on the market' is a complex legal construct defined in the Blue Guide of the European Commission on the implementation of EU product rules (Commission Notice C(2016) 1958, 5 April 2016). It can have different meanings depending on the sales channel used to market a product and effectively provides a temporal determination of the legal responsibility of the producer.*

Table 11 Annual collection and recovery targets (mass %) under the WEEE Directive

	Annual collection targets	**Annual recycling/Recovery targets**
Original WEEE Directive (2002/96/EC)	4 kg/inhabitant	75% recovery, 65% recycling
Revised WEEE Directive (2012/19/EU) up to 2016	4 kg/inhabitant	Start with 75% recovery, 65% recycling, 5% increase after 3 years
Revised WEEE Directive (2012/19/EU) from 2016 to 2018	45% (by mass) of all equipment put on the market	80% recovered and 70% prepared for reuse and recycled
Revised WEEE Directive (2012/19/EU) from 2018 and beyond	65% (by mass) of all equipment put on the market or 85% of waste generated[13]	85% recovered and 80% prepared for reuse and recycled

13. Products put on the market are reported by producers so these figures have a low uncertainty. However, a 65% target is unrealistic for items like PV panels, which have a very long life. It will not account for increasing amounts of historic waste (not recorded in the past) as well as varying life cycle curves per product category. An alternative measure is provided to account for the actual waste generated alone.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Box 8 EU end-of-life management through 'high-value recycling'

The environmental and socio-economic impacts of the different end-of-life waste-management options for PV panels have been widely assessed in previous literature (GlobalData, 2012; Münchmeyer, Faninger and Goodman, Sinha and Cossette, 2012; Held, 2009; Müller, Schlenker and Wambach, 2008; Sander, *et al.*, 2007). These assessments have concluded that 'high-value recycling,' is the option preferred for all technologies for the benefit of society in general. It not only ensures the recovery of a particular mass percentage of the total panel but also accounts for minor fractions. The high-value recycling approach is now the foundation for the WEEE Directive and ensures the following:

- Potentially harmful substances (e.g. lead, cadmium, selenium) will be removed and contained during treatment;
- Rare materials (e.g. silver, tellurium, indium) will be recovered and made available for future use;
- Materials with high embedded energy value (e.g. silicon, glass) will be recycled;
- Recycling processes will consider the quality of recovered material (e.g. glass).

The European Commission also asked the European Committee for Electrotechnical Standardization to develop specific, qualitative treatment standards for different fractions of the waste stream to complement the high-value recycling approach. As part of that mandate (European Commission, 2013), a supplementary standard and technical specification for PV panel collection and treatment is under development (European Committee for Electrotechnical Standardization CLC/TC 111X, 2015). The findings are due to be released in 2016 and may lead to another revision of the WEEE Directive.

Future WEEE Directive revisions might impose even further cost-effective, high-quality and high-yield recovery and recycling processes as these become available. They would minimise societal material losses that could occur through 'downcycling'. The term 'downcycling' refers to the deterioration of intrinsic material or energy value of a secondary raw material by using it for new purposes (e.g. using a high-grade semiconductor material such as broken silicon scrap as backfill for street construction).

In addition to quotas and treatment requirements, the revised WEEE Directive also references measures specific to PV panels to prevent illegal shipments (European Parliament and Council, 2006) and new obligations for trade (Directive 2012/19/EC, Art. 14). Modified provisions to trade include, for example, the need to provide information to end-users on environmental impact. They equally contain proper collection mechanisms and the acceptance of old products free-of-charge if a replacement is bought (European Parliament and Council, 2012).

The WEEE Directive sets minimum requirements which member states may adjust when they transpose the directive into their own legislation. They may, for instance, define more stringent requirements or target quotas and add requirements. At the time of this report's publication, all EU member states have incorporated the WEEE Directive into national legislation, sometimes with the addition of certain country-specific regulations.

This can pose challenges for producers because almost every member state has implemented slightly varying definitions of extended-producer-responsibility (see Chapter 5 for case studies on Germany and the UK). Since the directive has been transposed very recently (in some cases as recently as early 2016), no statistical data on PV collection and recycling is available at the time of the publication of this report in June 2016.

WEEE Directive financing schemes

Varying requirements for end-of-life PV panels under the WEEE Directive have included classifying the waste stream as 'waste from private households' in France and the option to classify the waste as 'waste from other users than private households' in the UK. These differing definitions have implications for collection and recycling financing as well as waste responsibilities. Another important issue that has evolved during transposition is the different estimates of treatment costs among member states.

Two financing approaches can be distinguished in the WEEE Directive:

- Individual pre-funding or collective joint-and-several liability schemes;
- Contractual arrangements between producer and customer (dependent on B2C or B2B transaction).

The implementation of the original WEEE Directive of 2003 has shown that pre-funding approaches are only practical for e-waste sold in very low quantities such as specialty e-waste (e.g. custom-made fridges). Thus, the pre-funding scheme for collecting and recycling high-volume e-waste such as PV panels has not proved cost effective. Producer pay-as-you-go (PAYG) approaches combined with last-man-standing insurance and joint-and-several liability producer schemes are therefore more commonplace today although the revised 2012 directive still allows the pre-funding scheme.[14]

PV CYCLE

The revised WEEE Directive distinguishes between private household or business-to-consumer (B2C) transactions and non-private household or B2B transactions when mandating an effective financing mechanism (see Box 9). The regulation is flexible on the responsible party (owner or producer) and financing methods. This depends on the characteristics of the PV system (e.g. system size) and the characterisation of PV panels themselves in the respective member state. For example, France stipulates that all PV panels are characterised as B2C product independent of system size or other product attributes.

To fulfil the ambitious WEEE Directive recycling targets starting 2016, PV panels will have to be rapidly incorporated into new or existing waste management systems. Several national schemes by EU member states have already been managing other parts of the electrical and electronic waste stream for years, organising collection, treatment, recycling and reporting to regulators. These can serve as an important reference point to manage increasing PV panel waste streams.

The next chapter describes in more detail the EU legal framework and different national applications in EU member states such as Germany and the UK.

14. *In a pay-as-you-go (PAYG) approach, the cost of collection and recycling is covered by market participants when waste occurs. By contrast, a pay-as-you-put (PAYP) approach involves setting aside an upfront payment for estimated collection and recycling costs when a product is placed on the market. Last-man-standing insurance is an insurance product that covers a producer compliance scheme based on a PAYG approach if all producers disappear from the market. In that situation, the insurance covers the costs for collection and recycling. In a joint-and-several liability scheme, producers of a certain product or product group agree to jointly accept the liabilities for waste collection and recycling for a specific product or product group. How the concept is put in practice is explained in the next chapter in the case of Germany.*

Box 9 Financing framework under the WEEE Directive

The WEEE Directive defines the framework for two financing mechanisms depending on the end-use (private household or not) of the product. Under this framework, each EU member state can further determine the financial responsibility of stakeholders and related transactions.

Private households (B2C transactions)

Requiring the producer to collect and recycle has proved to be more enforceable and efficient than forcing private household customers to recycle e-waste at their end-of-life. PAYG approaches combined with last-man-standing insurance/joint-and-several liability schemes (producer compliance schemes) are more efficient and viable for equipment sold in a B2C context.

For B2C transactions the producer is not allowed to enter into a contractual arrangement with the customer on financing. However, it is required to fulfil the mandatory requirements set out by the regulator.

Non-private households (B2B transactions)

In B2B transactions both customer and producer may be capable of collecting and recycling end-of-life e-waste. For example, for large volume or big equipment like large-scale PV plants, the project owner may be best positioned to fulfill the recycling obligation. It has the option to use project cash flows, hire the original producer or hire a professional third party to recycle. For B2B transactions a regulatory framework ensuring collection and recycling to common standards for all industry players and allowing contractual arrangements between producer and customer for financing end-of-life obligations is considered most effective.


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NATIONAL APPROACHES TO PV WASTE MANAGEMENT

This chapter analyses current approaches to PV waste management. It begins with an overview of how today's most comprehensive end-of-life PV regulation, the EU WEEE Directive (see Chapter 4), is applied in selected EU member states, including Germany and the UK. In the following sections, PV panel waste management approaches are outlined for Japan and the US. Finally, this chapter also includes case studies of China and India, two of the most important growing PV markets globally. The six case studies were chosen to span a range of maturity of both PV deployment markets, and regulatory and voluntary approaches.

5.1 GERMANY: MATURE MARKET WITH EU-DIRECTED, PV-SPECIFIC WASTE REGULATIONS

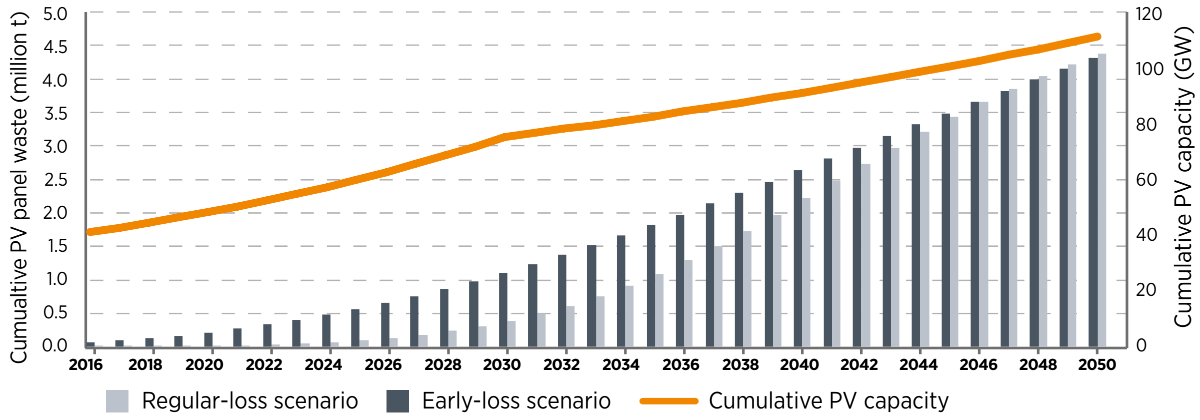
PV market and waste projection

The German PV market started growing in the 1990s. In that decade the first support schemes were introduced, clearly targeted at residential use, and there were scientific assessments of the feasibility of grid-connected, decentralised rooftop PV systems. One example was the 1,000 Rooftop Programme (Hoffmann, 2008). In the early 2000s this rooftop PV support programme was extended to 100,000 roofs and eventually led to the renewable energy support act, the first of its kind. This set a feed-in-tariff for electricity generated from renewable energy, including PV. The feed-in-tariff kick-started the German PV market and provided a significant global impetus for the PV industry to grow to the next scale.

In 2015, PV contributed 6% of total net electricity consumption in Germany with a total installed capacity of almost 40 GW distributed over 1.5 million PV power plants (IRENA, 2016b and Wirth, 2015). Germany was the world's largest PV market for two consecutive decades. Only in 2015 was it overtaken by China to become today the second-largest PV market.

In line with the Chapter 2 model, Germany's expected end-of-life PV panel waste volumes will cumulatively range between 3,500 t and 70,000 t by 2016. This is mainly due to its historic installed PV capacity. The figure varies according to scenario selected. In 2030 and by 2050 the regular-loss and early-loss scenario forecast between 400,000 t and 1 million t and 4.3-4.4 million t respectively (see Figure 13). Bearing in mind uncertainties inherent in these projections, as explained in Chapter 2, Germany will clearly be one of the first and largest markets for PV recycling technologies in coming years.

Figure 13 End-of-life PV panel waste volumes for Germany to 2050



Regulatory and non-regulatory frameworks

National regulation

The revised EU WEEE Directive (see previous section) was transposed into German Law in October 2015 through a revision of the Electrical and Electronic Equipment Act (Elektroaltgerätegesetz or ElektroG). Hence, the new requirements on the collection and recycling of PV panels have come into effect in Germany since that date.

Germany's e-waste management is regulated through the National Register for Waste Electrical Equipment (Stiftung Elektro-Altgeräte Register or Stiftung EAR). Stiftung EAR was founded during the implementation of the original WEEE Directive by producers as their clearing house (Gemeinsame Stelle) for the purposes of applying to the ElektroG (see Box 10). Entrusted with sovereign rights by the Federal Environment Agency (Umweltbundesamt), Stiftung EAR registers e-waste producers. It co-ordinates the provision of containers and pick-up at the öffentlich-rechtliche Entsorgungsträger (örE, public waste disposal authorities) in entire Germany (Stiftung EAR, 2015).

However, Stiftung EAR is not accountable for operational tasks such as collecting, sorting, dismantling, recycling or disposing of e-waste. These fall under the responsibility of producers accountable for e-waste recycling and disposal since March 2005 under the original Electrical and Electronic Equipment Act (ElektroG, 2005).

Box 10 Overview of Stiftung EAR clearing-house activities

Stiftung EAR is independent in terms of financing and personnel. Its work is funded by fees and expenses set by cost regulation from the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (Bundesumweltministerium) (Stiftung EAR, 2015). The Stiftung EAR clearing house performs the following functions for all e-waste producers, including PV panel producers:

- Registers producers placing e-waste on the market in Germany;
- Collects data on e-waste amounts placed on the market;
- Co-ordinates the provision of containers and e-waste takeback at the public waste disposal authorities (örE);
- Reports the annual flow of materials to the Federal Environment Agency;
- Ensures that all registered producers may participate in the internal setting of rules;
- Identifies free riders and reports these to the Federal Environment Agency.

- **Implementation of WEEE Directive**

In line with the new transposed WEEE Directive in 2015, Germany has approved specific provisions for PV panel panel collection, recovery and recycling (Table 12). These set the amount of financial guarantee any producer must provide for each new panel sold.

The guarantee calculation depends on the form of financing selected by the producer. If the producer selects the joint-and-several liability scheme for B2C panels sold, the following simplified formula provides an understanding of the principle:

Cost responsibility =
basic amount for registration
(PV panel tonnage put on the market)
x presumed return rate (%)
x presumed disposal costs (EUR/t)

For B2B PV panels, the German regulator allows contractual arrangements between producer and owner to fulfil the legal requirements through recycling service agreements, for example.

Germany has also established a separate collection category for PV panels and thus provides separate collection and treatment of waste panels at municipal collection points. This means any PV panel owner who wishes to discard it can take it to a municipal collection point, where it will be accepted free of charge. This is the disposal pathway open to private customers owning residential PV systems. However, since removing a PV panel requires professional skills, most end-of-life PV panels are expected to be returned through B2B networks. This is because installers who remove rooftop panels will most likely also take care of the disposal. These PV panels will either be directly returned to B2B e-waste compliance schemes or to collection and recycling systems owned by producers.

Prior to the implementation of the revised ElektroG in Germany, there were a number of non-regulatory initiatives which organised the collection and recycling of end-of-life PV panels. They were mainly based on voluntary producer initiatives (e.g. PV CYCLE). These schemes will either cease or have to become compliant with the new regulation and register themselves as B2B e-waste compliance schemes.

- **National financing schemes under the WEEE Directive**

The most important aspect of the WEEE Directive is financing collection, recovery and recycling in coming years given the massive amounts of historic installed capacity in Germany destined to become waste. The German government foresees two distinct mechanisms based on the WEEE Directive depending on the type of transaction. They are outlined below.

Business-to-consumer (B2C) transactions

The new ElektroG mandates producers selling e-waste to private households (or users other than private households but with similar demand i.e. dual-use e-waste) to fulfil associated present and future

Table 12 Stiftung EAR factors for calculating guaranteed sum for PV panels

Category	Type of equipment	Presumed return rate	Presumed medium-life expectancy	Average maximum-life expectancy	Presumed disposal costs/ group
Consumer equipment and PV panels	PV panels for use in private households	30%	20 years	40 years	EUR 200/t

Based on Stiftung EAR (2015)

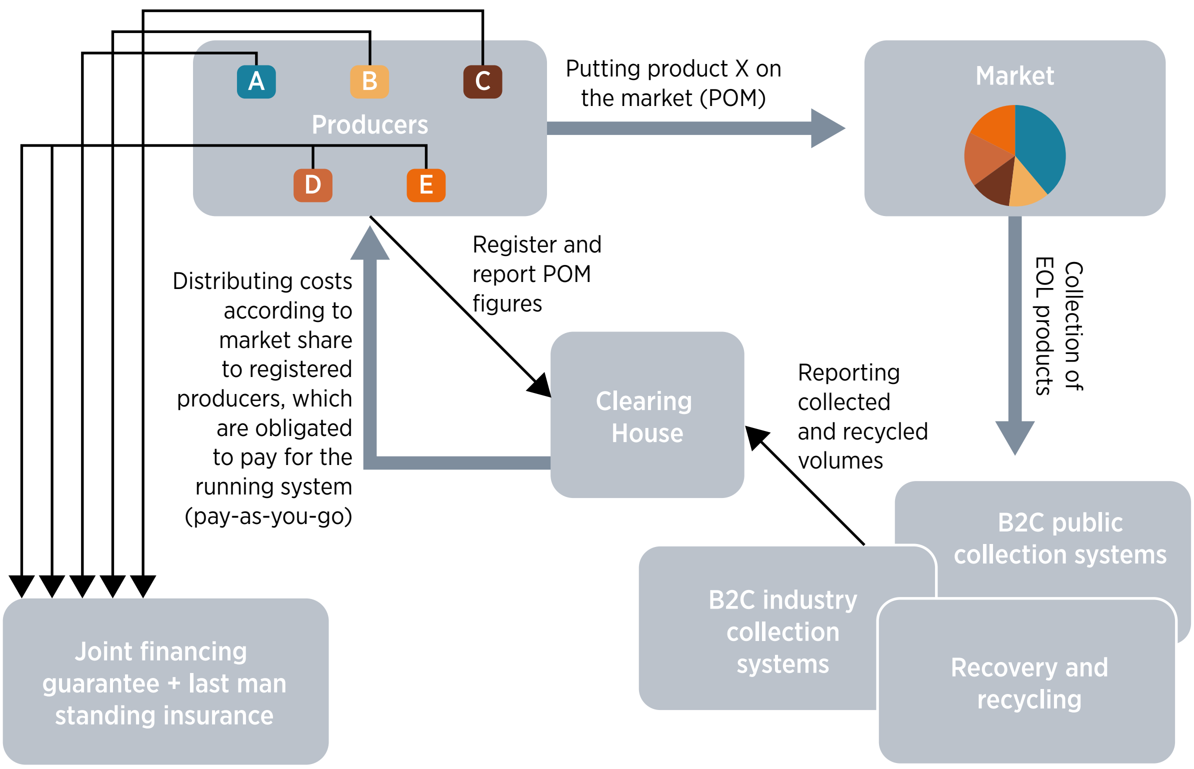
end-of-life obligations. This ensures producers are taking care of end-of-life management of PV panels sold to private households (e.g. residential rooftop systems) when placing products on the market. The approach is the result of previous experience of accredited producer compliance schemes that follow a joint-and-several liability format as illustrated in Figure 14.

The collective producer compliance system establishes two levels of operation and financing:

- Level 1 covers collection system operation and costs related to immediate collection and recycling of products (including historic products put on the market before being included in the scope of the law).
- Level 2 ensures that sufficient financing is available for future collection and recycling of products put on the market today i.e. after inclusion into the scope of the law. The costs forming the basis of Level 2 financing are uniform for the PV equipment category. They are calculated by the regulator, taking into consideration the average lifetime, the return quota at municipal collection points, and the treatment and logistic costs.

Level 1 costs are covered using a PAYG system for all market participants who put products of a certain category (e.g. PV panels) on the market through B2C transactions. In addition, before being allowed access to the market, producers must register with a clearing house. They have to declare they have made an agreement to cover Level 2 costs for B2C products placed on the market. At the same time, they have to accept responsibility for Level 1 costs based on their current market share (i.e. accepting the liability for other market participants). The clearing house then provides a producer e-waste registration number that must be printed on the product and invoices.

Figure 14 Collective producer responsibility system for end-of-life management of B2C PV panels



The producer now decides how to fulfil its Level 1 contribution. For example, it can run an individual collection and recycling system or join a co-operative system. Either way, costs for collecting and recycling all the B2C waste in a particular product category are distributed among all registered market participants according to volume collected. This ensures that historic waste (or orphan waste in the case of products made by producers now defunct) is collected and treated. If a producer demonstrates that it collected and recycled its share individually, those volumes will be deducted from the remaining fraction. If a producer disappears from the market, its market share will be taken up by the others along with the responsibility for financing collection and recycling.

Each producer must also ensure that sufficient Level 2 financing is available for B2C products placed on the market today. This occurs naturally if the joint Level 1 system continues to run. However, if all producers of a certain product category disappear, last-man-standing insurance has to provide financing. All Level 1 participants pay an annual premium for insurance that guarantees costs are covered if all market players disappear. Usually this premium is minimal because the likelihood of all market players disappearing is very low.

Business-to-Business (B2B) transactions

Germany's new ElektroG provides a different way of financing end-of-life PV obligations for producers that sell products on a B2B basis only owing to quantities, size, level of complexity etc. This is because collection and recycling could be more effectively organised if the final equipment or installation owner provides for it. It is up to the contractual partners to agree on end-of-life responsibilities as prescribed by the WEEE Directive either by contracting the producer to collect and recycle or seeking competitive market bids.

The B2B approach also includes the flexibility to agree on a funding/financing mechanism. For large-scale PV plants this will most likely result in models that generate funds for collection and recycling from near-commercial end-of-life project cash flows. Consequently, very cost-effective financing will be provided that enables previously agreed (pre-WEEE) end-of-life obligations to be honoured by contractual partners. Historic waste volumes will thus be covered.

Box 11 Outlook for Germany

Germany will most likely become the first end-of-life PV panel recycling market to reach profitable economies of scale. The current disposal costs identified by the regulator reflect the average treatment costs outlined in Table 12 above. However, with increasing amounts of waste, these costs should decrease once the industry has gone through a learning curve. This trend has already been observed in other parts of the e-waste stream. A number of R&D initiatives are currently driving the improvement of recycling technologies for the different PV technology families. These aim to further decrease recycling costs and increase the potential revenue streams from the secondary raw materials recovered through the recycling process.

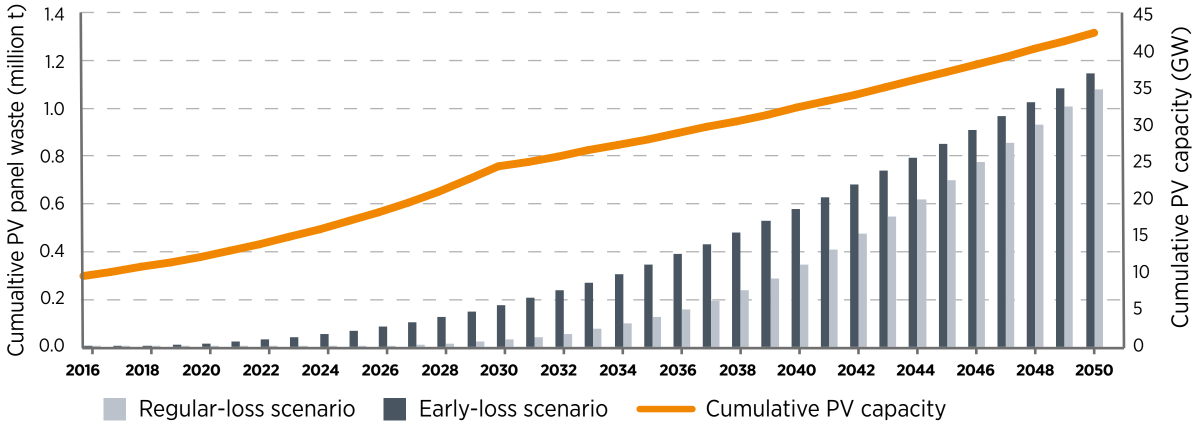
5.2 UK: YOUNG MARKET WITH EU-DIRECTED, PV-SPECIFIC WASTE REGULATIONS

PV market and waste projection

The UK is still a relatively young market for PV and thus end-of-life panels. However, it has recently experienced rapid PV deployment with an increase from just under 1 GW in 2011 to over 9 GW in 2015 and now more than 750,000 installations (IRENA, 2016b; UK Department of Energy and Climate Change, October 2015). Three-quarters of the existing PV capacity was installed after the WEEE Directive came into effect in the UK in early 2014 (UK WEEE Directive, 2013).

Figure 15 displays the UK's predicted end-of-life PV panel waste volumes modelled following the methods described in Chapter 2. The near-term cumulative volumes of PV panel waste are still limited (250-2,500 t). It is thus highly likely that most of the country's waste panels will be exported to centralised European treatment facilities or co-processed with other e-waste streams domestically to start with. However, in the medium and long term, PV panel waste is projected to increase exponentially. Regular-loss and early-loss scenarios estimate cumulative waste at 30,000-200,000 t by 2030. However, this figure could climb to 1-1.2 million t by 2050.

Figure 15 End-of-life PV panel waste volumes for the UK to 2050



Regulatory and non-regulatory frameworks

Since the UK's PV market is still young, the status quo for collection, treatment and recycling is essentially reflected in the implementation of the WEEE Directive transposed on 1 January, 2014. Prior to the WEEE Directive the UK was also covered by voluntary producer initiatives (e.g. PV CYCLE) and by takeback and recycling systems owned by producers. Due to the limited number of PV installations before 2014, the majority of end-of-life PV panels occurring then would have been covered by producer warranties and returned through the B2B channel.

The UK has set out some specific rules when it comes to defining a PV producer and hence the extended-producer-responsibility principle when transposing the WEEE Directive into national law. A PV producer under the UK WEEE legislation is defined as follows:

- UK manufacturer selling PV panels under its own brand;
- Importer of PV panels into the UK market;
- UK business selling PV panels manufactured or imported by someone else under its own brand.

As in other European markets, all PV producers in the UK must register via a producer compliance scheme (a takeback and recycling scheme managed by industry). They must submit relevant data on products destined for household (B2C) and non-household (B2B) markets.

However, when it comes to financing for B2C and B2B sales, the UK WEEE legislation contains requirements that differ significantly from the EU WEEE Directive.

- PV producers are required to finance the collection of household (B2C) PV panels on the basis of market share. For example, a producer placing 10% (by weight) of new panels on the UK market in any given year pays for the collection and treatment of 10% of old panels collected in the following year. The year when they were first placed on the market is ignored.
- PV producers must finance the collection and recycling of non-household (B2B) panels carrying the wheelie-bin symbol as well as those that do not if such panels are simultaneously being replaced by new ones.

In addition to the producer compliance scheme, the UK WEEE legislation has introduced a new requirement for installers to join a distributor takeback scheme. The UK now has several producer compliance schemes and distributor takeback schemes that offer their services for very similar fees (UK Environment Agency, 2015).

Box 12 UK WEEE legislation: Creation of a separate category for PV panels

After consultation between the PV sector and the UK Government, national legislation created a new separate category dedicated to financing the collection and recycling of PV panels. Had a new category not been created, PV producers would have paid heavily for the collection and recycling of consumer WEEE. This is because the financing obligations relate to the weight of products placed on the market and PV panels are by far the heaviest 'appliance' used by householders.

This special category status was granted "on the basis that the UK Government is satisfied that PV producers are able to deliver a sustainable strategy for the collection and treatment of end-of-life PV panels" (UK Department for Business, Innovation and Skills, 2014). The creation of a separate PV category will give the PV sector more control over financing PV panel collection and recycling.

The UK's WEEE legislation requires first-level treatment of PV panels, which includes the registration of collected volumes, to take place within the UK. Further treatment will most likely happen abroad, since the economies of scale would not currently allow dedicated PV recycling facilities in the UK. In principle, the UK WEEE legislation requires waste to be treated in the UK.

However, in specific cases (such as PV panels) no high-value treatment facilities are available in the UK. Export to other EU member states is thus possible as long as the facilities there comply with the UK treatment facility requirements.

Box 13 Outlook for the UK

The UK PV panel recycling market will probably remain minor over the next couple of years. However, pricing dynamics and a strong political focus on building-integrated PV (BIPV) might motivate new technology developments for recycling BIPV components, for instance, as part of buildings waste streams.

5.3 JAPAN: ADVANCED MARKET WITHOUT PV-SPECIFIC WASTE REGULATIONS

PV market and waste projection

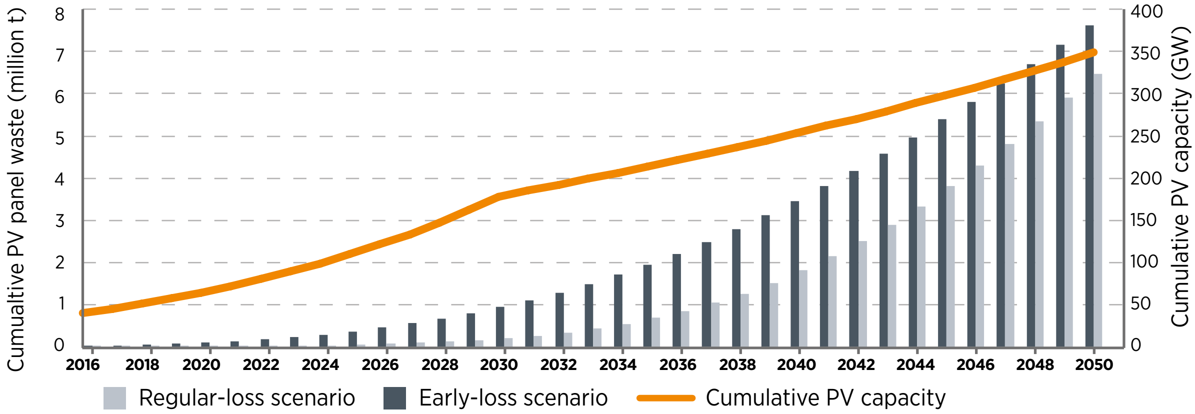
Japan has been a PV pioneer, contributing substantial R&D for decades and home to several of the world's leading manufacturers (e.g. Sharp, Kyocera and Panasonic). Although the country's own PV market was relatively small to start with, a feed-in-tariff introduced in July 2012 has stimulated rapid expansion. Cumulative installed PV capacity in Japan jumped from over 6.7 GW in 2012 to 34.3 GW in 2015 (IRENA, 2016b; IEA-PVPS, 2014b and IEA-PVPS, 2015).

Figure 16 and Box 14 show estimates for PV panel waste according to this report's model and Japanese governmental forecasts. Cumulative waste could amount to 7,000-35,000 t by 2016 rising to between

200,000 and 1 million to 2030. By 2050 it could reach 6.5-7.6 million t according to the scenarios employed in this report.

Ministry of Economy, Trading and Industry (METI) and Ministry of Environment (MOE) estimates are lower, predicting waste volumes at later date than figures in this report (see Box 14). This is mainly due to the methodology used herein, which includes early-stage failures covered through warranty replacements, and is not fully incorporated into end-of-life volume predictions by METI/MOE.

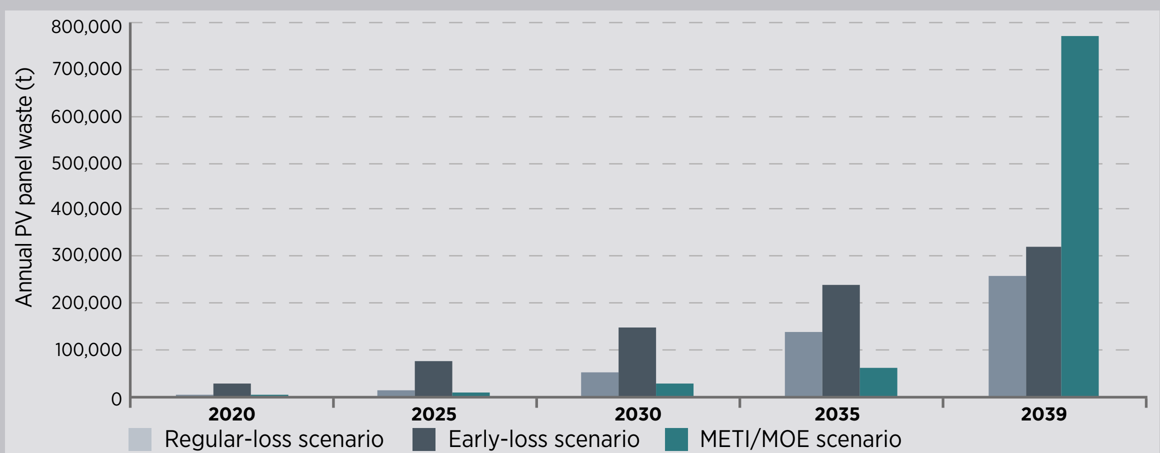
Figure 16 End-of-life PV panel waste volumes for Japan to 2050



Box 14 Japan's PV panel waste projections

According to Japan's Guidelines on Management of End-of-Life PV Panels released in April 2016 (METI and MOE, 2016), end-of-life PV panels will come to approximately 2,808 t per year in 2020. This will rise to an annual amount of 9,580 t in 2025 and 28,800 t after 2030, leading to 61,000 t in 2035 and finally 775,000 t in 2039. These estimates assume an expected panel lifetime of 25 years and initial failure and/or warranty activation in 0.3% of panels installed each year. Figure 17 compares the report's annual PV panel waste volumes for selected years with the METI/MOE scenario. In the national Japanese scenario, waste streams are lower than in the regular-loss and early-loss scenarios but jump far ahead of this report's scenarios after 2035.

Figure 17 Comparison of PV panel end-of-life scenarios for Japan



Regulatory and non-regulatory frameworks

Japan has no specific regulations for end-of-life PV panels, which therefore must be treated under the general regulatory framework for waste management: the Waste Management and Public Cleansing Act (METI and MOE, 2015). The act defines wastes, industrial waste generator and handler responsibilities, industrial waste management including landfill disposal etc.

In addition, the Construction Waste Recycling Law (METI and MOE, 2015) prescribes how to manage construction and decommissioning waste. The law requires recovery and recycling of concrete, wood and construction materials (containing concrete, iron and asphalt). Although PV panels are not specifically identified in the law, PV panels integrated with building material might require recycling, according to current interpretations. Panels in ground-mounted PV plants are not affected by this regulation. However, system components made of concrete or iron would also be subject to the law.

A proposed amendment to Japan's feed-in-tariff scheme for renewable electricity includes the consideration of end-of-life management with recycling but without obligations and penalties (METI, 2015).

Since 2013, METI and MOE have jointly assessed how to handle end-of-life renewable energy equipment such as PV, solar water heaters and wind turbines. A June 2015 report produced a roadmap for promoting a scheme for collection, recycling and proper treatment. It also covered the promotion of technology R&D, environmentally friendly designs, guidelines for dismantling, transportation, and treatment, and publicity to users (METI, 2015 and METI and MOE, 2015).

On the basis of this roadmap, the first edition of guidelines for promoting proper end-of-life treatment including recycling was published in April 2016 (METI and MOE, 2016). The guidelines cover basic information such as relevant law and regulations on decommissioning, transportation, reuse, recycling and industrial waste disposal. It is expected that these reports will lead to further consideration of policies on end-of-life management of PV panel waste.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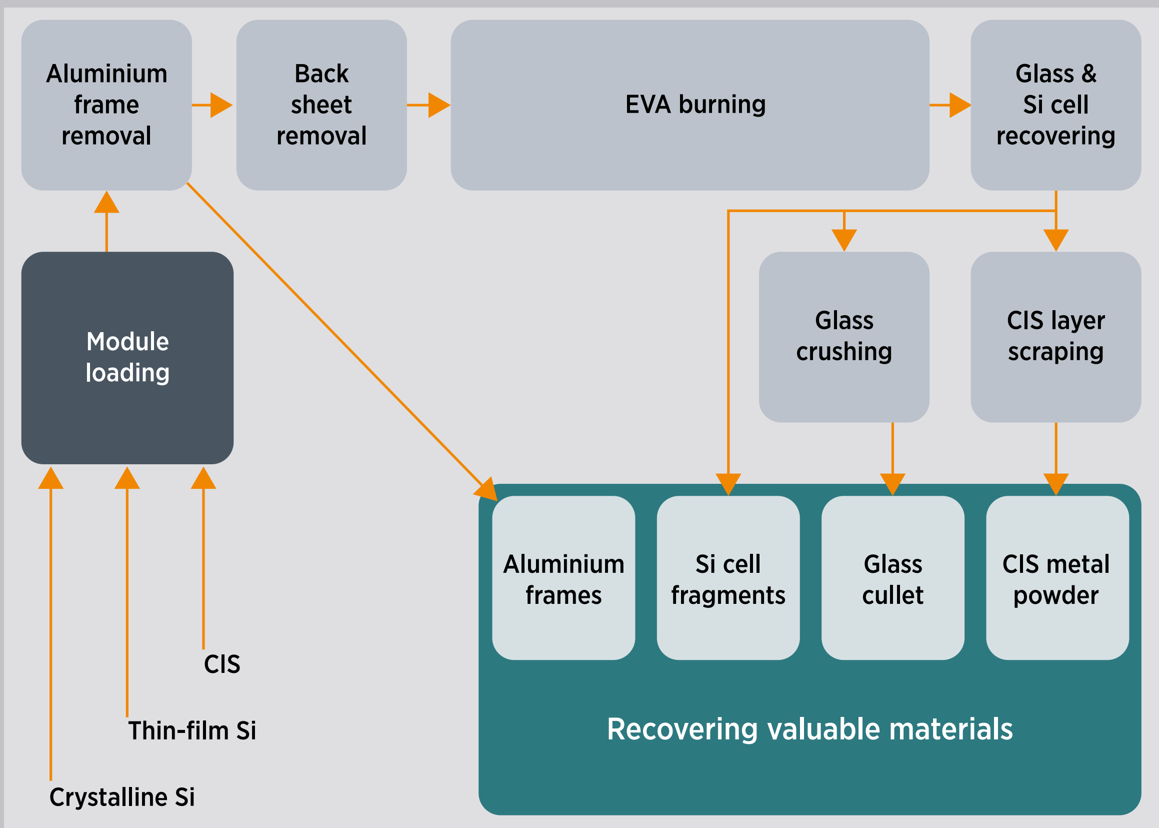
Box 15 R&D on PV panel recycling in Japan

In Japan, PV R&D has been conducted by the New Energy and Industrial Technology Development Organization (NEDO), and some PV panel recycling projects have taken place. Figure 18 shows an example of PV recycling technology developed under NEDO in 2014. The technology enables the automatic separation of different types of panels (c-Si, thin-film Si and copper indium selenide – CIS) and consists of four main processes: aluminium frame removal, backsheet removal, ethylene-vinyl-acetate resin burning and CIS layer scraping (for CIS panels only). The technology is currently in its experimental phase. Its early loss annual throughput is about 12 MW for c-Si panels and 7 MW for CIS panels, depending on panel type and size. Long-term field tests are expected in order to verify performance at potential industrial scale, including operating cost, throughput and stability (Noda *et al.*, 2014).

Figure 18 Foundation for Advancement of International Science (FAIS) PV panel recycling system



Based on Noda et al., (2014)

The objective of a different NEDO PV recycling R&D project (Komoto, 2014) is to contribute to a social system for PV recycling. This is achieved by establishing low-cost recycling technology and investigating optimal removal, collection and sorting. The R&D project has advanced to the demonstration stage since 2015. Further R&D for low-cost reuse technologies will be launched in 2016 and R&D should be concluded by 2018.

There are no specific schemes for treating end-of-life PV panels in Japan so they are expected to be dealt with in much the same way as other industrial wastes. PV panels will be removed from buildings or installation sites and transported to intermediate processors for waste treatment. There, components of PV panels will be separated as much as possible, and valuable materials will be recovered and recycled. For example, recoverable metals will be transported to companies which refine metals and recycled as secondary metals. Glass that can be separated and retain high purity will be recycled as glass cullet. Materials difficult to separate, recover and recycle will be sent to landfill subject to regulation and classification of hazardous content.

Box 16 Outlook for Japan

Despite a lack of current statistical data on end-of-life PV panels in Japan, the volume will probably be low in the near term given only recent market growth to significant levels. Although Japan has no specific regulations for end-of-life PV panels, several political trends and R&D activities are helping build the groundwork for recovery and recycling.

5.4 US: ESTABLISHED, GROWING MARKET WITHOUT PV-SPECIFIC WASTE REGULATIONS

PV panel market and waste projection

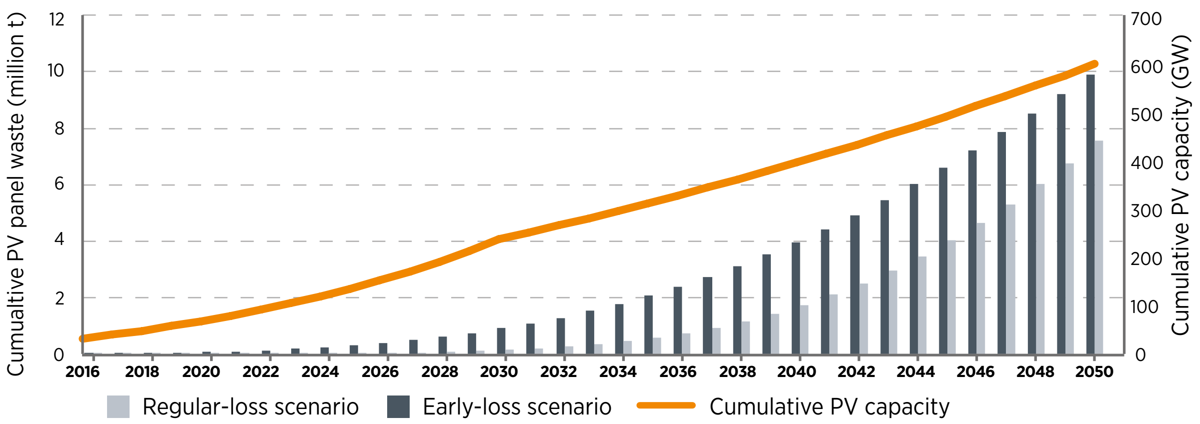
Since the mid-2000s, the US PV market has been growing rapidly, and cumulative installed capacity reached over 25 GW by the end of 2015 (IRENA, 2016b). With 7.2 GW new PV capacity installed in 2015 alone, the US presents today the fourth largest PV market in the world after China, Germany and Japan (IRENA 2016 and IEA-PVPS, 2015).

Large-scale PV deployment in the US has only occurred in the past ten years. Thus cumulative end-of-life PV waste volumes in the US are expected to remain low at the end of 2016 at 6,500-24,000 t. In 2030 cumulative waste is projected to rise to between 170,000 t and 1 million t and then possibly increase sevenfold to 7.5-10 million t in 2050 (see Figure 19).

Regulatory and non-regulatory framework

There is no PV-specific waste law in the US and no regulations mandating the collection and recycling of end-of-life PV panels. Hence, PV panels have to be disposed of in line with the Resource Conservation

Figure 19 End-of-life PV panel waste volumes for the US to 2050



and Recovery Act (Resource Conservation and Recovery Act, 1976) that is the legal framework for managing hazardous and non-hazardous solid waste.

As the Resource Conservation and Recovery Act does not include specific requirements for PV panels, they have to be treated under its general regulatory framework for waste management. For instance, there are two types of hazardous waste – characteristic hazardous waste and listed hazardous waste. The latter refers to actual listings of specific types of hazardous waste. Since end-of-life PV panels are not a listed hazardous waste, they must be evaluated using the characteristic hazardous waste method (US Environmental Protection Agency Method 1311 Toxicity Characteristic Leaching Procedure). This is done by assessing whether the extract from a representative sample of the waste contains contaminants exceeding regulatory levels. Within the US, different states can use additional leaching procedures such as California with the Total Threshold Limit Concentration and Soluble Threshold Limit Concentration for waste classification.

In California's 2014-2015[15] legislative session, Senate Bill 489 was proposed. It authorises the California Department of Toxic Substances Control to change the classification of end-of-life solar PV panels identified as hazardous waste to universal waste. This means they would meet Total Threshold Limit Concentration/Soluble Threshold Limit Concentration standards and be subject to Department of Toxic Substances Control regulations and proper management (California Legislature, 2015). The bill has been enacted into California law now. However, it will not take effect until the US Environmental Protection Agency authorises the addition of hazardous waste PV panels in California alone as an additional universal waste category under California's hazardous waste programme.

15. *Senate Bill 489, an act to add Article 17 (commencing with Section 25259) to Chapter 6.5 of Division 20 of the Health and Safety Code, relating to hazardous waste.*

Voluntary collection and recycling of end-of-life PV panels has been provided by several PV industry stakeholders. For example, the company First Solar operates a commercial-scale recycling facility with a daily capacity of 30 t in Ohio for its own CdTe products (Raju, 2013). The US Solar Energy Industries Association maintains a corporate social responsibility committee that reviews developments related to PV recycling.

Box 17 Outlook for the US

No federal regulations currently exist In the US for collecting and recycling end-of-life PV panels, and therefore the country's general waste regulations apply. California is in the process of developing a regulation for the management of end-of-life PV panels within its borders, though several steps remain before this regulation is implemented.

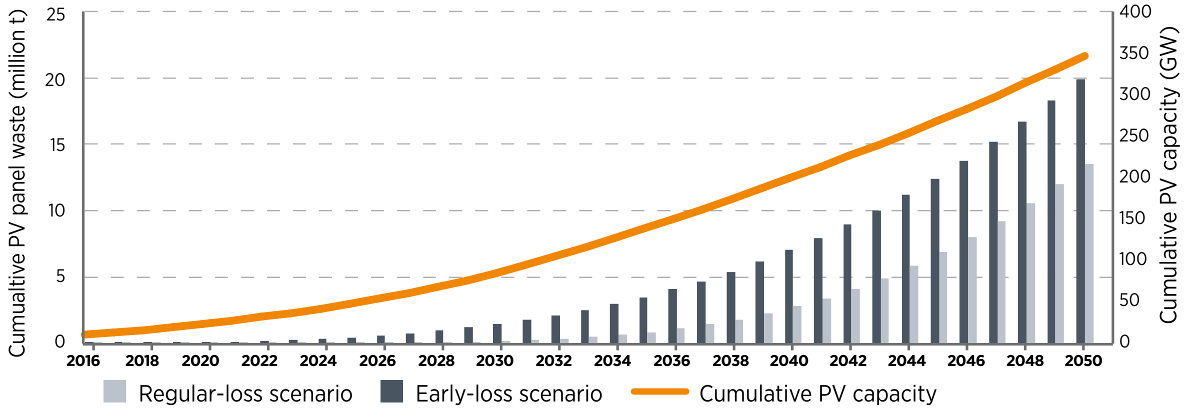
5.5 CHINA: LEADING MARKET WITHOUT PV-SPECIFIC WASTE REGULATIONS

PV market and waste projection

In 2015 China installed 15 GW of PV, for the second consecutive year reaching its 10 GW target for average annual growth and maintaining its position as the world's largest PV market. In December 2015 the National Energy Administration issued its 13th Solar Energy National Plan 2016-2020 (National Energy Administration, 2015). The main near-term targets proposed by 2020 are 150 GW PV of cumulative installation. This is to be composed of 70 GW of distributed PV and 80 GW of large-scale ground-mounted PV.

This report projects cumulative PV panel waste streams of 8,000-100,000 t in 2020. This is due to climb to between 200,000 t and 1.5 million t by 2030 and surge to 13.5-19.9 million t until 2050 (see Figure 20).

Figure 20 End-of-life PV panel waste volumes for China to 2050

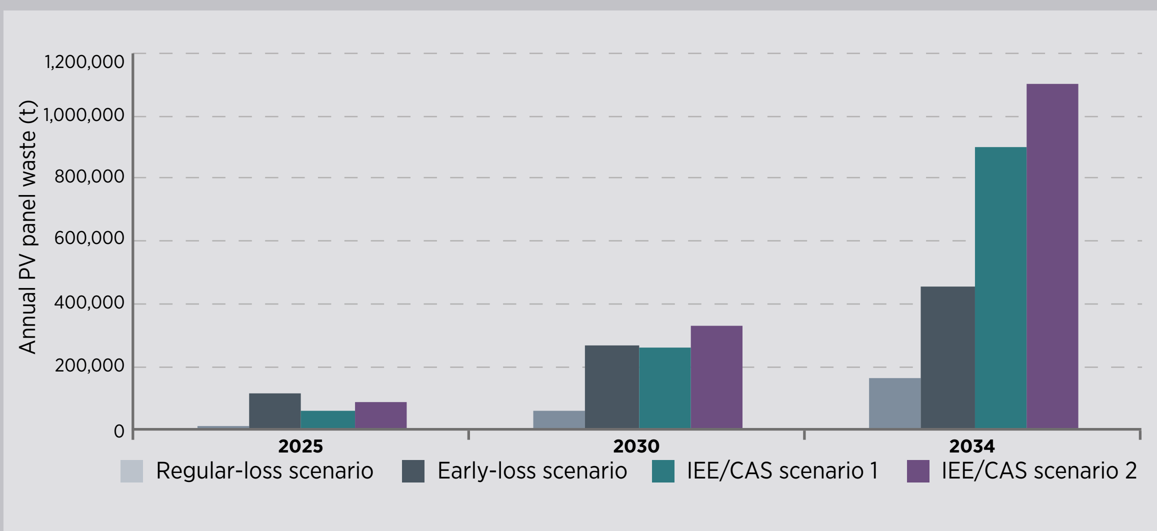


Because of China's rapidly developing PV industry, PV panel recycling is receiving more attention from the government and PV producers. China has therefore developed its own national PV panel waste projections outlined in Box 18.

Box 18 China's PV panel waste projections

China has developed its own PV panel waste projections through its Institute for Electrical Engineering of the National Academy of Sciences (IEE) (Zhang and Fang, 2014). The IEE produced two case scenarios (CAS), a business-as-usual scenario and a better-treatment scenario. Both consider different operation and maintenance behaviours over the lifetime of deployed panels. Overall, the IEE estimates are similar to the results of the regular-loss and early-loss scenarios of this report to 2034. The two IEE scenario annual predictions amount to 61,250 t up to 87,000 t for 2025, rising to 262,000-330,000 t for 2030. From 2034 the IEE scenarios show higher end-of-life volumes than this report's scenarios with 900,000 t per year and 1.1 million t per year for 2034 respectively (see Figure 21).

Figure 21 Comparison of PV panel end-of-life scenarios for China



Regulatory and non-regulatory frameworks

At present, PV panels in China do not have specific requirements for end-of-life treatment. In February 2009 the State Council promulgated the Waste Electrical and Electronic Product Recycling Management Regulation which came into effect in January 2011 (State Council of the People's Republic of China, 2011). The 2011 regulation requires e-waste to be collected in various ways and recycled in a centralised processing system. Producers can collect and recycle the products by themselves or entrust collection to the sellers, after-sales service agencies or e-waste recyclers and entrust recycling/disposal to qualified institutions. At present, however, PV panels are not included in the waste electrical and electronic products processing directory of the regulation.

Because of the current low volume of waste, China does not have a mature PV panel recycling industry. China has sponsored R&D on PV recycling technologies, focusing on two recycling methods for c-Si PV under China's National High-tech R&D Programme PV Recycling and Safety Disposal Research from 2012 to 2015. These methods are based either on physical or thermal recycling. In the physical method various processes — including crushing, cryogenic grinding and separation — yield aluminium, glass cullet, copper, ethylene-vinyl-acetate and backsheet particles as well as a silicon powder mixture. The recycling rate is at about 90% by mass but silicon cannot be recycled for use in the PV industry owing to low purity. In the thermal method the clean cell debris goes through a thermal process and is then used for chemical experiments for recycling silicon, silver and aluminium.

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Box 19 Outlook for China

China currently has no specific regulations for end-of-life PV panels, and related technology research has just begun. However, the National High-tech R&D Programme PV Recycling and Safety Disposal Research provides policy and technology signposts for the future. On the policy side, these include the need for special laws and regulations for end-of-life PV panel recycling, targets for recycling rates and the creation of necessary financial frameworks. On the technology and R&D side, recommendations concentrate on developing and demonstrating high-efficiency, low-cost and low-energy consumption recycling technologies and processes for c-Si and thin-film PV panels. Specific attention should thereby be given to improving the onsite/mobile recycling and disposal platform for c-Si PV power plants.

5.6 INDIA: GROWING MARKET WITHOUT PV-SPECIFIC WASTE REGULATIONS

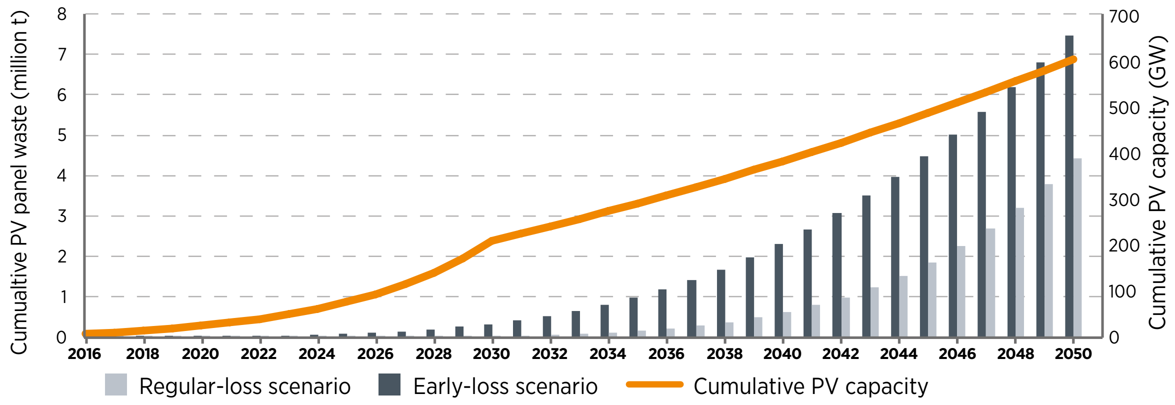
PV market and waste projection

Since 2012, India has installed over 1 GW of PV annually achieving a cumulative capacity of almost 5 GW in 2015 (IRENA, 2016b). This places India today amongst the top ten PV markets in the world (IEA-PVPS, 2014b). The Indian power sector faces two main challenges. Firstly, it needs to alleviate energy poverty (more than one-third of India's population lacks electricity access). Secondly, it needs to meet increased electricity demand arising from rapid economic growth (electricity demand is forecast to increase five- to sixfold by mid-century) (IEA, 2011). This represents a significant opportunity for renewable energy, including PV.

The Jawaharlal Nehru National Solar Mission (JNNSM) aims to install 100 GW of grid-connected PV systems by 2022 (Government of India, 2011). PV in India also represents an alternative to traditional grids, and the JNNSM targets to install 2 GW of off-grid systems.

Large-scale PV deployment has taken place only recently so major end-of-life PV waste volumes in India may not be expected until after 2030. Figure 22 shows India's expected end-of-life PV panel waste volumes in 2016-2050. Minimal waste is projected in 2016. However, waste could average 50,000-320,000 t by 2030, possibly culminating in 4.4-7.5 million t by 2050 (depending on scenario chosen).

Figure 22 End-of-life PV panel waste volumes for India to 2050



Regulatory and non-regulatory frameworks

India has no regulations mandating collection, recovery and recycling of end-of-life PV panels. This means waste PV panels generated today are covered by general waste regulations. Waste is managed by the Ministry of Environment, Forest and Climate Change under the 2016 Solid Waste Management Rules and the Hazardous and Other Wastes (Management and Transboundary Movement) Rules (Ministry of Environment, Forest and Climate Change, 2016a and 2016b). The recently amended Hazardous Waste Rules include use of Toxicity Characteristic Leaching Procedure. Transfer of hazardous waste requires authorisation from the State Pollution Control Board, and interstate transport is permitted under certain conditions (Ministry of Environment, Forest and Climate Change, 2016b).

Legislation covering requirements for general e-waste and restrictions on the use of hazardous substances in electronic products are included in the E-waste (Management and Handling) Rules of 2016 (Ministry of Environment, Forest and Climate Change, 2016c). However, these rules only apply to household electronics and not PV. Accordingly, an industrial-scale e-waste recycling infrastructure already exists in India but only covers household electronics and not PV.

Box 20 Outlook for India

In 2015 the original JNNSM deployment target of 20 GW of grid-connected PV systems by 2022 was updated to 100 GW by 2022. If supported by funding and grid infrastructure, progress towards the updated target would increase end-of-life PV panel waste volume projections for India by 2030 and especially by 2050. Although India currently has no specific PV-related waste regulation, increasing growth rates will most likely lead to waste regulations for end-of-life PV panels in the future.

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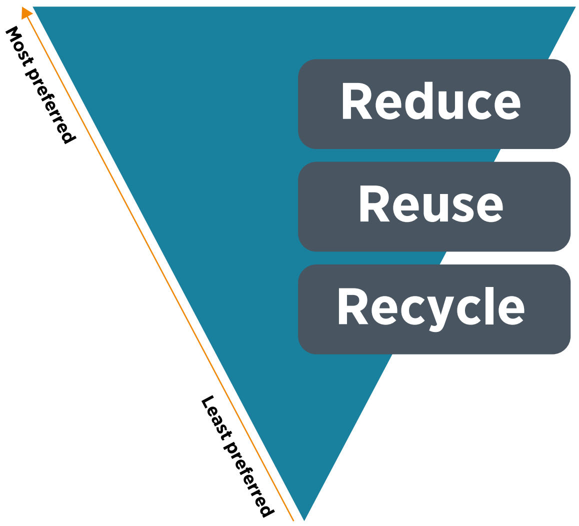
VALUE CREATION FROM END-OF-LIFE PV PANELS

Opportunities for value creation exist in each segment of the PV value chain, including the end-of-life stage. This chapter provides an overview of value creation opportunities relating to reductions in material use, options for repair and reuse and finally recycling and treatment considerations for PV panel waste. In the first section PV panel recycling is set in the context of well-known waste-reduction principles: reduce, reuse and recycle. The second section describes how socio-economic and environmental value is derived from end-of-life PV panels.

6.1 OPPORTUNITIES TO REDUCE, REUSE AND RECYCLE PV PANELS

The framework of a circular economy (cradle-to-cradle opportunities) and the classic waste reduction principles of the 3Rs (reduce, reuse, and recycle) can also be applied to PV panels (see also Chapter 4 on Waste Management Options). The preferred option among these is the reduction of material in PV panels and thus an increase in efficiency. Strong market growth, scarcity of raw materials and downwards pressure on PV panel prices are driving more efficient mass production, reduced material use, material substitutions and new, higher-efficiency technologies. This works towards cutting materials use per unit of generation.The reuse option follows the reduce option. This encompasses different repair and reuse modalities. Recycling is the least preferred option (apart from disposal) and only takes place after the first two options have been exhausted. It provides for the processing and treatment of PV panels and can unlock raw materials for new PV panel manufacturing or other products (see Figure 23).

Figure 23 Preferred options for PV waste management



PV panel material savings through R&D (reduce)

Chapter 2 included a projection of changes in PV panel composition between now and 2030. The following analysis will summarise potential "reduce" options for the material components used in different PV technologies.

Box 21 Definition of resource and material efficiency

Resource or material efficiency means using the world's limited resources in a sustainable manner while minimising impacts on the environment. Resource/material efficiency enables the creation of more value (e.g. products) with less input (e.g. resources or materials).

The mix of materials within PV panels has not changed significantly in the past. However, considerable material savings have been achieved due to increased resource and material efficiency (see Box 21 for definition). For instance, materials savings and even substitutions have been and are continuing to be researched for lead, cadmium and selenium so that the amount of hazardous materials can be reduced. For the other materials used for different PV panel technologies, research mainly focuses on minimising amount per panel to save costs. Since total consumption of rare and valuable materials will increase as the PV market grows, availability and prices will drive reduction and substitution efforts. Recent studies agree that PV material availability is not a major concern in the near term although critical materials might impose limitations in the long term. In addition, increasing prices will improve the economics of recycling activities and drive investment for more efficient mining processes. This includes extraction of metals used in the PV manufacturing process like silver, aluminium, copper and tin (Marini *et al.*, 2014; Marwede, 2013; Zimmermann, 2013; Taoa, Jiang and Taoa 2011 and Erdmann, 2011).

PV R&D has specifically set priority topics for material use reduction or substitution for different components commonly used in current PV panels[16] including for:

- c-Si panels: glass, polymer, silicon, aluminium, silver and lead and others;
- CIGS panels: glass, polymer, aluminium, cadmium, gallium, indium, selenium and others;
- CdTe panels: glass, polymer, cadmium telluride, nickel and others.

Furthermore, considerable R&D is focused on new materials and material replacements. The following is an illustrative set:

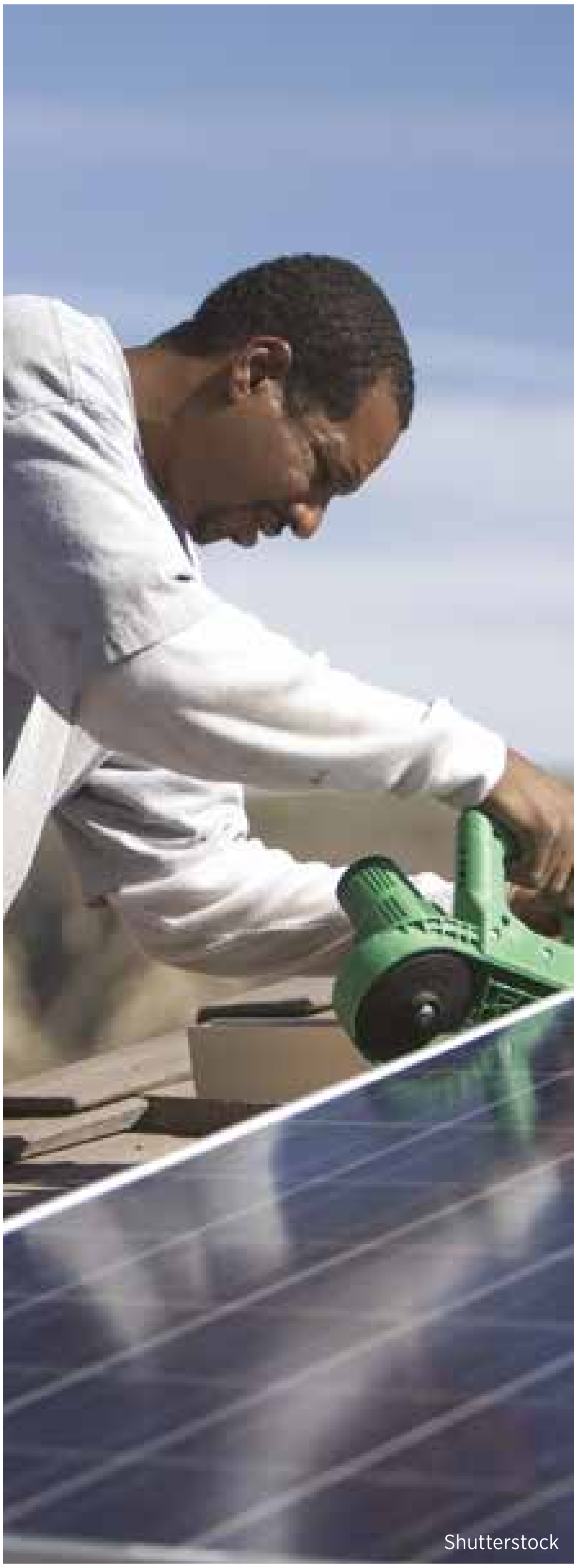
- **Indium.** New transparent conducting oxide layers incorporating more abundant and hence cheaper compounds like fluorine doped tin-oxide may replace indium-tin-oxide as front electrodes (Calnan, 2014). This reduces the use of indium in indium-tin-oxide available in some thin-film PV technologies as transparent conducting oxide.

- **Glass.** Further optimisation of glass composition, thickness, anti-reflective coating and surface structures will increase the transmission of the front glass panes by another 2% by 2024. The use of glass two millimetres thick or even less in a single-pane laminate will require additional mechanical stabilisation effort which might be achieved by double-glass panels with a thin encapsulation layer. These are proven constructions deployed for decades in thin-film PV panels and could lead to significant material reductions by substituting the need for a backsheet (Raithel, 2014).

- **Polymers.** Encapsulants and backsheet foils are not recycled today because the duroplastic materials that dominate the market cannot be dissolved or melted for recycling without decomposition. Research is looking at reducing or replacing the amount of polymers, especially for backsheets that use a polyethylene terephthalate foil. They contain up to a few hundred parts per million of antimony used as polymerisation catalyst (Ramaswami, 2014). For example, the research project led by the Energy Research Centre of the Netherlands and PV CYCLE (CU-PV)[17] will develop and demonstrate alternatives to current practices. One example is the use of thermoplastics, which are easier to separate, as encapsulant. Another is the elimination of encapsulant use altogether (CU PV, 2016 and Oreski, 2014).

- **Silicon.** Thinner cells can reduce the amount of silicon used in c-Si cells. For instance, by moving to a back-contact cell design, the use of silicon could be cut by half, and energy consumption could be reduced by about 30% (Raithel, 2014).

- **Silver.** About 95% of c-Si solar cells are now produced with screen-printed silver contact lines on the front side covering roughly 6%–8% of the cell area. A significant reduction of silver on cells is expected by 2018 according to International Technology Roadmap for Photovoltaic (ITRPV) study (Raithel, 2014) owing to recent progress in inkjet and screen-printing technologies. This allows the use of other metals like copper in combination with nickel and aluminium. Use of rear-contact or bifacial cells can help further reduce silver consumption per watt (W) by enhancing cell efficiency (Raithel, 2014 and Perez-Santalla, 2013). For example, the research project led by CU-PV will develop new metallisation methods suitable for thinner wafers. These are based on inkjetting seed layers plated afterwards with nickel and copper and result in at least a 99% reduction in silver. The silver components used in PV panels are further explained in Box 22.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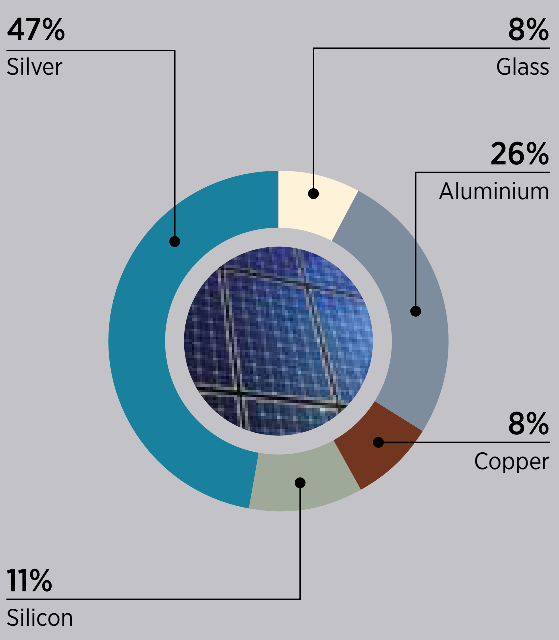
16. *The list in this chapter focuses on key materials which are the subject of active materials reduction research for panels. This list may differ from the materials rank ordered by weight per panel as reported in Chapter 3.*
17. *The CU-PV research project aims to address PV sustainability concerns by improving the recyclability of PV panels through advanced designs and collaboration over the value chain on recycling solutions.*

Box 22 Silver components

From a value standpoint, silver is by far the most expensive component per unit of mass of a c-Si panel, followed by copper, silicon, aluminium, glass and polymer (see Figure 24). The PV industry consumes about 3.5%-15% of global silver production (Berry, 2014 and Marini *et al.*, 2014). The higher numbers in this range include production losses while the lower numbers result from analysis of the silver content of solar cells. On average, a typical c-Si panel contains about 6-10 grammes of silver.

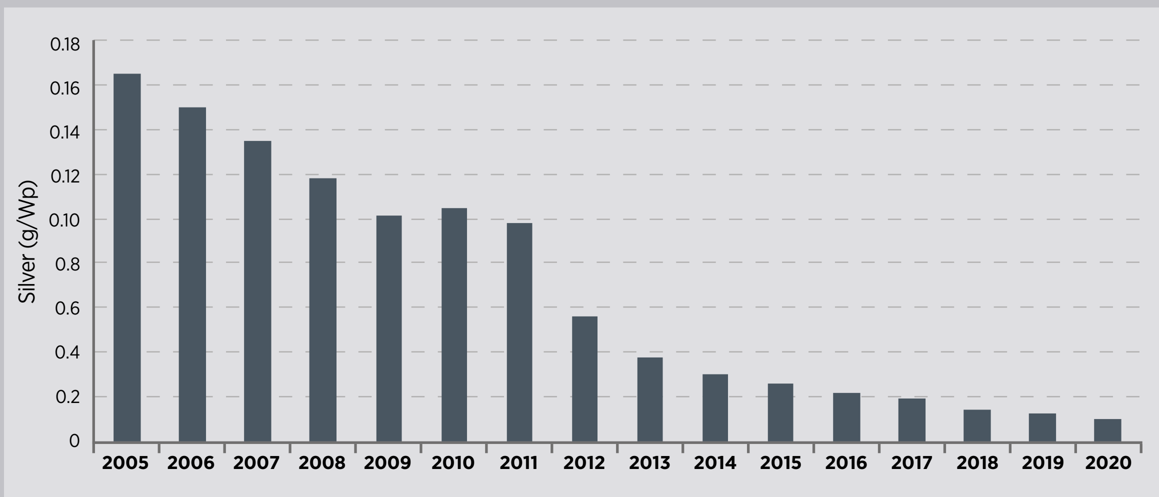
Figure 24 Relative material value (%) of a c-Si PV panel



Based on Raithel (2014)

Figure 25 shows recent silver consumption per watt and future projections. New printing techniques and pastes brought in silver savings of more than 30% in 2009-2012 (Silver Institute, 2014; Schubert, Beaucarne and Hoornstra 2013 and Perez-Santalla, 2013). Owing to expected growth rates in the global PV industry, the Silver Institute forecasts a mid- to long-term increase in silver consumption although the use per unit of power will shrink further. Silver consumption per watt is projected to decline by two-thirds from 2013 to 2017 while total silver consumption is expected to be the same in 2017 as in 2013 (Silver Institute, 2014). Assuming the silver contacts are ten microns thick and cover roughly 10% of a cell's surface, total c-Si cell manufacturing capacity would be limited by silver availability to five terawatt-peak (assuming 15% efficiency) (Tao, Jiang and Tao 2011). According to Raithel (2014), improved efficiencies, reduced consumption and better recovery should increase this limit in coming years.

Figure 25 Historic and expected specific silver consumption per watt-peak



Estimates based on Perez-Santalla (2013)

Various new technologies for cells, backsheets, coatings and encapsulation materials have been implemented, resulting in over 50,000 panel types (Photon, 2015 and 2016). Tracking all materials for the purposes of waste treatment and recycling is challenging and will continue to be so. Establishing global information flow systems with panel and material databases could facilitate the objective of long-term end-of-life management systems that maximise material recovery.

The next section analyses the different end-of-life options for PV panels. The environmentally preferable approach is to repair a potential end-of-life panel and make it fit for reuse.

Repair of PV panels (reuse)

Most PV systems were installed in the last six years (from 15 GW in 2008 to 222 GW in 2015), which means that these have aged to an early loss of 20% of the expected average lifetime (30 years) today. If defects are discovered during the early phase of a PV panel's life, customers may try to claim warranties or guarantees for repair or replacement provided the contract partner still exists. Insurance companies may be involved to compensate for some or all of the repair/replacement costs within the contract agreements. In such cases the ownership of the panels often changes to the insurance company. Most defective panels are thus typically returned to the contract partner, a producer service partner or the producer itself for inspection and repair.

In order to recover some value from a returned panel through resale, quality tests have to be made checking mainly electrical safety and power output. A flash test characterisation and a wet leakage test is one example. When repairs are both required and feasible, they typically involve applying a new frame, new junction box, diode replacement, new plugs and sockets and more. Solar cells may even be replaced, and panels relaminated. This is similar to the 'B-spec' and 'C-spec' qualities[18] in panel products that might be sold into special projects or relabelled to another brand name in some cases prior to marketing. In consequence, the product receives a new label with new guarantees (in compliance with national laws).

The repaired PV panels can be resold as replacements. Alternatively they can be **resold as used panels** at a reduced market price of approximately 70% of the original sales price compared to new panels, according to research conducted for this report. Partly repaired panels or components might be sold in a second-hand market. A modest **used panel market** has already been emerged supported by virtual internet platforms such as www.secondsol.de and www.pvXchange.com. With more and more PV installed, the number of these second-generation panels or components may well increase, generating a market for their use. Chapter 6.2 provides further information on emerging industry stakeholders in this market.

According to the Weibull statistics applied to the PV forecast in this report, a proportion of installed panels may remain intact even after an average lifetime of 30 years. If a PV system is dismantled after its nominal lifetime, these panels may be reused after a quality check and refurbishment. This creates a good opportunity for a significant secondary market of used panels and new repair service jobs in the future.

Panels that cannot be repaired or reused will be taken apart (see next section) and then forwarded to local waste treatment companies for further processing according to local regulations.

18. Panels are grouped according to the results of the final quality inspection. An A-panel is of excellent quality, a B-panel may suffer from some minor quality issues like a scratch, stains and other discoloration or slightly wrong cell position. The next letters (C, D...) indicate more defects. Such panels usually are sold at lower prices.

Decommissioning and treatment of PV panels (recycle)

Disassembly and dismantling

The types and sizes of PV systems installed have important implications for future waste management. For example, the proliferation of highly dispersed, small rooftop PV systems can add significant costs to dismantling, collection and transport of expired PV panels. By contrast, waste management for large utility-scale PV applications is logistically easier.

It is useful to distinguish two different scenarios for the collection of PV panels depending on size and geographic location:

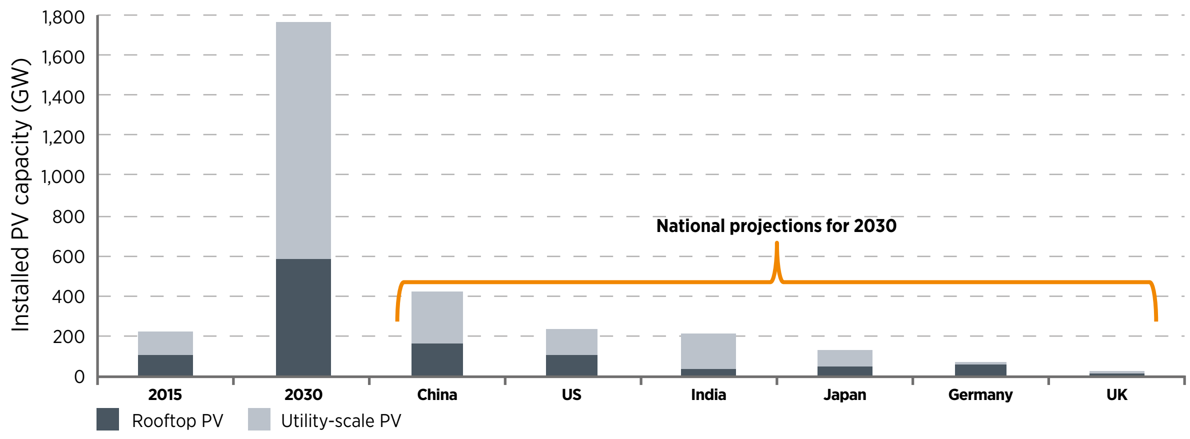
- Utility scale (> 100 kilowatts – kW);
- Home single-panel system (< 500 W), small rooftop (< 5 kW) and large rooftop system (> 5 kW).

Utility-scale systems (> 100 kW) are usually ground-mounted, regularly serviced and monitored. The panels may be placed on racks of aluminium or steel with concrete bases. The electrical system is based on string or central inverters with a grid connection. In some cases even an energy storage system may be present, which can be based on lithium-ion batteries, lead-acid batteries or other technologies.

For these large plants, competition among decommissioning actors results in high cost efficiency. Dismantling, packing, transport and recycling can be easily contracted for parts of or the whole system. Dismantling and pick-up services for transport to the recycling facilities will usually be defined during contractor bidding processes and supervised and performed by skilled workers. The tendering processes may include the entire dismantling of the plant or parts of it depending on the intended use of the area afterwards. It can be assumed that relatively high quality standards will be applied in such a case. The components of the PV plant will be stored separately: panels, cables, electronics (inverters, charge controllers, transformers, monitoring electronics etc.), metals (aluminium, steel), typical buildings and construction demolition waste etc. The quantities of the different wastes are relatively high and can easily be collected separately at reasonable cost for transport to specialised recyclers or landfill sites (Brellinger, 2014 and Fthenakis, 2000). Depending on the local regulations, some components — typically some batteries or power transformers — may be considered hazardous or toxic waste.

Costs of dismantling **smaller installations (5-100 kW)** depend on the type of PV system (ground-based, BIPV, rooftop, etc.) and the location. Dismantling small PV installations may require skilled workers like roofers and electricians. Single panels, small **home single-panel systems (< 500 W)** or other **small systems (< 5 kW)** might be returned by bring-in or pick-up services. In these cases, logistics costs

Figure 26 Projected rooftop and utility-scale PV deployment in 2030 compared to 2015



Based on IRENA (2016a)

can dominate the overall costs of the takeback and recycling systems. The different wastes will be sent to recyclers or landfill sites depending on local regulations and the presence of specialised waste-treatment companies.

IRENA's *REmap* study (IRENA, 2016a) predicts that rooftop deployment with system sizes of a few kilowatts up to the megawatt range will be substantial through to 2030 with 580 GW installed. Nevertheless, larger utility-scale (mostly ground-mounted) applications will make up larger share of total installed capacity at 1,180 GW (see Figure 26).

Logistics costs can become decisive in takeback systems for PV panels in remote areas like islands or rural areas. On the basis of the dismantled PV generator costs at Pellworm Island in Germany's North Sea, the costs for ship and truck transport can be at least three to five times higher than with mainland installations (United Nations Conference on Trade and Development, 2014). The presence of monopolistic structures (e.g. in the logistics system) can be an additional cost driver given the general observation that competition can reduce prices.

Damage to PV panels should be avoided during dismantling, transport and storage to support sound waste treatment with best available technologies and best possible results. Cables, junction boxes and frames should not be removed during dismantling. These may require special attention for their secondary material value and possibly in line with local legal requirements (Wambach *et al.*, 2009).

- **Recycling**

Since currently only moderate PV waste quantities exist on the global waste market, there are not sufficient quantities or economic incentives to create dedicated PV panel recycling plants. End-of-life PV panels are thus typically processed in existing general recycling plants. Here, the mechanical separation of the major components and materials of PV panels is the focus. This still achieves high material recovery by panel mass even although some higher value materials (that are small in mass) may not fully be recovered. This current strategy offers legal compliance without the need for new PV-specific recycling investments. In the long term, however, constructing **dedicated PV panel recycling plants** could increase treatment capacities and maximise revenues owing to better output quality. In addition, it could increase recovery of valuable constituents.

Recycling technologies for PV panels have already been researched for the past 15 years. This knowledge has provided a foundation for developing specialised recycling plants once the waste streams are sufficiently large for profitable operation. For example, extensive research was conducted by solar PV companies including AEG, BP Solar, First Solar, Pilkington, Sharp Solar, Siemens Solar, Solar International and many others (Sander *et al.*, 2007). Research institutes have also examined different recycling options for PV. Examples include the Brookhaven National Laboratories in the US, the National Institute of Advanced Industrial Science and Technology in Japan, the Interuniversity MicroElectronics Center in Belgium and the Energy Research Centre in the Netherlands (CU PV, 2016). All future recycling processes will need to keep abreast of ongoing cell and panel innovations to obtain the best possible results at acceptable costs. Such processes will have to recover major components like glass, aluminium, copper and other potentially scarce or valuable materials (e.g. silver, indium) at sufficient quality for sale on the world market. They might equally need to handle modest quantities of hazardous and toxic materials (e.g. cadmium) (see Chapter 3 for PV panel waste composition).

One of the main technical challenges in PV recycling is the delamination or the removal of the encapsulant material (e.g. ethylene-vinyl-acetate). Various methods have been explored for effective delamination, including mechanical crushing (Giachetta *et al.*, 2013 and Berger *et al.*, 2010), thermal processing (Wang *et al.*, 2012), organic solvents (Kang *et al.*, 2012 and Doi, 2001), pyrolysis and vacuum blasting

(Berger *et al.*, 2010 and Kushiya, 2003), micro-emulsions (Marwede and Reller, 2012) and ultrasonic radiation (Kim and Lee, 2012).

The following points are important for designing any future PV panel waste recycling systems independent of the PV technology used: These considerations would produce the best possible results, including high recovery rates and high quality even for materials present in low quantities (Sander *et al.*, 2007).

- Avoid further damage to the PV panel during dismantling, collection and transport phases;
- Depending on economic feasibility, reclaim as much valuable (e.g. silver, copper, silicon, glass, aluminium), scarce (e.g. indium, tellurium) and most hazardous materials (e.g. cadmium, lead, selenium) as possible;
- Use durable labelling to help identify the product;
- Link material compositions relevant to recycling and recovery processes to the label;
- Create recycling-friendly panel designs.

In the rest of this section, some of the more commonly used methods are described for the two main PV technologies: crystalline silicon and thin-film PV panels.

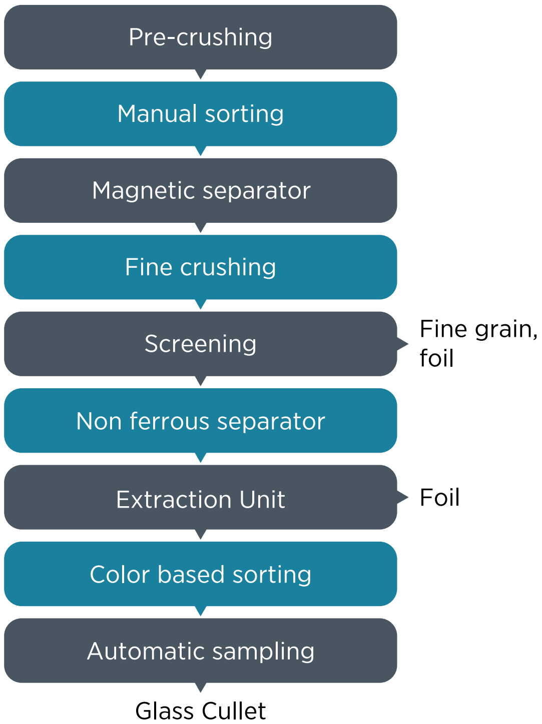
Recycling crystalline silicon PV panels

The major components of c-Si panels, including glass, aluminium, and copper, can be recovered at **cumulative yields greater than 85%** by panel mass through a purely mechanical separation. However, without a combination of thermal, chemical or metallurgical steps, impurity levels of the recovered materials could be high enough to reduce resale prices (Pennington *et al.*, 2016 and Sander *et al.*, 2007).

Separation of the major components such as laminated glass, metal frames, wiring and polymers is the first step in current and first-generation recycling processes. Recycling strategies for each of these major components is discussed below.

Recycling the laminated glass component of c-Si panels is a relatively low-cost process which flat-glass recycling companies can implement with little additional investment (see Figure 27). The process is frequently run in batches to enable adjustment of parameters and account for the modest quantities available for processing today. Typical equipment for removing impurities like polymer (glue) residues or screws from the glass cullet includes magnets, crushers, sieves, eddy-current devices, optical sorters, inductive sorters and exhaust systems. The resulting crushed-glass fraction, which may still be heavily contaminated with silicon, polymers and metals, can be blended with other recycled glass as thermal insulating material in the glass-foam or glass-fibre industries. Research conducted for this report shows a blend composition including 15%–20% of PV panel glass is thereby achievable. However, with increasing waste PV streams, this market could become saturated, and investments in new recycling technologies will be required.

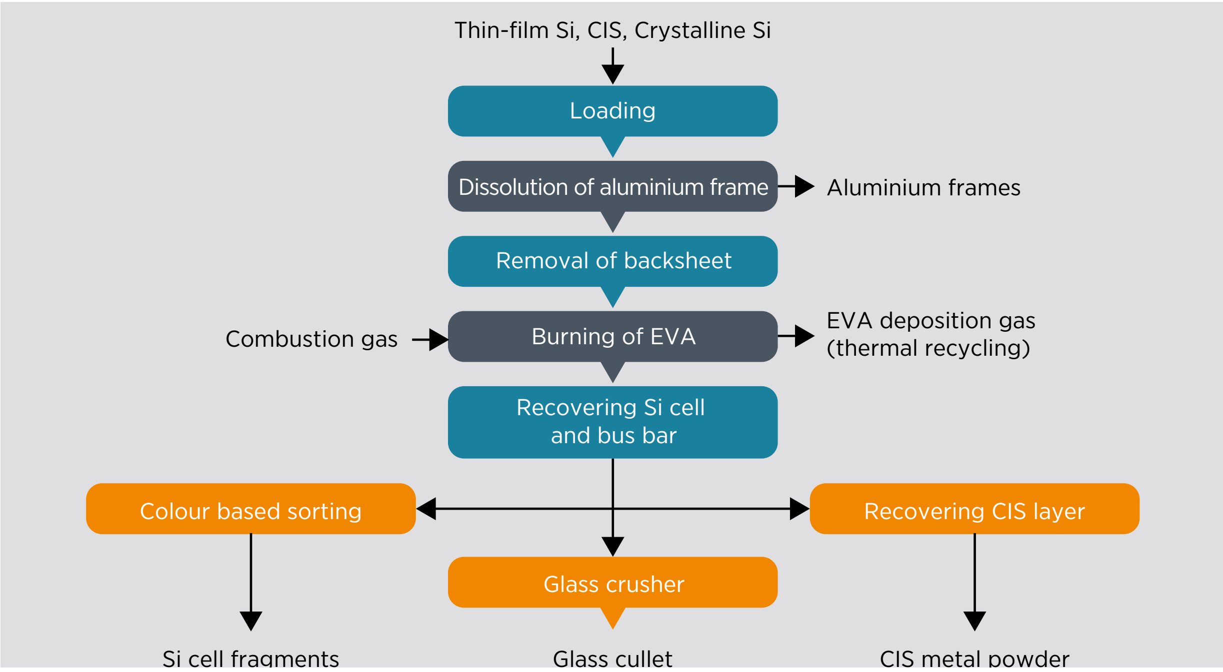
Figure 27 Process for laminated glass recycling



The aluminium or steel of the frames, and the copper of the cables can become part of the already well established metal recycling loops and therefore have easy potential for recycling. The polymer fractions can partly be processed in waste-to-energy plants provided they meet the input specifications of the plants.

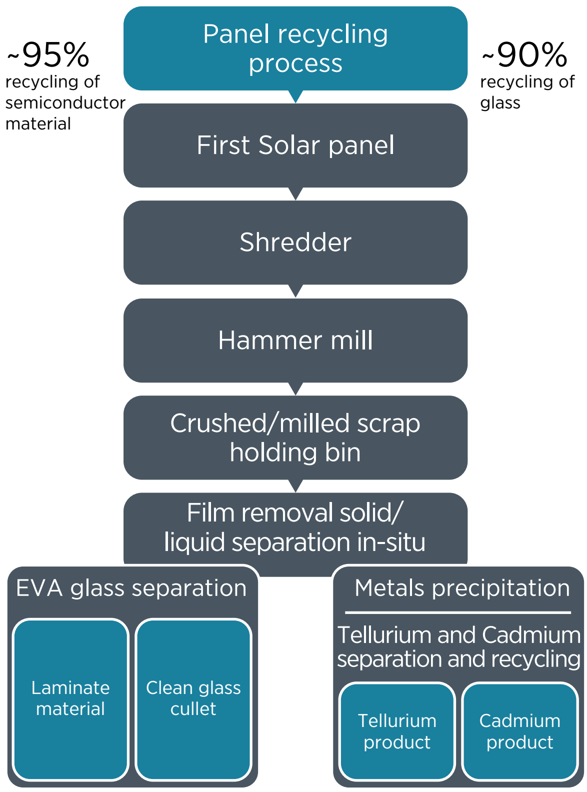
Recovering small amounts of valuable (e.g. silver, copper), scarce (e.g. indium, tellurium), or most hazardous materials (e.g. cadmium, lead, selenium) as components might require additional and more advanced processes. These are found predominantly in the glass and encapsulant (polymer) fractions. For example, the technical feasibility of recovering and purifying silicon from end-of-life c-Si PV panels has been demonstrated by Wambach *et al.*, (2009) which separated the panels in a pyrolysis step. It removed the solar cell metallisation and dopant layers in several selective etching steps and cast a new silicon ingot from the silicon obtained. A very similar process was developed by the Japanese NEDO programme by the FAIS – see Figure 28 (Komoto, 2014). The pilot plant also relies on pyrolysis of the polymers in a conveyor kiln. One main difference is the removal of frames and backsheet foil prior to the thermal step that precedes semiconductor material recovery (Si or CIS) and the glass cullet (see also Chapter 5.3 on Japan).

Figure 28 Recycling scheme proposed by NEDO/FAIS



Based on Komoto (2014)

Figure 29 Thin-film recycling process



Based on First Solar (2015a); cadmium and tellurium separation and refining are performed by a third party

Recycling thin-film PV panels (CIGS and CdTe)

The large-scale recycling of thin-film PV panels is still in its early stages and will improve as waste volumes and corresponding waste treatment knowledge increases. Thin-film panels are currently processed and recycled using a combination of mechanical and chemical treatments (see Figure 29).

A prominent example of this process includes the following steps (Sinha and Cossette, 2012) which can achieve about 90% recovery of the glass and about 95% of the semiconductor material by mass:

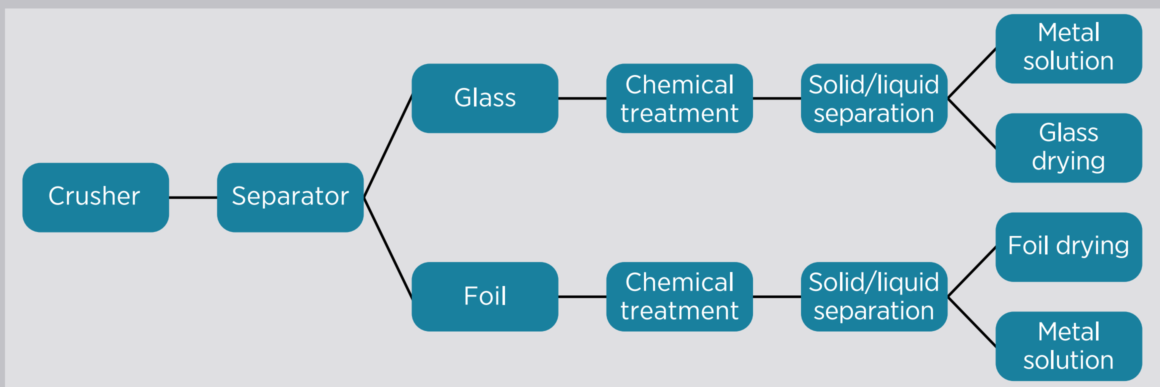
1. Panels are shredded and crushed in a hammer mill to particles of about 5 millimeters to break the lamination bond. The dust is then collected in an aspiration system equipped with a high-efficiency particulate air filter.

2. Semiconductor layer etching is carried out with a mixture of sulphuric acid and hydrogen peroxide. The glass and larger pieces of ethylene-vinyl-acetate are separated in a classifier and on a vibrating screen. Finally, the glass is rinsed with water and dried on a belt filter unit.

Box 23 Innovative treatment processes for thin-film PV panels

Loser Chemie (Palitzsch and Loser, 2014) has developed and patented new processes to enrich the compound semiconductor metals or silver of solar cells via chemical treatment after panels are pre-crushed (see Figure 30). The aluminium metallisation can subsequently be used for producing wastewater treatment chemicals (aluminium oxides).

Figure 30 Loser Chemie recycling process



3. The filtration liquids with the metals can be extracted via ion exchangers or precipitated. The cadmium and tellurium can be further purified by third parties for reuse in the solar industry.

Several new treatment processes for thin-film PV panels are currently undergoing research. The innovative Loser Chemie process described in Box 23 is one example.

6.2 MATERIAL SUPPLY AND SOCIO-ECONOMIC BENEFITS

With estimated PV panel waste volumes growing steadily in the coming years, the last section of this report assesses value creation of end-of-life PV by looking at potential socio-economic and environmental benefits. If approached and co-ordinated in time, significant opportunities can arise from managing the end-of-life of PV panels.[19]

Unlocking raw materials and their value

Important value can be created by extracting secondary raw material from end-of-life PV panels and making them available on the market again. Having an average lifetime of 30 years, PV panels will build up a large stock of raw materials embodied in products that will not become available for recovery for a considerable period of time. For example, a large flow of silver from panel recycling is not expected until 2025 (Perez-Santalla, 2013).

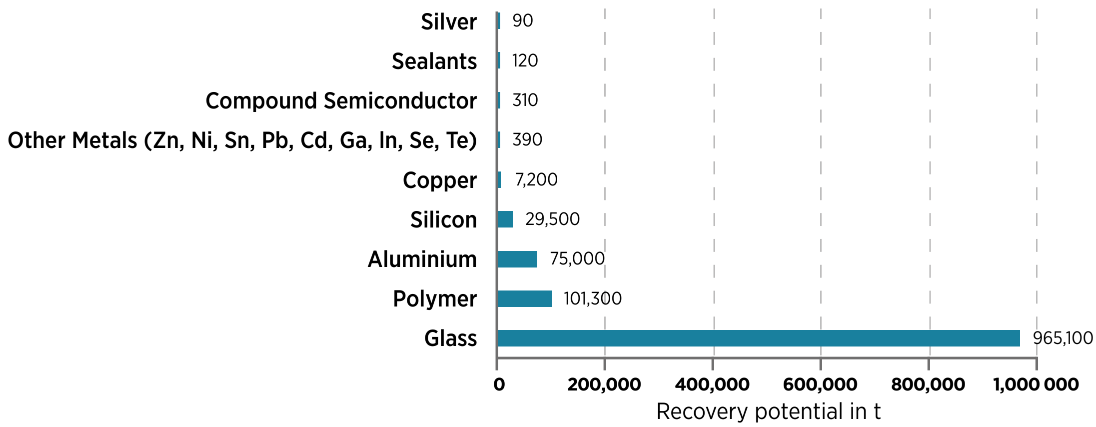
Value creation from unlocking raw materials is estimated below. The following assumptions are used:

- Raw materials can be treated and recycled at a rate of 65%-70% by mass. These recovery rates are already achievable today and are in line with the only existing regulation for PV panel recycling to date, the EU WEEE Directive (see Chapter 4). They are also a blended rate and assume a collection rate of 85% of total end-of-life PV waste stream as well as high value treatment and recycling technologies available to recover the majority of material fractions. This excludes losses from mechanical processing (e.g. shredder and mill dusts) and thermal recovery of non-recyclable polymer fractions (e.g. duro-plastics).
- The estimates are based on expected PV cell technology ratios and related waste composition multiplied by the cumulative waste volume of 1.7 million t for 2030 under the regular-loss scenario.
- Monetary value estimates reported are based on April 2016 market prices (Europäischer Wirtschaftsdienst, 2016) and may vary in future due to 1) possible price fluctuations on the raw material market and 2) changes in the raw material composition of PV panels.

The results of potential cumulative raw materials recovered by 2030 are displayed in Figure 31.

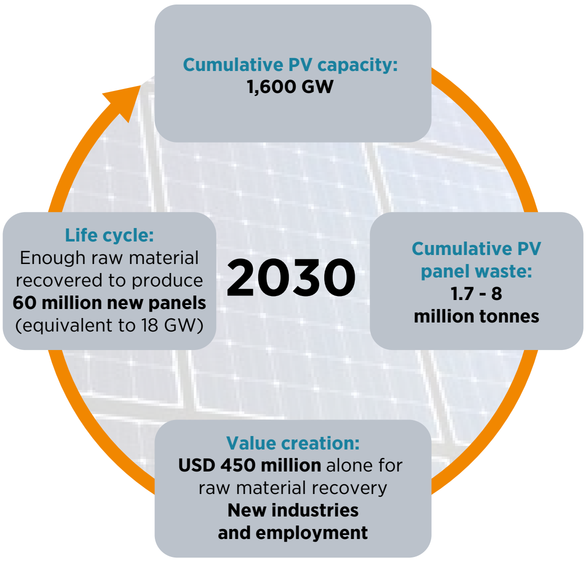
19. The value creation in different segments of the solar value chain has been studied in IRENA's publications "The Socio-economic Benefits of Solar and Wind" (2014) and "Renewable Energy Benefits: Leveraging Local Industries" (2016 forthcoming).

Figure 31 End-of-life recovery potential under regular-loss scenario to 2030 (t)



The total potential material value recovered through PV panel treatment and recycling amounts to USD 450 million by 2030. This is equivalent to the current raw material value needed to produce 60 million new panels or 18 GW. By comparison, 180 million new panels were produced in 2015.

Figure 32 Potential value creation through PV end-of-life management to 2030



Over 80% of the weight of panels made through any PV technology is **glass**; thus the greatest mass of recycling material comes from glass, estimated at approximately 960,000 tonnes by 2030. Hence, development of efficient recycling technologies for PV panel glass is essential. With an average secondary material market price for glass at USD 30-50/t depending on recovery quality (Eurostat Statistics, 2014), the potential for recovery value exceeds USD 28 million.

Significant amounts of **aluminium** (approximately 75,000 tonnes) and **copper** (approximately 7,000 tonnes) are projected to be re-released on the secondary material market through PV panel treatment. Both can easily be recycled using mature infrastructure available today. Their current combined value is up to USD 140 million (Europäischer Wirtschaftsdienst, 2016). If compared with world production in 2015 (see Table 13), these unlocked materials offer an important additional raw material supply by 2030.

Material usage for **silicon** cells has been reduced significantly during the last ten years, from around 16 grammes/Wp to less than 4 grammes/Wp due to increased efficiencies and thinner wafers. Silicon crystalline technologies continue to dominate the PV market. This means up to 30,000 tonnes of silicon, a valuable material, can potentially be recovered in 2030, assuming low yield losses. This is equivalent to the amount of silicon needed to produce over 45 million new panels or around USD 380 million (using current polysilicon prices at USD 20/kg and a value recovery rate of 70%).

Silver recovered from PV panels also has significant potential value. Based on an estimate of 90 tonnes recovered in 2030 and at a current market price (April 2016) (Europäischer Wirtschaftsdienst, 2016), the value of recovered silver is estimated at USD 50 million. This is enough to produce 50 million new panels.

The potential recoverable mass of **other materials** is 390 tonnes. These include zinc, nickel, gallium, indium, selenium tellurium and others. By comparison, the world production of these raw materials amounted to 3 billion tonnes in 2015 (see Table 13). This is equivalent to approximately USD 180 million. Up to 60 million new PV panels can be manufactured with this amount of material assuming increasingly efficient use of rare materials in manufacturing processes as well as improved recovery of purity in recycling treatments.

The potential recoverable amount of **semiconductors** is 310 tonnes, a relatively low number compared to the other materials discussed above. However, this could be used for the production of 40 million new PV panels.

Sealants and **polymers** are hard to recover today. New treatment and recycling processes are needed in order to create value for over 100,000 tonnes of these materials and substances potentially recoverable by 2030.

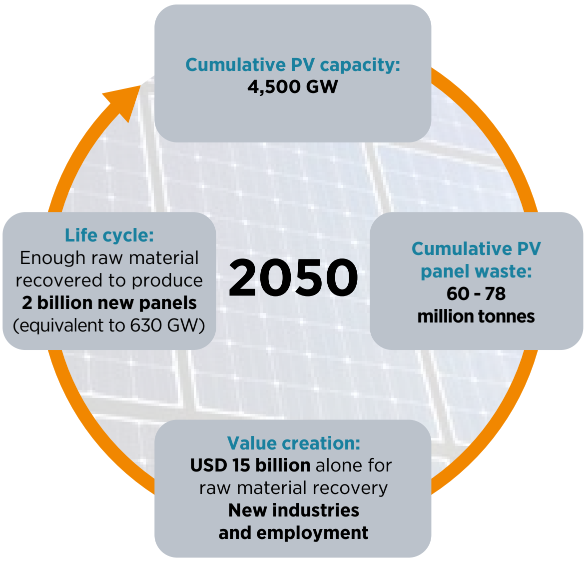
Table 13 World production of mineral commodities used in PV panels, 2015

	World production 2015 (thousand t)
Aluminium	58,300
Cadmium	24,200
Copper	18,700
Gallium	435
Indium	755
Lead	4,710
Lithium	32,500
Molybdenum	267,000
Nickel	2,530,000
Selenium	> 2,340
Silicon[20]	8,100
Silver	27,300
Tellurium	> 120
Tin	294,000
Sum	**3,268,460**

Based on US Geological Survey, 2016

20. Production quantities are combined totals of estimated silicon content for ferrosilicon and silicon metal.

Figure 33 Potential value creation through PV end-of-life management to 2050



As shown above, significant value could be created by recovering secondary raw materials by 2030. Applying the same regular-loss scenario until 2050, the value potential for unlocked raw materials is expected to surge to over USD 15 billion. This equates to the raw material needed to produce two billion new panels – 630 GW.

Recovered raw material tonnage can be traded and shipped just like primary raw materials from traditional extractive resources. The volumes injected back into the economy can serve for the production of new PV panels or other products, thus increasing the security of future PV supply or other products dependent on raw materials used in PV panels. As a result, rapidly growing panel waste volumes over time will stimulate a market for secondary raw materials originating from end-of-life PV.

Additional R&D and optimisation of recycling processes will be required to realise the full potential of material recovery, especially considering previous and current panel designs not yet incorporated into designs for recycling.

Creating new industries and jobs in PV

The overall waste management industry includes different stakeholders such as producers, importers, dealers, system operators, utilities, municipalities, governments, waste treatment companies and end-users. Co-operation is needed among these players to guarantee the acceptance of future PV panel waste management systems.

End-of-life PV panel management for holds the potential to develop new pathways for industry growth and offers employment opportunities to different stakeholders. These jobs are distributed among the public sector (governments, public research, etc.) and private sector (producers, waste management companies, etc.) (see Figure 32).

The emerging PV recycling industry will necessitate trained staff with specific skills and knowledge of recycling processes. Specific education and training programmes will need to become part of the renewable energy education sector. This will supply the technical skillset required to make the renewable energy industry part of the 3R and circular economy model.

Figure 34 Industry value creation from end-of-life PV management

R&D Organisations

- Public and private institutions
- Producers

Repair/Reuse services industry

- Producers
- Independent service partners
- Producer-dependent contract and service partners (e.g. installation and construction companies
- Waste collectors and companies
- Pre-treatment companies

Recycling treatment industry

- Public waste utilities and regulators
- Waste management companies
- Pre-treatment companies
- Producers

Firstly, **R&D organisations** will have an important role to play to achieve the further reduction of materials, increase efficiencies and further investigate the best available recycling and treatment processes for PV panels. As seen in Chapter 5, **public institutes** in several countries (e.g. Germany, Japan and China) have already started to research recycling methodologies with support from the **local government**.

With PV panel cost reduction as a primary driver, **producers** have since the industry's infancy built high-tech research capabilities to increase material and panel efficiencies. However, traditionally producers have concentrated more on production rather than end-of-life (repair/treatment and recycling). This is also explained by the renewable energy industry's relatively recent significant growth. The increasing PV waste volumes will change this perspective and should redirect R&D to the entire life cycle of a panel.

The private sector is also expected to be at the forefront of a new **repair and reuse service industry** for PV panels. Most likely, additional employment opportunities will arise for the **producers** themselves and **independent or contract and service partners** dependent on producers (e.g. installation and construction companies). However, **waste collectors and companies** and **pre-treatment companies** are also expected to expand their portfolio as investment opportunities in this sector rise.

Most importantly, the end-of-life management of PV panels in itself will trigger an important **recycling and treatment industry**. All waste management is regulated by governments so it entails different responsibilities for concerned stakeholders, depending on the legislation. Everywhere except in the EU, PV panels are part of regular waste streams. At the same time, actors mostly include **general waste utilities and regulators or waste management and pre-treatment companies**. No formal and established PV panel recycling market exists today. Yet waste treatment companies are studying the new business case for PV panel treatment given the increase in e-waste regulations and PV markets (see Chapter 5 country case studies).

With binding extended-producer-responsibility through the EU WEEE Directive, for instance, **producers** have become additional players essential to driving end-of-life management practices for PV. According to Nasr and Thurston (2006) "… (when a product manufacturer has a leading role in the entire product life cycle… (it) promotes… efficient material use and reuse." Contracting waste management partners with specialised knowledge in PV end-of-life has therefore become essential for big producers to maintain market competitiveness. A small number of producers have or are also in the process of investigating the option of developing their own recycling production facilities (e.g. First Solar).

This study has analysed how different frameworks for end-of-life PV provide the potential to grow local PV recycling industries, especially in jurisdictions with specific PV waste legislation, such as the EU. Yet the recycling industry is also one of the few true global industries today and therefore needs to be treated accordingly. For PV panel waste, many opportunities can therefore emerge in developing or transitioning economies with informal sectors dominating collection and recycling services. Producers are active in many of these countries so a mandatory PV waste system could retain additional employment, especially in the repair/reuse and recycling/treatment industries. At the same time, it would improve national waste management practices.

Box 24 Socio-economic benefits of the WEEE Directive in the EU

According to Monier and Hestin (2011), the main socio-economic benefits of the WEEE Directive arise from the inclusion of PV panels in the regulatory framework.

Firstly, they estimate that the environmental impact of end-of-life PV panels can be reduced by a factor of six in comparison to a baseline scenario which assumes no pre-treatment and recycling of PV panels. By implementing high-value recycling processes, the recovery of a certain mass percentage of the total panel is guaranteed but also minor fractions are accounted for. For e-waste, it means the costs of collection and treatment are more than offset by potential revenues of materials recovered from the PV panels and create additional value. Monier and Hestin estimate that jobs will increase alongside the quantity of end-of-life PV panels collected and properly treated in high-value recycling operations.

The evaluation concludes that the resulting net benefits of including PV panels in the WEEE Directive could amount to up to EUR 16.5 billion in 2050.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CONCLUSIONS: THE WAY FORWARD

Effective deployment policies have supported the growth of renewables globally, including PV. In early 2015, more than 145 countries had introduced regulatory support mechanisms (e.g. feed-in tariff, net-metering or auctions), fiscal incentives and public financing (e.g. capital subsidy, investment or production tax credit). Overall, the number of incentives related to renewable energy has increased nearly tenfold over the past decade, leading to a global cumulative installed capacity of 222 GW at the end of 2015 (IRENA, 2016). PV now makes up a distinct share of the energy mix in several countries. Substantial growth is anticipated in coming decades, leading to a projected installed capacity of approximately 4,500 GW in 2050.

PV panels have a long life (average life expectancy is 30 years) and in most countries have only since the middle of the 2000s been installed at a large scale. This study predicts that significant amounts of PV panel waste will be generated by 2030 as these long-lived PV systems age.

PV end-of-life recycling systems and regulatory schemes to deal with PV end-of-life management have only recently emerged. Certain countries and regions are ahead of that curve, such as the EU. Long lead times have already preceded the implementation of environmentally and economically robust technological and regulatory policies for e-waste. Given this experience, the time to start devising these systems for PV panel waste in many countries is now.

A range of potential policy options exist for PV waste management which can be adapted to the unique conditions of each country or region. Previous experience, particularly in relatively mature EU markets, has identified numerous lessons learned and best practices from which newer market entrants can draw. For example, various models for financing PV collection and recycling have evolved and been tested. However, voluntary-producer and public-private-partnership programmes have not achieved the desired results, making way for uniform regulatory regimes with clearer roles and responsibilities.

End-of-life management policies need to be part of a broad range of cross-cutting enabling instruments that support the transition to sustainable PV life cycle policies. Tailored to specific national conditions and relative PV sector maturity, the enabling framework should focus on adopting a system-level approach. It should build institutional, technological and human capacity, strengthening a domestic or regional PV recycling industry and creating a financial framework in support of end-of-life management.

CENTRAL ROLE OF AN ENABLING FRAMEWORK

Institutional development is essential to supporting sustainable end-of-life practices for PV. Sustainable management of end-of-life PV panels will be strongly influenced by the abilities of public sector institutions and the private sector to take informed and effective decisions on management and treatment opportunities. Thus far, end-of-life regulation exists only in the EU, which is pioneering rules that categorise PV panels as a type of e-waste. However, other countries are investigating institutional capacities to implement end-of-life policies (e.g. China, Japan). To improve decision-making and ensure better planning, a monitoring and reporting system covering PV waste streams needs to be included into national and regional regulations. This can in turn provide the statistical data needed to enhance waste stream predictions, better understand the causes of panel failure and further refine regulatory frameworks.

A system-level approach to PV end-of-life management can enhance the integration of different stakeholders, including PV suppliers and consumers alike, as well as the waste sector. Considerable efforts to develop technologies and policies to support PV deployment have taken root over the last few years. To meet the challenge of managing greater PV waste volumes in a sustainable way, support will also need to include end-of-life technologies and policies. Such support can ensure deeper integration across the different PV life cycle stages and other policies targeting a comprehensive life cycle approach of products (e.g. 3R concept, circular economy approach). End-of-life management can affect a variety of stakeholders, including producers and owners, such as households and larger consumers. Growing PV panel waste is transforming the ownership structures in the sector. For instance, PV panel producers wishing to sell in the EU are now liable for the end-of-life phase of a panel and financing waste management (see Chapter 4 on extended-producer-responsibility framework in the EU). A system-level approach to policy making for PV end-of-life can balance the ambitions and responsibilities of PV suppliers with those of PV consumers, new entrants (e.g. waste companies) and other stakeholders.

R&D, education and training, are all needed to support PV end-of-life management to design and implement socio-technological systems. Support for R&D in PV end-of-life activities can improve technological performance and produce greater value from the recycling output. Further technology innovations can create high-value recycling processes for rare, valuable and potentially hazardous materials which surpass legal requirements and provide additional environmental and socio-economic benefits and that do not exist today. Industrial cluster cultivation between the energy and waste sectors as well as cross-cutting R&D programmes can contribute to increased quality for recycling technologies and processes. Just as importantly, technological R&D must be coupled with prospective techno-economic and environmental analyses to maximise societal returns, minimise detrimental outcomes and avoid unintended consequences. This requires systematic access to human talent across different disciplinary fields, including engineering, science, environmental management, finance, business and commerce. In addition, vocational training programmes will be necessary. They can, for instance, retrain PV installers on potential repair and reuse opportunities for PV panels showing early failures.

With the right policies and enabling frameworks in place, the spawning of new industries that recycle and repurpose old solar PV panels will drive considerable economic value creation. This will be an essential element in the world's transition to a sustainable energy future.

Strengthening domestic capabilities and boosting the development of local PV recycling industries can help to maximise the value creation of PV end-of-life. As a result of increasing PV waste streams, new markets will emerge. They will create new trade flows while providing local opportunities for the energy and waste sectors in different segments of the decommissioning stage (e.g. repair or recycling of PV panels). The ability to localise depends on the characteristics and competitiveness of local complementary industries – mainly the waste sector. It relies on the quantity, quality and reliability of supply of projected local waste streams and projected demand for secondary panels and secondary raw material extraction. The nascent PV waste and recycling industry can be further supported through measures that create demand for local recycled goods and services (e.g. purchase tax rebates for secondary raw material recovered through PV recycling processes).

Stimulating investment and innovative financing schemes for PV end-of-life management is necessary to overcome financing barriers and ensure the support of all stakeholders. Previous experience has produced technological and operational knowledge on financing end-of-life PV panel management that can inform the organisation of increasingly large waste streams. Experience in mature markets like Germany has shown that forcing household consumers to recycle WEEE is impractical. Voluntary approaches ultimately fail owing to the financial risks of free riders misusing the system and to a lack of enforceability over the long lifetime of the products. Extended-producer-responsibility schemes have thus proved the most successful in practice, including pay-as-you-go combined with last-man-standing insurance, and joint-and-several liability approaches in which producers become responsible for PV panel collection and recycling. The costs of proper treatment and recycling can be included in the production sales price through a modest fee per kilowatt-hour produced, for example.

Outlook

As countries strengthen their policy and regulatory frameworks to transform their energy systems, they have the unique opportunity to address sustainable end-of-life management goals at the same time. Establishing PV end-of-life management policies can generate value and secure long-term socio-economic benefits such as material recovery through recycling, creating new industries and jobs.

Going forward, holistic, adaptable frameworks capturing and measuring the multiple impacts of PV end-of-life management (e.g. EU WEEE Directive) can tip the balance in favour of sustainable life cycle practices and policies worldwide.

Governments and stakeholders in the PV sector need more complete analysis of projected PV waste management streams and compositions to make decisions. The IRENA and IEA-PVPS study *End-of-life Management: Solar Photovoltaic Panels* provides a first glimpse of the opportunities offered by the sustainable management of PV end-of-life. The report intends to establish a foundation to move countries more quickly up the learning curve in policies and technologies for PV end-of-life management. It leads the way for further exploration of this field.

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PV Life Cycle Analysis

Managing PV Assets over an Uncertain Lifetime

Nadav Enbar
Principal Project Manager

Solar Power International
14 September 2016

Agenda

- Background
  - Industry needs
  - Overview of EPRI project
- Research Findings
  - PV site surveys
  - Repowering and decommissioning guidance
- Conclusions and Next Steps

EPRI ELECTRIC POWER RESEARCH INSTITUTE

Background
Industry Needs

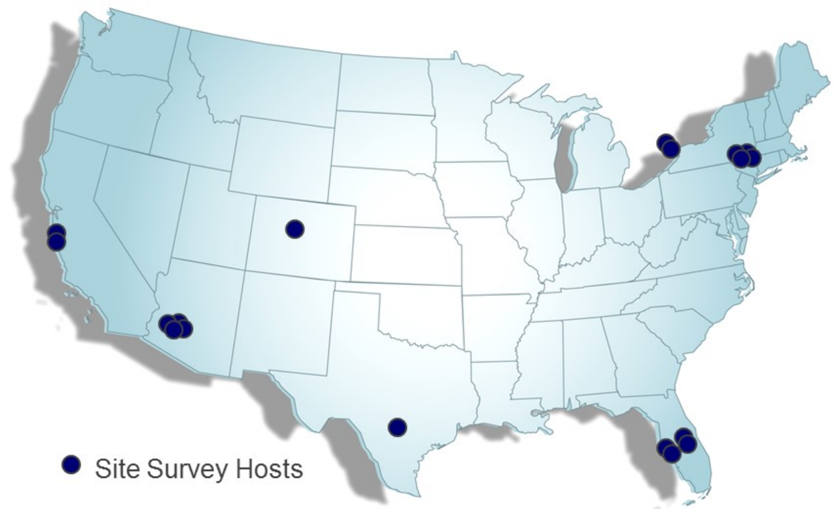
The Issue

- PV project lifetimes are not well-understood
- Factors that influence lifetimes have not been quantified
- Underperforming assets can be a burden to project owners
- Options and steps to restore power or decommission systems need to be defined

ELECTRIC POWER RESEARCH INSTITUTE

Background
Overview of EPRI Project

The project provides guidance to PV system owners around assessing plant health—performance and safety issues—and determining best options for repowering and decommissioning.



Scope

1. Develop detailed methodology for PV site condition surveys
2. Conduct surveys of 30 PV systems
3. Develop processes for a) re-powering PV systems and b) decommissioning PV systems
4. Develop generic economic model to allow plant owners to compare repowering options
5. Research options for recycling and disposing of modules and other plant components

<u>EPRI Supplemental Project Stats</u>:

- Schedule: 2013-2017
- $660k study funded by 6 utilities
- EPRI Report (3002008832) to be published late-Sept. 2016

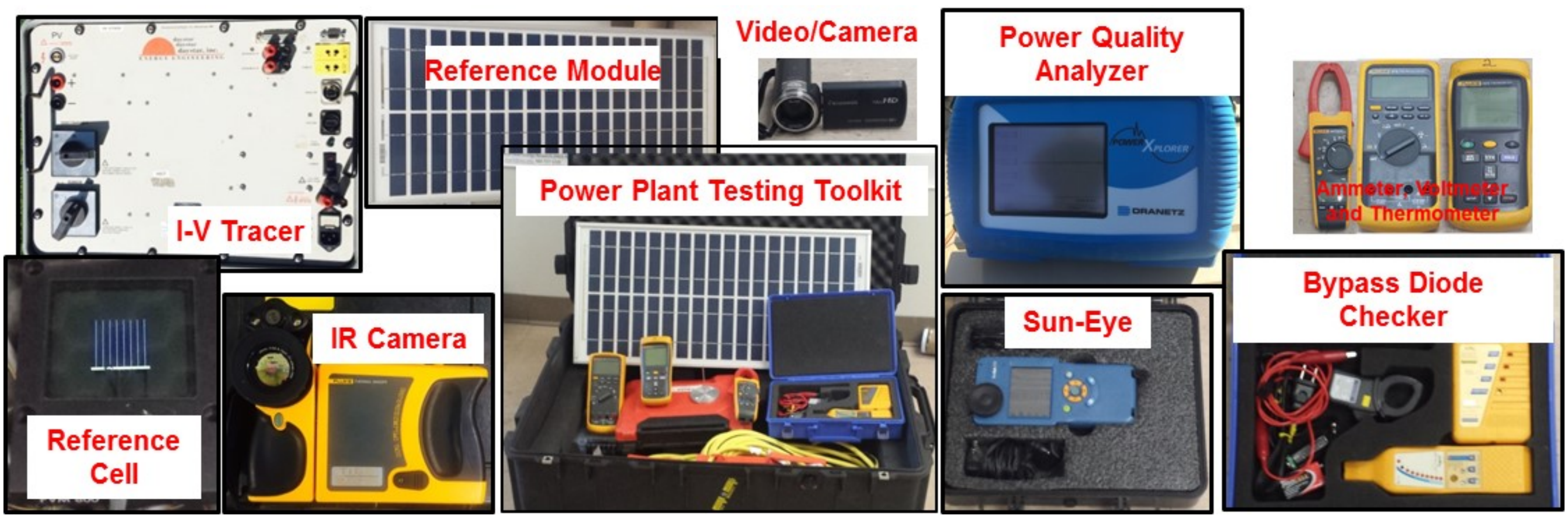
Results were packaged into a PV Life Cycle Analysis Manual, which provides guidance for owners and operators of PV systems.

Research Findings
PV Site Surveys

Background

Site Survey Methodology

- Visual Inspection
- Measurements
  - I-V curves
  - Bypass diode check
  - Infrared scanning
  - Power quality analysis
  - Shading analysis



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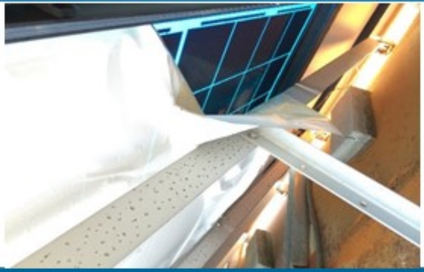
Research Findings
Examples of Safety Failures

Broken Module

Backsheet Delamination



Damaged Rack

Missing Lid

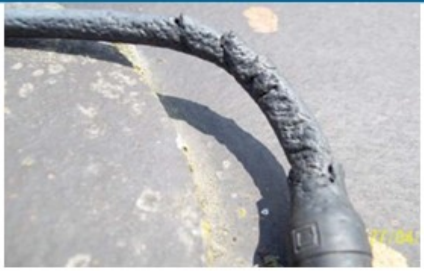
Backsheet Burns

Backsheet Cuts

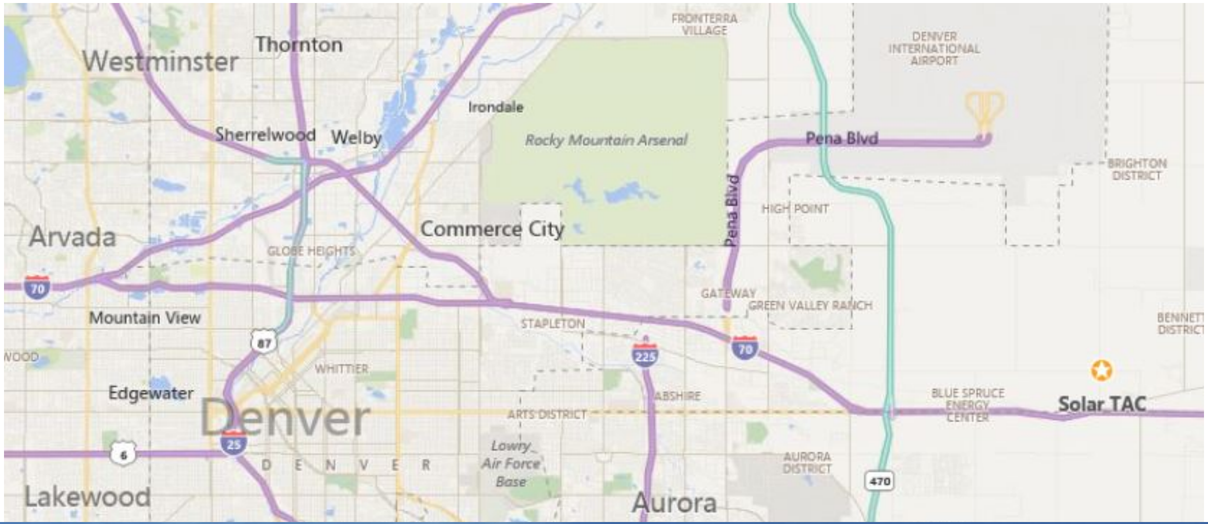
Edge Delamination

Burnt Wire

Animal Bites



Research Findings
Example Site Survey Results: SolarTAC



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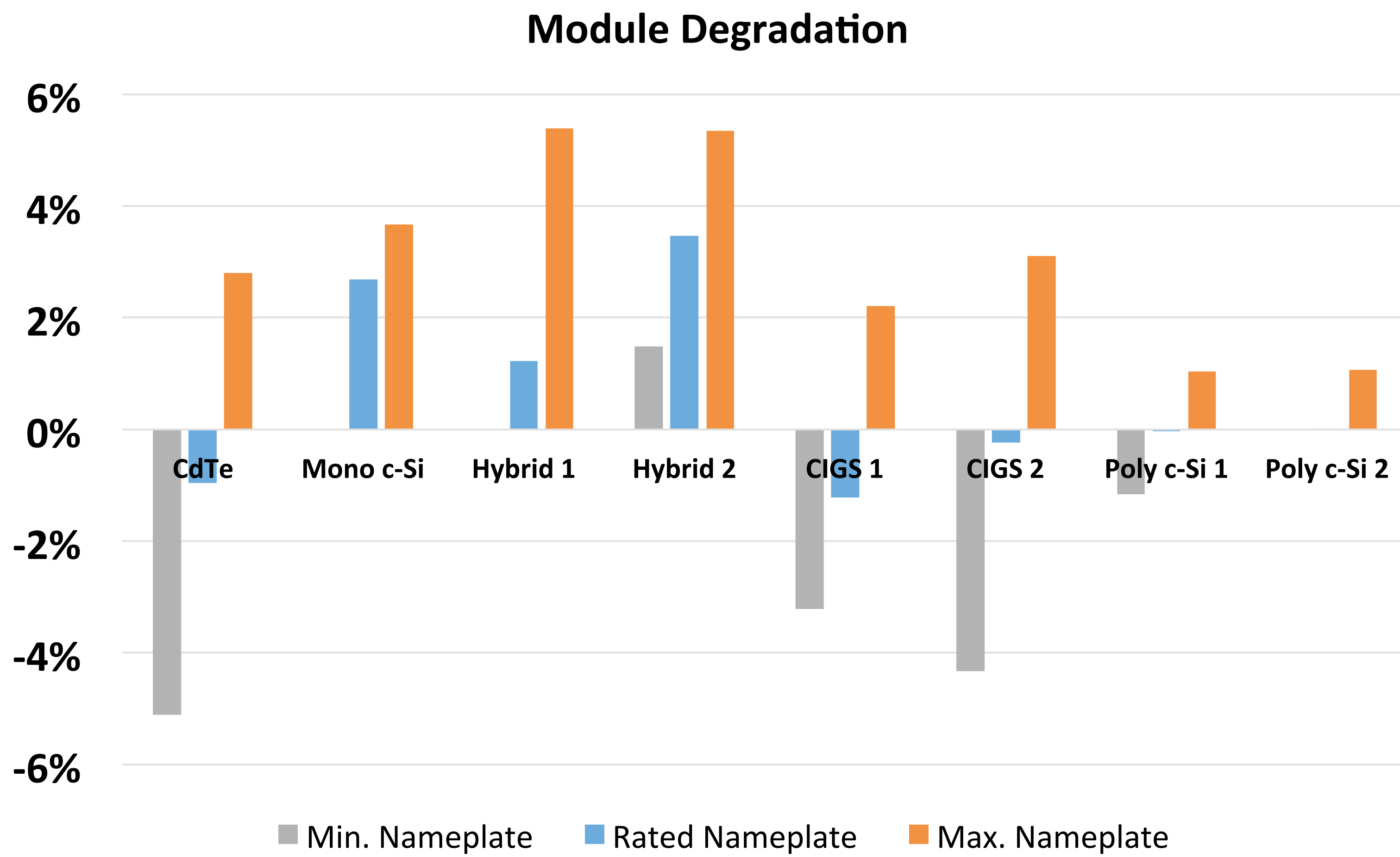
Research Findings

Example Site Survey Results: SolarTAC



Negative degradation rates, or performance gains, may be due to manufacturer underrating of modules, whereas positive values may indicate underrating.

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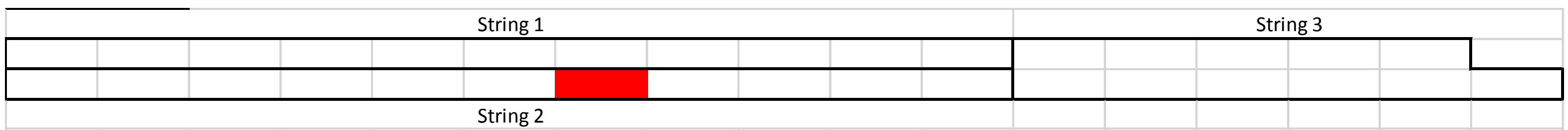
Research Findings
Example Site Survey Results: SolarTAC Poly c-Si 1 System



System
- Size: 9.4 kWdc
- Modules: 33 (3 strings)
- Tilt: Latitude (20°)
- Installation: November 2010
- Status: Operational

Inverter
- Size: 10 kWac
- Quantity: 1
- Status: Operational

Example Results

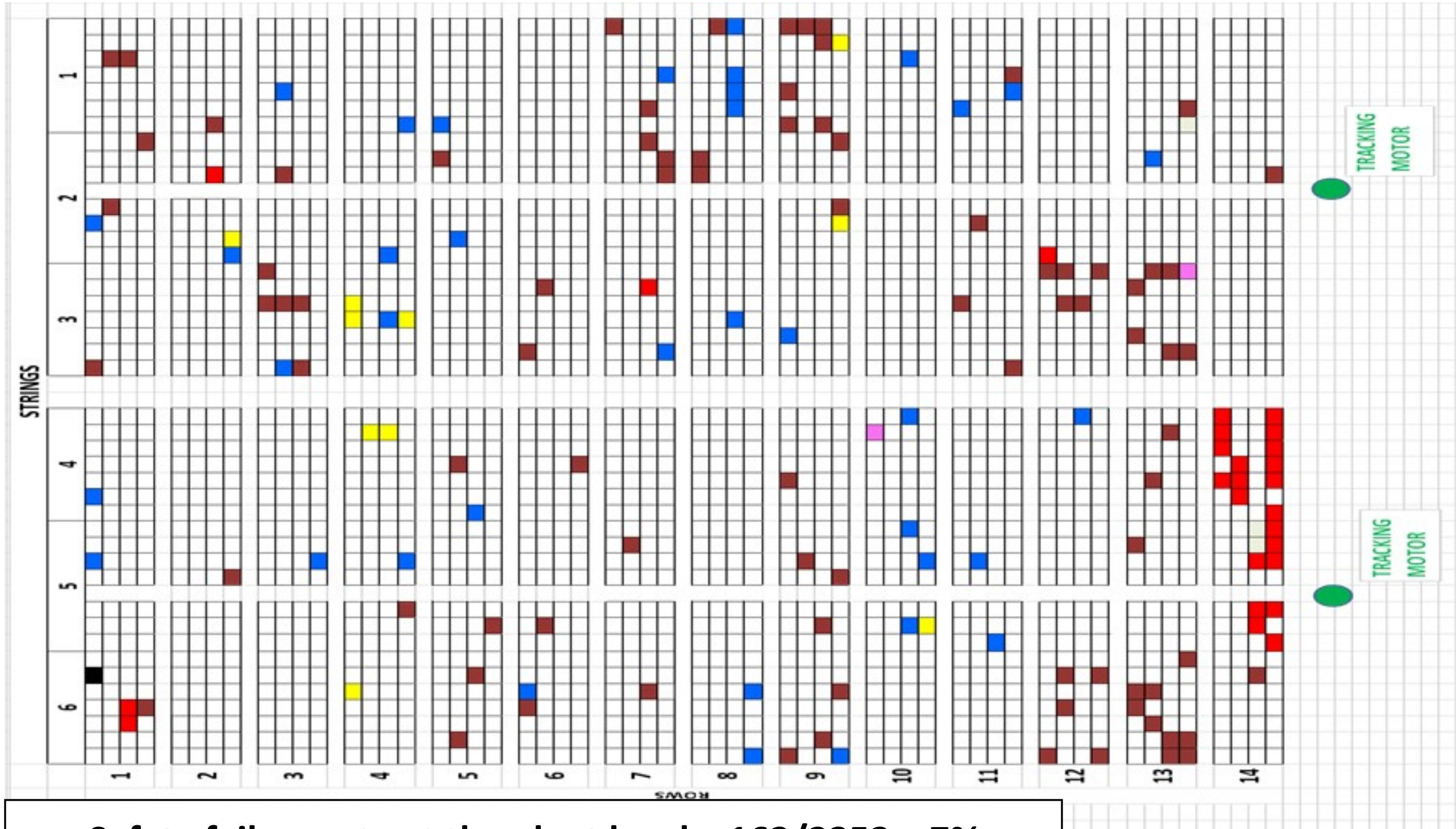
One safety failure: failed diode

Average String Degradation: **0.31%/yr**

Average Module Degradation: **0.03%/yr**

Research Findings

Example Safety Failure Mapping for a Older, Larger Site

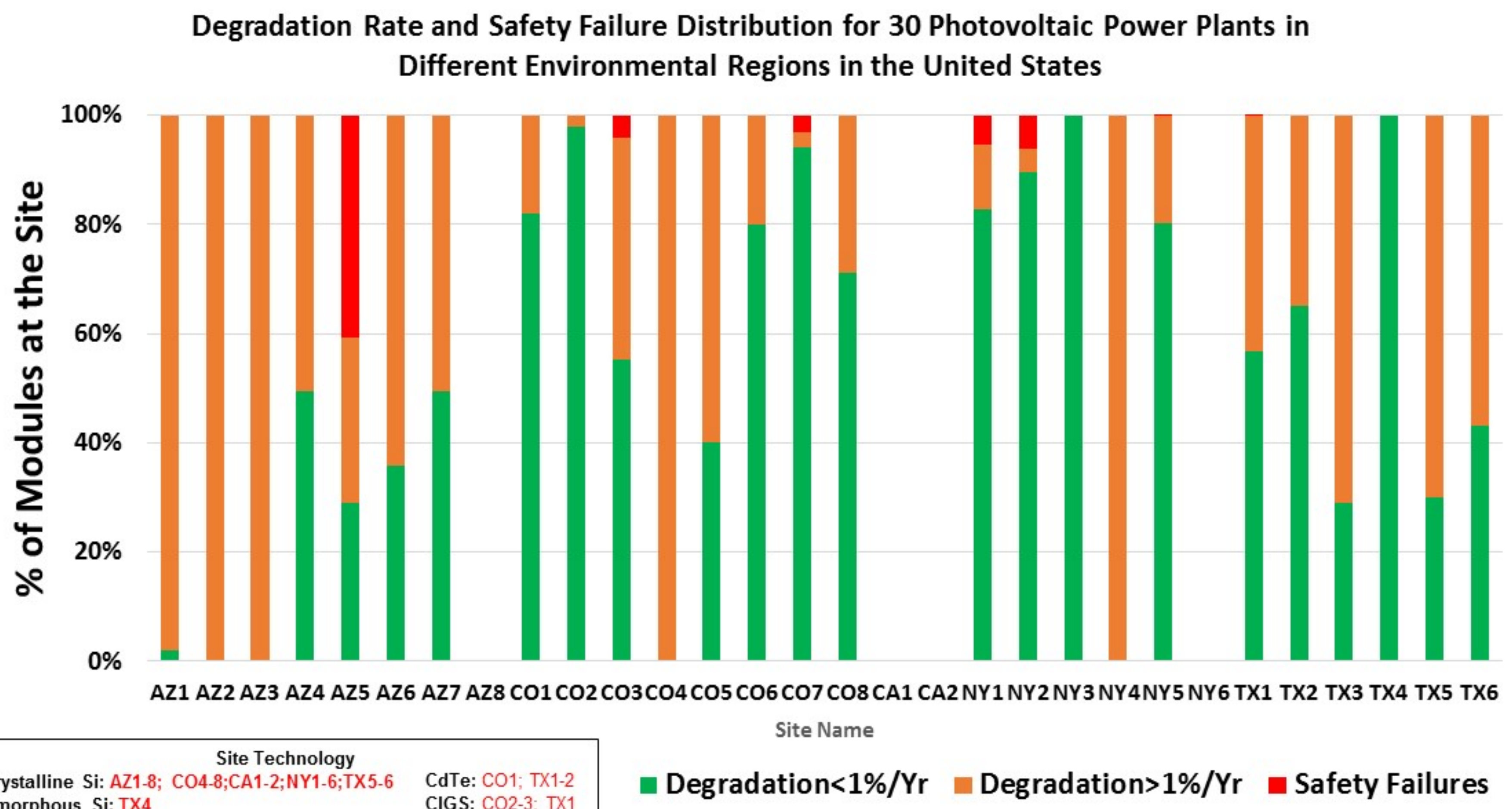


Safety failure rate at the plant level = 162/2352 = 7%

(blue)	**Hotspot issues leading to backsheet burn (37/2352)**
(brown)	**Ribbon-ribbon solder bond failure with backsheet burn (86/2352)**
(red)	**Failed diode wih no backsheetburn (26/2352)**
(black)	**Hotspot issues with backsheet burn + Ribbon-ribbon solder bond with backsheet burn (1/2352)**
(yellow)	**Backsheet Delamination (10/2352)**
(pink)	**Backsheet Delamination + Ribbon-ribbon solder bond failure (2/2352)**

Research Findings

Summary of Module Distribution (all sites)



Site Technology

Crystalline Si: AZ1-8; CO4-8;CA1-2;NY1-6;TX5-6 CdTe: CO1; TX1-2

Amorphous Si: TX4 CIGS: CO2-3; TX1

Degradation generally seems higher in the hotter climates (AZ and TX)
Cool climates (NY) tend to have lower degradation, and CO systems fall in between.

Research Findings
Repowering and Decommissioning

Repowering and Decommissioning Guidance
Process for Determining Best Path

Steps for PV System Owners and Utilities

1. Conduct site survey
2. Identify issues to be fixed
   - Safety
   - Performance
   - May include non-PV assets like roof repairs, infrastructure upgrades
3. Develop scope of work (perhaps for multiple options)
   - May include re-design
   - Can be reduced to time & materials (or sub-contracts)
   - Meet latest code for safety and performance
     - Authority Having Jurisdiction (AHJ) dependent
     - Grandfathering may apply
     - PV specific code changes: 2014 NEC for PV
4. Perform cost-benefit analysis

Repowering Guidance
2014 NEC Code With Legacy PV Plants

- The 2011 and 2014 NEC code cycles made significant changes to Article 690
  - Improved safety
  - Improved performance
- Allow ungrounded DC systems
- Require use of PV Wire <u>not</u> USE-2 for ungrounded systems
- Improved ground fault detection
- Require arc fault detection
- Rapid disconnects required for rooftop systems

The above changes significantly affect repowering <u>legacy</u> PV plants

Repowering Guidance
Implications of Inverter Replacement for Legacy PV Plant

- For some legacy systems, to replace the inverter means:
  - Switch to a transformerless inverter due to limited availability of isolated inverters and lack of manufacturer support/ warranties
    - Unground the PV system, as required by the transformerless inverter
      - Replace all modules with products that have PV wire
      - Replace home runs and combined wires (no white wire)
    - Restring to 1000 V to match inverter specifications
      - Replace combiner boxes to support positive and negative fusing
      - Replace disconnects to support positive and negative disconnecting means
    - Relabel entire system

Replacing the inverter may cost almost as much as a new installation.

PV Plant Decommissioning

- Reasons for decommissioning include:
  - End of project life
  - Economic viability
  - Safety
- Decommissioning plans include steps to restore sites to their intended use:
  - Land and water use restoration
  - Salvage, recycling, and disposal of plant equipment
  - "Safe" disposal of all materials (although plans often don't specify what to do or how to do it)

Decommissioning PV Plants
Balance of System

- Equipment removal, disposal, and recycling
  - Inverters and other electronic components – e-waste recycling
  - Module mounting structures – steel recycle, resale
  - Concrete – recycle
  - Electrical equipment – reuse or recycle
  - Wiring – copper recycling
- Equipment abandon in place
  - Underground conduit
  - Certain structures
- Equipment reuse
  - Infrastructure improvements – roads, fences, etc.
  - Substations, communication towers
  - Maintenance buildings

Decommissioning PV Plants
Modules

Recycling

- No federal, state, or local regulations require PV module recycling in the U.S.
- No 3rd party or public module recycling programs in the U.S., with the exception of limited manufacturer take-back programs
- Recycling technologies exist to extract/reuse ~80% of module material

Disposal

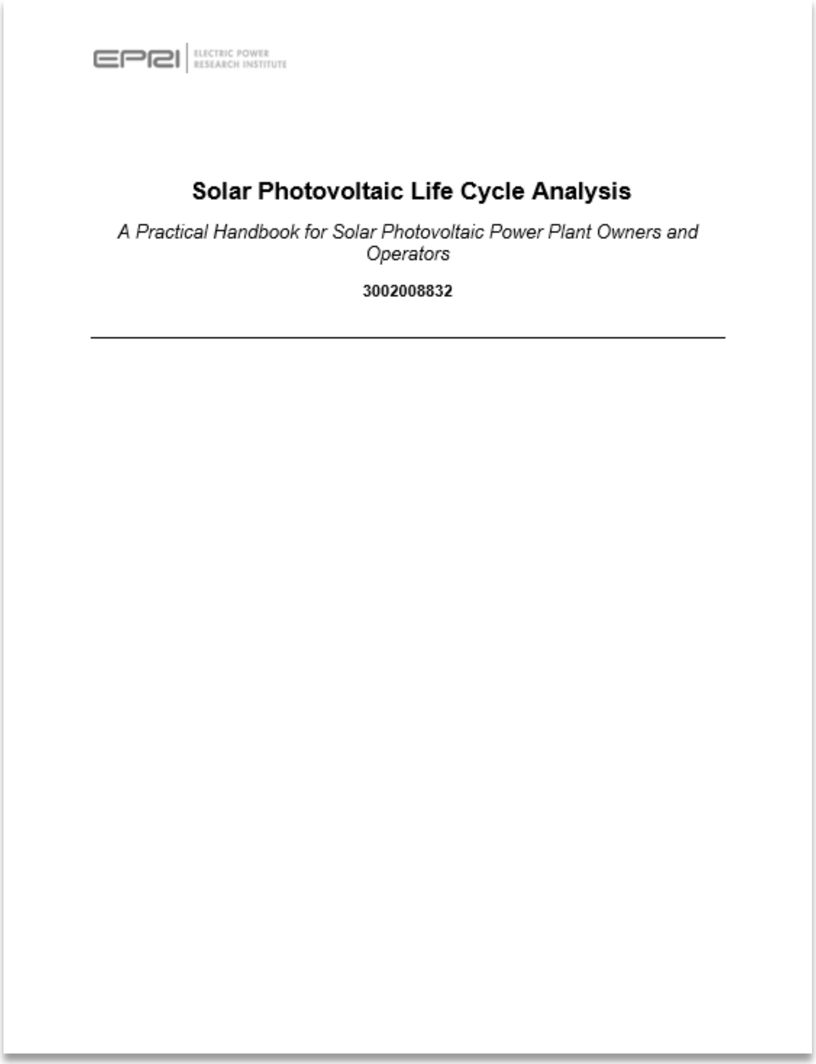
- PV modules are not classified as hazardous waste, but they contain hazardous materials
- Disposal options in U.S.
  - Modules that fail the Toxicity Characteristic Leaching Procedure (TCLP) must be disposed of in hazardous waste landfills
  - Long-term storage in storage containers may be best option until recycling becomes available

Module waste volumes are 0.1-0.6% of total e-waste today, but by 2050 panel waste may surge to over 10% of 2014 global e-waste levels*

*Source: IEA-PVPS Report: T12-06:2016 (June 2016)

Conclusions

- Interest in PV plant repowering and decommissioning is growing as PV plants age and experience performance and safety issues
- Module disposal is potentially a major issue
  - Some modules contain hazardous waste, but limited data available to verify which modules fail the Toxicity Characteristic Leaching Procedure (TCLP)
  - Some deployment estimates show that PV waste could equal 10% of today's e-waste by 2050
  - Disposal in regular landfills not recommended in case modules break and toxic materials leach into the soil
- Regulatory environment
  - Europe regulates panel recycling, and Japan and Korea are establishing recycling programs
  - Currently no regulatory framework in U.S. and no public PV recycling facilities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Solar Photovoltaic Life Cycle Analysis

A Practical Handbook for Solar Photovoltaic Power Plant Owners and Operators

3002008832

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Next Steps

Planned Work

- Deeper dive study on PV recycling feasibility in the U.S.
  - Regulatory environment
  - Feasibility of developing a comprehensive collection system
  - State of the art in PV recycling technology
  - Limited TCLP testing to determine module toxicity in landfill environment

Proposed Projects

- Comprehensive test and evaluation program to assess various factors that may influence TCLP outcomes
- Technical and cost considerations for the decommissioning and disposal of PV plants

More data is needed to clarify the extent to which module toxicity is a pervasive issue.

Together…Shaping the Future of Electricity

Questions for potential discussion

- Who budgets for PV **end-of-life costs**?
  - Method and considerations in your cost calculation?
  - Is PV salvage value positive or negative? Anecdotal data?
- Has anyone **repowered or decommissioned** a plant?
  - Challenges and/or key questions during the process?
  - Chosen method of module and/or balance of plant disposal?
  - Compatibility of new vs. old equipment?
- **Hazardous waste** associated with PV plant disposal?
  - Aware of Toxicity Characteristic Leaching Procedure?
  - Usefulness to include on module or BOS spec sheet?
- Do you think the U.S. needs to regulate PV **recycling**?
  - What are the biggest challenges, e.g., economics / value of materials, collection?
  - Percentage of project developers opting to include recycling in the upfront purchase contract?

ELLEN MACARTHUR FOUNDATION

NEW PLASTICS ECONOMY

THE NEW PLASTICS ECONOMY
CATALYSING ACTION

THE NEW PLASTICS ECONOMY
CATALYSING ACTION

Preface

In January 2016, the World Economic Forum, the Ellen MacArthur Foundation and McKinsey & Company published the report *The New Plastics Economy – Rethinking the future of plastics*. It was produced as part of MainStream – a multi-industry, global initiative which aims to accelerate business-driven innovations and help scale the circular economy. For the first time, the report provided transparency on global plastics material flows and associated economics. It found that, while plastics and plastic packaging are a key part of the global economy, the current plastics economy has significant drawbacks that are becoming more apparent by the day. In addition, it presented a blueprint for a more effective plastics system based on circular economy principles – in effect, a New Plastics Economy.

In May 2016, the Ellen MacArthur Foundation launched the New Plastics Economy initiative – a bold, three-year project to mobilise the report's recommendations, together with its Lead Philanthropic Partner – the Eric and Wendy Schmidt Fund for Strategic Innovation; its Philanthropic Funders – MAVA Foundation, Oak Foundation, and players of People's Postcode Lottery (GB); its Core Partners – Amcor, The Coca-Cola Company, Danone, MARS, Novamont, Unilever and Veolia; and a broad group of participant companies, cities and governments across the value chain.

This new report is one of the first key deliverables of the New Plastics Economy initiative. It represents a logical next step to the 2016 report: from *rethinking the future of plastics* to *catalysing action*. To trigger action, the report aims to make three original contributions to the transition towards the New Plastics Economy:

- Three distinct transition strategies for three plastic packaging categories covering the entire market (Redesign and innovate; Reuse; Recycle) based on a granular, segment-by-segment analysis and a quantification of the economic value creation potential for core aspects of the Reuse and Recycling categories
- A set of priority actions for each category, mobilising the strategies and setting a common direction for players across the global plastics packaging value chain
- A targeted plan for the New Plastics Economy initiative to carry out in 2017 to catalyse progress on the priority actions.

Foreword

The World Economic Forum, the Ellen MacArthur Foundation and McKinsey & Company joined forces in 2014 to create Project Mainstream, a cross-industry, CEO-led global initiative to help scale the circular economy by unravelling systemic stalemates. Taking a global, cross-sectoral look at material flows, the project quickly identified plastics as one of the value chains most representative of the current linear model, bringing undisputed functionality to a variety of applications, but also entailing significant economic losses and severe negative externalities.

The resulting report, *The New Plastics Economy: Rethinking the future of plastics*, launched at the World Economic Forum Annual Meeting 2016 in Davos-Klosters, analysed these global flows for the first time and set out a vision for a new and effective plastics packaging system, guided by circular economy principles, and fit for the long term. This compelling vision provided the impetus for the Ellen MacArthur Foundation to set up an ambitious three-year initiative, the New Plastics Economy, to act on the report's insights and turn the vision into reality.

The initiative has made a strong start. Leading players from the plastic packaging supply chain have committed to it, alongside major capital cities, philanthropists, policy-makers and academics. The momentum gathered is indicative of its exceptionally collaborative approach that builds bridges along value chains, across silos, and between the private and public sectors to initiate a genuine system shift. The interest it has generated echoes a growing consensus on the need to phase out the negative impacts associated with today's patterns of use by notably redesigning certain materials and rethinking business models.

This new report shows that we are now firmly at the action stage. The initiative has solidified its five building blocks – dialogue, harmonisation, innovation, analysis and outreach – and each has catalytic actions planned for 2017. All these elements will be needed on the road ahead and the insights presented in this paper make the next steps on that journey clear.

We look forward to following the progress of this singular and powerful initiative over the coming years as it stimulates the innovation, redesign and new thinking needed to pave the way towards creating a plastics system that works.

Dame Ellen MacArthur
Founder and Chair of Trustees

ELLEN MACARTHUR FOUNDATION

Richard Samans
Head of the Centre for the Global Agenda and Member of the Managing Board

WORLD ECONOMIC FORUM

Dominic Waughray
Head of Public-Private Partnership and Member of the Executive Committee

WORLD ECONOMIC FORUM

Prof. Dr. Martin R. Stuchtey
Founder and Managing Partner

SYSTEMIQ

In Support of the New Plastics Economy

We urgently need to transform global plastic packaging material flows if we are to continue to reap the benefits of this versatile material. This report marks a major milestone, calling out specific actions to capture opportunities for redesign and innovation, reuse, and recycling. It's now up to us all to get it done.

PAUL POLMAN, CEO, UNILEVER

Resources management should not be summarised as a matter of cost optimisation but as a powerful driver of shared value creation. This belief runs through our entire business at Danone, fundamental to our relationships with suppliers, partners and our customers. Danone has embedded the principles of the circular economy in its value chain, managing now plastic as a cycle rather than as conventional linear supply chain. We are hugely supportive of the New Plastics Economy report as it lays out actions to turn the challenges posed by plastics today into an opportunity that will deliver value tomorrow. I am excited that Danone is taking a leading role in this initiative to help drive systemic change.

EMMANUEL FABER, CEO, DANONE

It will take a concerted effort involving various stakeholders to make the systemic changes needed to transition to a circular economy. This is especially true for plastics. Veolia believes that the New Plastics Economy initiative provides an excellent collaborative platform to catalyse the transition. The initiative's latest report, "The New Plastics Economy: Catalysing action", builds on the findings of the previous report and provides a clear roadmap of priority actions for 2017 to drive progress towards a global plastics system that works: a system that will capture material value and contribute to improved economic and environmental outcomes. Veolia looks forward to its continued participation in these efforts.

ANTOINE FRÉROT, CEO, VEOLIA

Shifting towards a circular economy based systems whereby the biological and technical cycles are linked and driven by innovative products delivered through new supply chains and systems will not be easy, but will result in significant benefits for the economy and environment. To make this transition successful, it is crucial to know where we want to go and what we want to achieve, which is exactly what the first New Plastics Economy report lays out. At Novamont we welcome this second report which now helps develop further our collective learning and is a call to action for the creation of tangible new links between upstream and downstream value chains.

CATIA BASTIOLI, CEO, NOVAMONT

Through innovation and collaboration, The Dow Chemical Company is committed to advancing a circular economy to deliver economic, societal, and environmental value. This important report by the Ellen MacArthur Foundation offers a key step in delivering science-based solutions by providing options that help us close resource loops for plastics and facilitate the transition towards a New Plastics Economy.

ANDREW LIVERIS, CHAIRMAN AND CEO, THE DOW CHEMICAL COMPANY

SUEZ is delighted to have contributed to this next milestone and to continue its collaboration within the New Plastics Economy initiative. This report underwrites SUEZ' view of transitioning towards a plastic packaging system in line with circular economy principles, through a concerted, cross-value chain approach. The initiative's Pioneer Projects, with tangible actions and concrete goals, are a great example of how SUEZ aims to overcome plastics challenges.

JEAN-LOUIS CHAUSSADE, CEO, SUEZ

Healthy oceans can support healthy people and healthy profits; if we let them. That means governments, business and individual citizens backing an inclusive, circular economy. It means using legislation, innovation and consumer choices to replace plastic related demand and pollution with better alternatives that create jobs and still look after our planet. And it means supporting this initiative by ensuring that each us knows how we can help rethink, reuse and recycle plastic. This report is a great place to start.

ERIK SOLHEIM, EXECUTIVE DIRECTOR, UN ENVIRONMENT

The New Plastics Economy initiative is undertaking groundbreaking efforts to prove that positive economic and environmental progress can coexist in supply chains that have become increasingly global. The initiative's work complements Mayor de Blasio's OneNYC Plan and New York City's goals of achieving an 80% reduction in greenhouse gas emissions by 2050, and zero waste to landfills by 2030. At NYCEDC, we look forward to opportunities to apply this report's findings to promote innovative and sustainable approaches to design, infrastructure, and new business models.

MARIA TORRES-SPRINGER, PRESIDENT AND CEO, NEW YORK CITY ECONOMIC DEVELOPMENT CORPORATION

Carrefour fully supports the New Plastics Economy initiative. Our group pledges to continue its worldwide efforts working with industry partners and other stakeholders to move toward a circular model for plastics. Together we will create innovative and tangible actions to achieve this goal.

GEORGES PLASSAT, CHAIRMAN AND CEO, CARREFOUR

The New Plastics Economy represents a huge opportunity for design, as evidenced in this report. From more circular products and services to new business models and industry systems, design is needed in the absence of established roadmaps or models that we can simply re-tune or optimise. To deliver the step change in industry practices that is required, we need to recognise that transitioning to the circular economy is one of the biggest creative challenges of our time. The New Plastics Economy initiative plays an important role, inspiring and supporting designers to capture the opportunity.

TIM BROWN, CEO, IDEO

The New Plastics Economy report calls attention to the vast amount of plastic packaging material that is lost to the economy after only a single use. Amcor understands the challenge, but we also see a tremendous opportunity to continually develop packaging that is better for the environment throughout its life: production, use and re-use.

RON DELIA, CEO, AMCOR

Packaging has an outsized impact on our planet. As a global consumer goods company, we need to find ways to drastically improve the environmental, as well as economic, impact of plastic packaging, while keeping protecting and presenting our products effectively. Mars joined the New Plastics Economy initiative as a core partner in order to proactively drive this effort in our industry. We applaud this report and fully support the initiative's ongoing efforts to promote a circular economy approach for plastics.

BARRY PARKIN, CHIEF SUSTAINABILITY AND HEALTH & WELLBEING OFFICER, MARS, INCORPORATED

At Coca-Cola we've been a long-time proponent of circular thinking, particularly when it comes to packaging. We introduced refillable bottles 120 years ago. As market and consumer preferences shifted so did we, offering recyclable PET bottles and then a fully recyclable PET bottle made partially from plants. It's time for another change—a plastics system fully aligned with the circular economy. The market and environment demand it and Coca-Cola is proud to support the New Plastics Economy Initiative. We applaud the Ellen MacArthur Foundation as they lead this innovative and responsible endeavor.

BEA PEREZ, CHIEF SUSTAINABILITY OFFICER, THE COCA-COLA COMPANY

Borealis, as a leading provider of innovative solutions in the field of polyolefins, is committed to realising the opportunities presented by the New Plastics Economy. The initiative has already convened all stakeholders to work effectively together. With this new report, the initiative now offers a roadmap to create effective markets based on circular economy principles – an action plan where Borealis wants to take an active and leading role.

MARK GARRETT, CEO, BOREALIS

As one of the world's leading retailers Schwarz Gruppe relies on packaging materials. If we want to safeguard future resources, eliminate waste and save energy, it is of central importance that we circulate resources -including our packaging- effectively. Ellen MacArthur Foundation's New Plastics Economy initiative is an excellent platform to meet this challenge together with other leading companies.

GERD CHRZANOWSKI, CEO, SCHWARZ CENTRAL SERVICES (LIDL & KAUFLAND)

At TriCiclos, we understand the urgency on rethinking the plastic industry worldwide; and strongly support the idea on setting the principles of the New Plastics Economy through cooperation between all the actors of the value chain. We are very proud to be involved with the New Plastics Economy initiative, contributing with our experience on improving plastic packaging design and harmonising collection and sorting systems towards circular economy models for packages. This report is totally aligned with our mission, as it offers a clear way forward to solve a highly relevant problem. We are eager to carry on the journey!

GONZALO MUÑOZ, CO-FOUNDER AND CEO, TRICICLOS

Enhancing packaging is a key driver for L'Oréal in achieving our commitments on improved environmental and social profile of our products while providing equal or greater benefits to the customer. This new report of the New Plastics Economy initiative shows a tangible way forward to innovate our plastic packaging - we believe this is the right direction to go, and are ready to drive this transition to a circular plastics system!

ALEXANDRA PALT, CHIEF SUSTAINABILITY OFFICER, L'ORÉAL

The world is at a turning point. For millennia, production and consumption cycles were circular, consistent with the "waste = input" flows inherent in nature. The invention of plastics fostered disposable goods and packaging that were cheaper to replace with virgin rather than recycled materials. The age of waste, symptom of the linear economy, unfolded globally. Today, the companies and NGOs participating in the New Plastics Economy initiative are pioneering steps, presented in this report, to move towards a circular economy for plastics. This critical global initiative is urgent, timely and achievable.

TOM SZAKY, CEO, TERRACYCLE

The City of Phoenix handles more than 54,000 tons of plastics every year, and has been actively working with local partners to boost plastics recycling over the past few years. The report 'New Plastics Economy: Catalysing action' is helping cities like Phoenix build a framework for systemic change to transition plastics from the linear take-make-dispose model to a true circular economy.

GREG STANTON, MAYOR, CITY OF PHOENIX

A new circular plastic paradigm will create great value for business and society. Many actions can be taken individually, but we need collaborative effort to make a meaningful shift. This report on catalysing action by the New Plastics Economy initiative provides an excellent view of the opportunities across the plastics value chain while explaining the interplay between design innovation and after-use systems. The action steps put forward are practical ideas that will help bring a new plastics economy from vision to reality.

ANDREW AULISI, SENIOR DIRECTOR, GLOBAL ENVIRONMENTAL POLICY, PEPSICO

It is incumbent on companies of every size around the world to take an honest look at how they are using resources, and focus their ingenuity on reducing waste. Sealed Air is committed to deliver even more value for its customers and the wider society, by taking the next steps to make dramatic improvements that prevent waste and reuse resources, as laid out in this new report.

JEROME PERIBERE, CEO, SEALED AIR CORPORATION

In 2016, the Ellen MacArthur Foundation provided for the first time what had long been lacking – a comprehensive, truly global perspective on plastics innovation needs at a societal level, and on the business opportunity for industry. Now, the 2017 report nicely advances the thinking, with specific, actionable priorities that strike the right balance between 'evolutionary' and 'revolutionary' – respecting current materials in the market, while simultaneously creating space for significant new materials innovation.

MARC VERBRUGGEN, CEO, NATUREWORKS

As one of the world's leading manufacturers of flexible packaging and labels, Constantia Flexibles understands the importance of modern plastic packaging design. We are delighted to see how the New Plastics Economy initiative is bringing together other major players in the plastic packaging value chain to improve design and thus create both economic and environmental benefits for all stakeholders.

ALEXANDER BAUMGARTNER, CEO, CONSTANTIA FLEXIBLES

Think Beyond Plastic believes in harnessing the forces of innovation and entrepreneurship to advance the New Plastics Economy. Essential for the success of this endeavour is building the entire innovation eco-system and mobilising the cumulative power of the participants of the New Plastics Economy initiative.

DANIELLA RUSSO, CEO, THINK BEYOND PLASTIC INNOVATION ACCELERATOR

As a global leading provider of technology for handling post-use plastics, TOMRA aims to be a frontrunner in the transition towards a New Plastics Economy. We engage in this initiative because we believe it provides a common vision for the industry combined with a unique platform for pre-competitive collaboration and action. With this report these two elements are now complemented by tangible guidance for the way forward.

STEFAN RANSTRAND, PRESIDENT & CEO, TOMRA SYSTEMS ASA

MMBC supports the New Plastics Economy initiative as a platform for the creation of a global circular plastics system. While MMBC has been able to achieve significant progress in recycling plastics at a local level, we need this type of initiative to be able to address the growing issue of plastics at a global scale.

ALLEN LANGDON, MANAGING DIRECTOR, MULTI-MATERIALS BRITISH COLUMBIA (MMBC)

P&G believes transformational change can be achieved by combining the perspectives of all stakeholders, including industry, governments and consumers. We are actively engaged in several multi-stakeholder collaborations that seek to improve recycling uptake, quality and economics. The New Plastics Economy initiative's collaborative way of working is aligned with ours and represents a powerful opportunity to drive positive change in the plastics system.

VIRGINIE HELIAS, VICE PRESIDENT GLOBAL SUSTAINABILITY, PROCTER & GAMBLE

Through first-hand experience, KKPKP knows how recyclable plastics create income for waste pickers in India. The New Plastics Economy initiative attempts to ambitiously take a detailed and long term view on the trade with a multi-pronged approach of value enhancement - critical for informal recyclers - and format and delivery model redesign for plastics packaging. This new report has tremendous potential to influence policy at the global and local levels and we look forward to how it will impact the recycling economy.

MALATI GADGIL, TREASURER, KAGAD KACH PATRA KASHTAKARI PANCHAYAT (KKPKP)

The New Plastics Economy initiative represents a truly momentous and unique opportunity to completely rewrite the rules of global resource management, in line with the circular economy principles. Whilst the ambition is breathtaking this report sets outs some key steps to transition to the New Plastics Economy. The London Waste and Recycling Board is proud to be part of this initiative.

WAYNE HUBBARD, COO, LONDON WASTE AND RECYCLING BOARD

As a family owned company, Werner&Mertz is fully committed to capturing the value of plastic packaging after use, and so creating economic and environmental benefits. By using post-consumer recycled plastics for our branded goods packaging, we show how recycling allows to close the loops while meeting the highest quality standards. We whole heartedly support the New Plastics Economy initiative and are happy to be part of this tremendous important programme.

REINHARD SCHNEIDER, CEO AND SOLE OWNER, WERNER & MERTZ GROUP

We are proud to explore together with the New Plastics Economy initiative how plastic packaging design can enable circular material flows in addition to the delivery of safe, high-quality products to our customers. This report shows the crucial role of such design in moving towards a plastics system that works economically, socially and environmentally. Crucially it offers a practical transition strategy for the different packaging applications enabling us to turn theory into reality rapidly and with scale.

MIKE BARRY, DIRECTOR, PLAN A, MARKS & SPENCER

As an innovative recycling company, APK Aluminium und Kunststoffe AG continuously strives to improve the quality and economics of plastic packaging recycling. Connecting different players in the supply chain, from designers to recyclers, will be crucial to create an effective plastics system, as laid out in this report. The New Plastics Economy initiative's collaborative approach is exactly what is needed to turn this endeavour into a success.

KLAUS WOHNIG, CEO, APK ALUMINIUM UND KUNSTSTOFFE AG

As shown in this report, innovation is essential for a successful transition to the New Plastics Economy. As an innovator, Loop Industries is proud to support this shift with our high-quality depolymerisation technology.

DANIEL SOLOMITA, FOUNDER AND CEO, LOOP INDUSTRIES

As one of the leaders in the field of polyethylene recycling, RPC bpi recycled products understands the many benefits of closing material loops. This new report shows how we can further strengthen recycling economics, by moving towards the New Plastics Economy - a promising journey we are pleased to be part of!

GERRY MCGARRY, MANAGING DIRECTOR, RPC BPI RECYCLED PRODUCTS

WRAP welcomes this new report on the New Plastics Economy as it provides a global vision that builds on the extensive work WRAP has focussed on in the UK over the last few years, including packaging design, collection harmonisation and plastic packaging recycling infrastructure.

MARCUS GOVER, CEO, WRAP

At Surfdome many of our staff, customers, suppliers and I are regularly faced with the results of a dated linear economy, with plastic pollution consistently visible in our oceans. We've been working hard to reduce our impact on the world, protect our waves, and the waters they belong to, but it's dramatically clear how the plastic pollution crisis is escalating. This report from the New Plastic Economy initiative is vital for guiding all on the best path to improve the negative impact and unavoidable outcome that will arise if action isn't taken.

JUSTIN STONE, FOUNDER & MANAGING DIRECTOR, SURFDOME

Recycling Technologies believes that fundamental innovation is needed to move some of the most challenging plastic packaging segments forward, as explained in this report. As a recycling technology innovator, we are eager to drive industry collaboration within the New Plastics Economy initiative towards a system in which plastics never become waste.

ADRIAN GRIFFITHS, CEO, RECYCLING TECHNOLOGIES

Transforming the current plastics system is a key priority for OVAM and Circular Flanders, our public private partnership to boost the circular economy in Flanders. This report is a major step towards the New Plastics Economy vision described in the previous report, and clearly outlines the key actions for the plastic packaging value chain to focus on. As a participant of the initiative, we are excited to start working on this plan!

HENNY DE BAETS, CEO, PUBLIC WASTE AGENCY OF FLANDERS (OVAM)

Bringing many benefits, plastics have become an indispensable part of our daily life. Currently this versatile material also entails serious economic and environmental disadvantages, to which a solution needs to be actively and consequently pursued. Thanks to the Ellen MacArthur Foundation's New Plastics Economy initiative, renowned companies from the plastics industry, non-profit organisations and municipalities are working together to achieve such a solution.

AXEL KÜHNER, CHAIRMAN OF THE BOARD, GREINER GROUP

New York City, under the leadership of Mayor Bill de Blasio, has set ambitious goals to reduce our greenhouse gas emissions 80 percent by 2050 and to send zero waste to landfills by 2030 ensuring that we create a more sustainable, resilient, and equitable NYC. Achieving these goals from our OneNYC plan requires a shift towards a more circular economy, with improved recycling rates and economics. The first New Plastics Economy report has introduced a revolutionary vision for plastic material management - this second report will inform our work and encourage a paradigm shift in the way the global community thinks about and acts on plastics.

MARK CHAMBERS, DIRECTOR, NEW YORK CITY'S OFFICE OF SUSTAINABILITY

To ensure we can retain the benefits of plastic packaging, we have to rethink and change how we use it, dispose of it and of course, how we create plastic material in the first place. Solegear believes that renewable bioplastics are an important element of the New Plastic Economy. This new report shows how to move from rethinking the plastics system to taking action towards a circular economy - we are ready to play our role!

PAUL ANTONIADIS, CEO, SOLEGEAR BIOPLASTIC TECHNOLOGIES INC.

In line with our technology to capture more value by recycling plastics, we fully endorse this report and its messages on how to create a more effective after-use system for plastics. We're excited to translate these strategic plans into actions on the ground.
RAFAEL GARCIA, CEO, CADEL DEINKING

As enthusiastic supporters of the reimagined plastics economy we know the great value a targeted action plan will bring to the plastics cycle. The New Plastics Economy looks at more than just the global material flow and advocates for a fundamental redesign of the whole system. We, and the planet, cannot wait to see the new innovations and solutions scale - time is of the essence!
MOLLY MORSE, CEO, MANGO MATERIALS

At Reflow, we are determined to put plastic recycling at the heart of 3D printing, sparking a societal and manufacturing revolution. To ensure this technology fits into an effective plastics system, a profound shift is needed. The transition strategies at the core of this new report resonate with our mission and we found its realistic yet positive message truly inspiring!
JASPER MIDDENDORP, FOUNDER AND CEO, REFLOW

Zero Waste Scotland was involved in the New Plastics Economy initiative from the beginning, and we continue to support its aims. Scotland is a small nation making big steps towards a more circular economy. We know that redesigning, reusing and optimising the recycling of plastics can create new economic opportunities as well as stop the harmful impacts of the linear economy. To achieve that goal, collective endeavours like the New Plastics Economy initiative need widespread support and commitments to turn ideas into action - and this report provides an excellent blueprint to do so.
IAN GULLAND, CEO, ZERO WASTE SCOTLAND

Nextek believes industry leaders should take a close look at this valuable work of the New Plastics Economy initiative, so that they, together with governments and NGOs, can transform the current plastics economy into a circular one. In this way we do not only respond to pressures on resources and waste reduction, but also create a value-adding plastics system at every level.
EDWARD KOSIOR, MANAGING DIRECTOR, NEXTEK

A wealth of innovation is ready for a New Plastics Economy, which can be unlocked if policymakers, corporations and consumers work together. The work of the Ellen MacArthur Foundation to start the conversation and create a new space is leading by example. This report on actions towards a circular economy for plastics is just the beginning, and we look forward to contributing expertise and watching it grow!
SUSANNA CARSON, FOUNDER AND CEO, BSIBIO PACKAGING SOLUTIONS

Advisory Board Members of the New Plastics Economy Initiative

The New Plastics Economy initiative is grateful for the support of its Advisory Board members:

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EXECUTIVE SUMMARY


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Executive Summary

Global momentum for a fundamental plastics rethink is greater than ever. Plastics have become the ubiquitous workhorse material of the modern economy: combining unrivalled functional properties with low cost, their use has increased twentyfold in the past half-century. While plastics and plastic packaging are an integral part of the global economy and deliver many benefits, their archetypically linear, take-make-dispose value chains entail significant economic and environmental drawbacks. It is only in the past few years that the true extent of these drawbacks has become clear. We now know, more than 40 years after the launch of the first universal recycling symbol, that only 14% of plastic packaging is collected for recycling globally. Each year, USD 80-120 billion plastic packaging material value is lost to the economy. Given projected growth in production, in a business-as-usual scenario, by 2050 oceans could contain more plastics than fish (by weight). Across the entire range of plastic products, not just packaging, concerns are raised about the potential negative impact of certain substances on society and the economy. Businesses and governments are now, for the first time, recognising the need to fundamentally rethink the global plastics system.

This growing recognition is triggering action across the world. Policy-makers continue to broaden and refine regulations for plastics, introducing landmark legislation worldwide throughout 2016, such as restrictions and bans on single-use plastic (carrier) bags. The European Commission is planning to publish a strategy on plastics as part of its Circular Economy Action Plan by the end of 2017. NGOs and the wider public are increasingly calling for change, with movements such as the #breakfreefromplastic campaign gaining traction. Front-running businesses and industry groups are taking action. It is clear that the topic of plastics is coming to a head. The key question is, will societies gradually reject the material due to its negative effects and forgo its many benefits, or will they carve out a future for it characterised by innovation, redesign and harmonisation, based on circular economy principles?

The New Plastics Economy presents a bold and much-needed vision for a plastics system that works. It provides a new way of thinking about plastics as an effective global material flow, aligned with the principles of the circular economy. It aims to harness the benefits of plastics while addressing its drawbacks, delivering drastically better system-wide economic and environmental outcomes. This vision, laid out initially in the 2016 report, *The New Plastics Economy – Rethinking the future of plastics*, has inspired businesses, policy-makers and citizens worldwide. It forms the basis for the ambitious New Plastics Economy initiative, launched in May 2016 and supported by dozens of leading businesses, philanthropists, cities and governments.

This report is the first to provide a concrete set of actions to drive the transition, based on three strategies differentiated by market segment. Thorough analytical work, including a detailed segment-by-segment analysis of the plastic packaging market, numerous interactions with players across the plastics value chain and discussions with experts revealed that a programme of concerted action across three key areas could trigger an accelerated transition towards the New Plastics Economy. The three key transition strategies and related priority action areas are:

1

Without fundamental redesign and innovation, about 30% of plastic packaging will never be reused or recycled.

Today, these packaging applications – representing at least half of all plastic packaging items, or about 30% of the market by weight – are, by their very design, destined for landfill, incineration, or energy recovery, and are often likely to leak into the environment after a short single use. This segment includes *small-format* packaging, such as sachets, tear-offs, lids and sweet wrappers; *multi-material* packaging made of several materials stuck together to enhance packaging functionality; *uncommon* plastic packaging materials of which only relatively low volumes are put on the packaging market, such as polyvinyl chloride (PVC), polystyrene (PS) and expanded polystyrene (EPS, sometimes referred to under its brand names Styrofoam or Thermocol); and highly *nutrient-contaminated* packaging, such as fast-food packaging.

Their lack of a viable after-use pathway and often small size make these items particularly prone to escaping collection systems and ending up in the natural environment, especially in emerging economies where most of the leakage occurs. Even when collected, their after-use material value is hard or impossible to capture at scale. Fundamental redesign and innovation are required: for some segments, this means reinvention from scratch; for other categories, it means scaling existing solutions or accelerating progress made so far. As many of these packaging items have important functional benefits, their drawbacks should not be seen as arguments to remove *all* these applications from the market *today;* rather, they set the direction and focus for redesign and innovation. Priority actions for the global plastic packaging value chain include:

- Fundamentally redesign the packaging formats and delivery models (and after-use systems) for *small-format* plastic packaging, avoiding such small formats where relevant and possible
- Boost material innovation in recyclable or compostable alternatives to the currently unrecyclable *multi-material* applications as described above
- Actively explore replacing PVC, PS and EPS as *uncommon* packaging materials with alternatives (converging to a few key materials being used across most of the market, while continuing to allow for innovation and entry of new materials into the market)
- Scale up compostable packaging and related infrastructure for targeted *nutrient-contaminated* applications
- Explore the potential as well as the limitations of chemical recycling and other technologies, to reprocess currently unrecyclable plastic packaging into new plastics feedstocks

2

For at least 20% of plastic packaging, reuse provides an economically attractive opportunity.

New, innovative delivery models and evolving use patterns are unlocking a reuse opportunity for at least 20% of plastic packaging (by weight), worth at least USD 9 billion. New models that effectively replace single-use packaging with reusable alternatives are already being demonstrated in the cleaning- and personal-care market by only shipping active ingredients in combination with reusable dispensers. For other applications, recent policy developments have demonstrated societal acceptance of reusable alternatives, exemplified by large reductions in the usage of single-use bags after the introduction of relatively minor levies. This societal acceptance could also reinvigorate tried and tested reuse systems, including returnable beverage bottles in cities. In addition, several companies have already successfully demonstrated the benefits of reusable packaging in the business-to-business market, where there remains significant room for scaling up. As always, when evaluating the shift to, or scaling up of, reuse models, it is important to take a system perspective and understand the broad impact of each solution, including environmental and societal aspects. Priority actions in the area of reuse include:

- Innovate towards creative, new delivery models based on reusable packaging
- Replace single-use plastic carrier bags by reusable alternatives
- Scale-up reusable packaging in a business-to-business setting for both large rigid packaging and pallet wrap

3

With concerted efforts on design and after-use systems, recycling would be economically attractive for the remaining 50% of plastic packaging.

Implementation of good practices and standards in packaging design and after-use processes as part of a Global Plastics Protocol, allowing for regional differences and continued innovation, would reinforce recycling as an economically attractive alternative to landfill, incineration and energy recovery. It would add an estimated USD 190-290 of value to every tonne of mixed plastic packaging collected, or USD 2-3 billion annually across OECD countries. In addition, it would improve resource productivity and reduce negative externalities, such as greenhouse gas emissions. Even though it would lift *average* profitability into positive territory, certain technological and economic barriers would remain for specific packaging segments, such as flexible films. Given the current fragile economics of recycling, demand-pull for recycled plastics and other supporting policy measures could trigger progress in the near term. As part of the redesigned and reused packaging described above will also lead to recycling, the 50% mentioned here should not be interpreted as an upper limit for a recycling target. In regions with high levels of leakage into the natural environment, another critical short-term action is to deploy basic collection and management infrastructure – requiring dedicated and distinct efforts. This is already under way at the local level through, for example, the Mother Earth Foundation in the Philippines and, globally, through the Ocean Conservancy's Trash Free Seas Alliance. Priority actions for improving recycling economics, uptake and quality include:

- Implement design changes in plastic packaging to improve recycling quality and economics (e.g., choices of materials, additives and formats) as a first step towards a Global Plastics Protocol
- Harmonise and adopt best practices for collection and sorting systems, also as part of a Global Plastics Protocol
- Scale up high-quality recycling processes
- Explore the potential of material markers to increase sorting yields and quality
- Develop and deploy innovative sorting mechanisms for post-consumer flexible films
- Boost demand for recycled plastics through voluntary commitments or policy instruments, and explore other policy measures to support recycling
- Deploy adequate collection and sorting infrastructure where it is not yet in place

Design is essential to move ahead on all three categories above. To shift towards the New Plastics Economy, the entire plastic packaging value chain needs to be involved – from packaging designers at the beginning of the chain to recyclers at the end. The analysis in this report has revealed that design (of materials, packaging formats and delivery models) plays a particularly important role and is essential to mobilise the transition strategies for each of the plastic packaging categories, as reflected in the set of priority actions.

In addition to the priority actions above, sourcing virgin feedstocks from renewable sources would accelerate the transition to the New Plastics Economy by helping decouple plastics from fossil feedstocks.

To catalyse the transition, the New Plastics Economy initiative has mobilised a systemic and collaborative approach across five building blocks – with a targeted action plan for 2017. In May 2016, the Ellen MacArthur Foundation launched the New Plastics Economy initiative – an ambitious global programme, which has secured over USD 10 million funding to date and involves over 40 key stakeholders across the value chain – to accelerate the shift to the New Plastics Economy. This report forms the basis for a catalytic action plan the initiative will use to tackle this complex issue from all relevant angles. These catalytic actions for 2017 fit the five interlinked and mutually reinforcing building blocks on which the New Plastics Economy initiative is set up. The following actions are planned for 2017 (the initiative will continue to explore other areas in 2018 and beyond):

- **Dialogue Mechanism**: Put cross-value chain collaboration at the heart of the initiative by convening a group of over 40 leading companies, cities and governments across the plastic packaging value chain twice a year, and continuously driving collaborative pioneer projects.

- **Global Plastics Protocol**: Take the next step towards a Global Plastics Protocol by collaboratively developing a cross-value chain perspective on the top opportunities for design shifts; this will allow the prioritisation of changes that would most enhance recycling economics and material health.

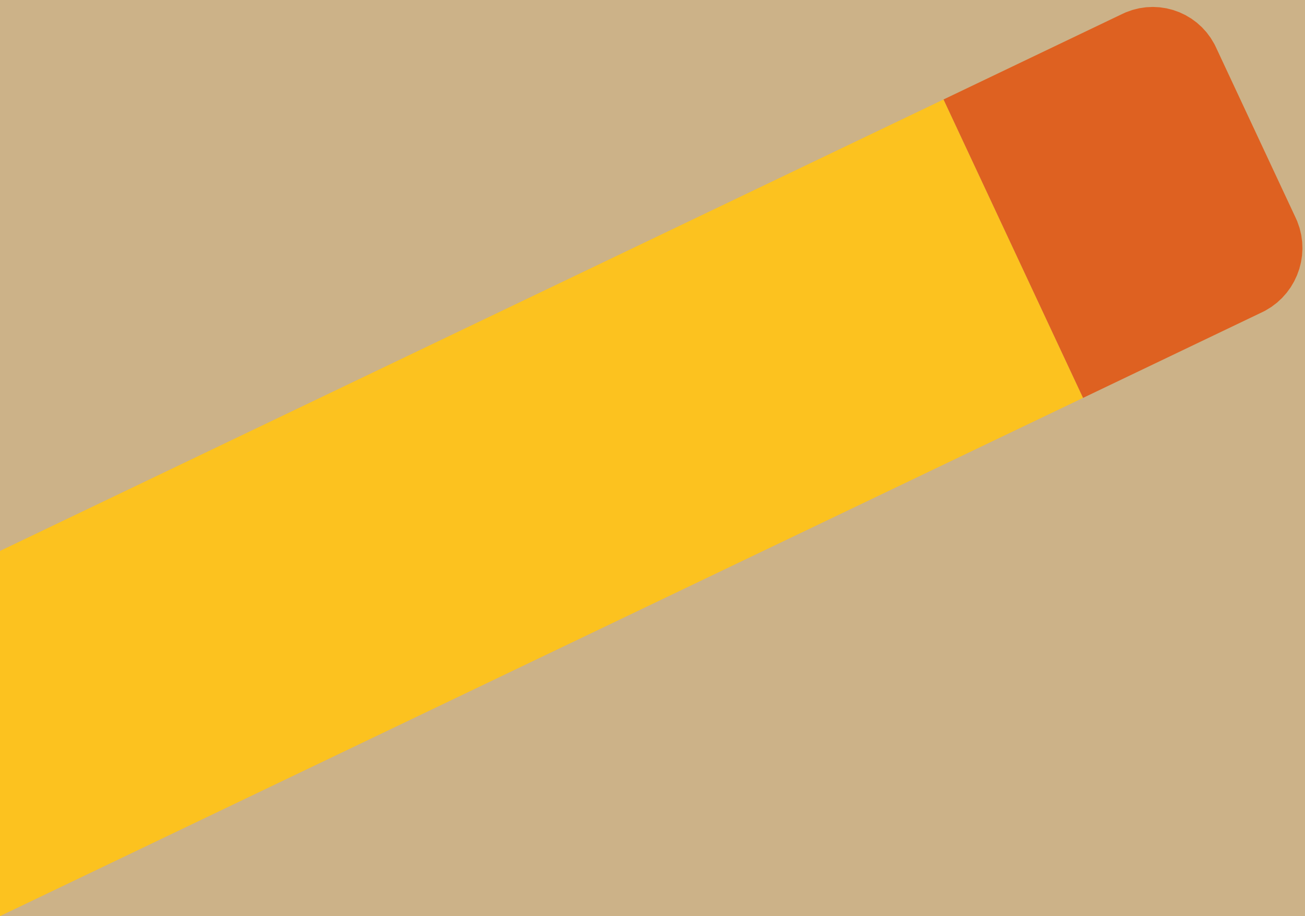
- **Innovation Moonshots**: Launch two innovation challenges to inspire a generation of material scientists and designers to develop solutions for the 30% of packaging that requires fundamental redesign and innovation.

- **Evidence Base**: Finalise the ongoing study with the Plymouth Marine Laboratory on the socio-economic impact of plastics in marine environments. Bridge other knowledge gaps such as, for example, the potential and limitations of material markers and chemical recycling.

- **Stakeholder Engagement**: Encourage the wider stakeholder group to work towards a system shift – designers, in particular, whose involvement is critical for successful action on each of the three transition strategies, and policy-makers, who can trigger progress in the near term. Launch and build on the Circular Design Guide – an online reference point on circular design – together with leading global design company IDEO, to inspire and support designers, innovators and change makers. Engage and inform policy-makers on the New Plastics Economy's vision and recommendations.

Through these actions, the New Plastics Economy initiative aims to set direction, inspire innovation and build momentum towards the vision of a plastics system that works, moving the plastics industry into a positive spiral of value capture, stronger economics and better environmental outcomes.

GLOBAL MOMENTUM FOR A PLASTICS RETHINK IS GREATER THAN EVER



Global Momentum for a Plastics Rethink is Greater than Ever

THE CASE FOR RETHINKING PLASTICS, STARTING WITH PACKAGING

While plastics and plastic packaging are an integral part of the global economy and provide it with many benefits, their typically linear value chains currently entail significant drawbacks, which are becoming more apparent by the day. Projected growth in plastics production could lead by 2050, in a business-as-usual scenario, to the oceans containing more plastics than fish (by weight), and the entire plastics industry could be consuming 20% of total oil production and 15% of the annual carbon budget. Looking at the full range of plastic products (not just packaging), concerns have been raised about the potential negative impact of some substances, such as certain phthalates in PVC and bisphenol A in polycarbonate, on society and the economy. Plastic packaging – the focus of the New Plastics Economy initiative – is plastics' largest application, representing 26% of the total volume, and encountered by virtually everyone daily.[1] Most plastic packaging is used only once and 95% of its value, estimated at USD 80-120 billion annually, is lost to the economy after its initial use. Additionally, plastic packaging, which is particularly prone to leakage into the environment, generates negative externalities, degradation of natural systems and greenhouse gas emissions, that have been valued conservatively by UNEP at USD 40 billion.[2] For these reasons, plastics and plastic packaging have gradually morphed from a fringe to a mainstream issue.

The global momentum for a plastics rethink has triggered a broad group of stakeholders to act. Policy-makers are introducing landmark legislation worldwide, affecting plastics and plastic packaging, with examples from 2016 including: further national regulations on single-use plastic bags in Indonesia, Colombia, and Morocco; a ban on non-biodegradable plastic cutlery, cups and plates in France; and a ban on EPS packaging in San Francisco.[3] In November 2016, citizens of California approved Proposition 67, which prohibits grocery and other stores from providing customers with single-use plastic takeaway bags. This is in addition to more 130 regulations, at a city level and county-wide, across 20 states, governing plastic packaging in the United States alone.[4] Importantly, the EU Commission aims to publish a strategy on plastics as part of its Circular Economy Action Plan by the end of 2017. The NGO community is also intensifying its efforts, as shown by the #breakfreefromplastic movement.[5] Launched in September 2016, the movement, which aims for a future free from plastic pollution, grew to over 500 member organisations in just a couple of weeks.

Academic experts are increasingly studying plastics and their impact on the economy and society. Aside from plastics leakage into the ocean, the impact of substances of concern in plastics (not just packaging) is one active area of research. Besides polymers, plastics contain a broad range of other substances, with some of them raising concerns about complex long-term exposure and compound effects on human health. As discussed in *The New Plastics Economy – Rethinking the future of plastics*, while scientific evidence on the exact implications of substances of concern is not always conclusive, some stakeholders are already acting.[6] They are motivated by different reasons – regulators are often driven by the precautionary principle and potential cost to society, and businesses anticipate reputational risks and aim to capture potential economic value.[7] For example, the European Commission continued in 2016 the development of science-based criteria for endocrine disruptors – chemicals which are considered within the EU chemicals policy (known as REACH; Registration, Evaluation and Authorisation of Chemicals) to be of similar regulatory concern as substances already classed as being of very high concern.[8]

Front-running businesses and industry groups are already responding in a variety of ways. They are improving the design of their products, packaging and delivery models, including, for example, public commitments on sourcing recycled content or eliminating single-use carrier bags. Companies are also collaborating to work on solutions across the after-use value chain, such as the REFLEX, FIACE and MRFF projects to improve recycling of flexible packaging.[9] Examples of industry-wide initiatives include the Recycling Partnership, Closed Loop Fund and, launched in October 2016, the Polyolefin Circular Economy Platform.[10]

THE NEW PLASTICS ECONOMY: A VISION OF A MORE EFFECTIVE SYSTEM, IN LINE WITH THE PRINCIPLES OF THE CIRCULAR ECONOMY

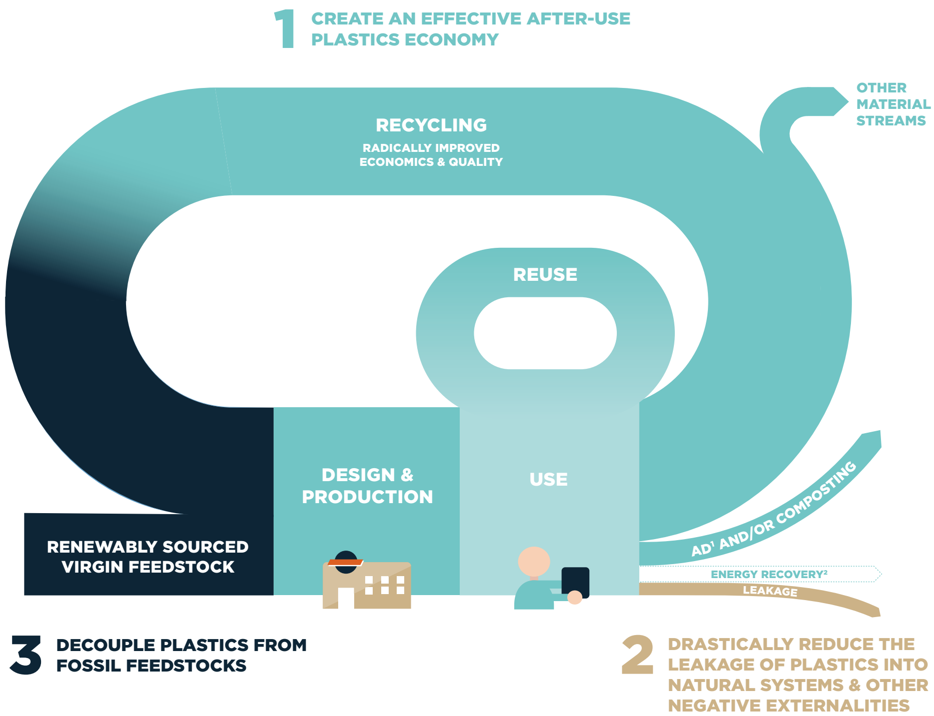
As laid out in the report, *The New Plastics Economy – Rethinking the future of plastics*, the New Plastics Economy offers a much-needed, fundamental rethink for plastics and plastic packaging. It presents an ambitious target state, enhancing system effectiveness to achieve better economic and environmental outcomes while continuing to harness the many benefits of plastic packaging. This bold vision builds on and aligns with the principles of the circular economy, an economic model that is restorative and regenerative by design. To move the plastics value chain into a positive spiral of value capture, stronger economics and better environmental outcomes, the New Plastics Economy has three main ambitions (see Figure 1).

1. Create an effective after-use plastics economy by improving the economics and uptake of recycling, reuse and controlled biodegradation for targeted applications. This is the cornerstone of the New Plastics Economy and its first priority, which will help it to realise the following two ambitions.

2. Drastically reduce leakage of plastics into natural systems (in particular, the ocean) and other negative externalities.

3. Decouple plastics from fossil feedstocks by – in addition to reducing cycle losses and dematerialising – exploring and adopting renewably sourced feedstocks.

FIGURE 1: THE NEW PLASTICS ECONOMY AND ITS THREE AMBITIONS



Source: *The New Plastics Economy – Rethinking the future of plastics*

THE ROAD AHEAD: THREE DISTINCT STRATEGIES TO DRIVE THE TRANSITION

The Road Ahead: Three Distinct Strategies to Drive the Transition

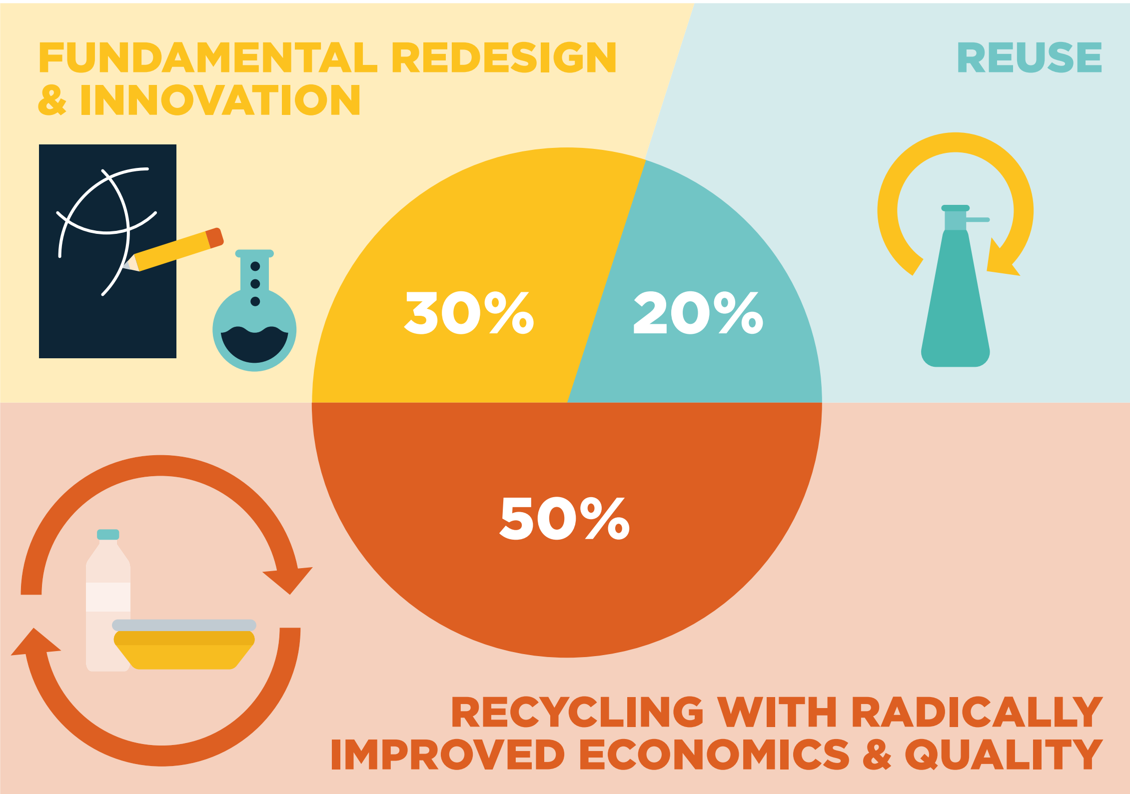
For the first time, a concrete set of priority actions for the global plastic packaging value chain to trigger an accelerated transition towards the New Plastics Economy has been identified. These actions are based on three major new insights. These insights were revealed through thorough analytical work, including a granular segment-by-segment analysis of the plastic packaging market, numerous interactions with players across the plastics value chain and discussions with over 75 experts. The three insights, which have the potential to drive a genuine transformation within the plastic packaging sector and herald the shift to the New Plastics Economy, are (see Figure 2):

1. **Without fundamental redesign and innovation, about 30% of plastic packaging will never be reused or recycled**

2. **For at least 20% of plastic packaging, reuse provides an economically attractive opportunity**

3. **With concerted efforts on design and after-use systems, recycling would be economically attractive for the remaining 50% of plastic packaging**

FIGURE 2: THREE DISTINCT TRANSITIONS STRATEGIES TO ACCELERATE THE SHIFT TOWARDS THE NEW PLASTICS ECONOMY (SHARE OF PLASTIC PACKAGING MARKET BY WEIGHT)



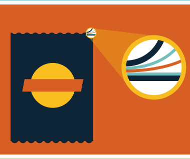
Source: New Plastics Economy initiative analysis (see Appendix for details)

1

Without Fundamental Redesign and Innovation, about 30% of Plastic Packaging Will Never Be Reused or Recycled

This category, representing at least half of the plastic packaging items and about 30% of the total market by weight, consists of four segments: *small-format* packaging; *multi-material* packaging; *uncommon* plastic packaging materials; and *nutrient-contaminated* packaging (see Figure 3). While often offering high functionality, these packaging types do not have a viable reuse or recycling pathway and are unlikely to have one at scale in the foreseeable future. To shift these segments to a more positive material cycle, fundamental redesign and innovation of materials, formats, delivery models and after-use systems is required.

FIGURE 3: PLASTIC PACKAGING SEGMENTS THAT NEED FUNDAMENTAL REDESIGN AND INNOVATION

	EXAMPLES	SHARE OF PLASTIC PACKAGING MARKET % BY WEIGHT	PRIORITY SOLUTIONS
SMALL-FORMAT Lids, tear-offs, caps, sachets and generally all items smaller than 40 – 70mm		~10%	**REDESIGN** packaging formats and/or delivery models (and after-use systems)
MULTI-MATERIAL Packaging with inseparable layers of different materials		~13%	**INNOVATE** in materials and reprocessing technologies
UNCOMMON MATERIALS Uncommon plastic packaging materials like PVC, EPS, PS		~10%	Actively explore to **REPLACE** as a priority PVC, EPS, PS by known alternatives
NUTRIENT-CONTAMINATED Coffee capsules, organic waste bags, takeaway food packaging		NOT QUANTIFIED	**SCALE UP** compostable plastics for targeted applications to help recover nutrients of packaging contents

FUNDAMENTAL REDESIGN AND INNOVATION is needed for >50% of plastic packaging (by no. of items), or >30% of plastic packaging (by weight)*

* Total is not the sum of separate categories due to overlap

Source: New Plastics Economy initiative analysis (see Appendix for details)

THERE ARE FOUR PLASTIC PACKAGING SEGMENTS WHICH HAVE A VARIETY OF BARRIERS IMPEDING AN EFFECTIVE AFTER-USE PATHWAY

***Small-format* plastic packaging (about 10% of the market, by weight, and up to 35%-50% by number of items), such as sachets, tear-offs, lids, straw packages, sweet wrappers and small pots, tend to escape collection or sorting systems and have no economic reuse or recycling pathway**. The small size of these items means they are likely to leak out of the system into the natural environment. This can be witnessed in emerging countries where their low after-use value makes them less likely to be collected by the informal sector (i.e. waste management activities carried out by waste pickers)[11] and in advanced economies, where items like lids, caps, straws and sweet wrappers are consistently mentioned as some of the plastic packaging items most found in litter.[12] Cleaning up these small-format items after they have escaped collection systems is particularly hard precisely because they are small. Sachets are a typical small-format example: they are used all over the world, but particularly in emerging markets, to sell products such as condiments and shampoo in small quantities, making them more convenient and affordable. Especially in countries without a formal collection system, many of these sachets end up as litter.

Even when they are collected, small-format items are hardly ever recycled due to significant technical and economic barriers. A study ordered by the industry association, PlasticsEurope, estimated the effective recycling potential for this segment to be zero, even in an optimistic scenario.[13] The main barrier is the difficulty of sorting small-format items – a critical step in the recycling process. One of the first stages in automated sorting facilities is a screen that removes all small items, such as loose dirt, stones and other materials that could damage equipment in subsequent sorting steps. During this process, all items smaller than 40mm-70mm fall through the mesh in the screen, end up in the fines fraction, and are sent for energy recovery, incineration or landfill.[14] Due to the small size and low value of these items, a successive layer of sorting technology to extract the plastics from the fines fraction is not economically viable and is unlikely to be so in the foreseeable future.[15] In theory, manual sorting could perhaps overcome the technical barriers small-format items pose to automated sorting, but it is economically challenging given the low volume-to-time ratio of sorting these items.

***Multi-material* packaging (about 13% of the market, by weight) currently cannot be economically, and often not even technically, recycled.** By combining the properties of materials, multi-material packaging can often offer enhanced performance versus its mono-material alternatives and resulting functional benefits, such as providing oxygen and moisture barriers at reduced weight and costs. However, this combination of multiple materials means that many of these applications, like those combining plastic and aluminium layers, are economically, and in some cases even technically, unrecyclable.

For some applications, technologies exist that, in theory, could capture part of the material value through downcycling, i.e. the process of converting materials into new materials of lesser quality, economic value and/or reduced functionality. For example, compatibilisers are chemical substances that can allow some multi-material packaging to be downcycled into blended materials. Still, such technologies lead to significant loss of material value in the recycling process and likely add just one extra use-cycle rather than creating a truly positive, virtuous material cycle.

***Uncommon* plastic packaging materials (about 10% of the market, by weight), while often technically recyclable, are not economically viable to sort and recycle because their small volumes prevent effective economies of scale.[16]** The economics of plastics sorting, which is a critical step in the recycling process, are highly dependent on scale. If the volume of a certain material is too low, the additional sorting step becomes unaffordable. This is particularly relevant for business-to-consumer packaging, mainly collected as a mixed plastic packaging stream, as opposed to business-to-business packaging, where sometimes mono-material volumes are collected in bulk.

PVC, PS, and EPS stand out as uncommon plastic packaging materials to focus on first. They collectively represent 85% of the uncommon plastic packaging materials, so dealing with these three would make a huge impact on this segment. Their low volumes lead to poor outcomes: less than 5% of PVC packaging is recycled in Europe,[17] and PS and EPS are rarely sorted from household waste and recycled[18] (although there are occasional exceptions, including some very large-scale facilities in Germany).[19] Even if volumes were higher, problems remain. For instance, EPS is often used in takeaway food packaging such as clamshells, which become heavily contaminated with organic matter and disposed of in public bins for residual litter, further reducing recycling potential. Also, these materials frequently contaminate streams of other plastics and harm their recycling economics. For example, even very small concentrations of PVC (0.005% by weight) lead to significant quality reductions in recycled polyethylene terephthalate (PET)[20] and EPS is a known contaminant for polyolefin recyclers as it is not removed during the float-sink separation process. In addition, there are safety concerns about PVC. It often contains vinyl chloride monomers, which are carcinogenic to humans, and many additives, including phthalates, a class including substances like bis(2-ethylhexyl) phthalate (DEHP), about which concerns have been raised relating to negative effects on human health and the environment.[21]

***Nutrient-contaminated* packaging is often difficult to sort and clean for high-quality recycling.** This segment includes applications that are prone to be mixed with organic contents during or after use. This could either be by design, such as in coffee capsules, or because the application leads to a high food waste-to-packaging ratio after use, such as food packaging for events, fast food restaurants and canteens. Either way, when there is high contamination with organic nutrients, recycling becomes problematic, as organic residues and odours might be hard to separate from the packaging in the recycling process.

A COMBINATION OF REDESIGN AND INNOVATION SOLUTIONS IS REQUIRED TO MAKE PROGRESS IN THESE FOUR CHALLENGING PLASTIC PACKAGING SEGMENTS

Given the wide variety of barriers impeding effective after-use pathways for the four segments, it is unlikely there will be one instant and effortless solution at scale for them all. However, when looking at each category individually, clear priority redesign and innovation areas emerge, as outlined below. As always, when making progress in these segments, it is important to take a system perspective and understand the broader impact of interventions, including the impact of packaging on packaged goods. Given that these products have significant functional benefits, their drawbacks are not necessarily arguments to remove them *all* from the market *today* but rather to start on a path of reinvention as outlined.

Format and delivery model redesign could reduce or eliminate the need for *small-format* plastic packaging items, while providing the same or even better functionality. Beverage cans are a classic example of the potential of format redesign. The tear-off tab, being a small-format item, was difficult to collect and prone to leakage until it was replaced in the 1970s by the stay-on tab that is prevalent today. The potential of format redesign can also be witnessed in innovative personal care bottles and tubes for which separate, small-format components have been designed out. Examples include the flip-top cap for ketchup or shampoo bottles, which connects the closure to the main packaging, or the Nephentes bottle concept, by which items can be closed without a cap.[22]

Delivery-model redesign could involve reusable or returnable packaging items, or even reduce the need for the packaging in its current form. For example, a dispenser could replace sachets in restaurants or shops; such a delivery model would have the potential to supplant billions of small-format items being used every year. The Disappearing Package illustrates how redesigning the packaging concept could work for several packaging applications, including laundry detergent pods. The new pods are water-soluble and stitched together forming a sheet, so the user can tear off a pod each time and use them one-by-one. With the last pod, the package itself is gone.[23]

While redesigning formats and delivery models is the most powerful approach for the small-format segment, such redesign efforts take time and might not be applicable to *all* small-format items. For some targeted applications, designing small-format items with compostable materials could be another potential solution – though its implementation brings a series of challenges that need to be addressed first. Also, the redesign efforts should be combined with actions focusing on after-use collection, sorting and reprocessing innovations for small-format items.

For *multi-material* packaging, both material and reprocessing technology innovations would need to be explored. Replacing layers of different materials by one material, while maintaining the same functionalities, could lead to packaging which is more suitable for recycling. For example, Dow Chemical, together with Printpack and Tyson Foods, developed a mono-material, stand-up pouch with improved recyclability versus the existing multi-material alternatives, suitable for a specific set of applications (e.g., certain frozen food segments).[24] Another potential way ahead is the development of compostable multi-material packaging, which combines enhanced performance due to the use of multiple layers of different materials, with an effective after-use pathway (such as composting or anaerobic digestion). The benefits of such compostable packaging, and the conditions needed for it to work, are laid out further in this section, when discussing solutions for nutrient-contaminated applications. To replace multi-material packaging with recyclable mono-material or compostable packaging – with similar performance, weight, and costs – continued innovation-at-scale is needed.

Innovation in reprocessing technologies could also create new, viable after-use pathways for multi-material packaging (and possibly some of the other plastic packaging segments for which there are currently no technical or economic recycling routes). Two prominent examples are:

- Thermochemical recycling technologies, such as pyrolysis, could, in theory, provide a closed-material loop for currently unrecyclable packaging items. They work by breaking down the material into a mix of hydrocarbon molecules, which could be refined into precursors for making new plastics. These technologies should not be relied on as silver bullets – they are an energy-intensive outer loop where little material value is retained, compared with, for example, reuse or mechanical recycling. Furthermore, it remains to be proven that these technologies, in practice, can realise closed-material loops with high yields of hydrocarbon output being fed back into the polymer production processes. Current applications of the technology are still largely confined to the conversion of plastics into a (non-renewable) fuel. This provides a brief second use but also leads to the definite loss of the material and so perpetuates a linear, take-make-dispose model. Other issues to be explored within this process are the potentially fragile economics, energy requirements and how it relates to substances of concern.[25]

- Disassembly of multi-material laminates could provide another alternative. Companies like Saperatec (delaminating),[26] Cadel Deinking (delaminating)[27] and APK (dissolving)[28] are developing or scaling up technologies that separate materials after use. Like the thermochemical recycling technologies, they currently only exist at pilot scale, with the first industrial-scale plants just built or planned to be built over the coming years. The potential impact of these technologies, and how their performance could be influenced by packaging design (e.g., design for easy disassembly), remains to be seen.

In summary, innovation in reprocessing technologies should be explored but not relied on as the single, simple solution. Rather, it should be investigated as part of the broad range of redesign and innovation activities outlined above to propel the multi-material segment and possibly some other plastic packaging segments for which, at the moment, there are no technical or economic recycling routes.

Replacing the *uncommon* materials PVC, EPS, and PS in packaging with known alternatives would need to be actively explored. This would enhance recycling economics and reduce the potential negative impact of substances of concern. As discussed in the 2016 *The New Plastics Economy – Rethinking the future of plastics* report, for many PVC, PS, and EPS packaging applications alternative solutions are already in place.[29] Also, the use of these materials in packaging is already declining, as businesses and policy-makers alike are reducing or phasing them out – their replacement represents an accelerated evolution rather than a revolution.[30] For cases where no clear solutions with similar cost and functionality yet exist, research and innovation would need to be focused on developing alternatives.

Of course, not *all* uncommon plastic packaging materials should be replaced by known alternatives. By definition, any new material will, on introduction to the market, initially have small volumes and there should be space for such innovation – it is a core aspect of the transition to the New Plastics Economy.

Scaling up the use of compostable materials and the infrastructure for targeted *nutrient-contaminated* applications could help return organic nutrients to the soil, thus contributing to natural capital maintenance. For example, when made of compostable materials, fast-food packaging could be disposed of, together with its contents, in an organics bin. This would increase the value capture of organic material through composting or anaerobic digestion. Compostable materials could also reduce the impact of unintentional leakage, if the material can truly degrade safely and completely in a range of different, uncontrolled environments – a strong assumption that would need serious innovation to become reality across a wide range of applications.

Of course, as laid out in *The New Plastics Economy – Rethinking the future of plastics*, several elements need to be in place to make wider use of compostable plastics beneficial. These include the development of adequate infrastructure to handle such materials (e.g., separate collection of organics, composting or anaerobic digestion facilities) – infrastructure which is emerging but not yet widely available in many parts of the world.

Priority actions to reinvent the 30% of the market without a viable reuse or recycling pathway are:

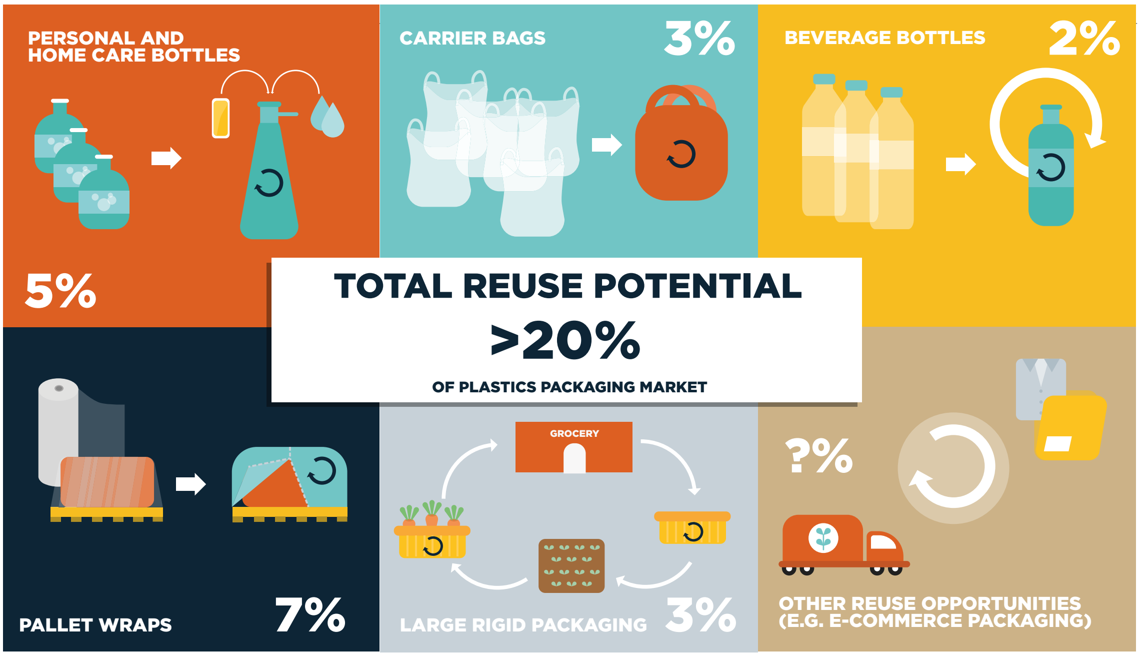
- Fundamentally redesign the packaging formats and delivery models (and after-use systems) for *small-format* plastic packaging, avoiding such small formats where relevant and possible
- Boost material innovation in recyclable or compostable alternatives to the currently unrecyclable *multi-material* applications as described above
- Replace PVC, PS and EPS, as a priority, as *uncommon* packaging materials with alternatives (converging to a few key materials being used across most of the market, while continuing to allow for innovation)
- Scale up compostable packaging and related infrastructure for targeted *nutrient-contaminated* applications
- Explore the potential as well as the limitations of chemical recycling and other technologies to reprocess currently unrecyclable plastic packaging into new plastics feedstocks

2

For at Least 20% of Plastic Packaging, Reuse Provides an Economically Attractive Opportunity

Reusable packaging was a common choice until roughly half a century ago. Since then, single-use, disposable packaging has increasingly become the preferred option. Nowadays, recent innovation, evolving use patterns, and societal acceptance are again positioning reuse models as attractive options for some plastic packaging segments. The plastic packaging reuse opportunities identified and quantified in this update report represent at least 20% of today's market, by weight (see Figure 4). The examples of personal and home-care bottles and carrier bags alone could generate about 6 million tonnes of material savings and an economic opportunity of USD 9 billion. More could be unlocked as business-model innovation continues to push the boundaries of application to create a variety of attractive reuse models. As always, when evaluating different reuse models, it is important to take a system perspective.

FIGURE 4: SELECTED PLASTIC PACKAGING REUSE OPPORTUNITIES



Source: New Plastics Economy initiative analysis (see Appendix for details)

PERSONAL AND HOME-CARE BOTTLES: INNOVATIVE DELIVERY MODELS COULD RESULT IN 80%-90% PACKAGING MATERIAL SAVINGS

Innovative delivery models can create value by encouraging the reuse of packaging in the home. Such new models could affect a range of segments, including laundry liquid, home cleaning, as well as bath and shower products. Many of these goods, which usually come in single-use bottles, mainly consist of water, with only a small volume of so-called "active ingredients". A delivery model using refillable bottles, for which only such active ingredients are sold and shipped, can offer significant material and transport savings. Splosh[31] – with dissolvable sachets – and Replenish[32] – with refill pods – show these models are viable. Their innovative delivery models could lead to 80%-90% packaging material savings and 25%-50% packaging cost savings, offering clear incentives for businesses and customers alike.[33] If such reuse models were to be applied to all bottles in beauty and personal care as well as home cleaning, this would amount to about 3 million tonnes or at least USD 8 billion packaging cost savings.[34] In addition, shipping only active ingredients would result in 85%-95% transport cost savings. Packaging and transport savings together would represent an 80%-85% reduction in greenhouse gas emissions versus today's traditional single-use bottles.[35] Such delivery models could also apply to other products that mainly consist of water, such as laundry products, sprays for lawn and garden use, pet-care products and even the beverage market, as demonstrated by Sodastream[36] and MiO[37].

CARRIER BAGS: REUSABLE BAGS COULD REPLACE OVER 300 BILLION SINGLE-USE CARRIER BAGS PER YEAR, GENERATING USD 0.9 BILLION IN MATERIAL COST SAVINGS

About 330 billion single-use plastic carrier bags are produced every year – that is over 10,000 bags per second.[38] They have an average use period ranging from only a couple of minutes to a few hours, after which many leak into the environment and almost none is recycled.[39] In emerging economies, the economics of waste picking are not favourable enough for collecting carrier bags as it takes so long to aggregate a significant mass of material.[40] In advanced economies, bags are prone to leak into the natural environment – plastic bags are among the most-found plastic packaging litter items.[41] Public awareness of this problem is growing and, with reusable alternatives available, so are regulatory interventions: at least 35 countries worldwide have taken action to tax or ban single-use carrier bags.[42] Also, front-running businesses are acting, as shown by the retailer Carrefour, which announced at the UN Climate Change Conference 2016 in Marrakech its commitment to eliminate all free single-use carrier bags throughout its worldwide integrated store network by 2020.[43] Encouragingly, these outcomes have often been achieved by very small charges on bags and without major resistance, indicating the readiness and acceptance of the public for this type of policy. For example, studies reported an instant 80%-95% drop in usage of single-use carrier bags and a reduction of over 90% in the share of plastic bags in the total visible litter items in the first year after such an intervention.[44]

If all countries in the world were to achieve 95% replacement of single-use carrier bags by reusable alternatives, this would represent an annual reduction of over 300 billion single-use plastic bags. Even when considering rebound effects in terms of increased production of reusable bags and bin liners (as single-use bags often get a second use as bin liner), this would lead to over 2 million tonnes of material savings and USD 0.9 billion material cost savings.[45] The latter is excluding additional cost savings in collecting and reprocessing carrier bags after use and a reduction in negative externalities related to the leakage of single-use carrier bags, such as impacts on infrastructure and the environment.

BEVERAGE BOTTLES: REUSE SYSTEMS COULD OFFER ECONOMIC AND ENVIRONMENTAL BENEFITS IN THE RIGHT CIRCUMSTANCES

Beverage bottles are a major plastic packaging application, representing at least 16% of the market (by weight).[46] While widely collected for recycling, the material value loss of single-use beverage bottles after each use cycle is still significant; even for PET bottles in Europe, this loss is over 50%.[47] As shown by various studies, reuse models – be it returnable bottle systems (with or without deposit) or refillable bottles at home or on the go – can, given the right local conditions, offer an attractive alternative with the potential for lower material costs and a considerably lower carbon footprint than single-use alternatives.[48] Moreover, reuse models for beverage bottles, both plastic and non-plastic ones, have a proven track record.

The success of return systems for beverage bottles relies on several factors: cost of raw materials relative to other input costs; cost and distance of collection and redistribution infrastructure; level of differentiation of packaging; regulatory framework; and use pattern.[49] Each of these factors needs to be considered to evaluate the potential benefits of reusable bottle systems for any specific case.

The success of refillable bottles at home or on the go is impacted by the availability of refill stations (e.g., drinking water fountains) and user preferences. As the global reusable water bottle market (valued by Transparency Market Research at about USD 7 billion in 2015) is estimated to grow by more than 4% year on year between 2016 and 2024, reuse models are again positioned as an attractive alternative.[50]

Considering the success factors, a reuse model is estimated to offer economic and environmental benefits for at least 10% of all beverage bottles worldwide, or at least 2% of the global plastic packaging market. Whether such a system should be based on returnable (deposit) bottles or user refillable bottles depends on the exact application and local circumstances.

BUSINESS-TO-BUSINESS LARGE RIGID PACKAGING: ALTHOUGH IMPLEMENTED IN SOME SECTORS, RETURNABLE PACKAGING COULD CREATE FURTHER ECONOMIC VALUE BY INCREASING ITS USE, POOLING, STANDARDISATION AND MODULARISATION

Large rigid business-to-business packaging items, such as pallets, crates, foldable boxes, pails and drums (i.e. cylindrical containers used for storing and shipping bulk cargo), have a sufficiently high material value to make reuse business models profitable. They are often used 20 to 100 times depending on the application and the vast majority are recycled afterwards.[51] These plastic reusable packaging items often replace non-plastic alternatives, such as cardboard boxes or wooden pallets. A study on the Schoeller Allibert's Maxinest® tray for food and grocery distribution shows that as soon as this reusable packaging is used 20 times, it is environmentally and economically beneficial versus single-use cardboard boxes. In reality, this type of product is estimated to have over 90 use cycles, on average, before being recycled.[52] The critical part of this reuse business model is the reverse logistics where crates or pallets are sent back, often empty. To overcome this, pooling solutions companies like Brambles offer logistics services, managing a shared pool of standardised pallets and crates across a wide and dense network of companies, leading to significant logistics savings.

There is still economic potential to be captured by implementing standardised returnable rigid packaging systems at scale. Currently, large differences exist in both the use of reusable transport packaging and the share of pooled versus non-pooled reusable packaging, both between and within industries.[53] These differences indicate the potential to capture further efficiency gains and, therefore, economic value. In addition, as mentioned in *The New Plastics Economy – Rethinking the future of plastics*, global standardisation and modularisation could facilitate pooling and help to realise the vision of the Physical Internet, a logistics system based on standardised, modularised and reusable containers, using open networks across industries with pooled assets and protocols.[54]

BUSINESS-TO-BUSINESS PALLET WRAP: SCALING UP EXISTING REUSE SOLUTIONS COULD CREATE ECONOMIC AND ENVIRONMENTAL VALUE

Single-use pallet wraps (e.g., stretch wraps and shrink hoods) are currently the default choice to stabilise and secure products on pallets during transport, leading to an estimated annual pallet wrap film production of 5 million-6 million tonnes.[55] Globally, most of the material value of these films is lost after one use cycle – even though in some regions, large and sometimes medium enterprises have dedicated collection systems for commercial film.[56] Several reusable solutions to address this material value loss are available.[57] Lid and strap systems, as provided by Loadhog, are already used in a range of industries, such as postal (e.g., Royal Mail), automotive (e.g., Honda) and healthcare (e.g., Baxter Healthcare UK).[58] Reusable pallet wrappers, offered by companies like Reusa-wraps, Envirowrapper and Dehnco, have already been adopted by other companies across various sectors such as Aldi, Universal, AkzoNobel, Budweiser, Coca-Cola, Pepsico, Verizon and Microsoft.[59] Taking the modularisation and standardisation of business-to-business packaging one step further, and developing containers that can be interlocked to act as one unit, might even avoid the need for wrapping altogether. This concept has been developed and researched by the MODULUSHCA project,[60] which is aligned with the Physical Internet vision.

DELIVERY MODEL INNOVATION AND CONTINUED INCREASE OF SOCIETAL ACCEPTANCE, AND EVEN PREFERENCE, COULD UNLOCK FURTHER PLASTIC PACKAGING REUSE OPPORTUNITIES

Alongside the above examples, other opportunities for reuse business models exist or could be envisioned across different sectors. Repack, for example, is a system for reusable transport packaging in the rapidly growing and packaging-intense e-commerce market. After unpacking the delivered item, people can simply fold the packaging, drop it in the nearest postbox to send it back, free of charge, for reuse, and receive a voucher for doing so.[61] The Repack example illustrates an innovative way of dealing with the reverse logistics challenge, often a key factor for successful implementation of reuse models. With innovators exploring new delivery models and people increasingly accepting – or even actively seeking – such reusable packaging, multiple reuse opportunities are likely to be discovered and successfully deployed.

TO CAPTURE THE REUSE OPPORTUNITY, A SET OF PRIORITY ACTIONS HAS BEEN IDENTIFIED:

- Innovate towards creative, new delivery models based on reusable packaging
- Replace single-use plastic carrier bags by reusable alternatives
- Scale up reusable packaging in a business-to-business setting for both large rigid packaging and pallet wrap

3

With Concerted Efforts on Design and After-use Systems, Recycling Would Be Economically Attractive for the Remaining 50% of Plastic Packaging

The uptake, economics and quality of plastic packaging recycling are currently in a fragile state. At the moment, only 14% of plastic packaging is collected for recycling globally[62] – a number that reflects the economic challenges of gathering and processing a diversity of packaging formats and materials through fragmented and sometimes under-developed after-use systems. Although recycling economics are stronger for some packaging applications, such as PET beverage bottles, on average, the cost of collection, sorting and recycling outweighs the generated revenues. Estimates suggest that in Europe this cost is about USD 170-250 per tonne collected, compared with the cost of collection and disposal of plastic packaging as part of residual waste[63] – an average across widely different collection and sorting systems, regulatory and geographical conditions and packaging types. This net cost estimate excludes the additional environmental and societal benefits of plastics recycling such as: reduced greenhouse gas emissions; reduced environmental impacts on land use, biodiversity and air quality; and job creation. For example, one tonne of plastic collected for recycling avoids emission of an estimated one tonne of carbon dioxide equivalent greenhouse gas compared with a mix of landfill and incineration with energy recovery.[64] This alone has an estimated societal value of more than USD 100 per tonne of plastics collected for recycling.[65]

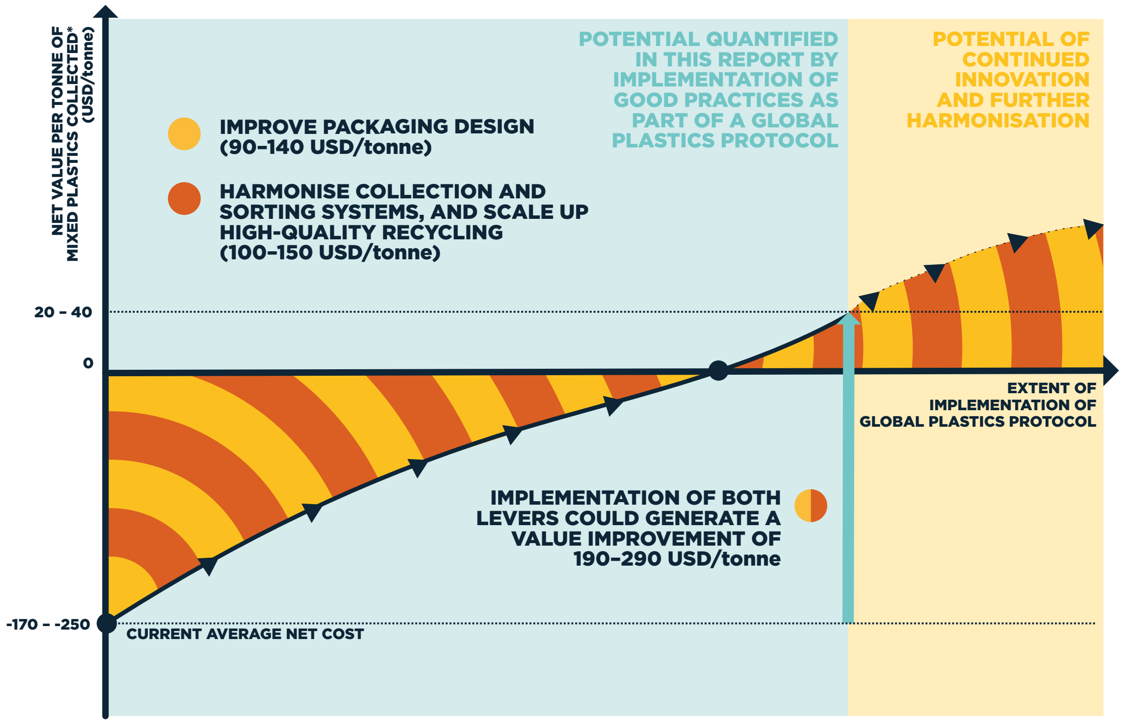
There are several reasons for these fragile economics of collection, sorting and recycling. Plastic packaging materials and formats are diverse and there is a further threat from continued, unrestrained diversification into new materials and formats, which, while often bringing important functional benefits, have lower value in the after-use recycling system and drive up its costs. Also, the entire system of collection and sorting is highly fragmented, which prevents economies of scale and the delivery of consistent, high-quality material streams to recyclers. Furthermore, both virgin and recycled plastic prices have been volatile and declining for many plastic types between 2012 and 2015, especially for PET, when the price of recycled PET dropped by 30%-40%.[66]

A MUCH-NEEDED COLLABORATIVE APPROACH TOWARDS PACKAGING DESIGN AND AFTER-USE SYSTEMS COULD INCREASE RECYCLING ECONOMICS BY USD 190-290 PER TONNE COLLECTED FOR RECYCLING[67] (USD 2-3 BILLION ANNUALLY IN THE OECD REGION).

A concerted, cross-value-chain, global approach is required to improve plastic packaging recycling uptake, economics and quality. Many – often local and small-scale – initiatives aim for these improvements, demonstrating the broad awareness and appetite for change. However, collectively they have not scaled up to the extent required, as evidenced by the current 14% global recycling rate. As described in *The New Plastics Economy – Rethinking the future of plastics*, a Global Plastics Protocol provides a common target state to innovate towards, that would overcome existing fragmentation and enable the creation of effective markets. It would guide convergence of packaging design (materials and formats) and after-use systems (collection, sorting and reprocessing) towards best practices, while allowing for regional differences and innovation, thus improving recycling economics.

Implementation of good practices in packaging design and after-use processes as part of a Global Plastics Protocol could generate a value improvement of USD 190-290 per tonne of plastics collected, lifting economics into positive territory. As detailed below, this improvement, representing USD 2-3 billion a year for OECD countries, requires concerted action both on packaging design and after-use systems – neither of these mutually reinforcing areas would be able to trigger this system shift on their own. Implementing such a set of good-practice levers would be no small feat but, if done successfully, would move recycling economics into positive territory (on average) (see Figure 5). In this way, it would reinforce recycling as an attractive, cost-competitive alternative to landfill, incineration, or energy recovery by increasing the capture of material value and resource productivity, as well as decoupling the system from fossil feedstocks and reducing greenhouse gas emissions and other negative externalities. While implementing such a Global Plastics Protocol would lift the *average* profitability of plastic packaging recycling, significant challenges remain for specific packaging segments, such as technological barriers for sorting post-consumer films. Also, the estimates in this report are based on current plastics prices. If these change significantly, the economics of the recycling situation could become very different too.

FIGURE 5: POTENTIAL IMPACT OF GLOBAL PLASTICS PROTOCOL IMPLEMENTATION ON THE ECONOMICS OF PLASTIC PACKAGING RECYCLING (AVERAGE FOR MIXED PLASTIC PACKAGING COLLECTED IN EU MEMBER STATES)



* Value is calculated as average net cost/benefit of collection, sorting and recycling relative to net cost of collect/dispose alternative; and as an average across geographies, materials and formats – some market segments have much better economics, some have worse.

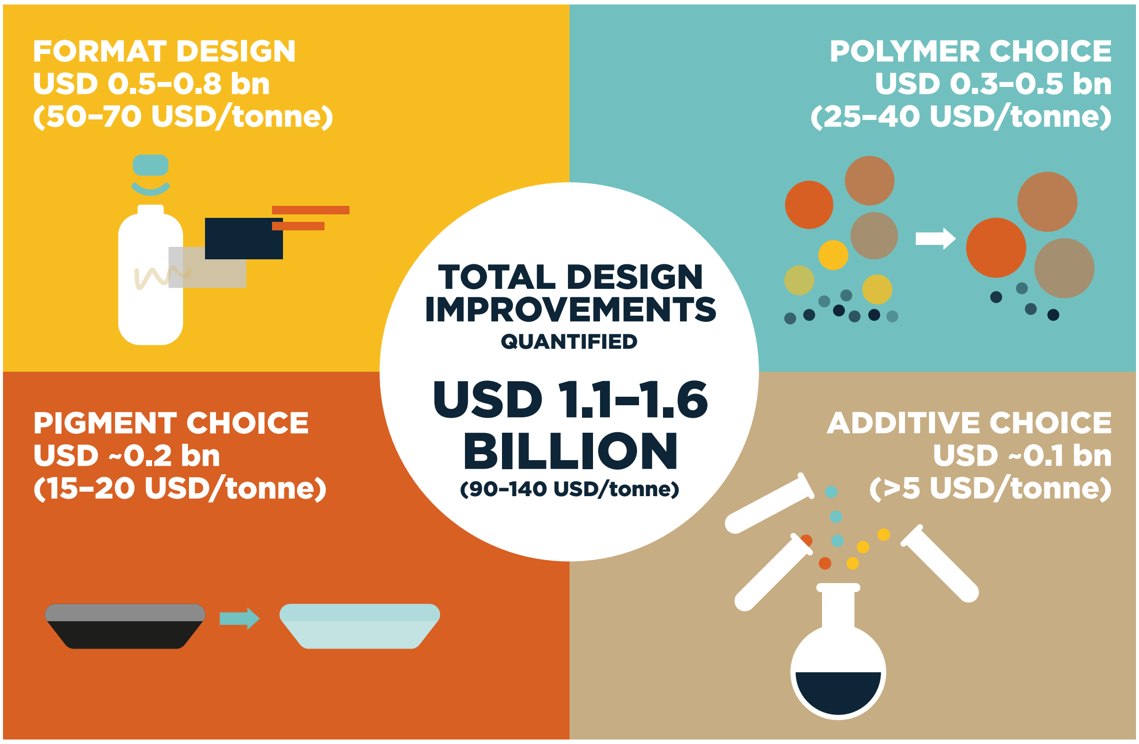
Source: New Plastics Economy initiative and SYSTEMIQ analysis (see Appendix for details)

PACKAGING DESIGN IMPROVEMENTS COULD CREATE AT LEAST USD 90-140 PER TONNE OF PLASTIC PACKAGING COLLECTED.

Packaging design has a direct and significant impact on the economics of collection, sorting and recycling. The choice of materials, colours, formats and other design factors determines whether a packaging item will generate positive after-use revenues – and how much – if it is recycled, or whether it will lead to the additional cost of disposal otherwise. Non-recyclable items entering the recycling stream incur an estimated additional net cost of up to USD 300-350 per tonne collected, compared with designs that are easily recyclable.[68] For example, with their low recyclability compared to clear bottles, opaque PET bottles (about 5,000-6,000 tonnes sold in France alone each year)[69] add an estimated USD 1-2 million a year in avoidable costs to the French recycling system.[70]

Implementing four areas of packaging design changes could have a positive impact on recycling economics amounting to USD 90-140 per tonne collected (USD 1.1-1.6 billion in OECD).[71]

FIGURE 6: ECONOMIC VALUE CREATION POTENTIAL OF SELECTED DESIGN CHANGES IN FOUR AREAS (ABSOLUTE VALUE FOR OECD REGION; USD; VALUE PER TONNE OF MIXED PLASTIC PACKAGING COLLECTED, USD/TONNE)



Source: New Plastics Economy initiative and SYSTEMIQ analysis (see Appendix for details)

The four areas for which impact has been quantified are (see Figure 6):

1. **Format design (USD 50-70 per tonne).** Format design improvements can have a direct and significant impact on the recycling economics, depending on the type of packaging. Examples include design choices relating to: labels; sleeves; inks and direct printing; glues; closures and closure liners; (silicone) valves, pumps and triggers; attachments and tear-offs; and the form or shape of the packaging. For example, one industry study from the Association of Plastic Recyclers identified that full sleeve shrink labels on PET bottles alone could affect recycler economics by USD 44-88 per tonne of recycled PET produced.[72] Input from industry experts and studies indicate that up to 15% of mixed plastic packaging collected is lost during sorting and recycling because of format design issues.[73] Assuming that format design improvements, excluding the changes below, can reduce material losses by 7.5% of plastic packaging collected (i.e. half of the estimated losses), this would lead to economic benefits of USD 50-70 per tonne of mixed plastic packaging collected.

2. **Polymer choice (USD 25-40 per tonne)**. As pointed out earlier, plastic materials uncommon in packaging are rarely recycled because they do not benefit from economies of scale

in sorting and recycling, and they can also hinder the recycling process of more prevalent polymers. As an example, replacing PVC in packaging applications by more common polymers would remove a source of contamination in the PET recycling process and thus positively impact the yield and recycled PET price. In addition, such replacement would turn collection and disposal costs of unwanted PVC into increased recycling volumes and revenues. Combining these effects, replacing all rigid PVC (1.5%-2% of plastic packaging market) by more widely recycled polymers would lead to an economic benefit of USD 15-20 per tonne of mixed plastic packaging collected. In addition, replacing PS and EPS as packaging materials (6% of the market) with more common polymers would improve system economics in a similar way, by an estimated USD 15-20 per tonne of mixed plastic packaging collected. As noted earlier in this report, implementing this change is an acceleration of an existing evolution rather than a revolution. The shares of these materials in the global packaging market are already declining.[74]

3. **Pigment choice (USD 15-20 per tonne).** Colouring plastics using pigments reduces the value of the recycled materials (up to USD 100-300 per tonne of recyclate).[75] Therefore, moving a greater share of plastic packaging from coloured or opaque materials to clear or light-coloured translucent materials would create substantial value in the after-use system. As an example, shifting an estimated three quarters of coloured rigid plastic packaging represents an economic opportunity of USD 10-15 per tonne of mixed plastic packaging collected. Werner & Mertz is one example of a company explicitly choosing not to colour its high-density polyethylene (HDPE) detergent bottles to allow the material to serve again as a bottle in its next-use cycles.[76] Also, phasing out the carbon black pigment in plastic packaging would reduce losses in the sorting process, as it is not detected by near-infra-red machines commonly used for automatic sorting. These sorting losses result in an avoidable cost of about USD 200 per tonne of such packaging collected for recycling, compared with packaging without carbon black. Looking at the total plastic packaging market, it is estimated that if all carbon black (used in 1.5%-2% of packaging, by weight) was replaced by other pigments already available, this would generate an economic benefit of USD 3-5 per tonne of mixed plastic packaging collected.[77]

4. **Additive choice (at least USD 5 per tonne).** Packaging design guidelines and expert interviews highlight that certain additives used in plastic packaging have a negative impact on recycling, even though the precise extent is unclear.[78] For example, PET bottle-to-bottle recyclers have reported discolouration of the recycled material[79] due to certain additives, leading to an estimated 30% decrease in revenues, or up to USD 300 per tonne of recyclate at current prices, for that specific material. If 2% of the bottle-to-bottle recycled PET is impacted in this way, it represents a USD 0.5-1 per tonne of plastic packaging collected across the board. In addition, certain additives affect the density of plastics, leading to avoidable losses during float-sink sorting processes.[80] For each tonne of plastic affected in this way, the additional cost to the after-use system is an estimated USD 300-350. Assuming 2% of polyolefins collected for recycling are lost in this way, replacing them by additives without density effects would increase the value by about USD 3-5 per tonne of mixed plastic packaging collected. More research is needed to understand the full effect of plastic additives, particularly if the recycling system continues to move to higher-quality processes and products.

The above estimates can be considered conservative as they provide a snapshot of economic opportunities from improving packaging design in the current after-use system, without the more complex effects and interdependencies that could lead to higher economic benefits. For example, the impact of certain design improvements is likely to be more apparent in a higher-quality recycling setting, compared with down-cycling processes that are more tolerant of diverse inputs and are still common nowadays.

To successfully implement the design changes above, communication between packaging designers at the front end and the after-use processors at the back end is an important enabler. Such feedback loops would also help to understand further design-improvement potential.

AS A KEY COMPLEMENT TO DESIGN IMPROVEMENTS, HARMONISATION OF AFTER-USE SYSTEMS COULD ENHANCE RECYCLING ECONOMICS BY AN ESTIMATED USD 100-150 PER TONNE OF COLLECTED PLASTIC.

Currently, collection and sorting systems are highly fragmented, negatively impacting the recycling economics. As discussed in more detail in *The New Plastics Economy – Rethinking the future of plastics*, after-use systems often operate at a small scale and with widely differing approaches, even within a given country or city. This disparity not only causes confusion for the wider public but also makes it hard for packaging designers to design for one target system, and it prevents the creation of economies of scale in the after-use system. This fragmentation also hinders delivery of consistent, high-quality material streams to recyclers, who frequently source materials from different collection systems and sorting plants. This complicates their operations and increases costs.[81]

Converging after-use collection and sorting systems towards good practice could improve plastic packaging recycling economics by an estimated USD 80-110 per tonne collected (USD 0.8-1.3 billion in OECD). This improvement estimate assumes that 75% of the total potential of successful harmonisation would be captured, including a range of good practices such as a cost structure in line with large-scale sorting facilities in Europe.[82] Of course, given the fragmented nature of the existing systems, such a harmonisation effort would take time. Encouragingly, multiple countries and regions (including British Columbia in Canada[83] and the UK[84]) recognise the benefits of this approach and have already started implementing a convergence agenda – a Global Plastics Protocol could play an important role in guiding this convergence worldwide.

At the reprocessing stage, a further scale-up of high-quality recycling, that is often low-quality today, could generate an estimated benefit of USD 30-40 per tonne collected (USD 0.3-0.5 billion in OECD). Increasing the share of high-quality recycling for plastic packaging would enable more high-value applications for the recycled material, with a corresponding increase in sales prices for recycled plastic. This approach has been adopted for PET bottle-to-bottle recycling facilities and is starting to be developed for other segments of the packaging market, particularly PE and PP.[85] While these two plastic types, compared with PET, might present additional challenges to achieving high-quality recycling (e.g., absorption of chemicals or odours), several companies have proven the feasibility of recycling these materials into high-quality applications including packaging (e.g., through the use of hot-washing and degassing).[86] Assuming that 25% of PE and PP recycling would shift to higher-quality recycling, the additional revenues, even minus the additional costs and yield losses, would generate an estimated benefit of USD 25-40 per tonne of mixed plastic packaging collected.

New technologies and approaches may provide further opportunities to improve the economics of the recycling system. There are multiple examples of such innovative technologies and approaches, even though it is too early in their development to quantify the potential impact. Material markers, such as chemical tracers or digital watermarks, are currently researched and piloted but industry views vary widely on their importance, feasibility and cost effectiveness.[87] Such markers could provide new sorting possibilities in regions where automatic sorting is available, resulting, for example, in an increasing opportunity to supply higher-value food grade plastics. Global convergence on marking standards would be required to maximise the impact. Finding a solution for sorting different types of flexible plastic packaging, a segment representing approximately one third of post-consumer packaging (by weight) and a production of around 1 trillion units a year, could significantly increase the volume of packaging available for recycling – although the impact on economics remains unclear.[88] Furthermore, depolymerisation (a chemical recycling process breaking down polymers into their monomer building blocks) could offer additional opportunities for high-quality recycling – a technology currently most advanced for polyesters like PET.

Combining continued innovation with further harmonisation of packaging design and after-use systems would drive a virtuous, positive spiral for the uptake, economics and quality of plastic packaging recycling. While the direct economic impact of implementing a Global Plastics Protocol would be sizeable, making recycling economically viable would also move the system into an upward spiral. There would be a financial incentive to collect and recycle more. Higher volumes would create further economies of scale and allow separation of purer grades, which, in turn, would increase yield. This would set a direct incentive for yet more collection and an indirect incentive for better material designs. Therefore, innovation and harmonisation both of packaging design and after-use systems are mutually reinforcing and the positive thrust they could generate would close the loop for a significantly higher share of plastic packaging, including more challenging segments. This upward spiral would eventually allow leakage and economic value loss to be overcome as recyclate quality steadily converges towards virgin material value.

GIVEN THE CURRENT FRAGILE RECYCLING ECONOMICS, A DEMAND-PULL FOR RECYCLED PLASTICS AND OTHER SUPPORTING POLICY MEASURES IS NEEDED TO START BUILDING POSITIVE MOMENTUM IN THE NEAR TERM.

Measures to support demand for recycled plastics would provide a critical incentive for system improvements. Voluntary industry commitments, public procurement policies and regulations can all create a demand-pull that can build positive momentum in the near term. Moreover, increased demand for *higher-quality* plastics, including for packaging, can be an impetus specifically for investments and improvements in the *high-quality* recycling processes outlined in this report. For example, the establishment of high-quality PET bottle-to-bottle recycling is often attributed in part to strong demand for recycled content from beverage companies[89] and California's Rigid Plastic Packaging Container Law (requiring producers of rigid containers to use at least 25% recycled content)[90] has been mentioned as a boost to HDPE recycling US-wide.[91] Similarly, these incentives could have an important impact on recycled PP and PE uptake, where high-quality recycling supply and demand is emerging but not yet widely seen.[92]

A range of other supporting policy measures could help trigger progress in the short term. Next to creating a demand-pull for recycled plastics, regulatory frameworks can provide other enabling conditions for enhancing the uptake, economics and quality of plastic packaging recycling. Such policy measures could include: recycling targets; levies and/or bans on landfilling and incineration; carbon or resource taxes; extended producer responsibility (EPR) schemes supporting after-use systems; deposit-for-recycling systems; and others. Within this context, it should be noted that, as part of the redesigned and reused packaging will lead also to recycling, the 50% mentioned in this chapter should not be considered as an upper limit for a recycling target. In addition, regulatory policies could specifically support the adoption of good design practices through, for example, eco-design rules or more granular (adaptive) EPR schemes with contributions differentiated per packaging design criteria. All these policy measures come with advantages and disadvantages, which would need to be carefully examined in local context before implementation. They have not been the focus of this report but merit further investigation.

DUE TO THEIR DIFFERENT STARTING POINTS, MATURE AND EMERGING ECONOMIES REQUIRE DISTINCT PATHS TOWARDS ADOPTING A GLOBAL PLASTICS PROTOCOL, BUT IMPROVING PACKAGING DESIGN IS A CRITICAL LEVER FOR BOTH.

Unlike mature markets, emerging economies often require the deployment of basic collection infrastructure as a critical short-term action. In most mature economies, the vast majority of plastic packaging gets picked up in a formal collection system, whereas in emerging economies, a substantial share often goes uncollected and ends up in natural systems or clogs urban infrastructure. In such regions, a critical first step often is deploying basic collection infrastructure. This report does not look in detail at the solutions to plastics leakage in these countries, as they have been proposed by other initiatives, including local projects such as the Mother Earth Foundation and Coastal Cleanup, both in the Philippines, and global efforts such as the Trash Free Seas Alliance®, initiated by the Ocean Conservancy.[93]

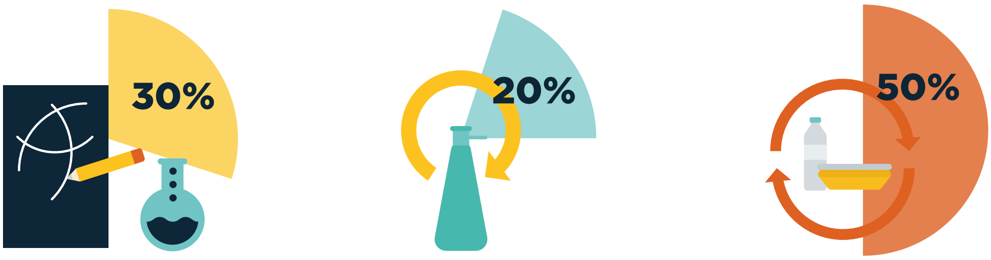
Adopting a Global Plastics Protocol that improves packaging design and after-use processes would make an important contribution to both mature and emerging economies. While the impact modelling in this report is mainly focused on OECD countries, many of its insights are relevant for both mature and emerging markets. This particularly holds true for design improvements. Various studies indicate that waste-pickers operating in the informal sector collect high-value but not low-value plastics.[94] This means designing plastic packaging for increased after-use value would result in higher collection rates and possibly higher incomes for waste-pickers – and would improve the economics of deploying formal collection infrastructure. At the same time, adoption of a Global Plastics Protocol would offer the opportunity to ensure the use of benign materials worldwide, reducing exposure to substances of concern.

PRIORITY ACTIONS TO ENHANCE THE UPTAKE, QUALITY AND ECONOMICS OF RECYCLING ARE:

- Implement design changes in plastic packaging to improve recycling quality and economics (e.g., choices of materials, additives and formats) as a first step towards a Global Plastics Protocol
- Harmonise and adopt best practices for collection and sorting systems, also as part of a Global Plastics Protocol
- Scale up high-quality recycling processes
- Explore the potential of material markers to increase sorting yields and quality
- Develop and deploy innovative sorting mechanisms for post-consumer flexible films
- Boost demand for recycled plastics through voluntary commitments or policy instruments, and explore other policy measures to support recycling
- Deploy adequate collection and sorting infrastructure where it is not yet in place

Figure 7 presents an overview of the priority actions identified for global plastic value chain. These actions will mobilise the distinct transition strategies for the three plastic packaging categories (covering the entire market) as discussed in this chapter.

FIGURE 7: PRIORITY ACTIONS FOR THE GLOBAL PLASTIC PACKAGING VALUE CHAIN TO MOBILISE THE THREE TRANSITION STRATEGIES TOWARDS THE NEW PLASTICS ECONOMY



FUNDAMENTAL REDESIGN & INNOVATION	REUSE	RECYCLING WITH RADICALLY IMPROVED ECONOMICS & QUALITY
• Fundamentally redesign the packaging formats and delivery models (and after-use systems) for small-format plastic packaging, avoiding such small formats where relevant and possible	• Innovate towards creative, new delivery models based on reusable packaging	• Implement design changes in plastic packaging to improve recycling quality and economics (e.g. choices of materials, additives, and formats), as a first step towards a Global Plastics Protocol
• Boost material innovation in recyclable or compostable alternatives to the currently unrecyclable multi-material applications as described above	• Replace single-use plastic carrier bags by reusable alternatives	• Harmonise and adopt best practices for collection and sorting systems, also as part of a Global Plastics Protocol
• Replace PVC, PS, and EPS, as a priority, as uncommon packaging materials with alternatives (converging to a few key materials being used across most of the market, while continuing to allow for innovation)	• Scale up reusable packaging in a business-to-business setting for both large rigid packaging and pallet wrap	• Scale up high-quality recycling processes
• Scale up compostable packaging and related infrastructure for targeted nutrient-contaminated applications		• Explore the potential of material markers to increase sorting yields and quality
• Explore the potential as well as the limitations of chemical recycling and other technologies, to reprocess currently unrecyclable plastic packaging into new plastics feedstocks		• Develop and deploy innovative sorting mechanisms for post-consumer flexible films
		• Boost demand for recycled plastics through voluntary commitments or policy instruments, and explore other policy measures to support recycling
		• Deploy adequate collection and sorting infrastructure where it is not yet in place

Source: New Plastics Economy initiative analysis

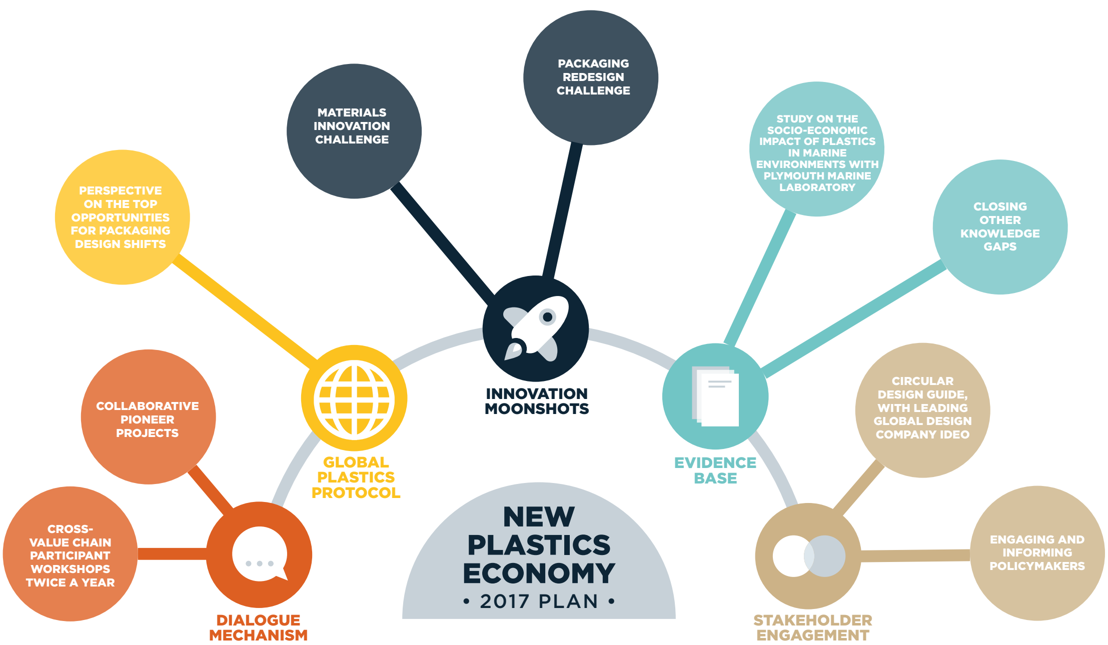
THE NEW PLASTICS ECONOMY INITIATIVE: A CATALYST FOR CHANGE

The New Plastics Economy Initiative: A Catalyst for Change

The New Plastics Economy is an ambitious, three-year initiative to build momentum towards a plastics system that works. Applying the principles of the circular economy, the initiative brings together key stakeholders to rethink and redesign the future of plastics, starting with packaging. Launched in May 2016, the initiative is spearheaded by the Ellen MacArthur Foundation, in collaboration with a broad group of leading companies, cities, philanthropists, policy-makers, designers, academics, students and NGOs.

The New Plastics Economy focuses on five interlinked and mutually reinforcing building blocks to create the enabling conditions for a transformative system shift. These building blocks are: Dialogue Mechanism; Global Plastics Protocol; Innovation Moonshots; Evidence Base; and Stakeholder Engagement. Since its inception, the initiative has made significant progress across all these key elements. Based on the analysis and insights from this report, the New Plastics Economy initiative has now defined a series of focus *catalyst actions* to drive further progress in 2017 (see Figure 8).

FIGURE 8: OVERVIEW OF THE NEW PLASTICS ECONOMY INITIATIVE'S FIVE BUILDING BLOCKS AND 2017 CATALYST ACTIONS



Source: New Plastics Economy initiative analysis

The Dialogue Mechanism places cross-value chain collaboration at the heart of the New Plastics Economy initiative.

It brings together a group of global consumer goods companies, retailers, plastics producers and packaging manufacturers, governments, cities and businesses involved in plastics collection, sorting and reprocessing. This group informs the other building blocks and the initiative's direction more broadly, together with the joint philanthropic-business advisory board and a group of civil society representatives.

Concrete actions within the Dialogue Mechanism include biannual *participant workshops* and the implementation of collaborative *pioneer projects*. The first two participant workshops took place in May 2016 and December 2016, bringing together a group of about 40 participant organisations and initiating the first collaborative pioneer projects.

In 2017, the initiative will continue to host six-monthly participant workshops and drive implementation of the collaborative pioneer projects launched in 2016.

The Global Plastics Protocol aims to provide a common target, helping to overcome existing fragmentation and enable the creation of effective markets. Today's ineffective plastics economy is the result of decades of highly fragmented, uncoordinated and incremental innovation, which has not been able to make progress on economic value capture and negative externalities. By fundamentally rethinking the system and driving convergence, the Global Plastics Protocol enables the creation of effective markets.

In 2016, the potential economic impact of a Global Plastics Protocol was assessed and the analysis clearly indicated that the implementation of changes to design and after-use systems as part of such a protocol would improve the economics of plastic packaging recycling.

In 2017, the initiative will take the next step towards the concrete development of a Global Plastics Protocol. It will collaboratively determine the top opportunities for design changes to enhance recycling quality and economics, as well as material health.

The Innovation Moonshots programme aims to mobilise innovations that could redefine what is possible across the whole system and create the conditions for a new economy. The global economy is being rewired by digitisation, automation and artificial intelligence. Fields as disparate as biology, engineering and design are merging, making the time for such moonshots now.

In 2016, over 100 experts from academia, industry, start-ups and disruptive innovators, NGOs and emerging markets were engaged in exploring which areas of innovation could be mobilised as a priority and through which mechanisms. Three key insights emerged through these consultations:

- The Innovation Moonshots programme should initially focus primarily on the most challenging segment of the market; i.e. the 30% of plastic packaging for which currently there is no viable reuse or recycling pathway.
- Alongside innovations aimed at solving *today's* priority challenges, the initiative should explore the potential of more disruptive innovations, which, if successful, could redefine the entire plastics system in the future. Just a few examples of such innovations include: 3D printing and other additive manufacturing; a universal identification system for all (packaging) materials; high-quality chemical recycling of complex and contaminated material streams; and triggers for biodegradation (e.g., like a banana skin).
- There is no one silver bullet moonshot; multiple innovations are required to further accelerate the transition to the New Plastics Economy.

In 2017, the Innovation Moonshots programme will focus on the 30% of plastic packaging for which fundamental redesign and innovation are required. It will inspire a generation of material innovators by launching a challenge to find recyclable or compostable alternatives to materials for which there is no viable reuse or recycling pathway today. It will ignite a programme of redesign by launching a contest to redesign formats and delivery models that can address, for example, some of the most challenging small-format packaging.

The Evidence Base offers a robust foundation from which to guide improvement and inform the global debate. It closes critical knowledge gaps by building an economic and scientific knowledge base from which to draw insights.

In 2016, the initiative has focused its Evidence Base efforts on the creation of this report. This included a granular, segment-by-segment analysis of the plastic packaging market to define an action plan for the global value chain that would accelerate the transition to the New Plastics Economy. This analytical work has been supported by SYSTEMIQ.

In 2017, the initiative will drive progress on different knowledge pieces by:

- Finalising an ongoing study, together with Plymouth Marine Laboratory, to understand the socio-economic impact of plastics in marine environments – a large-scale literature review is ongoing to extract insights, understand existing knowledge gaps and determine research priorities
- Bridge other knowledge gaps such as, for example, the potential and limitations of material markers and chemical recycling

Stakeholder Engagement involves a wide set of key players across the system to learn from, to inform and to work with on amplifying solutions. Businesses, policy-makers, students, educators, academics, designers, citizens, NGOs, industry associations and other stakeholders all play a role in transitioning to a new system – the initiative learns from, informs and engages all these stakeholders.

In 2016, insights and recommendations from *The New Plastics Economy – Rethinking the future of plastics* reached millions of people around the world. Thousands of news articles were published across five continents highlighting the report's insights, including coverage in in the *Financial Times*, *USA Today*, *The Guardian*, *Times of India*, *CNN* and *Al Jazeera*. High-powered individuals including US Secretary of State John Kerry, Academy Award-winning actor Leonardo DiCaprio, various Members of the European Parliament, and founder of *The Huffington Post* Arianna Huffington, have quoted the report publicly. Their recognition of the report indicates its contribution to raising awareness of plastics issues and – importantly – the need for solutions. The report was one of the most successful topics on social media to date of the World Economic Forum, with an estimated reach of millions of people. Members of the New Plastics Economy initiative team have presented the initiative's vision and recommendations at over 20 conferences and high-level meetings, including the World Economic Forum Annual Meeting 2016 in Davos-Klosters, the Our Ocean 2016 conference, the UN COP22 climate conference in Marrakech, and multiple high-level industry and policy-maker events. To understand how future generations of designers and innovators could be informed and inspired at scale, the initiative piloted in November a prototype workshop on redesigning plastic packaging specifically tailored to school pupils in Scotland, who learned about the New Plastics Economy and participated in an immersive plastics packaging redesign activity.

In 2017, the initiative will continue to reach out to the wider stakeholder group, with a focus on designers, whose involvement is essential for successful action on each of the three transition strategies outlined in this report, and on policy-makers, who can trigger progress in the near term by setting the right enabling conditions. The initiative has partnered with IDEO, a leading design and innovation consultancy, to develop the Circular Design Guide – an inspiring, online reference point on circular design, to inspire and support designers, innovators and change-makers to rethink and redesign products, delivery models and the broader ecosystems. Being co-created and prototyped with leading universities, entrepreneurs and corporates, it is available as a freely accessible website featuring over 20 practical methods (circulardesignguide.com), which will be further developed in 2017. In parallel, the initiative will build on the prototype workshop piloted in Scotland to explore how to reach an entire next generation of designers at scale. Policy-makers will be further engaged and informed through sharing latest insights at various meetings and gatherings.

How to measure success? The success of these actions will be measured against the three ambitions of the New Plastics Economy. A key metric to measure success in *creating an effective after-use plastics economy* – the focus ambition of this update report – is the share of plastic packaging going into a circular after-use pathway (i.e. reuse, recycling or composting).

Regarding *drastically reducing leakage of plastics into natural systems and other negative externalities*, a key metric could be volume (tonnes) of plastics leaked into the environment. Success in reducing other negative externalities, such as the impact of substances of concern on human health and the environment, would need separate metrics.

For *decoupling plastics from fossil feedstocks*, a key metric could be the quantity of oil and gas used as virgin feedstocks for plastic packaging. Decreasing this volume could be realised by increasing reuse and recycling rates, reducing total production volumes, and exploring and adopting renewably sourced feedstocks.

Taking the actions outlined in this report will contribute to achieving these ambitions, which together represent a systemic shift and the advent of an economically and environmentally effective plastics system – a New Plastics Economy.

APPENDIX: KEY ANALYTICAL ASSUMPTIONS

Appendix: Key Analytical Assumptions

The insights described in this report are the result of a detailed segment-by-segment analysis of the plastic packaging landscape, many of which are revealed for the first time. By its very nature, this requires assumptions, which are laid out below. When the analysis uses existing data, the sources are mentioned.

ANALYSIS ON "REDESIGN AND INNOVATE" SEGMENT (30% OF MARKET, BY WEIGHT)

Small-format packaging. The charity WRAP[95] found that about 12% (by weight) of plastic household packaging in materials recovery facilities (MRFs) ends up in the fines fraction (the samples were put on a 45mm x 45mm wire mesh and any articles that fell through the screen without assistance were classified as fines). Application of the 12% to the share of household packaging (about 70% of the plastic packaging market) in combination with the assumption that in business-to-business packaging the proportion of small-format items is only a third of that used in business-to-consumer packaging, results in an estimate of 9.5% of the market being made up of small-format items. This is in the same order of magnitude as the Austrian company Denkstatt's estimate of 7.5% based on data from Gesellschaft für Verpackungsmarktforschung, the German Society for Packaging Market Research.[96]

The share of small-format plastic packaging items in the market has been estimated based on a segmentation of the plastic packaging market volume by packaging type. This has been arrived at by allocating a lower-bound and upper-bound estimated average weight to each of those packaging segments (e.g., small format 1g-3g; PET bottles 10g-15g, etc.). This resulted in an estimated 35%-50% of all plastic packaging items being small-format.

Multi-material packaging. In 2011, the French Extended Producer Responsibility organisation, Eco-Emballages, reported that over 6% (by weight) of rigid household plastic packaging was multi-material.[97] Assuming none of the business-to-business rigid plastic packaging is multi-material, this represents 3% of total plastic packaging market volume. For the purposes of this report, it was estimated that around 26% (by weight) of all flexible plastic packaging is multi-material, which represents 10% of the total plastic packaging market by weight. This estimate is based on a US report on the flexible packaging market produced by the Flexible Packaging Association[98] and on analysis by the New Plastics Economy team. This is in line with estimates made by other industry experts during interviews. Together, this represents 13% of the plastic packaging market by weight.

Uncommon packaging plastic types. Volumes of plastic materials other than PE, PP and PET used in rigid and flexible plastic packaging are based on Smithers Pira market reports.[99] [100] The main uncommon plastic packaging materials are PS (4.7% of plastic packaging market by weight), PVC (2.5%) and EPS (1.3%). All others combined represent another 1.4% of the total global plastic packaging market by weight. Together, this represents around 10% of the plastic packaging market by weight.

Overlap. The three segments mentioned above overlap to some extent. A few straightforward assumptions were made when estimating this overlap, such as: share of small items is the same for uncommon packaging plastics and common packaging plastics; and all uncommon packaging plastics used in films are part of multi-layer films. Under these assumptions, the overall size of the segment requiring fundamental redesign and innovation is estimated at about 30% of the total global plastic packaging market by weight.

Share of plastic packaging items. This category represents at least 50% of all plastic packaging *items* (and 30% of market by weight) as it includes: (a) 35%-50% of all items which are small-format packaging (see above); and (b) multi-material packaging, uncommon plastic packaging materials and nutrient-contaminated packaging, which are collectively estimated to represent around 20% of the market by weight (taking into account the overlap discussed, and excluding small-format items) and at least as much in terms of number of items. The latter is based on the vast majority of multi-material packaging being flexible packaging (so low weight items), and typical applications of the other materials (e.g., PS used for yoghurt pots, PVC used for pharmaceutical blister packs, nutrient contamination happening in a takeaway food context) assumed to have at most an average packaging weight.

ANALYSIS ON "REUSE" SEGMENT (20% OF MARKET, BY WEIGHT)

Exchange rate. The euro to US dollar exchange rate used was USD 1.185 per EUR 1, which is the average exchange rate for January 2014 to October 2016.[101] This exchange rate has also been used for the analyses on recycling.

Personal- and home-care bottles. Analysis for this sector was based on confidential data from companies active in this segment. Numbers shown in this report assume 10 to 15 refills per bottle. The percentage savings from these companies' business models were applied to all bottles (i.e. PET, HDPE and others) in the beauty and personal-care sector, as well as in home care, based on Euromonitor 2015 data.[102] The economic value opportunity depends on the type of reuse model and the underlying costs and revenues. The potential for refill models based on selling and shipping active ingredients only could go beyond personal and home-care applications, but this was not included in the analysis.

Carrier bags. This analysis starts from a global annual production of 2.5 million tonnes or around 330 billion units of single-use plastic carrier bags – an estimate based on a calibration of data from different sources, including: the number of carrier bags put on the market in the UK;[103] a Denkstatt report showing that plastic carrier bags represent 3.2% of after-use plastic packaging in the EU by weight;[104] US single-use plastic packaging production of around 100 billion bags;[105] European single-use plastic packaging production of 0.77 million tonnes;[106] and estimated global single-use carrier bag production of 500 to 1,000 billion bags a year.[107] The conversion from volume (tonnes) to units (bags) is based on a study by Zero Waste Scotland.[108]

Beverage bottles. The starting point for this analysis was a global production figure of 12.5 million tonnes of PET beverage bottles.[109] In Germany, around 20%-25% of PET beverage bottles are refillable.[110] Acknowledging that not all regions in the world have the infrastructure or ability to organise such return-systems, the applicable, densely populated region was approximated by the global urbanisation rate (52%).[111] Combining these numbers, a reuse model is estimated to offer economic and environmental benefits for at least 10% of all beverage bottles worldwide, or at least 2% of the global plastic packaging market.

Business-to-business large rigid packaging. The share of large rigid items in the global plastic packaging market is based on the UK share of large rigid items in the total non-bottle rigid business-to-business plastic packaging market (35%) applied to the share of non-bottle rigid business-to-business plastic packaging in the global plastic packaging market (6%).

Business-to-business pallet wrap. The volume of pallet wrap is based on a global production of stretch wrap used as pallet wrap of around 4 million tonnes (taken from HJResearch, *Global Stretch Wrap Industry Market Research 2016)*. This number is then expanded to include stretch and shrink hoods based on the European split of pallet wrap by type (stretch wrap represents 70% of total pallet wrap in Europe, and stretch and shrink hoods the other 30%; outlined in the Applied Market Information Ltd – AMI consulting, *Palletisation Films Europe 2016* report), leading to an estimated annual pallet wrap film production of 5 million-6 million tonnes.

ANALYSIS ON "RECYCLE" SEGMENT (REMAINING SHARE OF THE MARKET)

Baseline model. The baseline for the recycling analysis is calculated from EU member states (EU-28) average costs, yields and net greenhouse gas emissions of collection, sorting, recycling and disposal of plastic packaging as published by

Plastic Recyclers Europe (PRE)/Deloitte.[112] It follows the 2012 baseline inputs in that published model with adjustments made for the average price decrease in recycled PET since 2012. Operational costs include amortised investment costs for each stage and use EU-28 average costs of sorting and recycling, assuming no export of plastics for recycling outside the EU. All numbers are EU-28 averages and it should be noted that the economics of recycling vary significantly across countries, regions, packaging types and uses of packaging (e.g., consumer or industrial). The estimated net cost of mixed plastic packaging collection, sorting and recycling also assumes local processing without the export of plastics for recycling outside the region.

The analysis covers the costs related to the share of plastic packaging collected for recycling (about 40% of all plastic packaging put into the market in EU, with collection systems in many countries targeting the packaging that is easiest to recycle[113]). Costs related to other plastic packaging items not collected for recycling (e.g., a segment of residual waste collection) are not part of the scope of this analysis. All cost-per-tonne values are costs per tonne of plastic packaging collected for recycling.

The baseline has been adapted to allow a more granular approach for modelling system improvements: by consumer versus industrial; by resin type; and by format (flexible, rigid). Several experts in collection, sorting and recycling have reviewed the data inputs for the baseline model.

When the costs of collection, sorting, and recycling are compared with collection and disposal of plastic packaging as part of residual waste, disposal was modelled as a 50/50 ratio between landfill and incineration with energy recovery. This gives an estimated average cost of collection and disposal of residual waste of USD 200 per tonne.[114]

Results expressed as total value for OECD have been scaled up from the EU-28 analysis, as based on the plastic packaging volume collected for recycling in OECD countries, which is estimated at 11 million tonnes a year.[115]

Lever quantification. Levers are applied to the baseline model assuming an inferred effect on cost, yield and recyclate price. To keep costs comparable to the baseline, no changes have been assumed in the volumes collected. The effect of higher capital investment costs on operational cost (which already includes amortised investment costs) is not incorporated in the model. The inputs used for quantifying the impact of these levers have been drawn from published material, case examples, expert interviews and assumptions as shown below. For calculating the effect of packaging design improvements, a synergy effect on the average price of recycled plastic (+8%) is assumed to account for the cumulative effect of applying design and after-use levers together (effect of higher-quality recycling on average plastic prices).

Format design. The report uses a top-down estimate of the effect of improving format design specific to types of plastic packaging. Examples include design choices relating to labels, sleeves, inks and direct printing, glues, closures and closure liners, valves, pumps and triggers, attachments or tear-offs, and form or shape of packaging. Expert interviews and published reports indicate that format design changes (not including material, pigment and additive changes already considered in other design levers) could avoid material losses during sorting or recycling of up to 15% of plastic packaging collected (compared with 38% material loss in the overall sorting and recycling process).[116] This lever assumes that format design improvements would reduce the overall material losses by 7.5% (half of the material losses attributable to format design issues).

Material choices.

- **PVC**: One percentage point increase in recycling yields is assumed for PET recycling due to avoided sorting losses prior to the extrusion (reprocessing) stage as the removal of PVC would lead to unintended losses of recyclable material. A small increase in the average price of recycled PET is modelled (+3%) to account for the effect of PVC contamination on optical and mechanical properties of recycled PET, and the substitution of rigid PVC for alternatives that are more likely to be recycled, reduces cost and increases value for the recycling system.

- **EPS/PS**: It is assumed that EPS and PS in plastic packaging are not recycled in most countries because they are present in small volumes and do not warrant investment in additional sorting equipment. The model estimates the effect of substituting EPS/PS for materials that are more likely to be recycled (e.g., PET, PE, PP resins). Recyclers also indicated that PS can affect the extrusion (reprocessing) of other plastics. This effect, however, is not included in the calculation.

Pigment choices. Packaging with carbon black pigment cannot be detected by near-infrared (NIR) sorting equipment used in most sorting facilities. Calculations assume that packaging with carbon black is collected for recycling at the same average rate as other plastic packaging, then lost into the residual waste stream during sorting. The share of packaging with carbon black follows published estimates at 1.5%-2% of packaging.[117] This lever assumes all carbon black is replaced by other NIR-detectable pigments. It is assumed that opaque PET bottles are not to be recycled, based on recycler input, and for this calculation they have been switched to a recycled alternatives (assumed to be 0.25% of the packaging stream[118]). In addition, calculations assume a switch from coloured packaging to clear or light-coloured translucent plastics, with an average 10%-20% increase in price for clear or light-coloured recycled plastic (depending on the type of plastic). Share of coloured plastics (excluding carbon black) in the packaging stream is estimated at 25% based on published information.[119] This improvement lever assumes that three quarters of that segment could be switched.

Additive choices. A small effect of additives in plastics used for packaging is included in this model (in total, about USD 5 per tonne of mixed plastics packaging collected) to account for discolouration of recycled PET, and density issues causing avoidable losses in the recycling system (e.g., losses in float-sink separation). Calculations assume 2% of the recycled bottle PET is impacted by discolouration and 2% of polyolefins collected for recycling are lost at the reprocessing facility due to density-affecting additives. The effect of additives is a subject for further investigation and could become more significant in higher-quality recycling processes.

Harmonised collection and sorting. Improvements are based on expert input on the effect of harmonising collection and sorting systems and adopting best practices. Collection and sorting performance are tightly linked, since harmonised collection makes for easier sorting. To avoid double-counting of effects the following assumptions are made:

- Sorting yields for rigid packaging increased to good-practice estimates of 85% (rigids) and 90% (PET bottles).
- Average sorting cost is reduced to proven good-practice example of about USD 120 per tonne (as already achieved by large-scale sorting facilities in Europe[120]).
- Small increase in recycling yield (two percentage points) to account for improved quality of inputs to reprocessing facilities.
- No change in collection cost is modelled as it is assumed that good-practice cost reductions would be balanced out by additional transport distances (since large sorting facilities would be further apart).
- For the purposes of modelling, it is estimated that good-practice effects (i.e., all assumptions listed above) are achieved in 75% of cases, as not all regions have a high enough population density to allow for large-scale sorting plants, and lower collection and transport costs; and for other, non-technical (e.g., geopolitical) reasons.
- No effect on quality of recycled product is modelled, although this would be expected if the raw material supply to recyclers was improved.

Shift to high-quality recycling for PE and PP. Higher-quality polyolefin recycling would enable significant (about 50%) increases in the average sale price for recycled plastics, offset, however, by higher (by about 15%) recycling costs and reduced (by five percentage points) recycling yields due to more rigorous sorting.[121] It is assumed that 25% of the polyolefin market would move to higher-quality recycling under a good-practice model.

Acknowledgements and Disclaimer

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DISCLAIMER

This report has been produced by a team from the Ellen MacArthur Foundation, which takes full responsibility for the report's contents and conclusions. While the New Plastics Economy Advisory Board members, participants and experts consulted have provided significant input to the development of this report, their involvement does not necessarily imply endorsement of the report's contents or conclusions.

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Endnotes

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13 Both in their "realistic" and "very optimistic" scenario Denkstatt estimated the maximum recycling potential of small packaging items to be zero. Denkstatt, *Criteria for eco-efficient (sustainable) plastic recycling and waste management – Fact based findings from 20 years of Denkstatt studies, Background report for associated presentation* (2014).

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15 Multiple experts confirmed they are not aware of any sorting facilities recovering small-format plastic items from the fines fraction. Also Denkstatt estimated the maximum eco-efficient material recycling rate to be zero for this segment, even in their "very optimistic scenario" (Denkstatt, *Criteria for eco-efficient (sustainable) plastic recycling and waste management: Fact based findings from 20 years of Denkstatt studies, Background report for associated presentation,* 2014).

16 PVC 2.5% of global plastic packaging market; EPS 1.3%; PS 4.7%; other less common packaging plastic together 1.4%. New Plastics Economy Analysis based on Smithers Pira, *The Future of Global Rigid Plastic Packaging to 2020* (2015) and Smithers Pira, *The Future of Global Flexible Packaging to 2018* (2013).

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18 Expert interviews with owners of sorting facilities, experts in sorting technology and producer responsibility organisations.

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24 Rick Lingle, *Tyson Foods debuts the first 100 percent recyclable stand-up pouch (Packaging Digest*, http://www.packagingdigest.com/flexible-packaging/tyson-foods-debuts-first-100-percent-recyclable-stand-pouch, 2013).

25 Experts indicate there is a risk regarding substances of concern (e.g. pyrolysis produces filtrates containing a range of substances), even though perceived lower than for incineration (e.g. generation of gaseous substances of concern is generally lower). As explained, further detailed research is needed and falls outside the scope of this report.

26 Saperatec delaminates composite materials using micro-emulsions. It plans to build a first industrial-scale plant for multi-material packaging in 2017 (http://www.saperatec.de).

27 Lab-scale activities to delaminate multi-layer film indicated that it is possible to separate the layers and remove the ink that was between them (http://cadeldeinking.com/en/).

28 APK dissolves one polymer (at a time), which may be present in one or more layers. It has one industrial-scale plant in operation today (https://www.apk-ag.de/en/).

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A" packaging target (*PackagingNews*, http://www.packagingnews.co.uk/news/marks-and-spencer-packaging-target-08-06-2012, 2012)); McDonald's began to phase out its iconic clamshell foam hamburger box in 1990 and is now phasing out styrofoam beverage cups. Alternatives exist for EPS, for example, as shipment protection (e.g., Ecovative's mushroom-based Myco Foam, see http://www.ecovativedesign.com/) or for fish boxes (e.g. CoolSeal Packaging, see www.coolseal.co.uk).

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63 This is the additional cost of collection, sorting and recycling over the cost of collection and disposal of plastic packaging as part of residual waste. The cost of collection, sorting and recycling plastic packaging and of disposal of residues and contamination minus the sales of recycled plastics is around USD 325-485 per tonne collected, assuming all sorting and recycling activities take place in OECD (i.e., no export to non-OECD countries). The cost of collection and disposal of plastic packaging as part of residual waste results in a net cost of around USD 170-250 per tonne collected, assuming disposal consists of a 50/50 ratio between landfill and incineration with energy recovery. All cost figures are averages across very different collection, sorting, recycling and disposal systems in EU countries and across different packaging types, and, therefore, could differ significantly for specific countries or packaging types. See Appendix for more details.

64 Calculation for greenhouse gas emissions avoided based on Deloitte, *Increased EU Plastics Recycling Targets: Environmental, Economic and Social Impact Assessment – Final Report* (2015). A 50/50 ratio between landfill and incineration with energy recovery is assumed.

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68 Assuming non-recyclable item gets collected for recycling and is removed at recycling facility and incurs cost of collection, sorting, residual waste disposal, and estimated one third of recycling cost (for recycler to sort out the material). Cost of treatment is compared to a substitute item that follows average cost and yield for collection, sorting and recycling plastic packaging. Average cost and yield data based on Deloitte, *Increased EU Plastics Recycling Targets: Environmental, Economic and Social Impact Assessment – Final Report* (2015).

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71 Numbers in this and following sections have been rounded for ease of communication; this explains small difference between economic benefit of individual levers, and total economic benefit.

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74 Price difference for coloured versus clear or light-coloured translucent recyclate is dependent on the resin, market and application. Estimated range is based on interviews with recyclers.

75 Ibid.

76 Werner & Mertz website states: "colouring of the plastic is avoided as this is the only way to continue maintaining a recyclate in the technical cycle and make sure the used bottles can serve as raw material source for new bottles". (http://wmprof.com/en/int/news_7/2016/world_innovation__first_pe_bottle_based_on_100___pcr__hdpe/world_innovation__first_pe-bottle_based_on_100___pcr__hdpe.html).

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81 Interviews with European plastics recyclers consistently highlight the challenge of diverse, variable and contaminated source materials.

82 See Appendix for more details.

83 Multi-Material British Columbia, a non-profit organisation, is financed by industry to manage residential packaging recycling programmes. For more details, see World Economic Forum, Ellen MacArthur Foundation and McKinsey & Company, *The New Plastics Economy – Rethinking the future of plastics* (2016, http://www.ellenmacarthurfoundation.org/publications).

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86 Werner & Mertz has recently launched a 100% post-consumer recycled HDPE bottle (*Werner & Mertz Professional presents its first PE-bottle based on 100% Post-Consumer-Recycled (PCR) HDPE* (http://wmprof.com/en/int/news_7/2016/world_innovation__first_pe_bottle_based_on_100___pcr__hdpe/world_innovation__first_pe-bottle_based_on_100___pcr__hdpe.html, 2016)); QCP is another example of a recently founded recycling company aiming for high-quality recycling of PE and PP (interviews, http://www.qcpolymers.com).

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113 Deloitte, *Increased EU Plastics Recycling Targets: Environmental, Economic and Social Impact Assessment – Final Report* (2015). The approximate 40% often includes the easiest to recycle items; for example, Belgium only collecting bottles, many regions not collecting household flexible packaging. Sources: Fostplus website (www.fostplus.be); summary of plastic film collection in Europe studies by WRAP (WRAP, *Film reprocessing technologies and collection schemes* (2012)).

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121 Estimates for price, cost and yield impacts of higher-quality polyolefin recycling processes are from industry interviews.

About the Ellen MacArthur Foundation

The Ellen MacArthur Foundation was established in 2010 with the aim of accelerating the transition to the circular economy. Since its creation the charity has emerged as a global thought leader, establishing the circular economy on the agenda of decision makers across business, government and academia. With the support of its Core Philanthropic Funder, SUN, and Knowledge Partners (Arup, IDEO, McKinsey & Company, and SYSTEMIQ), the Foundation's work focuses on five interlinking areas:

EDUCATION

Inspiring learners to re-think the future through the circular economy framework

The Foundation has created global teaching, learning and training platforms built around the circular economy framework, encompassing both formal and informal education. With an emphasis on online learning, the Foundation provides cutting edge insights and content to support circular economy education, and the systems thinking required to accelerate a transition.

Our formal education work includes Higher Education programmes with partners in Europe, the U.S., India, China and South America, international curriculum development with schools and colleges, and corporate capacity building. Our informal education work includes the global, online Disruptive Innovation Festival.

BUSINESS AND GOVERNMENT

Catalysing circular innovation and creating the conditions for it to reach scale

Since its launch, the Foundation has emphasised the real-world relevance of the circular economy framework, recognising that business innovation sits at the heart of economic transitions. The Foundation works with its Global Partners (Cisco, Danone, Google, H&M, Intesa Sanpaolo, NIKE Inc., Philips, Renault, and Unilever) to develop scalable circular business initiatives and to address challenges to implementing them.

The Circular Economy 100 programme brings together industry leading corporations, emerging innovators, affiliate networks, government authorities, regions and cities, to build circular capacity, address common barriers to progress, understand the necessary enabling conditions, and pilot circular practices, in a collaborative, pre-competitive environment.

INSIGHT AND ANALYSIS

Providing robust evidence about the benefits and implications of the transition

The Foundation works to quantify the economic opportunity of a more circular model and to develop approaches for capturing its value. Our insight and analysis feeds into a growing body of economic reports highlighting the rationale for an accelerated transition towards the circular economy, and exploring the potential benefits across stakeholders and sectors.

The circular economy is an evolving framework, and the Foundation continues to widen its understanding by working with international experts, key thinkers and leading academics.

SYSTEMIC INITIATIVES

Transforming key material flows to scale the circular economy globally

Taking a global, cross-sectoral approach to material flows, the Foundation is bringing together organisations from across value chains to tackle systemic stalemates that cannot be overcome in isolation. Plastics was identified through initial work by the Foundation with the World Economic Forum and McKinsey & Company as one of the value chains most representative of the current linear model, and is therefore the focus of the Foundation's first Systemic Initiative. Applying the principles of the circular economy, the New Plastics Economy initiative, launched in May 2016, brings together key stakeholders to rethink and redesign the future of plastics, starting with packaging.

COMMUNICATIONS

Engaging a global audience around the circular economy

The Foundation communicates cutting edge ideas and insight through its circular economy research reports, case studies and book series, using multiple channels, web and social media platforms. It uses relevant digital media to reach audiences who can accelerate the transition, globally. The Foundation aggregates, curates, and makes knowledge accessible through Circulate, an online information source dedicated to providing the latest news and unique insight on the circular economy and related subjects.

Northwest Product Stewardship Council

FOR IMMEDIATE RELEASE
July 18, 2017

Contact:
Amanda Reykdal, Washington Coordinator – coordinator@productstewardship.net - (425) 445-4759

First-in-the-nation legislation requiring manufacturers to recycle used solar units signed into law

The Solar Incentives Job Bill requires manufacturers to manage and finance the safe recycling of solar units at end of life, at no cost to the owner of the product

Olympia, WA— The Solar Incentives Job Bill (ESSB 5939) was signed into law by Gov. Jay Inslee of Washington State on July 7, requiring manufacturers to finance and manage a product stewardship program that ensures used solar units are recycled. This is a significant step toward a truly sustainable and responsible solar energy industry, and the stewardship requirement is the first of its kind for solar modules in the United States.

"This legislation establishes Washington State as a leader in sustainability and stewardship of this technology," said State Rep. Norma Smith (R-Clinton), who championed the product stewardship requirement. "We included the product stewardship element in this bill as part of a comprehensive approach to solving our state's most pressing environmental issues. It would be shortsighted to introduce a bill that expands the number of solar units in our state, and not have a strategy for safe recycling when they're no longer functional."

"The Solar Incentives Job Bill sets a precedent for future solar legislation to include a recycling program," explains Heather Trim, Executive Director at Zero Waste Washington. Zero Waste Washington worked with the Northwest Product Stewardship Council in drafting policy language. "This requirement models a producer responsibility approach as a component to include as other states expand solar programs."

In Washington, the stewardship requirement is part of larger bill that incentivizes solar unit ownership and creates solar jobs locally. The stewardship requirement states that manufacturers who sell solar units in the state of Washington after July 1, 2017, are responsible for financing and providing a recycling program for their units. Manufacturers who do not provide a recycling program cannot sell solar modules after January 1, 2021. This recycling requirement covers:

- Solar modules used on or in buildings
- Freestanding off-grid power generation systems such as water pumping stations
- Electric vehicle charging stations
- Solar fencing, solar-powered signs and solar-powered street lights.

It does not include small solar-powered consumer electronics such as watches and calculators.

Smith contends that “we need to be responsible stewards for each and every one of these technologies.” Solar modules contain hazardous materials, rare earth elements, and other materials that have to be recycled properly. “As we pursue our conservation goals, it is critical that we pay the cost of our own consumption and not leave that to another generation.”

By law, the stewardship program must provide regional take back locations where solar modules can be delivered for proper recycling at no cost to the last owner. Manufacturers have the flexibility to collect discarded modules individually or collectively with other companies. The Department of Ecology will provide guidance to manufacturers on developing their programs.

New solar module recycling jobs and businesses are expected as a result of the legislation. Washington State already has job-producing stewardship laws for electronics and mercury lighting. Four counties have stewardship laws for leftover medicine.

Learn more about NWPSC’s work on the NWPSC website, or contact Amanda Reykdal at (425) 445-4759.

About the Northwest Product Stewardship Council
The Northwest Product Stewardship Council (NWPSC) is a coalition of government organizations in Washington and Oregon that operates as an unincorporated association of members and is comprised of a Steering Committee, Associates and Committees. NWPSC's mission is to enhance Washington’s and Oregon’s reuse, recycling and waste management systems by working with the waste and recycling industry, consumers, manufacturers and others to connect producers with the costs associated with the end-of-life management of their products to provide incentives for reducing waste, increasing recyclability, and reducing the toxicity of their products.
Follow us on Twitter @StewardshipNW.

It’s time to plan for solar panel recycling in the United States

By Kelly Pickerel | April 2, 2018
End-of-life panels might not need recycling for another 15 years, but that doesn’t mean we should ignore the growing issue today.

In 2017, the United States installed 10.6 GW of new solar energy. Using rough math (if every panel was 300 W), that’s 35.3 million new solar panels installed last year. In about 30 years, a wave of 35.3 million panels may reach the end of their lifespans, not counting the hundreds of millions of panels that flooded the U.S. market in the last decade that may need to be disposed of sooner.

What to do with this future solar waste has been bothering many in the industry, especially Sam Vanderhoof, owner of consulting firm Solar CowboyZ and former president of Schott Solar.

“I’ve been working in solar since 1976. I’ve been doing it a long time, and that’s part of my guilt. I’ve been involved with millions of solar panels going into the field, and now they’re getting old,” he said. “The industry seems to think—myself included—that there isn’t a problem yet. The reality is that there is a problem now, and it’s only going to get larger, rapidly expanding as the PV industry expanded 10 years ago.”

Solar panel disposal and recycling isn’t a huge issue right now in 2018 because there isn’t a big enough volume to cause concern. Solar panels are warrantied to perform more than 25 years, and once the warranty expires, panels will still produce energy, albeit not at their advertised peak. Solar installations in the United States didn’t really take off until 2010. Any influx of panels needing replaced today happens after freak weather events or other accidents.

But where are those damaged panels going now? With no dedicated national program or requirement to safely dispose of solar panels, some unfortunately find their way to landfills. If the system owner is green-minded and has the money, panels may get shipped to a recycling facility. Other industry players are warehousing damaged or old panels until a practical recycling program is established.

That’s why Vanderhoof and a few colleagues recently started a new recycling program in the United States—Recycle PV—modeled after Europe’s successful program. The program is still in its early stages, but Vanderhoof hopes his efforts will start a movement.

“Who is responsible for it? In the U.S., nobody is,” he said of solar panel recycling guidelines. “It is important for the industry to step up to address it. Solar is supposed to be renewable and clean energy, but there is this dirty side to it. There is a waste stream after time that hasn’t been addressed.”

Vanderhoof isn’t alone in these concerns. There are many U.S. players trying to get plans in place before safe panel disposal becomes a national issue. Determining guidelines now will make things easier when panels reach the end of their useful lives.

Economics vs. regulations

Cara Libby, senior technical leader of solar energy at the Electric Power Research Institute (EPRI), has been doing solar PV recycling research on behalf of the organization's utility members. Libby said utilities asked for EPRI's help understanding the feasibility of recycling in the United States since many own solar arrays approaching 20 years old. Libby and her research partners have been looking at various recycling technologies, whether modules should be classified as hazardous waste and how other countries have already approached recycling regulations.

"It's still a little premature for dedicated PV recycling facilities [in the United States]," Libby said. "In the future, maybe around 2030, there will be a surge in PV waste volumes. Then we'll have to start thinking about a better way to collect and recycle efficiently."

EPRI found that most panel recycling in Europe through the Waste Electrical and Electronic Equipment (WEEE) Directive—which established rules for solar panel recycling in 2012—happens at glass recyclers. Panels are crushed or shredded and then glass and metals are separated. Other chemical and thermal processes may be used to recover high-value material like silver or copper.

System owners recycle their panels in Europe because they are required to. Panel recycling in an unregulated market (like the United States) will only work if there is value in the product. The International Renewable Energy Agency (IRENA) detailed solar panel compositions in a 2016 report and found that c-Si modules contained about 76% glass, 10% polymer (encapsulant and backsheet), 8% aluminum (mostly the frame), 5% silicon, 1% copper and less than 0.1% of silver, tin and lead. As new technologies are adopted, the percentage of glass is expected to increase while aluminum and polymers will decrease, most likely because of dual-glass bifacial designs and frameless models.

CIGS thin-film modules are composed of 89% glass, 7% aluminum and 4% polymers. The small percentages of semiconductors and other metals include copper, indium, gallium and selenium. CdTe thin-film is about 97% glass and 3% polymer, with other metals including nickel, zinc, tin and cadmium telluride.

There's just not a large amount of money-making salvageable parts on any type of solar panel. That's why regulations have made such a difference in Europe.

"In Europe, we've seen that when it's mandated, it gets done," Libby said. "Either it becomes economical or it gets mandated. But I've heard that it will have to be mandated because it won't ever be economical."

There's nothing yet mandated at a national level, but there are a few states trying to get the required recycling ball moving. In July 2017, Washington became the first state to pass a solar stewardship bill (ESSB 5939), requiring manufacturers selling solar products into the state to have end-of-life recycling programs for their own products. Manufacturers that do not provide a recycling program or outline will not be able to sell solar modules into the state after Jan. 1, 2021. Regional takeback locations will be set up to accept solar panels at no cost to the system owner, and the state may charge manufacturers for the program. Final plans are still being decided.

Washington-based solar panel manufacturer Itek Energyassisted with the bill's writing.

“Most of us here at the company feel strongly about being strong environmental stewards,” said Evan Bush, special programs coordinator at Itek. “It’s important to spearhead these efforts before there’s a big volume that will need to be disposed. With this in place, we’ll be more prepared.”

Itek’s modules are already in compliance with the new bill; the company uses a recycling partner in Idaho to take damaged panels and manufacturing scrap. Itek has been accepting back other brands of modules just to keep them out of landfills.

“There are reasons beyond just doing the right thing that should encourage others to [recycle panels],” Bush said. “Given the value of the component materials in modules, this shouldn’t be a burden to us or other participants.”

New York has a similar bill on the Senate calendar this year. Bill S2837A would require solar panel manufacturers to collect end-of-life panels for recycling. Critics argue that panel manufacturers should not bear the burden of recycling panels alone, although that is how the WEEE Directive works in Europe.

California SB 489 passed in 2015 and encourages safe disposition of old panels. California designates end-of-life solar panels as universal waste, a type of hazardous waste that is widely used in homes and businesses (like TVs or batteries). By California law, universal waste cannot be trashed or landfilled, but no guidelines are given on the proper way to recycle solar panels.

A U.S. recycling veteran

One U.S. company that has recycling figured out is CdTe thin-film module manufacturer First Solar. In 2005, the company made a commitment to extended producer responsibility. First Solar execs understood that in order for a renewable energy technology to truly be green, it was important to consider its end-of-life management. First Solar’s recycling program was established at the beginning of production to responsibly recycle manufacturing scrap, warranty returns and end-of-life panels. This environmental decision also had a financial perspective—tellurium doesn’t just grow on trees.

“There is a finite amount of tellurium,” said First Solar global recycling director Sukhwant Raju. “They wanted to make sure there was a way to recover the valuable stuff so it becomes sustainable growth for First Solar. It’s not just about being green, but how do we stay sustainable in the long term?”

First Solar recycling plants are attached to its manufacturing facilities—in Ohio, Malaysia and under construction in Vietnam. There’s also a stand-alone recycling plant in Germany.

“We have the capacity to recycle 2 million panels globally on an annual basis,” Raju said. “As more panels start reaching the end of their 25-year lifetimes, recycling will increase drastically.”

The company only recycles CdTe panels currently, even if the panels are not manufactured by First Solar (other CdTe panel manufacturers include Calyxo of Germany and Advanced Solar Power (ASP) of China). Raju said the company may develop techniques to handle crystalline silicon panels.

“We have a decade’s worth of experience in recycling, and we want to utilize that to broaden our efforts,” he said.

The progression of First Solar recycling advancements. The first photo (top left) shows the first version of recycling, the second photo (top right) shows the second version, and finally the bottom photo shows the current recycling process used in First Solar facilities.

As with the decommissioning of other energy technologies, there’s still a financial obligation on behalf of the system owner. The company’s initial recycling program was pre-funded. When a First Solar panel was sold, a portion of that money went into a fund that could only be used for end-of-life recycling. In 2012, the company switched gears but continues to honor historical commitments under the prefunded module collection and recycling program.

“We realized we were not doing anyone any favors by charging customers 20 to 30 years in advance for end of life recycling,” Raju said. “The better approach was to do pay-as-you-go since it is more cost-efficient to finance PV recycling through later-year project cash flows instead of upfront funding. Now when we sell our panels, we offer a global recycling services agreement. Customers have the option to use our services when the panels get to the end of life stage. We’ll do the recycling, and they’ll pay the price at that time.”

This customer-funded recycling effort is dependent on system owners willing to pay the price to do the right thing. Raju thinks that as volume increases, recycling costs will come down and the greener option will be more attractive than just throwing panels away. First Solar is also taking steps to reduce recycling costs to ensure recycling becomes the preferred end-of-life management approach.

“Limited land availability and regulatory requirements will only increase the costs of landfilling,” he said. “Meanwhile, recycling costs will continue to go down. While customers may only be sending 100 panels today for recycling, by the time most of their panels get to end of life, our cost ratio will be way lower. They see the value in getting on the recycling bandwagon.

“But at the end of the day,” Raju continued, “there is nothing to force them, other than in places where there are regulations.”

The need for crystalline recycling

For c-Si modules needing recycling now in the United States, there are a few scattered options. Various glass and electronics recyclers have taken on solar panel recycling, but usually not on dedicated lines or on a grand scale. Industry advocacy group SEIA has begun organizing recycling efforts through its PV Recycling Working Group. SEIA will choose preferred recycling partners that offer benefits to SEIA members. ECS Refining and Cleanlites Recycling have recently been approved as SEIA recycling partners.

Cleanlites began in the early 1990s as a light bulb recycler, taking on other items like batteries and electronics, until it found a niche with “difficult to recycle” items. It has been catering to a solar crowd for the last few years and recycled 1.5 million lbs of solar panels last year (again, using rough math of 50 lbs per panel, that’s 30,000 panels).

“I saw the impending need for solar panel [recycling]. Those coming out of commission from now to the next 10 years is astronomical,” said Tim Kimmel, Cleanlites vice president.

Cleanlites uses optical, magnetic and hand sorting to separate aluminum, other metals and electronics from c-Si solar panels at its Cincinnati-based facility. The company is hesitant to accept other types of panels right now until it can determine safe processes. The leftover glass and silicon wafers (which may also have copper and silver mixed in) are sent to a smelter for further extraction. The process works for now, but it could be improved.

“We’re looking to put a new process line in that will be able to separate all the components and recover the silicon wafers and recycle the units 100%,” Kimmel said. “The goal is to avoid landfilling all these units, which is going to be a vast number here shortly.”

As solar panels are processed on the current lines, Cleanlites collects the scrap and sends 45,000-lb loads out at a time.

“At times, we get thousands of panels in a month, and on those times, we process twice a week, making the material and sending to the smelter on a consistent basis,” Kimmel said. “Other times, they come in slowly and we build them up until we are able to process a whole shipment.”

It costs money to send “solar scrap” to a smelter, and Cleanlites incorporates that cost and the cost of transportation into its recycling prices.

“There is a cost, so you have to weigh… do you want to be an environmentally sustainable company, or do you want to landfill thousands of pounds of material and have that show up?” Kimmel said. “The benefit of sending it to us, we’re able to receive it, ensure that the metals are recovered, and we recycle it. You’re not creating any waste or hazardous waste.”

A solar panel’s level of hazardous waste is up for debate. If panels are just old, there are usually no reasons to worry. EPRI research found the chance of chemical leaching grows if panels are damaged.

“We’ve conducted some toxicity testing on modules, and we have seen results showing that the presence of lead is higher than the threshold allowed by the TCLP (toxicity characteristic leaching procedure). There is a lot of variation between module types,” Libby said. “There is a potential for leaching of toxic materials such as lead in landfill environments. If modules are intact, it’s a low risk, but as soon as they’re broken or crushed, then the potential for leaching is increased.”

Recycling panels is the safest way to dispose of them, and SEIA and recycling centers are trying to make it easy to do the right thing.

Planning for future volume

There are clearly recycling options available now to U.S. solar owners, but their fragmented nature is what led Vanderhoof to form Recycle PV.

“There’s a little effort for sure, but it’s not concentrated. The information isn’t out there,” he said. “There’s not a good, simple flow of information and processes and procedures to deal with the waste stream.”

Recycle PV went straight to the pros, partnering with PV Cycle (the successful non-profit organization that offers waste management help to solar companies in Europe) and German panel refurbisher Rinovasol for the U.S. market. Slightly damaged or underperforming panels can find a second life on the refurbished market. Rinovasol will take care of those, and PV Cycle sets up memberships to get recyclable panels to partner facilities. Thus far, Recycle PV has shipped two containers of panels to Germany for recycling, which is expensive but the only way to fully take advantage of the PV Cycle process right now.

The plan for Recycle PV is to get volumes large enough to build a dedicated solar recycling plant in the United States. Vanderhoof said once Recycle PV is processing 10,000 panels a month, a U.S. facility will make more sense.

“It’s not an outrageous goal,” he said. “Right now in Europe, they can recycle that much a day, but it’s been going on for a long time already.”

It’s a lofty goal for Vanderhoof and his partners to start a brand new operation, but he felt he had to do something.

“We’ve gone to a lot of waste management and EPA meetings. You look around the room and it’s all waste management people, not solar people,” he said. “Those guys are in there trying to work on the policies that affect all of us, and they’d like it to be a more expensive policy because they make more money off it. The solar guys aren’t as engaged as they could be.”

The most promising solution for the United States is if SEIA can successfully tap into the PV Cycle model and pick up recycling plants across the nation willing to invest in solar processing. If more states adopt Washington’s requirements to have all panels backed by recycling programs, national recycling plans might automatically form. A big solar name may be willing to forgo Washington sales, but it’d have a harder time losing out on California sales just because it doesn’t have a recycling plan in place.

Time is ticking. The United States has about 15 years before solar panel recycling becomes a major issue. Plenty of time to figure out the best course of action, but also plenty of time to procrastinate. Here’s hoping we set early deadlines.

ABOUT THE AUTHOR

Comments

1. ## Neal Collier

February 7, 2019 at 8:55 pm

Many PV panels can be recycled in the form of reuse. I am up to about 10kw of reliable PV power from recycled panels, most of which have cracked cells because they were stomped and thrown off the roof! I have a good many panels that have broken glass and put out just fine. In one experiment, I took a 280 watt panel that had been bashed by a tractor hard enough to dismount it. It still made useful power. Checking a friend's claim that they'll work with a hole in them, I shot it repeatedly with a pistol and a shotgun. It still puts out enough to charge a battery. Solar cells are merely rocks with wires. Repairing broken wires and burnt diodes is not usually a big deal.

I've traveled thousands of miles in my solar boat, using "B" panels, with no problem. My friend, John Kimball, of Sun Electronics, in Miami, has repurposed tens of thousands of modules removed from old solar farms and other sources. "Scratch and dent" panels at bargain prices allow people on smaller budgets to provide their own power.

I'd say the best recycling of old PV modules is reuse. Consider that before crushing to reclaim materials.

Reply

2. ## Jennifer Woolwich

December 28, 2018 at 2:52 pm

My name is Jennifer Woolwich. I am the founder and was CEO of pv recycling, llc in the United States. We were based in Arizona with an office in San Jose, CA. I was surprised to see this article with no reference to the 5 years of work that my company did related to national regulation development, international relations, logistics, process engineering and everything else involved in commercializing a start-up. Figures that women's history in the solar industry will be made non-existent.

Reply

- ## Kelly Pickerel

  January 2, 2019 at 7:52 am

Jennifer, I reached out to you several times for comments but did not receive a response. Of course, we are very supportive of women here at Solar Power World. I do hope to hear more of your work within solar in the coming years.

Reply

3. **Hassan Yarpezeshkan**

December 9, 2018 at 10:06 pm

Kelly,
Very useful information hope the politician taking PV recycling seriously, thank you I learn a lot from this article

Reply

4. **Jack Melson**

December 7, 2018 at 4:18 pm

You should look Into a company called WellPower. They repurpose old solar panels to power solar water filtration systems in the developing world. Reusing should always come before recycling. Their website is http://www.wellpower.tech

Reply

5. **Stuart.**

October 8, 2018 at 3:53 pm

Excellent that the EU is again taking a lead on sustainability and showing Uncle Sam how not to behave. Any new technology should have not just R&D but an entire life cycle analysis. Really hope solar (and wind – composite blades are difficult to recycle too) doesn't become the next big plastic issue.

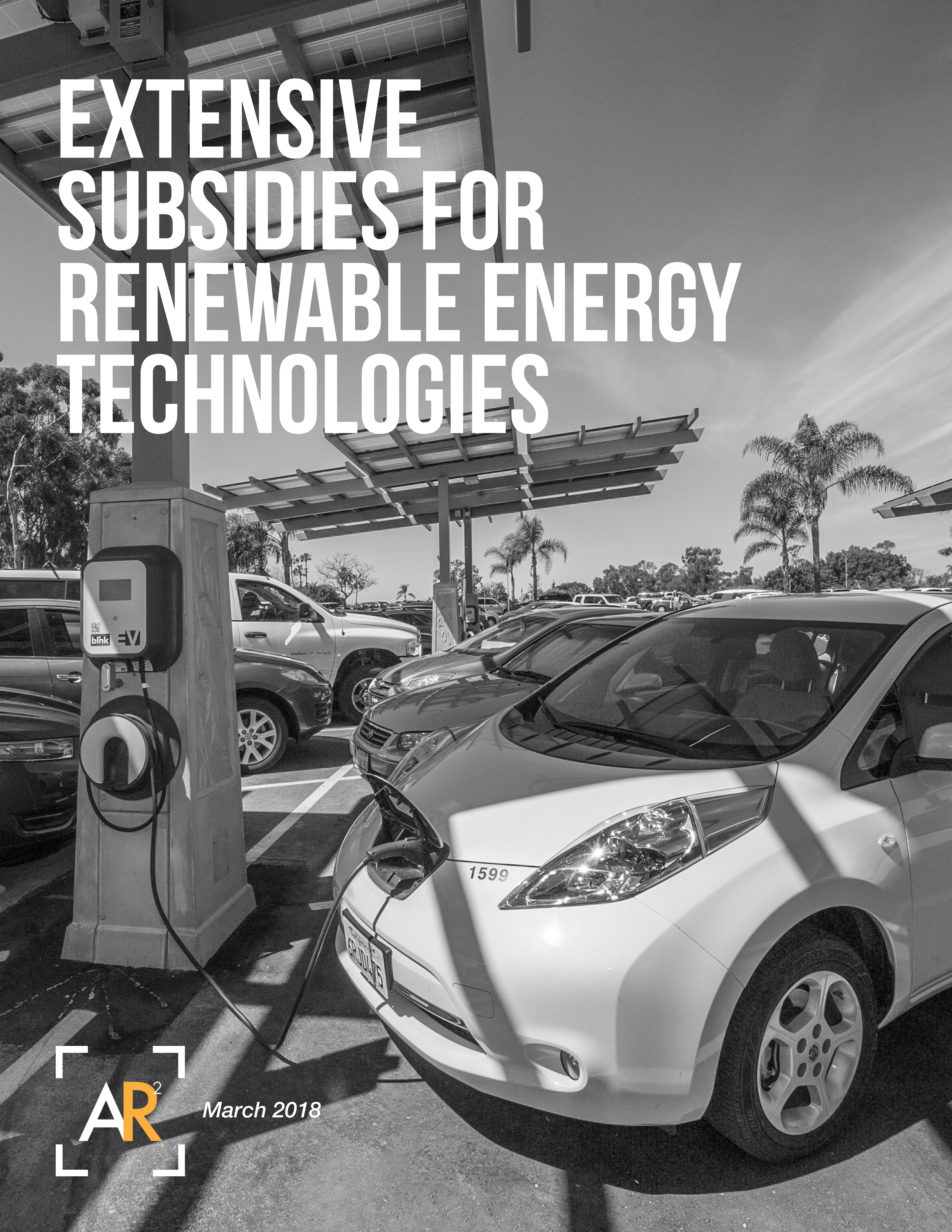
Reply

6. **Eric Stikes**

April 5, 2018 at 2:15 pm

Nice report Kelly, and good work Sam! Once again you're leading the charge. For non-damaged, old PV modules and still functioning equipment, our non-profit, Good Sun Solar (www.goodsun.life) accepts donations and re-purposes this equipment for utility off-set and educational projects at schools, other non-profits, and LMI households. We're helping to increase solar access to those that have trouble affording the tech., and we are focused on education: helping the up-coming generations to learn about and receive hands-on training on renewable energy and sustainable technology. We also generate revenue through our local projects that helps support international projects in the developing world, where the need for clean power is dire. Visit our website to learn more about donating used PV equipment and helping others.

EXTENSIVE SUBSIDIES FOR RENEWABLE ENERGY TECHNOLOGIES



March 2018

EXECUTIVE SUMMARY

Across the United States, the federal government and many state and local governments have prioritized what they claim are clean energy programs that will help combat climate change. Financial incentives have been introduced in order to encourage commercial and residential customers to use technology that does not increase fossil fuel use. In 2016, according to the Congressional Budget Office, $13.6 billion was spent by the federal government on tax expenditures related to renewable energy and energy efficiency.[1] These technologies include using solar, geothermal, and wind power to generate electricity rather than more traditional methods like coal or oil. Many of these programs overlap with one another and thus are a redundant waste of taxpayer money. In addition, the introduction of so many financial incentives for clean energy program artificially alters the market for these technologies, effectively subsidizing the products. This puts the government in the role of picking winners and losers in the marketplace.

There appear to be so many programs offering direct and indirect subsidies to renewable energy that it is very difficult to catalogue them all. In an attempt to capture a great number of these programs in one place, America Rising Squared (AR2) examined a database of incentives at North Carolina State University, the North Carolina Clean Energy Technology Center's Database Of State Incentives For Renewables & Efficiency (DSIRE). This examination revealed roughly 1,000 programs in the United States that offer financial incentives to promote "renewable energy technologies" for residential and commercial customers. The financial incentives include rebate programs, tax credits, as well as loan and financing options. All fifty states and the District of Columbia offer some type of program in addition to seventeen different federal programs.[2]

Minnesota has more programs than any other state in the country with 96 different programs, despite being only 22nd in the United States in population. The most populated state in the country, California, has 53 different programs [3]

Twenty-nine different states have renewable portfolio standards and eight states have renewable energy goals. The standards require utilies to sell a specific percentage or amount of renewable electricity.[4] President Barack Obama was very active in encouraging federal agencies to obtain a greater percentage of their energy from green sources by adopting renewable portfolio standards. In 2013, he signed an executive order mandating that federal agencies replace at least 20 percent of their electricity with renewable energy by 2020. The order had the effect of essentially tripling the use of renewable energy by the federal government.[5]

In several states, three different levels of government offer separate programs for solar or geothermal technology. State government, county government, and municipal governments all operate individual programs with their own financial incentives independent of the other government programs. For example, in California, property tax reductions are given to home owners who use solar energy systems on their own even though several different municipalities including Palo Alto and San Francisco have similar programs.[6]

Overwhelmingly, these state clean energy programs cater to multiple technologies within solar or geothermal energy. For example, many states offer rebates or loans on solar water heat, solar photovoltaics, biomass, or geothermal heat pumps all within one program. There are eleven programs

1. *Terry Dinan, "Federal Support For Developing, Producing, And Using Fuels And Energy Technologies," Congressional Budget Office, 3/29/17*
2. *Database Of State Incentives For Renewables & Efficiency, North Carolina Clean Energy Technology Center, North Carolina State University, Accessed 11/29/17*
3. *Ibid.*
4. *"State Renewable Portfolio Standards And Goals," National Conference Of State Legislatures, Accessed 2/5/18*
5. *Cheryl K. Chumley, "Executive Order: Obama Ups Green-Energy Mandate On Feds To 20 Percent," The Washington Times, 12/5/13*
6. *Database Of State Incentives For Renewables & Efficiency, North Carolina Clean Energy Technology Center, North Carolina State University, Accessed 11/29/17*

nationally that cater exclusively to wind technology in addition to hundreds that include wind as part of their larger renewable energy programs.

At the federal level, Congress over the last decade has offered tax credits for commercial and residential solar projects that can offset more than 30 percent of the price. In 2014, solar companies and homeowners claimed almost $3 billion in solar tex credits.[7] The wind industry also benefits from production tax credits that award credit for every kilowatt-hour of energy produced by wind projects. Orginally, the tax incentives for the solar and wind industry were due to expire in 2007, but they have been extended several times and once again were extended in the recent tax reform bill passed by Congress.[8] The tax incentives originally were given to both industries to help the industries mature and develop but have not been scaled back or altered as both industries have grown in size.

There are 86 programs that exclusively offer incentives for solar photovoltaic programs, including 25 just in California.[9] These programs provide benefits for residential and commercial customers to use solar technology to generate electricity from light. The solar panels necessary to incorporate this technology would be significantly more expensive for customers without the government subsidies, making it difficult for other industries to compete against subsidized technologies.[10]

State bureaucrats have also built extensive systems to support clean energy through the use of taxpayer money to encourage electric vehicle purchases and expanded generation of solar and wind power. However, there is limited discussion of the actual environmental cost "clean technology" comes with, the largest of which comes in the manufacturing of these products and the need for abundant sources of rare earth metals.

Rare earth elements are not only hard to find, but also energy intensive to extract and refine. Used in solar panels, electric vehicles (EVs) and wind turbines, these technologies present geopolitical issues, environmental impact and concerns over labor standards.[11]

As far back as 2010, the growing demand for rare earth metals Indium, Gallium And Tellurium used primarily in solar cell manufacturing has concerned the Department of Energy.[12] From magnets used in wind turbines to lithium needed in electric vehicle batteries, rare earth is a significant factor required in clean energy manufacturing. Whether its lithium mined in the deserts of South America, crushing rock in Australia for lithium, or the processing of lithium in China, the environmental footprint throughout the whole of the supply chain is concerning.[13] The Union of Concerned Scientists has noted lithium-ion batteries are a particularly energy-intensive material to produce.[14] Lithium batteries are crucial to producing electric vehicles limiting, any environmental impact electric cars could have on the environment due to the environmental costs of producing them. Lithium is also a key component of wind turbines and solar panels used for power generation.[15] Another issue with rare earth is that recycling of these materials is quite limited, with as little as about one percent of potentially critical rare earth metals being recycled, stressing supply chains and adding to the environmental impact of rare earth.[16] Environmental activists and the state leaders advocating for these programs fail to confront the fundamental realities that surround supposedly clean technologies.

7. *"What Is The Solar Investment Tax Credit," Institute For Energy Research, Accessed 2/7/18*
8. *Ari Natter and Chris Martin, "Tax Tool Crucial To Wind, Solar Appears Spared In GOP Deal," Bloomberg, 12/14/17*
9. *Database Of State Incentives For Renewables & Efficiency, North Carolina Clean Energy Technology Center, North Carolina State University, Accessed 11/29/17*
10. *"Mineral Commodity Summaries: Rare Earths," U.S. Geological Survey, 1/16*
11. *"U.S. Department Of Energy Critical Materials Strategy," Energy.gov, 12/10*
12. *"Ibid.*
13. *Henry Sanderson, "Electric Car Growth Sparks Environmental Concerns," Financial Times, 7/7/17*
14. *"Cleaner Cars from Cradle to Grave (2015)," Union Of Concerned Scientists, 2015*
15. *Jessica Shankleman, Tom Biesheuvel, Joe Ryan, And Dave Merrill, "We're Going To Need More Lithium," Bloomberg, 9/7/17*
16. *Saleem H. Ali, Damien Giurco, Nicholas Arndt, et al, "Mineral Supply For Sustainable Development Requires Resource Governance," Nature, 3/16/17*

Cap-and-trade is the cornerstone of the plan in California to reduce greenhouse gas emissions after the Global Warming Solutions Act was passed in 2005. The California Air Resources Board (CARB) in California is responsible for developing a plan to reduce greenhouse gas emissions across the state.[17] In order to comply with environmental regulations, businesses can either reduce their emissions to levels below those set by the CARB or buy carbon allowances from the state which allows them to pay a fee for their emissions above the permissible level. These allowances can also be bought and sold on the secondary market meaning that the prices of these allowances can fluctuate over time. However, the number of allowances made available by the state each year decreases and the level of permissible emissions also decreases putting more pressure on businesses to comply with the regulations set by the state.[18]

There is limited evidence that cap-and-trade is behind the drop in greenhouse gas emissions in California in recent years since the recession forced companies to adopt more efficient methods and look to cut costs. Emissions would have dropped by a similar rate anyway as economic output decreased.[19] In addition, there are concerns that some businesses have saved up enough allowances over several years allowing them to maintain their emissions at the same level and defeating the purpose of the program. The allowances don't expire over time so companies have the option of purchasing an abundance of them to be used in the future when emissions targets become harder to meet. [20]

The American Recovery and Reinvestment Act of 2009 created a federal tax credit for any purchaser of an electric vehicle up to $7,500. The size of the credit depends on the size of the vehicle's battery, encouraging consumers to buy cars with larger vehicles.[21] The tax credit artificially inflates the market for electric vehicles by making it cheaper for consumers while not providing traditional cars with the same credit putting them at a disadvantage. Additionally in 2016, the Obama Administration announced several executive actions designed to increase electric vehicle use through expanding the infrastructure for charging electric vehicles. $4.5 billion was announced in loan guarantees and public-private partnerships were also encouraged by the Obama Administration to boost the production of batteries and charging stations.[22]

In California, there are also state-level incentives designed to encourage purchases of electric vehicles in addition to federal incentives. Owners of electric vehicles are given permits to drive in carpool lanes regardless of how many passengers are in the car and low income reidents are given financial incentives for trading in cars with higher level of emissions in exchange for electric vehicles.[23]

17. *Dana Hull, "13 Things To Know About California's Cap-And-Trade Program," Bloomberg, 11/29/12*
18. *Michael Hiltzik, "California's Cap-And-Trade Program Has Cut Pollution. So Why Do Critics Keep Calling It A Failure," Los Angeles Times, 7/29/16*
19. *Michael Hiltzik, "Emissions Cap-And-Trade Program Is Working Well In California," Los Angeles Times, 6/12/15*
20. *Michael Hiltzik, "No Longer Termed A 'Failure,' California's Cap-And-Trade Program Faces A New Critique: Is It Too Successful," Los Angeles Times, 1/12/18*
21. *"Effects Of Federal Tax Credits For The Purchase Of Electric Vehicles," Congressional Budget Office, 9/1/12*
22. *Fred Lambert, "White House Unlocks $4.5 Billion For Electric Vehicle Infrastructure And Announces New EV Programs," Electrek, 7/21/16*
23. *Marisa Lagos, "Brown Signs Several Clean-Air Vehicle Bills," San Francisco Chronicle, 9/22/14*

FEDERAL

Administrator	Name	Type	Technologies	Last Updated	Start Date	End Date
U.S. Internal Revenue Service	Modified Accelerated Cost-Recovery System (MACRS)	Corporate Depreciation	Solar Water Heat, Solar Space Heat, Geothermal Electric, Solar Thermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Wind (All), Biomass, Geothermal Heat Pumps, Municipal Solid Waste, Combined Heat & Power, Fuel Cells using Non-Renewable Fuels, Landfill Gas, Tidal, Wave, Ocean Thermal, Wind (Small), Geothermal Direct-Use, Anaerobic Digestion, Fuel Cells using Renewable Fuels, Microturbines	1/11/16	1/26/86	N/A
U.S. Internal Revenue Service	Business Energy Investment Tax Credit (ITC)	Corporate Tax Credit	Solar Water Heat, Solar Space Heat, Geothermal Electric, Solar Thermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Wind (All), Geothermal Heat Pumps, Municipal Solid Waste, Combined Heat & Power, Fuel Cells using Non-Renewable Fuels, Tidal, Wind (Small), Geothermal Direct-Use, Fuel Cells using Renewable Fuels, Microturbines	2/20/17	N/A	N/A
U.S. Internal Revenue Service	Renewable Electricity Production	Corporate Tax Credit	Geothermal Electric, Solar Thermal Electric, Solar Photovoltaics,	9/22/17	N/A	N/A

	Tax Credit (PTC)		Wind (All), Biomass, Hydroelectric, Municipal Solid Waste, Landfill Gas, Tidal, Wave, Ocean Thermal, Wind (Small), Hydroelectric (Small)			
U.S. Internal Revenue Service	Residential Energy Conservation Subsidy Exclusion (Corporate)	Corporate Tax Exemption	Solar Water Heat, Solar Space Heat, Solar Photovoltaics, Yes; specific technologies not identified	5/26/16	N/A	N/A
U.S. Department of Energy	Tribal Energy Program Grant	Grant Program	Solar Water Heat, Solar Space Heat, Geothermal Electric, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Refrigerators/Freezers, Water Heaters, Lighting, Lighting Controls/Sensors, Chillers, Furnaces, Boilers, Air conditioners, Programmable Thermostats, Energy Mgmt. Systems/Building Controls, Caulking/Weather-stripping, Duct/Air sealing, Building Insulation, Windows, Siding, Roofs, Comprehensive Measures/Whole Building, Other EE, Wind (Small)	3/3/17	N/A	N/A
USDA Rural Utilities Service	USDA - High Energy Cost Grant Program	Grant Program	Solar Water Heat, Solar Space Heat, Solar Thermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Yes; specific technologies	6/9/16	1/26/15	N/A

			not identified, Wind (Small), Hydroelectric (Small)			
US Department of Agriculture	USDA - Repowering Assistance Biorefinery Program	Grant Program	Biomass, Municipal Solid Waste, Landfill Gas	3/18/16	N/A	N/A
U.S. Department of Agriculture	USDA - Rural Energy for America Program (REAP) Grants	Grant Program	Solar Water Heat, Solar Space Heat, Geothermal Electric, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Hydrogen, Geothermal Heat Pumps, Combined Heat & Power, Tidal, Wave, Ocean Thermal, Yes; specific technologies not identified, Wind (Small), Hydroelectric (Small), Geothermal Direct-Use, Anaerobic Digestion, Fuel Cells using Renewable Fuels, Microturbines	2/11/16	N/A	N/A
U.S. Internal Revenue Service	Clean Renewable Energy Bonds (CREBs)	Loan Program	Geothermal Electric, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Municipal Solid Waste, Landfill Gas, Tidal, Wave, Ocean Thermal, Anaerobic Digestion	4/16/15	9/1/10	N/A
N/A	Energy-Efficient Mortgages	Loan Program	Solar - Passive, Solar Water Heat, Solar Space Heat, Solar Photovoltaics, Daylighting, Yes; specific technologies not identified	6/24/15	N/A	N/A
N/A	FHA PowerSaver Loan Program	Loan Program	Solar Water Heat, Solar Photovoltaics, Wind (All), Geothermal Heat Pumps, Water Heaters, Furnaces, Air	3/7/16	1/26/15	N/A

			conditioners, Programmable Thermostats, Energy Mgmt. Systems/Building Controls, Caulking/Weather-stripping, Building Insulation, Windows, Doors, Comprehensive Measures/Whole Building			
U.S. Internal Revenue Service	Qualified Energy Conservation Bonds (QECBs)	Loan Program	Geothermal Electric, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Municipal Solid Waste, Landfill Gas, Tidal, Wave, Ocean Thermal, Yes; specific technologies not identified, Anaerobic Digestion	6/16/16	N/A	N/A
U.S. Department of Energy	U.S. Department of Energy - Loan Guarantee Program	Loan Program	Geothermal Electric, Solar Thermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Fuel Cells using Non-Renewable Fuels, Landfill Gas, Tidal, Wave, Ocean Thermal, Daylighting, Yes; specific technologies not identified, Fuel Cells using Renewable Fuels	8/18/16	N/A	N/A
US Department of Agriculture	USDA - Biorefinery Assistance Program	Loan Program	Biomass, Municipal Solid Waste, Landfill Gas	3/3/17	N/A	N/A
U.S. Department of Agriculture	USDA - Rural Energy for America Program	Loan Program	Solar Water Heat, Solar Space Heat, Geothermal Electric, Solar Thermal Electric, Solar Photovoltaics,	2/11/16	N/A	N/A

	(REAP) Loan Guarantees		Wind (All), Biomass, Hydroelectric, Hydrogen, Geothermal Heat Pumps, Combined Heat & Power, Tidal, Wave, Ocean Thermal, Yes; specific technologies not identified, Wind (Small), Hydroelectric (Small), Geothermal Direct-Use, Anaerobic Digestion, Fuel Cells using Renewable Fuels, Microturbines			
U.S. Internal Revenue Service	Residential Renewable Energy Tax Credit	Personal Tax Credit	Solar Water Heat, Solar Photovoltaics	3/17/17	1/1/06	N/A
U.S. Internal Revenue Service	Residential Energy Conservation Subsidy Exclusion (Personal)	Personal Tax Exemption	Solar Water Heat, Solar Space Heat, Solar Photovoltaics, Yes; specific technologies not identified	5/26/16	N/A	N/A

(Database Of State Incentives For Renewables & Efficiency, North Carolina Clean Energy Technology Center, North Carolina State University, Accessed 11/29/17)

ALABAMA

Administrator	Name	Type	Technologies	Last Updated	Start Date	End Date
Abundant Power	AlabamaSAVES Revolving Loan Program	Loan Program	Solar Water Heat, Geothermal Electric, Solar Photovoltaics, Biomass, Hydroelectric, Combined Heat & Power, Water Heaters, Lighting, Lighting Controls/Sensors, Steam-system upgrades, Energy Mgmt. Systems/Building Controls, Building Insulation, Windows, Doors, Other EE, Hydroelectric (Small), Fuel Cells using Renewable Fuels, LED Lighting, Commercial Refrigeration Equipment	5/3/17	N/A	N/A
Alabama Department of Economic and Community Affairs	Local Government Energy Loan Program	Loan Program	Solar - Passive, Solar Water Heat, Geothermal Electric, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Geothermal Heat Pumps, Combined Heat & Power, Daylighting, Lighting, Chillers, Furnaces, Boilers, Heat pumps, Air conditioners, Heat recovery, Energy Mgmt.	7/25/14	N/A	N/A

			Systems/Building Controls, Caulking/Weather-stripping, Duct/Air sealing, Building Insulation, Windows, Doors, Siding, Roofs, Motors, Motor VFDs, Custom/Others pending approval, Other EE, Wind (Small), Hydroelectric (Small), Geothermal Direct-Use, Other Distributed Generation Technologies			
South Alabama Electric Cooperative	South Alabama Electric Cooperative - Residential Energy Efficiency Loan Program	Loan Program	Geothermal Heat Pumps, Heat pumps, Building Insulation, Windows, Doors	4/1/15	N/A	N/A
Tennessee Valley Authority	TVA Partner Utilities - Energy Right Heat Pump Program	Loan Program	Geothermal Heat Pumps, Heat pumps	6/17/15	N/A	N/A
Tennessee Valley Authority	TVA - Green Power Providers	Performance-Based Incentive	Solar Photovoltaics, Wind (All), Biomass, Wind (Small), Hydroelectric (Small)	6/2/15	10/1/12	N/A
Tennessee Valley Authority	TVA - Mid-Sized Renewable Standard Offer Program	Performance-Based Incentive	Solar Photovoltaics, Wind (All), Biomass, Landfill Gas, Anaerobic Digestion	6/18/15	10/10/10	N/A
N/A	TVA - Solar Solutions Initiative	Performance-Based Incentive	Solar Photovoltaics, Furnaces, Heat pumps, Air conditioners, Caulking/Weather-stripping,	6/4/15	N/A	N/A

			Duct/Air sealing, Building Insulation, Windows, Doors, Siding, Roofs			
N/A	Wood-Burning Heating System Deduction	Personal Tax Deduction	Biomass	7/23/14	N/A	N/A
Alabama Department of Revenue	Local Option- Property Tax Exemption for Renewable Energy Faclities	Property Tax Incentive	Solar Photovoltaics, Wind (All), Biomass, Municipal Solid Waste, Tidal, Geothermal Direct-Use, Anaerobic Digestion	11/16/16	N/A	12/31/18
Alabama Gas Corporation	Alabama Gas Corporation - Residential Natural Gas Rebate Program	Rebate Program	Water Heaters, Furnaces, Air conditioners	1/21/16	N/A	N/A
Central Alabama Electric Cooperative	Central Alabama Electric Cooperative - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Water Heaters, Heat pumps, Comprehensive Measures/Whole Building	4/1/15	N/A	N/A
N/A	TVA Partner Utilities - eScore Program	Rebate Program	Geothermal Heat Pumps, Water Heaters, Heat pumps, Air conditioners, Duct/Air sealing, Windows, Doors, Insulation	8/31/17	N/A	N/A
Wiregrass Electric Cooperative, Inc.	Wiregrass Electric Cooperative - H2O Plus Program	Rebate Program	Geothermal Heat Pumps, Water Heaters	4/1/15	N/A	N/A
Alabama Department of Revenue	Local Option- Sales Tax Abatement for Renewable Energy Facilities	Sales Tax Incentive	Solar Water Heat, Solar Photovoltaics, Wind (All), Biomass, Municipal Solid Waste, Tidal,	11/16/16	N/A	N/A

			Ocean Thermal, Hydroelectric (Small), Geothermal Direct-Use			

(Database Of State Incentives For Renewables & Efficiency, North Carolina Clean Energy Technology Center, North Carolina State University, Accessed 11/29/17)

ALASKA

Administrator	Name	Type	Technologies	Last Updated	Start Date	End Date
Alaska Energy Authority	Renewable Energy Grant Program	Grant Program	Solar Water Heat, Geothermal Electric, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Geothermal Heat Pumps, Combined Heat & Power, Fuel Cells using Non-Renewable Fuels, Landfill Gas, Tidal, Wave, Geothermal Direct-Use, Anaerobic Digestion, Fuel Cells using Renewable Fuels	8/17/16	N/A	6/30/23
The Division of Economic Development, Department of Commerce, Community, and Economic Development	Alternative Energy Conservation Loan Fund	Loan Program	Solar Water Heat, Solar Space Heat, Solar Photovoltaics, Wind (All), Biomass, Furnaces, Boilers, Caulking/Weather-stripping, Duct/Air sealing, Building Insulation, Windows, Doors, Custom/Others pending approval, Wind (Small), Fuel Cells using Renewable Fuels, Other Distributed Generation Technologies	12/17/15	N/A	N/A
Alaska Industrial Development and Export Authority	Power Project Loan Fund	Loan Program	Solar Water Heat, Solar Space Heat, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Hydroelectric, Municipal Solid Waste, Combined Heat & Power, Custom/Others pending approval,	12/16/15	N/A	N/A

			Wind (Small), Hydroelectric (Small)			
Golden Valley Electric Association	Golden Valley Electric Association - Sustainable Natural Alternative Power (SNAP) Program	Performance-Based Incentive	Geothermal Electric, Solar Photovoltaics, Wind (All), Biomass, Landfill Gas, Tidal, Wave, Wind (Small), Hydroelectric (Small)	6/18/15	N/A	N/A
N/A	Local Option - Property Tax Exemption for Renewable Energy Systems	Property Tax Incentive	Solar Water Heat, Solar Space Heat, Solar Photovoltaics, Wind (All), Biomass, Wind (Small), Hydroelectric (Small), Other Distributed Generation Technologies	12/16/15	N/A	N/A
N/A	New Home Rebate	Rebate Program	Comprehensive Measures/Whole Building	12/16/15	N/A	N/A

(Database Of State Incentives For Renewables & Efficiency, North Carolina Clean Energy Technology Center, North Carolina State University, Accessed 11/29/17)

ARIZONA

Administrator	Name	Type	Technologies	Last Updated	Start Date	End Date
Arizona Department of Revenue	Non-Residential Solar & Wind Tax Credit (Corporate)	Corporate Tax Credit	Solar - Passive, Solar Water Heat, Solar Space Heat, Solar Thermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Wind (All), Daylighting, Solar Pool Heating, Wind (Small)	11/1/16	1/1/06	12/31/18
Arizona Department of Revenue	Renewable Energy Production Tax Credit (Corporate)	Corporate Tax Credit	Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Landfill Gas	11/1/16	12/31/10	12/31/20
N/A	Renewable Energy Tax Credit for International Operations Centers (Corporate)	Corporate Tax Credit	Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Landfill Gas, Anaerobic Digestion, Fuel Cells using Renewable Fuels	5/30/17	7/24/14	12/31/25
City of Scottsdale	City of Scottsdale - Green Building Incentives	Green Building Incentive	Solar - Passive, Solar Photovoltaics, Daylighting, Equipment Insulation, Water Heaters, Lighting, Furnaces, Boilers, Heat pumps, Programmable Thermostats, Energy Mgmt. Systems/Building Controls, Duct/Air sealing, Building Insulation, Siding, Roofs, Comprehensive Measures/Whole Building, Custom/Others pending approval, Other EE, Fuel Cells	11/17/16	N/A	N/A

			using Renewable Fuels, Tankless Water Heater			
Sulphur Springs Valley Electric Cooperative	Sulphur Springs Valley EC - Residential Energy Efficiency Loan Program	Loan Program	Heat pumps, Air conditioners, Caulking/Weather-stripping, Duct/Air sealing, Building Insulation, Windows, Doors, Siding, Roofs, Comprehensive Measures/Whole Building, Other EE	3/1/16	N/A	N/A
Arizona Department of Revenue	Non-Residential Solar & Wind Tax Credit (Personal)	Personal Tax Credit	Solar - Passive, Solar Water Heat, Solar Space Heat, Solar Thermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Wind (All), Daylighting, Solar Pool Heating, Wind (Small)	11/1/16	1/1/06	12/31/18
Arizona Department of Revenue	Renewable Energy Production Tax Credit (Personal)	Personal Tax Credit	Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Landfill Gas	11/1/16	12/31/10	12/31/20
N/A	Renewable Energy Tax Credit for International Operations Centers (Personal)	Personal Tax Credit	Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Landfill Gas, Anaerobic Digestion, Fuel Cells using Renewable Fuels	5/30/17	7/24/14	12/31/25
AZ Department of Revenue	Residential Solar and Wind Energy Systems Tax Credit	Personal Tax Credit	Solar - Passive, Solar Water Heat, Solar Space Heat, Solar Photovoltaics, Wind (All), Daylighting, Solar Pool Heating, Wind (Small)	11/1/16	1/1/95	N/A
N/A	Qualifying Wood Stove Deduction	Personal Tax Deduction	Biomass	3/21/17	1/1/94	N/A
Arizona Department of Revenue	Energy Equipment Property	Property Tax Incentive	Solar - Passive, Solar Water Heat, Solar Space Heat, Geothermal Electric,	5/24/17	N/A	N/A

	Tax Exemption		Solar Thermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Wind (All), Biomass, Geothermal Heat Pumps, Combined Heat & Power, Landfill Gas, Daylighting, Solar Pool Heating, Other EE, Yes; specific technologies not identified, Wind (Small), Hydroelectric (Small), Anaerobic Digestion			
Arizona Department of Revenue	Property Tax Assessment for Renewable Energy Equipment	Property Tax Incentive	Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric	5/24/17	N/A	12/31/40
APS	APS - Energy Efficiency Solutions for Business	Rebate Program	Lighting, Lighting Controls/Sensors, Compressed air, Programmable Thermostats, Energy Mgmt. Systems/Building Controls, Windows, Doors, Motors, Motor VFDs, Comprehensive Measures/Whole Building, Custom/Others pending approval, Other EE, Food Service Equipment, Vending Machine Controls, Data Center Equipment, Pool Pumps, Commercial Refrigeration Equipment	8/10/17	N/A	N/A
Duncan Valley Electric Cooperative	Duncan Valley Electric Cooperative	Rebate Program	Solar Water Heat, Solar Photovoltaics, Wind (All), Wind (Small)	6/18/15	N/A	N/A

	- SunWatts Rebate Program					
Mohave Electric Cooperative	Mohave Electric Cooperative - Renewable Energy Incentive Program	Rebate Program	Solar Water Heat, Solar Photovoltaics, Wind (All), Wind (Small)	6/18/15	N/A	N/A
Salt River Project	SRP - Solar Water Heating Program	Rebate Program	Solar Water Heat	8/10/17	N/A	N/A
Trico Electric Cooperative, Inc.	Trico Electric Cooperative - SunWatts Incentive Program	Rebate Program	Solar Water Heat	6/29/15	N/A	N/A
Department of Revenue	Solar and Wind Equipment Sales Tax Exemption	Sales Tax Incentive	Solar - Passive, Solar Water Heat, Solar Space Heat, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Daylighting, Solar Pool Heating, Wind (Small)	8/15/17	1/1/97	N/A

(Database Of State Incentives For Renewables & Efficiency, North Carolina Clean Energy Technology Center, North Carolina State University, Accessed 11/29/17)

ARKANSAS

Administrator	Name	Type	Technologies	Last Updated	Start Date	End Date
Arkansas Economic Development Commission	Wind Energy Manufacturing Tax Incentive	Industry Recruitment/Support	Wind (All), Wind (Small)	6/4/15	1/1/08	12/31/33
First Electric Cooperative	First Electric Cooperative - Home Improvement Loans	Loan Program	Geothermal Heat Pumps, Water Heaters, Heat pumps, Caulking/Weather-stripping, Duct/Air sealing, Building Insulation, Windows, Doors, Other EE	6/9/15	N/A	N/A
Arkansas Building Authority, Arkansas Energy Office	Sustainable Building Design Revolving Loan Fund	Loan Program	Solar Water Heat, Biomass, Geothermal Heat Pumps, Combined Heat & Power, Water Heaters, Lighting, Furnaces, Air conditioners, Heat recovery, Steam-system upgrades, Energy Mgmt. Systems/Building Controls, Caulking/Weather-stripping, Duct/Air sealing, Building Insulation, Windows, Motor VFDs, Comprehensive Measures/Whole Building, Custom/Others pending approval	6/8/15	1/8/10	N/A

(Database Of State Incentives For Renewables & Efficiency, North Carolina Clean Energy Technology Center, North Carolina State University, Accessed 11/29/17)

CALIFORNIA

Administrator	Name	Type	Technologies	Last Updated	Start Date	End Date
N/A	LADWP - Feed-in Tariff (FiT) Program	Feed-in Tariff	Solar Photovoltaics	2/2/17	2/1/13	N/A
N/A	Renewable Market Adjusting Tariff (ReMAT)	Feed-in Tariff	Geothermal Electric, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Municipal Solid Waste, Landfill Gas, Tidal, Wave, Ocean Thermal, Hydroelectric (Small), Anaerobic Digestion, Fuel Cells using Renewable Fuels	7/21/16	2/14/08	N/A
City of Burbank	Burbank Water & Power - Business Bucks Energy Efficiency Grant Program	Grant Program	Refrigerators/Freezers, Lighting, Air conditioners, Caulking/Weather-stripping, Duct/Air sealing, Building Insulation, Windows, Siding, Roofs, Motors, Custom/Others pending approval	3/4/16	N/A	N/A
Pacific Power	Pacific Power - Blue Sky Community Project Funds	Grant Program	Geothermal Electric, Solar Photovoltaics, Wind (All), Biomass, Tidal, Wave, Hydroelectric (Small), Anaerobic Digestion	3/16/16	N/A	N/A
Department of General Sevices	School Facility Program - Modernization Grants	Grant Program	Yes; specific technologies not identified	1/4/16	N/A	N/A
Rebates	Burbank Water & Power -	Green Building Incentive	Solar - Passive, Solar Water Heat, Solar Space Heat,	3/31/16	N/A	N/A

	Green Building Incentive Program		Solar Photovoltaics, Wind (All), Biomass, Geothermal Heat Pumps, Daylighting, Comprehensive Measures/Whole Building, Wind (Small), Hydroelectric (Small)			
City of San Diego Development Services	City of San Diego - Sustainable Building Expedited Permit Program	Green Building Incentive	Solar Photovoltaics, Comprehensive Measures/Whole Building	5/27/16	5/20/03	N/A
County of San Diego	San Diego County - Green Building Program	Green Building Incentive	Solar Photovoltaics, Comprehensive Measures/Whole Building	3/11/16	N/A	N/A
State Treasurer's Office	Sales and Use Tax Exclusion for Advanced Transportation and Alternative Energy Manufacturing Program	Industry Recruitment/Support	Geothermal Electric, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Municipal Solid Waste, Landfill Gas, Tidal, Wave, Ocean Thermal, Fuel Cells using Renewable Fuels	2/18/16	3/24/10	1/1/21
City of Santa Clara Water & Sewer Utility	Santa Clara Water & Sewer - Solar Water Heating Program	Leasing Program	Solar Water Heat, Solar Thermal Process Heat, Solar Pool Heating	5/19/15	N/A	N/A
California Energy Commission	Energy Efficiency Financing for Public Sector Projects	Loan Program	Solar Photovoltaics, Combined Heat & Power, Lighting, Lighting Controls/Sensors, Chillers, Furnaces, Boilers, Heat pumps, Air conditioners,	5/25/16	N/A	N/A

			Energy Mgmt. Systems/Building Controls, Building Insulation, Motors, Custom/Others pending approval, Other EE, Wind (Small), Other Distributed Generation Technologies			
CPUC	Renewable Auction Mechanism (RAM)	Other Incentive	Geothermal Electric, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Municipal Solid Waste, Landfill Gas, Tidal, Wave, Ocean Thermal, Hydroelectric (Small), Anaerobic Digestion, Fuel Cells using Renewable Fuels	5/17/16	N/A	N/A
FIGTREE Energy Financing	California Enterprise Development Authority (Figtree PACE) - Statewide PACE Program	PACE Financing	Solar Water Heat, Solar Photovoltaics, Wind (All), Geothermal Heat Pumps, Fuel Cells using Non-Renewable Fuels, Water Heaters, Lighting, Lighting Controls/Sensors, Chillers, Furnaces, Boilers, Heat pumps, Air conditioners, Steam-system upgrades, Programmable Thermostats, Duct/Air sealing, Building Insulation, Doors, Motor VFDs, Wind (Small), Pool Pumps, Tankless	1/13/16	N/A	N/A

			Water Heater, Commercial Refrigeration Equipment			
Renewable Funding	CaliforniaFIRST	PACE Financing	Solar Water Heat, Solar Space Heat, Solar Photovoltaics, Wind (All), Geothermal Heat Pumps, Fuel Cells using Non-Renewable Fuels, Equipment Insulation, Water Heaters, Lighting, Lighting Controls/Sensors, Furnaces, Heat pumps, Air conditioners, Heat recovery, Programmable Thermostats, Caulking/Weather-stripping, Duct/Air sealing, Building Insulation, Roofs, Other EE, Wind (Small), Fuel Cells using Renewable Fuels, Reflective Roofs, Tankless Water Heater	3/11/16	N/A	N/A
N/A	City of San Francisco - GreenFinance SF	PACE Financing	Solar Water Heat, Solar Photovoltaics, Water Heaters, Furnaces, Boilers, Air conditioners, Programmable Thermostats, Caulking/Weather-stripping, Duct/Air sealing, Building Insulation, Windows	3/1/16	4/12/10	N/A
N/A	Los Angeles County - Commercial PACE	PACE Financing	Solar Water Heat, Solar Photovoltaics, Fuel Cells using Non-Renewable Fuels, Lighting,	1/13/16	N/A	N/A

			Lighting Controls/Sensors, Chillers, Furnaces, Boilers, Heat pumps, Air conditioners, Programmable Thermostats, Energy Mgmt. Systems/Building Controls, Windows, Motors, Motor VFDs, Custom/Others pending approval, Fuel Cells using Renewable Fuels			
N/A	Sonoma County - Energy Independence Program	PACE Financing	Solar Water Heat, Solar Photovoltaics, Geothermal Heat Pumps, Combined Heat & Power, Solar Pool Heating, Water Heaters, Lighting, Lighting Controls/Sensors, Furnaces, Heat pumps, Air conditioners, Caulking/Weather-stripping, Duct/Air sealing, Building Insulation, Windows, Roofs, Motors, Other EE, Fuel Cells using Renewable Fuels, Reflective Roofs, Pool Pumps, LED Lighting	1/13/16	N/A	N/A
N/A	Western Riverside Council of Governments - Home Energy Renovation Opportunity (HERO)	PACE Financing	Solar Water Heat, Solar Photovoltaics, Wind (All), Geothermal Heat Pumps, Lighting, Furnaces, Boilers, Heat pumps, Air conditioners, Programmable	11/3/16	N/A	N/A

	Financing Program		Thermostats, Caulking/Weather-stripping, Duct/Air sealing, Building Insulation, Windows, Roofs, Custom/Others pending approval, Other EE, Wind (Small), LED Lighting			
N/A	Western Riverside Council of Governments - Large Commercial PACE	PACE Financing	Solar Water Heat, Solar Photovoltaics, Wind (All), Geothermal Heat Pumps, Lighting, Furnaces, Boilers, Heat pumps, Air conditioners, Programmable Thermostats, Caulking/Weather-stripping, Duct/Air sealing, Building Insulation, Windows, Roofs, Custom/Others pending approval, Other EE, Wind (Small), Pool Pumps, LED Lighting	3/31/16	N/A	N/A
City of Palo Alto Utilities	City of Palo Alto Utilities - Palo Alto CLEAN (Clean Local Energy Accessible Now)	Performance-Based Incentive	Solar Photovoltaics	6/17/15	4/2/12	N/A
Marin Clean Energy	Marin Clean Energy - Feed-In Tariff	Performance-Based Incentive	Geothermal Electric, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Municipal Solid Waste, Landfill Gas, Tidal, Wave, Ocean	6/17/15	N/A	N/A

			Thermal, Wind (Small), Hydroelectric (Small), Anaerobic Digestion, Fuel Cells using Renewable Fuels			
California State Board of Equalization	Property Tax Exclusion for Solar Energy Systems	Property Tax Incentive	Solar Water Heat, Solar Space Heat, Solar Thermal Electric, Solar Thermal Process Heat, Solar Photovoltaics	5/25/16	N/A	12/31/24
N/A	Bear Valley Electric Service - Solar Initiative Program	Rebate Program	Solar Photovoltaics	6/29/15	1/1/15	12/31/22
N/A	Burbank Water and Power - Solar Water Heater Rebate Program	Rebate Program	Solar Water Heat	6/29/15	N/A	N/A
N/A	California Solar Initiative - Low-Income Solar Water Heating Rebate Program	Rebate Program	Solar Water Heat	6/30/15	3/29/12	N/A
GRID Alternatives	California Solar Initiative - Single-Family Affordable Solar Housing (SASH) Program	Rebate Program	Solar Photovoltaics	3/9/17	7/1/09	12/31/21
California Energy Commission	CEC - New Solar Homes Partnership	Rebate Program	Solar Photovoltaics	5/25/16	N/A	N/A
City of Healdsburg	City of Healdsburg - PV Incentive Program	Rebate Program	Solar Photovoltaics	5/29/15	N/A	N/A
City of Lompoc Utilities	City of Lompoc	Rebate Program	Solar Photovoltaics	6/3/15	N/A	N/A

	Utilities - PV Rebate Program					
City of Palo Alto Utilities	City of Palo Alto Utilities - PV Partners	Rebate Program	Solar Photovoltaics	3/11/16	7/1/07	N/A
Center for Sustainable Energy	City of Palo Alto Utilities - Solar Water Heating Program	Rebate Program	Solar Water Heat	5/19/15	N/A	N/A
San Francisco Public Utilities Commission	City of San Francisco - Solar Energy Incentive Program	Rebate Program	Solar Photovoltaics	5/27/16	12/11/07	N/A
City of Shasta Lake Electric Utility	City of Shasta Lake Electric Utility - PV Rebate Program	Rebate Program	Solar Photovoltaics	6/3/15	N/A	N/A
Corona Department of Water & Power	Corona Department of Water & Power - Solar Partnership Rebate Program	Rebate Program	Solar Photovoltaics	5/26/15	N/A	N/A
Glendale Water and Power	Glendale Water and Power - Solar Solutions Program	Rebate Program	Solar Photovoltaics	7/1/15	N/A	N/A
Imperial Irrigation District	IID Energy - Commercial Rebate Program	Rebate Program	Heat pumps, Air conditioners, Motors, Motor VFDs, Custom/Others pending approval	6/15/15	N/A	N/A
Imperial Irrigation District	IID Energy - PV Solutions Rebate Program	Rebate Program	Solar Photovoltaics	6/3/15	N/A	N/A
Lassen Municipal Utility District	Lassen Municipal Utility District - PV Rebate Program	Rebate Program	Solar Photovoltaics	7/1/15	N/A	N/A

Public Benefits Specialist	Lassen Municipal Utility District - Residential Energy Efficiency Rebate Program	Rebate Program	Solar Water Heat, Clothes Washers, Dishwasher, Refrigerators/Freezers, Water Heaters, Lighting, Heat pumps, Air conditioners, LED Lighting	2/23/16	N/A	N/A
Merced Irrigation District	Merced Irrigation District - PV Buydown Program	Rebate Program	Solar Photovoltaics	6/3/15	N/A	N/A
PV Program Coordinator	Modesto Irrigation District - Photovoltaic Rebate Program	Rebate Program	Solar Photovoltaics	7/1/15	N/A	N/A
Moreno Valley Electric Utility	Moreno Valley Electric Utility - Solar Electric Incentive Program	Rebate Program	Solar Photovoltaics	7/1/15	N/A	N/A
Pacific Power	Pacific Power - wattsmart Business	Rebate Program	Geothermal Heat Pumps, Lighting, Chillers, Heat pumps, Air conditioners, Compressed air, Building Insulation, Windows, Motors, Motor VFDs, Custom/Others pending approval, Food Service Equipment, Personal Computing Equipment, Commercial Refrigeration Equipment	8/26/15	N/A	N/A
Pasadena Water and Power	Pasadena Water and Power - Solar Power	Rebate Program	Solar Photovoltaics	3/9/17	N/A	N/A

	Installation Rebate					
Plumas-Sierra REC	Plumas-Sierra REC - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Heat pumps, Building Insulation, Windows, Custom/Others pending approval, LED Lighting	1/19/16	N/A	N/A
Riverside Public Utilities	Riverside Public Utilities - Residential PV Incentive Program	Rebate Program	Solar Photovoltaics	6/17/15	N/A	N/A
Roseville Electric	Roseville Electric - Residential New Construction Rebate Program	Rebate Program	Solar Photovoltaics	4/23/15	N/A	N/A
Roseville Electric	Roseville Electric - Solar Rebate Program	Rebate Program	Solar Photovoltaics	8/15/16	N/A	N/A
California Public Utilities Commission	Self-Generation Incentive Program	Rebate Program	Wind (All), Combined Heat & Power, Fuel Cells using Non-Renewable Fuels, Wind (Small), Fuel Cells using Renewable Fuels	4/18/17	1/1/01	1/1/21
Silicon Valley Power	Silicon Valley Power - Commercial Energy Efficiency Rebate Program	Rebate Program	Lighting, Lighting Controls/Sensors, Heat pumps, Air conditioners, Compressed air, Energy Mgmt. Systems/Building Controls, Comprehensive Measures/Whole Building, Custom/Others	1/12/16	N/A	N/A

			pending approval, Other EE, Food Service Equipment, Data Center Equipment, LED Lighting, Commercial Refrigeration Equipment			
Sacramento Municipal Utility District	SMUD - Commercial Energy Efficiency Rebate Program	Rebate Program	Solar Water Heat, Dishwasher, Refrigerators/Freezers, Lighting, Lighting Controls/Sensors, Heat pumps, Air conditioners, Processing and Manufacturing Equipment, Custom/Others pending approval, Food Service Equipment, Vending Machine Controls, Commercial Cooking Equipment, Personal Computing Equipment, Data Center Equipment, LED Lighting, Commercial Refrigeration Equipment	6/6/16	N/A	N/A
Sacramento Municipal Utility District	SMUD - PV Residential Retrofit Buy-Down	Rebate Program	Solar Photovoltaics	5/24/16	N/A	N/A
Sacramento Municipal Utility District	SMUD - Residential Energy Efficiency Rebate Program	Rebate Program	Clothes Washers, Dishwasher, Refrigerators/Freezers, Water Heaters, Lighting, Heat pumps, Air conditioners, Duct/Air sealing,	5/17/16	N/A	N/A

			Building Insulation, Windows, Roofs, Other EE, Reflective Roofs, Pool Pumps, LED Lighting			
Sacramento Municipal Utility District	SMUD - Solar Water Heater Rebate Program	Rebate Program	Solar Water Heat	5/19/15	N/A	N/A
Truckee Donner Public Utility District	Truckee Donner Public Utility District - Energy Conservation Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Water Heaters, Lighting, Heat pumps, Air conditioners, Duct/Air sealing, Windows, LED Lighting	2/4/16	N/A	N/A
City of Ukiah	Ukiah Utilities - PV Buydown Program	Rebate Program	Solar Photovoltaics	11/3/16	N/A	N/A
California State Board of Equalization	Partial Sales and Use Tax Exemption for Agricultural Solar Power Facilities	Sales Tax Incentive	Solar Photovoltaics	3/31/16	N/A	N/A

(Database Of State Incentives For Renewables & Efficiency, North Carolina Clean Energy Technology Center, North Carolina State University, Accessed 11/29/17)

COLORADO

Administrator	Name	Type	Technologies	Last Updated	Start Date	End Date
N/A	EZ Investment Tax Credit Refund for Renewable Energy Projects	Corporate Tax Credit	Geothermal Electric, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Landfill Gas, Anaerobic Digestion	10/30/15	1/1/15	12/31/20
Boulder County ClimateSmart	City of Boulder - Solar Grant Program	Grant Program	Solar Water Heat, Solar Photovoltaics	2/12/16	N/A	N/A
Elevations Credit Union	Boulder County - Elevations Energy Loans	Loan Program	Solar Water Heat, Solar Photovoltaics, Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Water Heaters, Lighting, Furnaces, Heat pumps, Air conditioners, Energy Mgmt. Systems/Building Controls, Duct/Air sealing, Building Insulation, Windows, Doors, Roofs, Motors, Motor VFDs, Food Service Equipment, Personal Computing Equipment, Commercial Refrigeration Equipment	7/23/15	N/A	N/A
Elevations Credit Union	City and County of Denver - Elevations Energy Loans	Loan Program	Solar Water Heat, Solar Photovoltaics, Biomass, Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Water Heaters, Lighting, Furnaces, Boilers, Heat pumps, Air conditioners, Duct/Air sealing, Building Insulation,	9/28/15	N/A	N/A

			Windows, Doors, Motors, Food Service Equipment, Commercial Refrigeration Equipment			
Energy Smart Colorado	Eagle, Garfield, Gunnison, Lake, and Pitkin Counties - Energy Smart Colorado Loan Program	Loan Program	Solar Water Heat, Solar Photovoltaics, Water Heaters, Furnaces, Boilers, Duct/Air sealing, Building Insulation, Windows, Doors, Tankless Water Heater	2/24/16	N/A	N/A
N/A	Fort Collins Utilities - Home Efficiency Loan Program	Loan Program	Solar Photovoltaics, Water Heaters, Furnaces, Heat pumps, Air conditioners, Duct/Air sealing, Building Insulation, Windows, Comprehensive Measures/Whole Building, Tankless Water Heater	7/8/15	N/A	N/A
Colorado Housing Finance Authority	Green Colorado Credit Reserve	Loan Program	Geothermal Electric, Solar Photovoltaics, Yes; specific technologies not identified, Other Distributed Generation Technologies	5/19/16	N/A	N/A
Colorado Energy Office	Renewable Energy and Energy Efficiency for Schools Loan	Loan Program	Solar Water Heat, Solar Photovoltaics, Wind (All), Biomass, Equipment Insulation, Air conditioners, Duct/Air sealing, Building Insulation, Comprehensive Measures/Whole Building, Wind (Small), Hydroelectric (Small), Other Distributed Generation Technologies	3/15/17	N/A	N/A
N/A	Xcel Energy - Commercial	Loan Program	Comprehensive Measures/Whole	6/14/17	N/A	N/A

	Energy Efficiency Financing		Building, Yes; specific technologies not identified			
Sustainable Real Estate Solutions, Inc	C-PACE: Colorado Commercial Property Assessed Clean Energy	PACE Financing	Solar Water Heat, Solar Space Heat, Geothermal Electric, Solar Thermal Electric, Solar Photovoltaics, Biomass, Geothermal Heat Pumps, Lighting, Air conditioners, Heat recovery, Energy Mgmt. Systems/Building Controls, Caulking/Weather-stripping, Building Insulation, Windows, Doors, Other EE, Wind (Small), Hydroelectric (Small), Fuel Cells using Renewable Fuels, Other Distributed Generation Technologies	6/10/16	N/A	N/A
Black Hills Energy	Black Hills Energy - Solar Power Program	Performance-Based Incentive	Solar Photovoltaics	3/25/16	7/1/06	N/A
Xcel Energy	Xcel Energy - Solar*Rewards Community Program	Performance-Based Incentive	Solar Photovoltaics	3/15/16	8/15/12	N/A
Xcel Energy	Xcel Energy - Solar*Rewards Program	Performance-Based Incentive	Solar Photovoltaics	6/27/16	3/1/06	N/A
N/A	Property Tax Exemption for Community Solar Gardens	Property Tax Incentive	Solar Photovoltaics	7/21/15	1/1/15	12/31/20
Division of Property Taxation / Local Assessors	Property Tax Exemption for Residential Renewable Energy Equipment	Property Tax Incentive	Solar Photovoltaics	7/23/15	N/A	N/A
Department of Local Affairs	Renewable Energy	Property Tax Incentive	Geothermal Electric, Solar Thermal Electric, Solar Photovoltaics,	10/7/15	1/1/09	N/A

	Property Tax Assessment		Wind (All), Biomass, Wind (Small), Hydroelectric (Small)			
Boulder County Public Health	Boulder County - EnergySmart Commercial Energy Efficiency Rebate Program	Rebate Program	Solar Photovoltaics, Dishwasher, Lighting, Lighting Controls/Sensors, Furnaces, Boilers, Air conditioners, Compressed air, Programmable Thermostats, Windows, Motors, Motor VFDs, Other EE, Food Service Equipment, Vending Machine Controls, Commercial Cooking Equipment, LED Lighting, Commercial Refrigeration Equipment	5/11/16	N/A	N/A
N/A	Boulder County - EnergySmart Residential Energy Efficiency Rebate Program	Rebate Program	Solar Space Heat, Geothermal Heat Pumps, Dishwasher, Refrigerators/Freezers, Water Heaters, Furnaces, Boilers, Heat pumps, Air conditioners, Duct/Air sealing, Building Insulation, Other EE	1/25/16	N/A	N/A
City of Aspen	City of Aspen - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Water Heaters, Heat pumps, Programmable Thermostats, Caulking/Weather-stripping, Duct/Air sealing, Building Insulation, Windows, Doors, Custom/Others pending approval, LED Lighting	7/21/15	N/A	N/A
Colorado Springs Utilities	Colorado Springs Utilities - Renewable Energy	Rebate Program	Solar Water Heat, Solar Photovoltaics	2/9/17	1/1/06	N/A

	Rebate Program					
Delta-Montrose Electric Association	Delta-Montrose Electric Association - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Water Heaters, Heat pumps, Air conditioners, Motors, LED Lighting	3/15/17	N/A	N/A
Walking Mountains Science Center	Eagle County - Energy Smart Colorado Renewable Energy Rebate Program	Rebate Program	Solar Water Heat, Solar Photovoltaics	5/21/15	N/A	N/A
N/A	Efficiency Works - Residential Energy Efficiency Rebate Program (Offered by 5 Utilities)	Rebate Program	Geothermal Heat Pumps, Water Heaters, Lighting, Lighting Controls/Sensors, Furnaces, Boilers, Heat pumps, Air conditioners, Duct/Air sealing, Building Insulation, Windows, Insulation, LED Lighting, Tankless Water Heater	7/8/15	N/A	N/A
Gunnison County Electric Association, Inc.	Gunnison County Electric - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Water Heaters, Heat pumps, LED Lighting	6/22/16	N/A	N/A
Holy Cross	Holy Cross Energy - Commercial Energy Efficiency Rebate Program	Rebate Program	Lighting, Lighting Controls/Sensors, Air conditioners, Energy Mgmt. Systems/Building Controls, Motor VFDs, LED Lighting, Commercial Refrigeration Equipment	11/19/15	N/A	N/A

La Plata Electric Association	La Plata Electric Association - Energy Efficient Equipment Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Water Heaters, Heat pumps, Air conditioners, Motors, Other EE, LED Lighting	4/17/17	N/A	N/A
La Plata Electric Association	La Plata Electric Association - Renewable Generation Rebate Program	Rebate Program	Solar Photovoltaics, Wind (All), Wind (Small), Hydroelectric (Small)	10/31/16	N/A	N/A
Cloud City Conservation Center	Lake County - Energy Smart Colorado Renewable Energy Rebate Program	Rebate Program	Solar Water Heat, Solar Photovoltaics	3/3/15	N/A	N/A
Morgan County Rural Electric Association	Morgan County REA - Efficiency Credit/Rebate Programs	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Water Heaters, Heat pumps, Air conditioners, Motors, Other EE, LED Lighting	3/25/15	N/A	N/A
Mountain View Electric Association, Inc.	Mountain View Electric Association, Inc - Energy Efficiency Rebates Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Water Heaters, Lighting, Heat pumps, Motors, Other EE, LED Lighting	10/8/15	N/A	N/A
Community Office for Resource Efficiency (CORE)	Roaring Fork Valley - Energy Smart Colorado Renewable Energy Rebate Program	Rebate Program	Solar Water Heat, Solar Photovoltaics, Geothermal Heat Pumps, Hydroelectric (Small)	5/20/15	N/A	N/A

San Isabel Electric Association	San Isabel Electric Association - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Water Heaters, Lighting Controls/Sensors, Heat pumps, Air conditioners, Programmable Thermostats, Building Insulation, Other EE, LED Lighting	12/4/15	N/A	N/A
N/A	San Miguel Power Association - Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Water Heaters, Lighting, Heat pumps, Air conditioners, Duct/Air sealing, Building Insulation, Motors, Other EE, LED Lighting	12/8/15	N/A	N/A
San Miguel Power Association	San Miguel Power Association - Renewable Energy Rebate Program	Rebate Program	Solar Water Heat, Solar Photovoltaics, Wind (All), Wind (Small)	3/3/15	N/A	N/A
United Power & Tri-State Generation and Transmission	United Power - Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Water Heaters, Heat pumps, Air conditioners, Motors, Other EE, LED Lighting	7/2/15	N/A	N/A
United Power	United Power - Renewable Energy Rebate Program	Rebate Program	Solar Water Heat, Solar Photovoltaics, Wind (Small)	3/15/17	N/A	N/A
Xcel Energy	Xcel Energy - Home Performance	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers,	6/22/16	N/A	N/A

	with ENERGY STAR		Water Heaters, Lighting, Furnaces, Heat pumps, Air conditioners, Programmable Thermostats, Caulking/Weather-stripping, Duct/Air sealing, Building Insulation, Motors, Other EE, LED Lighting, Tankless Water Heater			
Xcel Energy	Xcel Energy (Electric) - Residential Energy Efficiency Rebate Programs	Rebate Program	Geothermal Heat Pumps, Water Heaters, Furnaces, Heat pumps, Air conditioners, Programmable Thermostats, Caulking/Weather-stripping, Duct/Air sealing, Building Insulation, Comprehensive Measures/Whole Building, Other EE, Tankless Water Heater	6/16/16	N/A	N/A
Boulder County ClimateSmart	City of Boulder - Solar Sales and Use Tax Rebate	Sales Tax Incentive	Solar Water Heat, Solar Photovoltaics, Solar Pool Heating	1/25/16	N/A	N/A
N/A	Sales and Use Tax Exemption for Renewable Energy Equipment	Sales Tax Incentive	Solar Water Heat, Solar Space Heat, Geothermal Electric, Solar Thermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Wind (All), Biomass, Wind (Small), Anaerobic Digestion	7/21/15	7/1/06	N/A

(Database Of State Incentives For Renewables & Efficiency, North Carolina Clean Energy Technology Center, North Carolina State University, Accessed 11/29/17)

CONNECTICUT

Administrator	Name	Type	Technologies	Last Updated	Start Date	End Date
Connecticut Department of Revenue	Sales and Use Taxes for Items Used in Renewable Energy Industries	Industry Recruitment/Support	Solar - Passive, Solar Water Heat, Solar Space Heat, Solar Thermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Wind (All), Geothermal Heat Pumps, Solar Pool Heating, Wind (Small), Geothermal Direct-Use	12/12/14	1/1/10	N/A
Connecticut Housing Investment Fund	Energy Conservation Loan	Loan Program	Solar - Passive, Solar Water Heat, Solar Space Heat, Solar Photovoltaics, Wind (All), Biomass, Geothermal Heat Pumps, Water Heaters, Furnaces, Boilers, Heat pumps, Air conditioners, Programmable Thermostats, Caulking/Weather-stripping, Duct/Air sealing, Windows, Siding, Roofs, Other EE, Wind (Small)	12/15/14	N/A	N/A
Connecticut Housing Investment Fund Inc.	Energy Efficiency Fund (Electric and Gas) - Residential Energy Efficiency Financing	Loan Program	Geothermal Heat Pumps, Water Heaters, Furnaces, Boilers, Heat pumps, Air conditioners, Caulking/Weather-stripping, Duct/Air sealing, Windows, Siding, Roofs, Motor VFDs, Custom/Others pending approval, Other EE, Tankless Water Heater	5/26/16	N/A	N/A

CT Green Bank	Low-Income Multifamily Energy Loan Program	Loan Program	Solar Photovoltaics, Geothermal Heat Pumps, Water Heaters, Furnaces, Boilers, Heat pumps, Air conditioners, Windows	9/1/17	N/A	N/A
CT Electric distrubition company and Banc of America	Low-Interest Loans for Customer-Side Distributed Resources	Loan Program	Solar Photovoltaics, Wind (All), Combined Heat & Power, Fuel Cells using Non-Renewable Fuels, Lighting, Other EE, Wind (Small), Fuel Cells using Renewable Fuels	5/12/15	N/A	N/A
CT Green Bank	Multifamily Navigator Pre-Development Energy Loan Program	Loan Program	Solar Photovoltaics, Geothermal Heat Pumps, Water Heaters, Furnaces, Boilers, Heat pumps, Air conditioners, Windows	9/1/17	N/A	N/A
CT Green Bank	Multifamily Sherpa Pre-Development Energy Loan Program	Loan Program	Solar Photovoltaics, Geothermal Heat Pumps, Water Heaters, Furnaces, Boilers, Heat pumps, Air conditioners, Windows	9/1/17	N/A	N/A
CT Green Bank in partnership with Energize Connecticut	Smart-E loans	Loan Program	Solar Photovoltaics, Geothermal Heat Pumps, Water Heaters, Furnaces, Boilers, Heat pumps, Air conditioners, Windows	6/7/17	N/A	N/A
Connecticut Green Bank	Local Option - Commercial PACE Financing	PACE Financing	Solar Water Heat, Solar Space Heat, Geothermal Electric, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Geothermal Heat Pumps, Municipal Solid Waste, Combined Heat & Power, Fuel Cells	6/6/17	N/A	N/A

			using Non-Renewable Fuels, Landfill Gas, Lighting, Lighting Controls/Sensors, Chillers, Furnaces, Boilers, Heat pumps, Air conditioners, Programmable Thermostats, Energy Mgmt. Systems/Building Controls, Caulking/Weather-stripping, Duct/Air sealing, Building Insulation, Windows, Siding, Roofs, Motor VFDs, Processing and Manufacturing Equipment, Comprehensive Measures/Whole Building, Custom/Others pending approval, Other EE, Yes; specific technologies not identified, Wind (Small), Hydroelectric (Small), Geothermal Direct-Use, Fuel Cells using Renewable Fuels, Other Distributed Generation Technologies, Data Center Equipment, Reflective Roofs, LED Lighting			
Programs administered locally	Local Option - Residential Sustainable Energy Program	PACE Financing	Solar Water Heat, Solar Space Heat, Solar Photovoltaics, Wind (All), Geothermal Heat Pumps, Caulking/Weather-stripping, Duct/Air	6/6/17	N/A	N/A

			sealing, Building Insulation, Windows, Siding, Roofs, Comprehensive Measures/Whole Building, Custom/Others pending approval, Other EE, Yes; specific technologies not identified, Wind (Small)			
Connecticut Department of Revenue Services	Local Option - Property Tax Exemption for Renewable Energy Systems	Property Tax Incentive	Solar Water Heat, Geothermal Electric, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Geothermal Heat Pumps, Combined Heat & Power, Fuel Cells using Non-Renewable Fuels, Landfill Gas, Wave, Ocean Thermal, Wind (Small), Geothermal Direct-Use, Anaerobic Digestion, Fuel Cells using Renewable Fuels	12/12/14	N/A	N/A
Connecticut Department of Revenue Services	Property Tax Exemption for Renewable Energy Systems	Property Tax Incentive	Solar - Passive, Solar Water Heat, Solar Space Heat, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Geothermal Heat Pumps, Combined Heat & Power, Fuel Cells using Non-Renewable Fuels, Landfill Gas, Tidal, Wave, Ocean Thermal, Wind (Small), Geothermal Direct-Use, Fuel	12/12/14	N/A	N/A

			Cells using Renewable Fuels			
UI, CL&P, SCG, CNG, and Yankeegas	(Electric and Gas) Residential New Construction Program	Rebate Program	Solar Water Heat, Geothermal Heat Pumps, Air conditioners, Duct/Air sealing, Building Insulation, Comprehensive Measures/Whole Building	4/20/15	N/A	N/A
CT Green Bank	Residential Solar Investment Program	Rebate Program	Solar Photovoltaics	6/6/17	3/2/12	12/31/22
Connecticut Department of Revenue Services	Sales and Use Tax Exemption for Energy-Efficient Products	Sales Tax Incentive	Geothermal Heat Pumps, Equipment Insulation, Water Heaters, Lighting, Furnaces, Boilers, Programmable Thermostats, Caulking/Weather-stripping, Duct/Air sealing, Building Insulation, Windows, Doors	12/12/14	6/1/06	N/A
Connecticut Department of Revenue Services	Sales and Use Tax Exemption for Solar and Geothermal Systems	Sales Tax Incentive	Solar Water Heat, Solar Space Heat, Solar Photovoltaics, Geothermal Heat Pumps, Geothermal Direct-Use, Other Distributed Generation Technologies	12/12/14	7/1/07	N/A
N/A	Connecticut Light & Power - ZREC and LREC Long Term Contracts	Solar Renewable Energy Credit Program	Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Landfill Gas, Fuel Cells using Renewable Fuels	2/23/15	5/1/12	5/1/18
N/A	The United Illuminating Company - ZREC and LREC Long	Solar Renewable Energy Credit Program	Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Landfill Gas, Fuel Cells using Renewable Fuels	2/23/15	5/1/12	5/1/18

	Term Contracts					

(Database Of State Incentives For Renewables & Efficiency, North Carolina Clean Energy Technology Center, North Carolina State University, Accessed 11/29/17)

DELAWARE

Administrator	Name	Type	Technologies	Last Updated	Start Date	End Date
Delaware Sustainable Energy Utility	Sustainable Energy Utility (SEU) - Revolving Loan Fund	Loan Program	Solar Water Heat, Solar Space Heat, Solar Photovoltaics, Wind (All), Biomass, Geothermal Heat Pumps, Yes; specific technologies not identified, Wind (Small), Other Distributed Generation Technologies	2/23/15	N/A	N/A
Delaware Department of Natural Resources and Environmental Control	Delaware Electric Cooperative - Green Energy Program Incentives	Rebate Program	Solar Water Heat, Solar Space Heat, Solar Photovoltaics, Wind (All), Geothermal Heat Pumps, Wind (Small), Fuel Cells using Renewable Fuels	5/27/15	1/26/15	N/A
Delaware Department of Natural Resources and Environmental Control	Delmarva Power - Green Energy Program Incentives	Rebate Program	Solar Water Heat, Solar Space Heat, Solar Photovoltaics, Wind (All), Geothermal Heat Pumps, Wind (Small), Fuel Cells using Renewable Fuels	3/9/16	1/26/15	N/A
Delaware Department of Natural Resources and Environmental Control	DEMEC Member Utilities - Green Energy Program Incentives	Rebate Program	Solar Water Heat, Solar Space Heat, Solar Photovoltaics, Wind (All), Geothermal Heat Pumps, Wind (Small), Fuel Cells using Renewable Fuels	2/3/16	1/26/15	N/A
Joint Grant Program of Delaware Sustainable Utility (DESEU) and Delaware Department of Natural	Green Grant- Solar Hot Water and Geothermal program	Rebate Program	Solar Water Heat, Geothermal Heat Pumps	5/29/15	8/4/14	N/A

Resources and Environmental Control (DNREC)						
N/A	Solar Renewable Energy Credits (SRECs) Spot Market Program	Solar Renewable Energy Credit Program	Solar Photovoltaics	5/27/15	6/1/08	N/A
N/A	SREC Procurement Program	Solar Renewable Energy Credit Program	Solar Photovoltaics	4/30/15	4/2/12	N/A

(Database Of State Incentives For Renewables & Efficiency, North Carolina Clean Energy Technology Center, North Carolina State University, Accessed 11/29/17)

DISTRICT OF COLUMBIA

Administrator	Name	Type	Technologies	Last Updated	Start Date	End Date
Department of the Environment	Property Assessed Clean Energy Financing	PACE Financing	Solar Photovoltaics, Daylighting, Equipment Insulation, Lighting, Chillers, Furnaces, Boilers, Heat pumps, Air conditioners, Heat recovery, Energy Mgmt. Systems/Building Controls, Caulking/Weather-stripping, Building Insulation, Windows, Doors, Custom/Others pending approval, Wind (Small), Geothermal Direct-Use	8/24/15	N/A	N/A
N/A	Solar Energy System and Cogeneration System Personal Property Tax Credit	Property Tax Incentive	Solar Water Heat, Solar Space Heat, Solar Thermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Combined Heat & Power	10/21/14	7/25/12	N/A
N/A	Solar Renewable Energy Credits	Solar Renewable Energy Credit Program	Solar Water Heat, Solar Photovoltaics	4/27/15	4/12/05	N/A

(Database Of State Incentives For Renewables & Efficiency, North Carolina Clean Energy Technology Center, North Carolina State University, Accessed 11/29/17)

FLORIDA

Administrator	Name	Type	Technologies	Last Updated	Start Date	End Date
Miami-Dade County, District 8	Miami-Dade County - Expedited Green Buildings Process	Green Building Incentive	Solar Water Heat, Solar Photovoltaics, Wind (All), Biomass, Geothermal Heat Pumps, Daylighting, Comprehensive Measures/Whole Building, Hydroelectric (Small)	8/6/15	N/A	N/A
Miami-Dade County, District 8	Miami-Dade County - Targeted Jobs Incentive Fund	Industry Recruitment/Support	Solar Thermal Electric, Solar Photovoltaics, Combined Heat & Power	7/15/15	N/A	9/30/20
City of Lauderhill	City of Lauderhill - Revolving Loan Program	Loan Program	Solar Water Heat, Solar Photovoltaics, Clothes Washers, Dishwasher, Refrigerators/Freezers, Air conditioners, Other EE, Tankless Water Heater	11/25/14	N/A	N/A
City of Tallahassee Utilities	City of Tallahassee Utilities - Efficiency Loans	Loan Program	Geothermal Heat Pumps, Clothes Washers, Refrigerators/Freezers, Heat pumps, Air conditioners, Heat recovery, Duct/Air sealing, Building Insulation, Windows, Roofs, Other EE, Pool Pumps	5/19/16	N/A	N/A
City of Tallahassee Utilities	City of Tallahassee Utilities - Solar Loans	Loan Program	Solar Water Heat, Solar Photovoltaics, Solar Pool Heating	7/7/16	N/A	N/A
Clay Electric Cooperative	Clay Electric Cooperative, Inc - Energy Conservation Loans	Loan Program	Solar Water Heat, Solar Thermal Electric, Solar Pool Heating, Refrigerators/Freezers, Water Heaters, Heat pumps, Air conditioners, Heat	9/22/15	N/A	N/A

			recovery, Programmable Thermostats, Duct/Air sealing, Building Insulation, Windows, Doors, Roofs, Other EE, Reflective Roofs			
Clay Electric Cooperative	Clay Electric Cooperative, Inc - Solar Thermal Loans	Loan Program	Solar Water Heat, Solar Pool Heating	9/22/15	N/A	N/A
Orlando Utilities Commission	Orlando Utilities Commission - Residential Solar Loan Program	Loan Program	Solar Water Heat, Solar Photovoltaics	12/4/15	N/A	N/A
St. Lucie County	St. Lucie County - Solar and Energy Loan Fund (SELF)	Loan Program	Solar Thermal Electric, Solar Photovoltaics, Air conditioners, Caulking/Weather-stripping, Building Insulation, Windows	8/18/15	N/A	N/A
Lakeland Electric	Lakeland Electric - Solar Water Heating Program	Other Incentive	Solar Water Heat	7/7/16	N/A	N/A
Programs administered locally	Local Option - Special Districts	PACE Financing	Solar Water Heat, Solar Space Heat, Solar Photovoltaics, Wind (All), Biomass, Hydrogen, Geothermal Heat Pumps, Daylighting, Lighting, Chillers, Furnaces, Boilers, Heat pumps, Air conditioners, Heat recovery, Energy Mgmt. Systems/Building Controls, Duct/Air sealing, Building Insulation, Windows, Other EE, Wind (Small)	1/26/16	N/A	N/A
Miami-Dade County	Miami-Dade County -	PACE Financing	Solar - Passive, Solar Water Heat, Solar	7/21/16	N/A	N/A

	Green Corridor Property Assessed Clean Energy District		Space Heat, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Hydrogen, Daylighting, Lighting, Lighting Controls/Sensors, Chillers, Furnaces, Boilers, Heat pumps, Air conditioners, Heat recovery, Energy Mgmt. Systems/Building Controls, Duct/Air sealing, Building Insulation, Windows, Custom/Others pending approval, Other EE, Yes; specific technologies not identified, Wind (Small)			
Orlando Utilities Commission (OUC)	Orlando Utilities Commission - Solar Programs	Performance-Based Incentive	Solar Water Heat, Solar Photovoltaics	6/8/15	N/A	N/A
N/A	Property Tax Abatement for Renewable Energy Property	Property Tax Incentive	Solar Water Heat, Solar Photovoltaics, Wind (All), Geothermal Heat Pumps, Wind (Small)	8/8/17	7/1/13	N/A
Beaches Energy Services	Beaches Energy Services - Residential Energy Efficiency Rebate Program	Rebate Program	Solar Water Heat, Water Heaters, Heat pumps, Air conditioners, Building Insulation, Windows, Other EE	9/24/15	N/A	N/A
Beaches Energy Services	Beaches Energy Services - Solar Water Heating Rebate Program	Rebate Program	Solar Water Heat	6/19/15	N/A	N/A
Longwood Community	City of Longwood -	Rebate Program	Solar Water Heat, Solar Photovoltaics,	9/22/15	1/18/12	N/A

Development Services Department	Raising Energy Efficiency Rebate Program		Solar Pool Heating, Building Insulation, Windows, Roofs, Other EE, Tankless Water Heater			
City of Tallahassee Utilities	City of Tallahassee Utilities - Solar Water Heating Rebate	Rebate Program	Solar Water Heat	6/19/15	N/A	N/A
City of Winter Park	City of Winter Park Energy Conservation Rebate Program	Rebate Program	Solar Water Heat, Duct/Air sealing, Building Insulation	9/24/15	N/A	N/A
Clay Electric Cooperative	Clay Electric Cooperative, Inc - Energy Smart Energy Efficiency Rebate Program	Rebate Program	Solar Water Heat, Water Heaters, Heat pumps, Building Insulation, Windows, Other EE	9/21/15	N/A	N/A
Clay Electric Cooperative	Clay Electric Cooperative, Inc - Energy Smart Solar Water Heater Rebate Program	Rebate Program	Solar Water Heat	6/19/15	N/A	N/A
Fort Pierce Utilities Authority	Fort Pierce Utilities Authority - Residential Energy Efficiency Rebate Program	Rebate Program	Solar Water Heat, Clothes Washers, Refrigerators/Freezers, Water Heaters, Heat pumps, Air conditioners, Building Insulation, Other EE, Insulation, Tankless Water Heater	6/22/16	N/A	N/A
Fort Pierce Utilities Authority	Fort Pierce Utilities Authority - Solar Water Heating Rebate	Rebate Program	Solar Water Heat	6/18/15	N/A	N/A

Gulf Power Company	Gulf Power - Residential Energy Efficiency Programs	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Refrigerators/Freezers, Water Heaters, Heat pumps, Air conditioners, Programmable Thermostats, Energy Mgmt. Systems/Building Controls, Duct/Air sealing, Building Insulation, Windows, Roofs, Motor VFDs, Other EE, Pool Pumps	7/23/15	N/A	N/A
JEA	JEA - Solar Incentive Program	Rebate Program	Solar Water Heat	11/9/16	4/1/02	N/A
N/A	Ocala Utility Services - Energy Efficiency Rebate Program	Rebate Program	Solar Water Heat, Clothes Washers, Dishwasher, Refrigerators/Freezers, Water Heaters, Lighting, Heat pumps, Air conditioners, Programmable Thermostats, Building Insulation, LED Lighting	6/22/16	N/A	N/A
Ocala Utility Services	Ocala Utility Services - Solar Hot Water Heating Rebate Program	Rebate Program	Solar Water Heat	6/18/15	N/A	N/A
Orlando Utilities Commission	Orlando Utilities Commission - Residential Solar Water Heater Rebate Program	Rebate Program	Solar Water Heat	6/8/15	N/A	N/A
Tampa Electric	Tampa Electric - Residential Energy	Rebate Program	Geothermal Heat Pumps, Heat pumps, Duct/Air sealing, Building Insulation,	8/4/15	N/A	N/A

	Efficiency Rebate Program		Windows, Comprehensive Measures/Whole Building, Other EE			
Florida Department of Revenue	Solar and CHP Sales Tax Exemption	Sales Tax Incentive	Solar Water Heat, Solar Space Heat, Solar Photovoltaics, Combined Heat & Power, Solar Pool Heating	5/5/15	7/1/97	N/A

(Database Of State Incentives For Renewables & Efficiency, North Carolina Clean Energy Technology Center, North Carolina State University, Accessed 11/29/17)

GEORGIA

Administrator	Name	Type	Technologies	Last Updated	Start Date	End Date
Georgia Interfaith Power and Light	Georgia Interfaith Power and Light - Energy Improvement Grants	Grant Program	Solar Water Heat, Equipment Insulation, Water Heaters, Lighting, Lighting Controls/Sensors, Chillers, Furnaces, Boilers, Heat pumps, Air conditioners, Programmable Thermostats, Energy Mgmt. Systems/Building Controls, Caulking/Weather-stripping, Duct/Air sealing, Building Insulation, Windows, Doors, Comprehensive Measures/Whole Building, Custom/Others pending approval, Food Service Equipment, Vending Machine Controls, Personal Computing Equipment, Commercial Refrigeration Equipment	2/2/16	N/A	N/A
Tennessee Valley Authority	TVA Partner Utilities - Energy Right Heat Pump Program	Loan Program	Geothermal Heat Pumps, Heat pumps	9/25/15	N/A	N/A
Georgia Green Loans	Georgia Green Loans Save & Sustain Program	Other Incentive	Solar Photovoltaics, Lighting, Chillers, Furnaces, Boilers, Heat pumps, Air conditioners, Caulking/Weather-stripping, Building Insulation, Windows, Doors, Custom/Others	2/2/16	4/1/10	N/A

			pending approval, Other EE, Yes; specific technologies not identified			
Tennessee Valley Authority	TVA - Green Power Providers	Performance-Based Incentive	Solar Photovoltaics, Wind (All), Biomass, Wind (Small), Hydroelectric (Small)	6/2/15	10/1/12	N/A
Tennessee Valley Authority	TVA - Mid-Sized Renewable Standard Offer Program	Performance-Based Incentive	Solar Photovoltaics, Wind (All), Biomass, Landfill Gas, Anaerobic Digestion	6/18/15	10/10/10	N/A
N/A	TVA - Solar Solutions Initiative	Performance-Based Incentive	Solar Photovoltaics	6/4/15	N/A	N/A
Blue Ridge Mountain Electric Membership Corporation	Blue Ridge Mountain Electric Membership Corporation - Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Water Heaters, Heat pumps, Air conditioners, Duct/Air sealing, Building Insulation, Windows, Doors, Comprehensive Measures/Whole Building	6/9/15	N/A	N/A
Central Georgia Electric Membership Corporation	Central Georgia EMC - Photovoltaic Rebate Program	Rebate Program	Solar Photovoltaics	6/18/15	N/A	N/A
Coweta-Fayette Electric Membership Corporation	Coweta-Fayette EMC - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Water Heaters, Heat pumps, Programmable Thermostats, Building Insulation, Windows, Other EE	6/16/15	N/A	N/A
Coweta-Fayette Electric Membership Corporation	Coweta-Fayette EMC - Residential Solar Water Heater Rebate Program	Rebate Program	Solar Water Heat	2/27/15	N/A	N/A
Diverse Power	Diverse Power -	Rebate Program	Geothermal Heat Pumps, Water	5/19/15	N/A	N/A

	Energy Efficient Existing Homes Rebate Program		Heaters, Heat pumps, Heat recovery, Programmable Thermostats, Duct/Air sealing, Building Insulation			
Diverse Power	Diverse Power - Energy Efficient New Construction Rebate Programs	Rebate Program	Geothermal Heat Pumps, Water Heaters, Heat pumps, Heat recovery, Comprehensive Measures/Whole Building	5/19/15	N/A	N/A
GreyStone Power	GreyStone Power - Photovoltaic Rebate Program	Rebate Program	Solar Photovoltaics	2/27/15	N/A	N/A
GreyStone Power	GreyStone Power - Solar Water Heating Program	Rebate Program	Solar Water Heat	2/27/15	N/A	N/A
Jackson Electric Membership Corporation	Jackson EMC - Residential Energy Efficiency Rebate Program	Rebate Program	Solar Water Heat, Water Heaters, Heat pumps, Duct/Air sealing, Building Insulation, Custom/Others pending approval	6/17/15	N/A	N/A
Jackson Electric Membership Corporation	Jackson EMC - Right Choice for Builders Rebate Program	Rebate Program	Comprehensive Measures/Whole Building	6/12/15	N/A	N/A
N/A	TVA Partner Utilities - eScore Program	Rebate Program	Geothermal Heat Pumps, Water Heaters, Heat pumps, Air conditioners, Duct/Air sealing, Windows, Doors, Insulation	8/31/17	N/A	N/A
Walton Electric Membership Corporation	Walton EMC - Residential Energy Efficiency Rebate Programs	Rebate Program	Geothermal Heat Pumps, Water Heaters, Heat pumps, Heat recovery, Other EE	4/3/15	N/A	N/A

Georgia Department of Revenue	Biomass Sales and Use Tax Exemption	Sales Tax Incentive	Biomass	8/3/15	7/1/06	N/A

(Database Of State Incentives For Renewables & Efficiency, North Carolina Clean Energy Technology Center, North Carolina State University, Accessed 11/29/17)

HAWAII

Administrator	Name	Type	Technologies	Last Updated	Start Date	End Date
Hawaii Green Infrastructure Authority	Green Infrastructure Bonds	Bond Program	Solar Water Heat, Solar Thermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Combined Heat & Power, Landfill Gas, Tidal, Ocean Thermal, Heat pumps, Custom/Others pending approval, Yes; specific technologies not identified, Wind (Small), Hydroelectric (Small), Anaerobic Digestion, Fuel Cells using Renewable Fuels	9/3/14	N/A	N/A
Hawaii Department of Taxation	Solar and Wind Energy Credit (Corporate)	Corporate Tax Credit	Solar Water Heat, Solar Space Heat, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Wind (Small)	5/29/15	7/1/09	N/A
N/A	Feed-in-Tariff	Feed-in Tariff	Geothermal Electric, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Municipal Solid Waste, Landfill Gas, Tidal, Wave, Ocean Thermal, Wind (Small), Hydroelectric (Small)	6/8/15	N/A	N/A
N/A	Priority Permit Processing for Green Buildings	Green Building Incentive	Solar - Passive, Solar Water Heat, Solar Space Heat, Solar Photovoltaics, Wind (All), Biomass, Geothermal Heat Pumps, Daylighting, Comprehensive Measures/Whole	8/28/14	5/12/06	N/A

			Building, Wind (Small), Hydroelectric (Small)			
City and County of Honolulu	City and County of Honolulu - Solar Loan Program	Loan Program	Solar Water Heat, Solar Photovoltaics	9/2/14	N/A	N/A
Hawaii Department of Agriculture	Farm and Aquaculture Alternative Energy Loan	Loan Program	Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Wind (Small)	9/19/14	7/1/08	N/A
Hawaii Community Reinvestment Corporation	GreenSun Hawaii	Loan Program	Solar Water Heat, Solar Photovoltaics, Refrigerators/Freezers, Lighting, Heat pumps, Air conditioners, Windows	9/3/14	N/A	N/A
County of Kauai Housing Agency	KIUC - Solar Water Heating Loan Program	Loan Program	Solar Water Heat	6/2/15	N/A	N/A
Hawaii Department of Taxation	Solar and Wind Energy Credit (Personal)	Personal Tax Credit	Solar Water Heat, Solar Space Heat, Solar Photovoltaics, Wind (All), Wind (Small)	5/29/15	7/1/09	N/A
City and County of Honolulu, Real Property Tax Assessment Division	City and County of Honolulu - Real Property Tax Exemption for Alternative Energy Improvements	Property Tax Incentive	Solar Water Heat, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Municipal Solid Waste, Combined Heat & Power, Landfill Gas, Tidal, Wave, Solar Pool Heating, Wind (Small), Anaerobic Digestion	9/2/14	10/1/09	N/A
Kauai Island Utility Coop	KIUC - Solar Water Heating Rebate Program	Rebate Program	Solar Water Heat	5/29/15	N/A	N/A
Hawaii Energy	Solar Water Heater Rebate	Rebate Program	Solar Water Heat	6/1/15	N/A	N/A

(Database Of State Incentives For Renewables & Efficiency, North Carolina Clean Energy Technology Center, North Carolina State University, Accessed 11/29/17)

IDAHO

Administrator	Name	Type	Technologies	Last Updated	Start Date	End Date
Idaho Energy Resources Authority	Renewable Energy Project Bond Program	Bond Program	Geothermal Electric, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Combined Heat & Power, Fuel Cells using Non-Renewable Fuels, Landfill Gas, Custom/Others pending approval, Fuel Cells using Renewable Fuels	12/18/15	N/A	N/A
Idaho Falls Power	Idaho Falls Power - Residential Energy Efficiency Loan Program	Loan Program	Geothermal Heat Pumps, Clothes Washers, Refrigerators/Freezers, Water Heaters, Lighting, Heat pumps, Air conditioners, Programmable Thermostats, Caulking/Weather-stripping, Duct/Air sealing, Building Insulation, Windows, Doors, Insulation, LED Lighting, Tankless Water Heater	7/9/15	N/A	N/A
Office of Energy Resources	Low-Interest Energy Loan Programs	Loan Program	Solar Water Heat, Solar Space Heat, Geothermal Electric, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Geothermal Heat Pumps, Combined Heat & Power, Water Heaters, Lighting, Furnaces, Heat pumps, Air conditioners, Caulking/Weather-stripping, Duct/Air sealing, Building	12/18/15	N/A	N/A

			Insulation, Windows, Motor VFDs, Agricultural Equipment, Comprehensive Measures/Whole Building, Custom/Others pending approval, Other EE, Wind (Small), Hydroelectric (Small), Geothermal Direct-Use			
Idaho Tax Commission	Residential Alternative Energy Tax Deduction	Personal Tax Deduction	Solar - Passive, Solar Water Heat, Solar Space Heat, Geothermal Electric, Solar Photovoltaics, Wind (All), Biomass, Geothermal Heat Pumps, Wind (Small)	12/18/15	N/A	N/A
Idaho State Tax Commission	Property Tax Exemption for Wind, Solar, and Geothermal Energy Producers	Property Tax Incentive	Geothermal Electric, Solar Thermal Electric, Solar Photovoltaics, Wind (All)	3/28/16	1/1/08	N/A
Idaho Falls Power	Idaho Falls Power - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Refrigerators/Freezers, Water Heaters, Lighting, Heat pumps, Air conditioners, Programmable Thermostats, Caulking/Weather-stripping, Duct/Air sealing, Building Insulation, Windows, Doors, Comprehensive Measures/Whole Building, Insulation, LED Lighting, Tankless Water Heater	7/9/15	N/A	N/A
Kootenai Electric Cooperative	Kootenai Electric Cooperative -	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Water	5/19/16	N/A	N/A

	Residential Efficiency Rebate Program		Heaters, Heat pumps, Duct/Air sealing, Building Insulation, Windows, Comprehensive Measures/Whole Building			
N/A	Northern Lights Inc. - Energy Conservation Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Lighting, Heat pumps, Comprehensive Measures/Whole Building	1/4/16	N/A	N/A
Questar Gas	Questar Gas - Residential Solar Assisted Water Heating Rebate Program	Rebate Program	Solar Water Heat, Solar Pool Heating	6/22/15	N/A	N/A
Rocky Mountain Power	Rocky Mountain Power - wattsmart Residential Efficiency Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Refrigerators/Freezers, Ceiling Fan, Water Heaters, Lighting, Chillers, Heat pumps, Air conditioners, Duct/Air sealing, Building Insulation, Windows, Custom/Others pending approval, Pool Pumps	8/21/15	N/A	N/A

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ILLINOIS

Administrator	Name	Type	Technologies	Last Updated	Start Date	End Date
Illinois Finance Authority	Renewable Energy and Energy Efficiency Project Financing	Bond Program	Solar - Passive, Solar Water Heat, Solar Space Heat, Geothermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Wind (All), Biomass, Geothermal Heat Pumps, Combined Heat & Power, Daylighting, Clothes Washers, Dishwasher, Refrigerators/Freezers, Dehumidifiers, Ceiling Fan, Water Heaters, Lighting, Lighting Controls/Sensors, Chillers, Furnaces, Boilers, Heat pumps, Air conditioners, Programmable Thermostats, Energy Mgmt. Systems/Building Controls, Building Insulation, Windows, Custom/Others pending approval, Yes; specific technologies not identified, Wind (Small), Fuel Cells using Renewable Fuels, Other Distributed Generation Technologies, LED Lighting, Commercial Refrigeration Equipment	3/25/15	1/1/10	N/A
SomerCor 504 Inc.	City of Chicago - Small Business Improvement Fund	Grant Program	Solar Water Heat, Solar Photovoltaics, Equipment Insulation, Lighting, Chillers, Furnaces, Boilers, Heat pumps, Air	12/17/15	N/A	N/A

			conditioners, Programmable Thermostats, Energy Mgmt. Systems/Building Controls, Windows, Roofs, Reflective Roofs, LED Lighting			
Illinois Department of Commerce and Economic Opportunity and Smart Energy Design Assistance Center	Efficient Living Energy Grant	Grant Program	Geothermal Heat Pumps, Clothes Washers, Refrigerators/Freezers, Ceiling Fan, Water Heaters, Lighting, Lighting Controls/Sensors, Furnaces, Boilers, Heat pumps, Air conditioners, Programmable Thermostats, Duct/Air sealing, Building Insulation, Motor VFDs, Other EE, Vending Machine Controls, LED Lighting, Tankless Water Heater	2/11/16	N/A	N/A
Illinois Clean Energy Community Foundation	Illinois Clean Energy Community Foundation Grants	Grant Program	Solar - Passive, Solar Water Heat, Solar Space Heat, Solar Thermal Process Heat, Solar Photovoltaics, Wind (All), Biomass, Geothermal Heat Pumps, Fuel Cells using Non-Renewable Fuels, Comprehensive Measures/Whole Building, Yes; specific technologies not identified, Wind (Small), Fuel Cells using Renewable Fuels, Other Distributed Generation Technologies	12/17/15	6/30/99	N/A
Chicago Center for	City of Chicago - Green Building Permit Programs	Green Building Incentive	Solar - Passive, Solar Water Heat, Solar Space Heat, Solar	12/17/15	N/A	N/A

Green Technology			Photovoltaics, Wind (All), Biomass, Geothermal Heat Pumps, Daylighting, Comprehensive Measures/Whole Building, Yes; specific technologies not identified, Wind (Small), Hydroelectric (Small)			
Illinois Department of Commerce and Economic Opportunity	Special Assessment for Solar Energy Systems	Property Tax Incentive	Solar Water Heat, Solar Space Heat, Solar Photovoltaics	12/17/15	N/A	N/A
Energy Services Office	City Water Light and Power - Commercial Energy Efficiency Rebate Programs	Rebate Program	Geothermal Heat Pumps, Water Heaters, Heat pumps, Building Insulation, Other EE	3/24/15	N/A	N/A
Energy Services Office	City Water Light and Power - Residential Energy Efficiency Rebate Programs	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Water Heaters, Heat pumps, Building Insulation	3/24/15	N/A	N/A
N/A	ComEd - Business Instant Lighting Discounts Program	Rebate Program	Lighting, Other EE, LED Lighting	3/31/17	N/A	N/A
Wabash Valley Power Association	Corn Belt Energy Coop - Commercial Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Refrigerators/Freezers, Lighting, Lighting Controls/Sensors, Chillers, Heat pumps, Air conditioners, Programmable Thermostats, Energy Mgmt. Systems/Building Controls, Motor VFDs, Agricultural Equipment, Custom/Others pending approval,	7/21/15	N/A	N/A

			Other EE, LED Lighting			
Power Moves - Wabash Valley Power Association	Corn Belt Energy Coop - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Refrigerators/Freezers, Water Heaters, Lighting, Heat pumps, Other EE, LED Lighting	3/16/17	N/A	N/A
Illinois Municipal Electric Agency	Illinois Municipal Electric Agency - Electric Efficiency Program	Rebate Program	Daylighting, Refrigerators/Freezers, Equipment Insulation, Lighting, Lighting Controls/Sensors, Chillers, Heat pumps, Air conditioners, Compressed air, Programmable Thermostats, Energy Mgmt. Systems/Building Controls, Building Insulation, Motors, Motor VFDs, Comprehensive Measures/Whole Building, Custom/Others pending approval, Other EE, Geothermal Direct-Use, Vending Machine Controls	6/10/16	N/A	N/A
Jo-Carroll Energy Cooperative, Inc.	Jo-Carroll Energy - Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Dehumidifiers, Water Heaters, Lighting, Lighting Controls/Sensors, Furnaces, Boilers, Heat pumps, Air conditioners, Programmable Thermostats, Duct/Air sealing, Comprehensive Measures/Whole Building, Other EE,	4/17/17	N/A	N/A

			Insulation, LED Lighting			
MidAmerican Energy Company	MidAmerican Energy (Electric) - Commercial EnergyAdvantage Rebate Program	Rebate Program	Geothermal Heat Pumps, Refrigerators/Freezers, Equipment Insulation, Water Heaters, Lighting, Lighting Controls/Sensors, Chillers, Heat pumps, Air conditioners, Programmable Thermostats, Energy Mgmt. Systems/Building Controls, Building Insulation, Motors, Motor VFDs, Custom/Others pending approval, Other EE, Food Service Equipment, Vending Machine Controls, LED Lighting, Commercial Refrigeration Equipment	3/24/15	1/1/15	N/A
MidAmerican Energy Company	MidAmerican Energy (Electric) - Residential Energy Efficiency Rebate Programs	Rebate Program	Geothermal Heat Pumps, Refrigerators/Freezers, Water Heaters, Furnaces, Heat pumps, Air conditioners, Programmable Thermostats, Other EE	5/3/17	N/A	N/A
MidAmerican Energy Company	MidAmerican Energy (Gas) - Commercial EnergyAdvantage Rebate Program	Rebate Program	Geothermal Heat Pumps, Water Heaters, Chillers, Furnaces, Boilers, Heat pumps, Air conditioners, Programmable Thermostats, Windows, Motors, Motor VFDs, Custom/Others pending approval, Other EE, Food	5/3/17	N/A	N/A

			Service Equipment, Commercial Cooking Equipment, LED Lighting, Tankless Water Heater, Commercial Refrigeration Equipment			
Illinois Department of Commerce and Economic Opportunity	Public Sector Energy Efficiency Programs	Rebate Program	Geothermal Heat Pumps, Refrigerators/Freezers, Water Heaters, Lighting, Lighting Controls/Sensors, Chillers, Furnaces, Boilers, Heat pumps, Air conditioners, Energy Mgmt. Systems/Building Controls, Motor VFDs, Custom/Others pending approval, Other EE, Food Service Equipment, Vending Machine Controls, LED Lighting, Tankless Water Heater	3/26/15	6/1/08	N/A
Wabash Valley Power Association	Wabash Valley Power Association (28 Member Cooperatives) - Commercial and Industrial Energy Efficiency Program	Rebate Program	Geothermal Heat Pumps, Lighting, Lighting Controls/Sensors, Chillers, Heat pumps, Air conditioners, Programmable Thermostats, Energy Mgmt. Systems/Building Controls, Motor VFDs, Custom/Others pending approval, Other EE, Food Service Equipment, LED Lighting, Commercial Refrigeration Equipment	3/22/17	N/A	N/A
Wabash Valley Power Association	Wabash Valley Power Association (28	Rebate Program	Geothermal Heat Pumps, Water Heaters, Heat pumps,	3/30/17	N/A	N/A

	Member Cooperatives) - Residential Energy Efficiency Program		Other EE, LED Lighting			
Illinois Department of Commerce and Economic Opportunity	Sales Tax Exemption for Wind Energy	Sales Tax Incentive	Wind (All)	12/17/15	7/1/09	N/A
N/A	Solar Renewable Energy Credits	Solar Renewable Energy Credit Program	Solar Photovoltaics	12/3/15	N/A	N/A

(Database Of State Incentives For Renewables & Efficiency, North Carolina Clean Energy Technology Center, North Carolina State University, Accessed 11/29/17)

INDIANA

Administrator	Name	Type	Technologies	Last Updated	Start Date	End Date
N/A	NIPSCO - Feed-In Tariff	Feed-in Tariff	Solar Photovoltaics, Wind (All), Biomass, Wind (Small)	10/5/15	7/13/11	N/A
Indiana Office of Energy Development	Community Conservation Challenge	Grant Program	Solar Water Heat, Geothermal Electric, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Geothermal Heat Pumps, Combined Heat & Power, Landfill Gas, Lighting, Chillers, Boilers, Air conditioners, Compressed air, Caulking/Weather-stripping, Duct/Air sealing, Building Insulation, Comprehensive Measures/Whole Building, Other EE, Wind (Small), Geothermal Direct-Use, LED Lighting	7/27/15	N/A	N/A
Department of Economic and Sustainable Development	City of Bloomington - Sustainable Development Incentives	Green Building Incentive	Solar Water Heat, Solar Photovoltaics, Wind (All), Geothermal Heat Pumps, Combined Heat & Power, Roofs, Comprehensive Measures/Whole Building, Yes; specific technologies not identified, Wind (Small), Fuel Cells using Renewable Fuels, Other Distributed Generation Technologies	12/14/15	1/26/15	N/A
Indianapolis Department of Code Enforcement	City of Indianapolis - Green Building	Green Building Incentive	Solar Photovoltaics, Wind (All), Geothermal Heat Pumps, Clothes Washers, Dishwasher,	12/14/15	8/1/10	N/A

and Office of Sustainability	Incentive Program		Refrigerators/Freezers, Dehumidifiers, Ceiling Fan, Water Heaters, Lighting, Chillers, Furnaces, Boilers, Heat pumps, Air conditioners, Comprehensive Measures/Whole Building, Yes; specific technologies not identified, Wind (Small), Geothermal Direct-Use			
Indiana Department of Local Government Finance	Renewable Energy Property Tax Exemption	Property Tax Incentive	Solar Water Heat, Solar Space Heat, Geothermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Wind (All), Hydroelectric, Geothermal Heat Pumps, Solar Pool Heating, Wind (Small), Geothermal Direct-Use	12/11/15	3/1/10	N/A
Bartholomew County REMC	Bartholomew County REMC - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Water Heaters, Heat pumps, Air conditioners, Duct/Air sealing, Other EE	4/6/15	N/A	N/A
Carroll County REMC	Carroll County REMC - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Refrigerators/Freezers, Heat pumps	7/27/15	N/A	N/A
Clark County REMC	Clark County REMC - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Water Heaters, Lighting, Heat pumps, Air conditioners, Duct/Air sealing, Other EE, LED Lighting	4/6/15	N/A	N/A

Dubois REC	Dubois REC - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Water Heaters, Lighting, Heat pumps, Air conditioners, Duct/Air sealing, Other EE, LED Lighting	4/8/15	N/A	N/A
Duke Energy	Duke Energy - Commercial and Industrial Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Lighting, Heat pumps, Air conditioners, Motors, Processing and Manufacturing Equipment, LED Lighting	1/13/16	N/A	N/A
Duke Energy	Duke Energy - Residential and Builder Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Heat pumps, Air conditioners, Duct/Air sealing, Building Insulation, Comprehensive Measures/Whole Building	1/13/16	10/1/12	N/A
Harrison REMC	Harrison County REMC - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Water Heaters, Heat pumps, Air conditioners, Duct/Air sealing, Building Insulation	7/27/15	N/A	N/A
Indianapolis Power & Light	Indianapolis Power & Light - Business Energy Incentives Program	Rebate Program	Geothermal Heat Pumps, Water Heaters, Lighting, Lighting Controls/Sensors, Chillers, Heat pumps, Programmable Thermostats, Energy Mgmt. Systems/Building Controls, Windows, Motor VFDs, Processing and Manufacturing Equipment, Custom/Others pending approval, Food Service	1/13/16	N/A	N/A

			Equipment, Commercial Cooking Equipment, Pool Pumps, LED Lighting			
Jackson County Rural Electric Membership Corporation	Jackson County REMC - Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Water Heaters, Heat pumps, Air conditioners, Duct/Air sealing, Other EE	4/8/15	N/A	N/A
Jasper County REMC and Power Moves	Jasper County REMC - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Water Heaters, Heat pumps	4/9/15	N/A	N/A
Jay County REMC	Jay County REMC - Geothermal and Air-Source Heat Pump Rebate Program	Rebate Program	Geothermal Heat Pumps, Water Heaters, Heat pumps	4/6/15	N/A	N/A
Johnson County Rural EMC	Johnson County REMC - Commercial Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Lighting, Heat pumps, Air conditioners, Programmable Thermostats, Motors, Motor VFDs	4/8/15	N/A	N/A
Johnson County Rural EMC	Johnson County REMC - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Water Heaters, Lighting, Heat pumps, Other EE, LED Lighting	3/10/17	N/A	N/A
Kosciusko REMC	Kosciusko REMC - Residential Geothermal and Air-source Heat	Rebate Program	Geothermal Heat Pumps, Water Heaters, Heat pumps	4/9/15	N/A	N/A

	Pump Rebate Program					
N/A	LaGrange County REMC - Business Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Chillers, Heat pumps, Air conditioners, Programmable Thermostats, Motor VFDs	4/8/15	N/A	N/A
LaGrange County REMC and Wabash Valley Power Association	LaGrange County REMC - Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Water Heaters, Lighting, Heat pumps, Other EE, LED Lighting	4/8/15	N/A	N/A
Marshall County REMC	Marshall County REMC - Geothermal and Heat Pump Rebate Program	Rebate Program	Geothermal Heat Pumps, Water Heaters, Heat pumps	4/7/15	N/A	N/A
Miami-Cass REMC & WVPA	Miami-Cass REMC - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Water Heaters, Heat pumps, Other EE	4/9/15	N/A	N/A
NineStar Connect	NineStar Connect - Residential Energy Efficient Equipment Rebate Program	Rebate Program	Geothermal Heat Pumps, Water Heaters, Lighting, Heat pumps	4/9/15	3/15/10	N/A
N/A	Noble REMC - Buisness Energy Efficiency Rebate Incentives	Rebate Program	Geothermal Electric, Lighting, Lighting Controls/Sensors, Chillers, Heat pumps, Air conditioners, Motor VFDs, LED Lighting	4/9/15	N/A	N/A
N/A	Noble REMC - Residential Energy Efficiency	Rebate Program	Geothermal Electric, Water Heaters, Lighting, Heat pumps, LED Lighting	4/9/15	N/A	N/A

	Rebate Incentives					
Northeastern REMC	Northeastern REMC - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Water Heaters, Heat pumps	7/27/15	N/A	N/A
Orange County REMC	Orange County REMC - Energy Efficient Equipment Rebate Program	Rebate Program	Geothermal Heat Pumps, Water Heaters, Lighting, Heat pumps, Air conditioners, Duct/Air sealing, Building Insulation	7/27/15	N/A	N/A
Parke County REMC	Parke County REMC - Energy Efficient Equipment Rebate Program	Rebate Program	Geothermal Heat Pumps, Water Heaters, Heat pumps	7/27/15	N/A	N/A
Rush Shelby Energy	RushShelby Energy - Residential and Commercial Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Water Heaters, Lighting, Heat pumps, Air conditioners, Duct/Air sealing	4/6/15	N/A	N/A
South Central Indiana Rural Electric Membership Corporation	South Central Indiana REMC - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Heat pumps, Duct/Air sealing	4/7/15	N/A	N/A
Southeast Indiana REMC	Southeastern Indiana REMC - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Water Heaters, Heat pumps, Duct/Air sealing, Building Insulation, Comprehensive Measures/Whole Building	3/2/17	N/A	N/A

Southern Indiana Rural Electric Cooperative	Southern Indiana Power - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Water Heaters, Heat pumps, Duct/Air sealing, Building Insulation, Other EE	7/27/15	N/A	N/A
Tipmont REMC	Tipmont REMC - Energy Efficiency Equipment Rebate Program	Rebate Program	Geothermal Heat Pumps, Water Heaters, Heat pumps, Other EE	4/2/15	N/A	N/A
Utilities District of Western Indiana REMC	Utilities District of Western Indiana REMC - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Water Heaters, Heat pumps, Air conditioners, Duct/Air sealing	4/7/15	N/A	N/A
Wabash County REMC	Wabash County REMC - Residential Geothermal and Air-source Heat Pump Rebate Program	Rebate Program	Geothermal Heat Pumps, Water Heaters, Heat pumps	4/6/15	N/A	N/A
Wabash Valley Power Association	Wabash Valley Power Association (28 Member Cooperatives) - Commercial and Industrial Energy Efficiency Program	Rebate Program	Geothermal Heat Pumps, Lighting, Lighting Controls/Sensors, Chillers, Heat pumps, Air conditioners, Programmable Thermostats, Energy Mgmt. Systems/Building Controls, Motor VFDs, Custom/Others pending approval, Other EE, LED Lighting, Commercial	3/29/17	N/A	N/A

			Refrigeration Equipment			
White County REMC	White County REMC - Residential Geothermal Heat Pump Rebate Program	Rebate Program	Geothermal Heat Pumps, Heat pumps	4/2/15	N/A	N/A
WIN Energy REMC	WIN Energy REMC - Residential Rebate Program	Rebate Program	Geothermal Heat Pumps, Water Heaters, Heat pumps, Air conditioners, Duct/Air sealing, Building Insulation, Other EE	7/27/15	N/A	N/A
Indiana Department of Revenue	Sales and Use Tax Exemption for Electrical Generating Equipment	Sales Tax Incentive	Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Landfill Gas, Wind (Small)	2/23/16	N/A	N/A

(Database Of State Incentives For Renewables & Efficiency, North Carolina Clean Energy Technology Center, North Carolina State University, Accessed 11/29/17)

IOWA

Administrator	Name	Type	Technologies	Last Updated	Start Date	End Date
Iowa Utilities Board	Renewable Energy Production Tax Credits (Corporate)	Corporate Tax Credit	Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Hydrogen, Municipal Solid Waste, Combined Heat & Power, Landfill Gas, Wind (Small), Anaerobic Digestion	12/9/16	6/15/05	N/A
Iowa Department of Revenue	Solar Energy Systems Tax Credit (Corporate)	Corporate Tax Credit	Solar Water Heat, Solar Space Heat, Solar Thermal Electric, Solar Thermal Process Heat, Solar Photovoltaics	5/24/16	1/1/12	N/A
Iowa Department of Revenue	Energy Replacement Generation Tax Exemption	Corporate Tax Exemption	Wind (All), Hydroelectric, Landfill Gas, Wind (Small)	1/29/16	N/A	N/A
Alliant Energy-Interstate Power and Light	Alliant Energy Interstate Power and Light (Gas and Electric) - Low Interest Energy Efficiency Loan Program	Loan Program	Geothermal Heat Pumps, Clothes Washers, Refrigerators/Freezers, Ceiling Fan, Water Heaters, Lighting, Furnaces, Boilers, Heat pumps, Air conditioners, Programmable Thermostats, Windows, Other EE, Vending Machine Controls, Tankless Water Heater	5/2/17	N/A	N/A
Iowa Energy Center	Alternate Energy Revolving Loan Program	Loan Program	Solar Water Heat, Solar Space Heat, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Landfill Gas, Wind (Small)	2/5/16	1/26/96	N/A
Iowa Economic Development Authority and	IADG Energy Bank Revolving	Loan Program	Solar - Passive, Solar Water Heat, Solar Space Heat, Solar	2/10/16	N/A	N/A

Iowa Area Development Group	Loan Program		Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Geothermal Heat Pumps, Combined Heat & Power, Lighting, Lighting Controls/Sensors, Chillers, Furnaces, Boilers, Heat pumps, Air conditioners, Building Insulation, Windows, Doors, Processing and Manufacturing Equipment, Other EE, Wind (Small), Hydroelectric (Small), LED Lighting			
Iowa Department of Natural Resources	Local Option - Special Assessment of Wind Energy Devices	Property Tax Incentive	Wind (All), Wind (Small)	11/13/15	1/1/94	N/A
Iowa Department of Natural Resources	Methane Gas Conversion Property Tax Exemption	Property Tax Incentive	Biomass, Landfill Gas, Anaerobic Digestion	2/8/16	N/A	N/A
Iowa Department of Natural Resources	Property Tax Exemption for Renewable Energy Systems	Property Tax Incentive	Solar - Passive, Solar Water Heat, Solar Space Heat, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Geothermal Heat Pumps, Wind (Small)	2/10/16	1/1/78	N/A
Alliant Energy-IP&L	Alliant Energy Interstate Power and Light (Electric) - Business Energy Efficiency Rebate Programs	Rebate Program	Geothermal Heat Pumps, Water Heaters, Lighting, Lighting Controls/Sensors, Chillers, Heat pumps, Air conditioners, Programmable Thermostats, Caulking/Weather-stripping, Duct/Air	3/19/15	N/A	N/A

			sealing, Building Insulation, Doors, Other EE, Food Service Equipment, Vending Machine Controls, LED Lighting, Commercial Refrigeration Equipment			
Alliant Energy	Alliant Energy Interstate Power and Light (Electric) - Residential Energy Efficiency Rebate Programs	Rebate Program	Geothermal Heat Pumps, Water Heaters, Furnaces, Heat pumps, Air conditioners, Programmable Thermostats, Duct/Air sealing, Building Insulation, Doors, Motors, Custom/Others pending approval, Other EE, Insulation, Tankless Water Heater	5/3/17	N/A	N/A
Alliant Energy	Alliant Energy Interstate Power and Light (Gas and Electric) - Farm Equipment Energy Efficiency Incentives	Rebate Program	Geothermal Heat Pumps, Lighting, Heat pumps, Heat recovery, Motors, Motor VFDs, Agricultural Equipment, Custom/Others pending approval, Other EE, LED Lighting	5/3/17	N/A	N/A
Alliant Energy	Alliant Energy Interstate Power and Light (Gas and Electric) - New Home Construction Incentives	Rebate Program	Geothermal Heat Pumps, Water Heaters, Furnaces, Boilers, Heat pumps, Comprehensive Measures/Whole Building, Tankless Water Heater	5/2/17	N/A	N/A
Interstate Light and Power (Alliant Energy)	Alliant Energy Interstate Power and Light (Gas) - Business	Rebate Program	Geothermal Heat Pumps, Refrigerators/Freezers, Equipment Insulation, Water Heaters, Lighting, Furnaces,	5/2/17	N/A	N/A

	Energy Efficiency Rebate Programs		Boilers, Heat pumps, Air conditioners, Steam-system upgrades, Programmable Thermostats, Duct/Air sealing, Building Insulation, Motors, Motor VFDs, Comprehensive Measures/Whole Building, Custom/Others pending approval, Food Service Equipment, Vending Machine Controls, LED Lighting, Commercial Refrigeration Equipment			
Alliant Energy	Alliant Energy Interstate Power and Light (Gas) - Residential Energy Efficiency Rebate Programs	Rebate Program	Geothermal Heat Pumps, Water Heaters, Furnaces, Heat pumps, Air conditioners, Programmable Thermostats, Duct/Air sealing, Building Insulation, Motors, Insulation, Tankless Water Heater	5/2/17	N/A	N/A
Ames Electric Department	Ames Electric Department - Residential Energy Efficiency Rebate Programs	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Lighting, Lighting Controls/Sensors, Heat pumps, Air conditioners, Programmable Thermostats, Comprehensive Measures/Whole Building, LED Lighting	7/9/15	N/A	N/A
Bright Energy Solutions/Missouri River Energy Services	Business Energy Efficiency Rebate	Rebate Program	Geothermal Heat Pumps, Lighting, Heat pumps, Air conditioners, Compressed air,	11/9/15	N/A	N/A

	(Offered by 16 Utilities)		Building Insulation, Motor VFDs, Custom/Others pending approval, Other EE, Food Service Equipment, LED Lighting, Commercial Refrigeration Equipment			
Cedar Falls Utilities	Cedar Falls Utilities - Commercial Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Refrigerators/Freezers, Dehumidifiers, Water Heaters, Lighting, Lighting Controls/Sensors, Furnaces, Boilers, Heat pumps, Air conditioners, Compressed air, Programmable Thermostats, Energy Mgmt. Systems/Building Controls, Duct/Air sealing, Building Insulation, Motors, Motor VFDs, Other EE, Food Service Equipment, Vending Machine Controls, LED Lighting	5/12/16	N/A	N/A
Cedar Falls Utilities Energy Services	Cedar Falls Utilities - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Refrigerators/Freezers, Dehumidifiers, Water Heaters, Lighting, Furnaces, Boilers, Heat pumps, Air conditioners, Programmable Thermostats, Caulking/Weather-stripping, Duct/Air sealing, Building Insulation, Doors,	1/28/16	N/A	N/A

			Other EE, LED Lighting, Tankless Water Heater			
N/A	Corn Belt Power Cooperative Rebate Program	Rebate Program	Solar Water Heat, Geothermal Heat Pumps, Water Heaters, Lighting, Heat pumps, Air conditioners, Heat recovery, Building Insulation, Comprehensive Measures/Whole Building	11/12/15	N/A	N/A
Farmers Electric Cooperative	Farmers Electric Cooperative (Kalona) - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Refrigerators/Freezers, Water Heaters, Lighting, Heat pumps, Air conditioners, LED Lighting	10/29/15	N/A	N/A
Customer Service	Indianola Municipal Utilities - Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Lighting, Lighting Controls/Sensors, Heat pumps, Air conditioners	7/9/15	N/A	N/A
Linn County Rural Electric Cooperative Association	Linn County Rural Electric Cooperative - Agricultural Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Ceiling Fan, Water Heaters, Lighting, Lighting Controls/Sensors, Heat pumps, Motor VFDs, Agricultural Equipment, LED Lighting	10/28/15	N/A	N/A
Linn County Rural Electric Cooperative Association	Linn County Rural Electric Cooperative - Commercial Energy Efficiency	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Dehumidifiers, Water Heaters, Lighting, Chillers, Heat pumps, Air conditioners, Heat recovery, Motor VFDs,	10/27/15	N/A	N/A

	Rebate Program		Agricultural Equipment, Custom/Others pending approval, Commercial Cooking Equipment, LED Lighting, Commercial Refrigeration Equipment			
Linn County Rural Electric Cooperative Association	Linn County Rural Electric Cooperative - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Water Heaters, Lighting, Heat pumps, Air conditioners, Heat recovery, Duct/Air sealing, Building Insulation, Other EE, LED Lighting	10/28/15	N/A	N/A
Linn County Rural Electric Cooperative	Linn County Rural Electric Cooperative - Solar Water Heater Rebate Program	Rebate Program	Solar Water Heat	6/19/15	N/A	N/A
MidAmerican Energy Company	MidAmerican Energy (Electric) - Residential Energy Efficiency Rebate Programs	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Refrigerators/Freezers, Water Heaters, Lighting, Heat pumps, Air conditioners, Programmable Thermostats, Duct/Air sealing, Building Insulation, Windows, Doors, Siding, Other EE	12/3/15	N/A	N/A
MidAmerican Energy	MidAmerican Energy Commercial Rebate Program	Rebate Program	Geothermal Heat Pumps, Water Heaters, Lighting, Lighting Controls/Sensors, Chillers, Heat pumps, Air conditioners, Programmable Thermostats, Building	11/30/15	N/A	N/A

			Insulation, Windows, Motors, Motor VFDs, Other EE, Food Service Equipment, Vending Machine Controls, LED Lighting			
Muscatine Power and Water	Muscatine Power and Water - Commercial and Industrial Energy Efficiency Rebates	Rebate Program	Geothermal Heat Pumps, Water Heaters, Lighting, Lighting Controls/Sensors, Chillers, Heat pumps, Air conditioners, Programmable Thermostats, Motors, Motor VFDs, Custom/Others pending approval, LED Lighting	10/29/15	N/A	N/A
Muscatine Power and Water	Muscatine Power and Water - Residential Energy Efficiency Rebates	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Water Heaters, Lighting, Heat pumps, Air conditioners	1/28/16	N/A	N/A
Bright Energy Solutions/Missouri River Energy Services	Residential Energy Efficiency Rebate (Offered by 16 Utilities)	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Dehumidifiers, Lighting, Heat pumps, Air conditioners, Programmable Thermostats, Energy Mgmt. Systems/Building Controls, Building Insulation, Other EE, LED Lighting	11/9/15	N/A	N/A
Central Iowa Power Cooperative	Rural Electric Cooperatives Energy Efficiency Rebate Programs (Offered by 12 Utilities)	Rebate Program	Solar Water Heat, Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Dehumidifiers, Water Heaters, Lighting, Heat pumps, Air conditioners, Motors,	6/23/15	N/A	N/A

			Motor VFDs, Agricultural Equipment, Comprehensive Measures/Whole Building, Commercial Refrigeration Equipment			
Waverly Light & Power	Waverly Light & Power - Residential Energy Efficiency Rebates	Rebate Program	Geothermal Heat Pumps, Water Heaters, Lighting, Heat pumps, Air conditioners, Duct/Air sealing, Building Insulation, Insulation, LED Lighting	7/9/15	N/A	N/A
Waverly Light & Power	Waverly Light & Power - Residential Solar Thermal Rebates	Rebate Program	Solar Water Heat	6/23/15	7/1/09	N/A
Iowa Department of Revenue	Renewable Energy Equipment Exemption	Sales Tax Incentive	Solar Water Heat, Solar Space Heat, Solar Thermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Wind (All), Hydroelectric, Solar Pool Heating, Wind (Small), Hydroelectric (Small)	2/10/16	N/A	N/A

(Database Of State Incentives For Renewables & Efficiency, North Carolina Clean Energy Technology Center, North Carolina State University, Accessed 11/29/17)

KANSAS

Administrator	Name	Type	Technologies	Last Updated	Start Date	End Date
Kansas Corporation Commission	Renewable Energy Property Tax Exemption	Property Tax Incentive	Geothermal Electric, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Landfill Gas, Wind (Small)	6/8/15	N/A	N/A
Kansas City Board of Public Utilities	Kansas City Board of Public Utilities - Commercial Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Water Heaters, Heat pumps, Other EE	11/13/15	N/A	N/A

(Database Of State Incentives For Renewables & Efficiency, North Carolina Clean Energy Technology Center, North Carolina State University, Accessed 11/29/17)

KENTUCKY

Administrator	Name	Type	Technologies	Last Updated	Start Date	End Date
Kentucky Cabinet for Economic Development (Dept. of Financial Incentives)	Tax Credits for Renewable Energy Facilities	Corporate Tax Credit	Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Landfill Gas	6/9/16	1/1/08	N/A
County Agricultural Development Councils, Governor's Office of Agricultural Policy	On-Farm Energy Efficiency & Production Grants	Grant Program	Solar Water Heat, Water Heaters, Lighting, Lighting Controls/Sensors, Furnaces, Boilers, Heat recovery, Programmable Thermostats, Building Insulation, Windows, Siding, Roofs, Motors, Motor VFDs, Processing and Manufacturing Equipment, Agricultural Equipment, Custom/Others pending approval, Other EE, LED Lighting, Tankless Water Heater	8/3/15	N/A	N/A
Kentucky Cabinet for Economic Development (Dept. of Financial Incentives)	Incentives for Energy Independence	Industry Recruitment/Support	Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Landfill Gas	12/1/15	1/1/08	N/A
Finance and Administration Cabinet	Energy Efficiency Loans for State Government Agencies	Loan Program	Solar Water Heat, Solar Photovoltaics, Wind (All), Biomass, Geothermal Heat Pumps, Combined Heat & Power, Clothes Washers, Equipment Insulation, Water Heaters, Lighting, Lighting	11/30/15	N/A	N/A

			Controls/Sensors, Chillers, Furnaces, Boilers, Heat pumps, Air conditioners, Heat recovery, Steam-system upgrades, Compressed air, Programmable Thermostats, Energy Mgmt. Systems/Building Controls, Motors, Motor VFDs, Comprehensive Measures/Whole Building, Custom/Others pending approval, Other EE, Yes; specific technologies not identified, Wind (Small), Anaerobic Digestion			
N/A	Greater Cincinnati Energy Alliance - Residential Loan Program	Loan Program	Solar Water Heat, Solar Photovoltaics, Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Dehumidifiers, Ceiling Fan, Water Heaters, Lighting, Duct/Air sealing, Building Insulation, Windows	4/15/15	N/A	N/A
Inter-County Energy	Inter-County Energy Efficiency Loan Program	Loan Program	Geothermal Heat Pumps, Chillers, Furnaces, Heat pumps, Air conditioners, Other EE	11/20/15	N/A	N/A
Mountain Association for Community Economic Development (MACED)	Mountain Association for Community Economic Development - Energy Efficient Enterprise Loan Program	Loan Program	Solar Water Heat, Geothermal Electric, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Geothermal Heat Pumps, Daylighting, Clothes Washers, Dishwasher, Refrigerators/Freezers, Dehumidifiers, Ceiling	5/29/15	N/A	N/A

			Fan, Water Heaters, Lighting, Chillers, Furnaces, Boilers, Heat pumps, Air conditioners, Compressed air, Caulking/Weather-stripping, Duct/Air sealing, Building Insulation, Windows, Siding, Roofs, Agricultural Equipment, Other EE, Wind (Small), Hydroelectric (Small), Reflective Roofs, LED Lighting, Commercial Refrigeration Equipment			
Tennessee Valley Authority	TVA Partner Utilities - Energy Right Heat Pump Program	Loan Program	Geothermal Heat Pumps, Heat pumps	9/25/15	N/A	N/A
Tennessee Valley Authority	TVA - Green Power Providers	Performance-Based Incentive	Solar Photovoltaics, Wind (All), Biomass, Wind (Small), Hydroelectric (Small)	6/2/15	10/1/12	N/A
Tennessee Valley Authority	TVA - Mid-Sized Renewable Standard Offer Program	Performance-Based Incentive	Solar Photovoltaics, Wind (All), Biomass, Landfill Gas, Anaerobic Digestion	6/18/15	10/10/10	N/A
N/A	TVA - Solar Solutions Initiative	Performance-Based Incentive	Solar Photovoltaics	6/4/15	N/A	N/A
Clark Energy	Clark Energy - Residential Energy Efficiency Rebate Programs	Rebate Program	Geothermal Heat Pumps, Heat pumps, Air conditioners, Duct/Air sealing, Building Insulation, Windows, Doors, Comprehensive Measures/Whole Building	11/12/15	N/A	N/A
Duke Energy	Duke Energy - Residential Efficiency	Rebate Program	Geothermal Heat Pumps, Furnaces, Heat pumps, Air conditioners, Duct/Air	6/10/15	N/A	N/A

	Rebate Program		sealing, Building Insulation, Comprehensive Measures/Whole Building, Other EE, Pool Pumps			
Inter-County Energy	Inter-County Energy Efficiency Program	Rebate Program	Geothermal Heat Pumps, Furnaces, Heat pumps, Caulking/Weather-stripping, Duct/Air sealing, Building Insulation, Windows, Doors, Other EE	1/28/16	N/A	N/A
Inter-County Energy	Inter-County Energy Touchstone New Construction Program	Rebate Program	Geothermal Heat Pumps, Comprehensive Measures/Whole Building, Insulation	5/19/16	N/A	N/A
Jackson Energy Cooperative	Jackson Energy Cooperative - Residential Energy Efficiency Rebate Programs	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Heat pumps, Caulking/Weather-stripping, Duct/Air sealing, Building Insulation, Comprehensive Measures/Whole Building, Other EE	9/25/15	N/A	N/A
Kenergy	Kenergy - Residential Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Refrigerators/Freezers, Heat pumps, Air conditioners	11/3/15	N/A	N/A
N/A	Meade County RECC - Residential Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Refrigerators/Freezers, Heat pumps, Other EE	11/3/15	N/A	N/A
Salt River Electric Cooperative	Salt River Electric - Residential Energy Efficiency	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Water Heaters, Lighting, Heat pumps,	10/6/15	N/A	N/A

	Rebate Programs		Air conditioners, Caulking/Weather-stripping, Duct/Air sealing, Building Insulation, Comprehensive Measures/Whole Building, Custom/Others pending approval			
South Kentucky Rural Electric Cooperative Corporation	South Kentucky RECC - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Water Heaters, Heat pumps, Air conditioners, Duct/Air sealing, Comprehensive Measures/Whole Building, Other EE	10/6/15	N/A	N/A
N/A	TVA Partner Utilities - eScore Program	Rebate Program	Geothermal Heat Pumps, Water Heaters, Heat pumps, Air conditioners, Duct/Air sealing, Windows, Doors, Insulation	8/31/17	N/A	N/A
Office of Energy Policy	Tax Exemption for Large-Scale Renewable Energy Projects	Sales Tax Incentive	Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Landfill Gas	6/9/16	1/1/08	N/A

(Database Of State Incentives For Renewables & Efficiency, North Carolina Clean Energy Technology Center, North Carolina State University, Accessed 11/29/17)

LOUISIANA

Administrator	Name	Type	Technologies	Last Updated	Start Date	End Date
Louisiana Department of Natural Resources	Home Energy Loan Program (HELP)	Loan Program	Solar Water Heat, Solar Space Heat, Solar Photovoltaics, Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Lighting, Chillers, Furnaces, Boilers, Heat pumps, Air conditioners, Programmable Thermostats, Building Insulation, Windows, Custom/Others pending approval	7/22/14	N/A	N/A
LA Department of Revenue	Solar Energy System Exemption	Property Tax Incentive	Solar - Passive, Solar Water Heat, Solar Space Heat, Solar Photovoltaics, Solar Pool Heating	8/5/14	N/A	N/A
Entergy New Orleans	New Orleans City - Energy Smart Program	Rebate Program	Solar Water Heat, Lighting, Air conditioners, Duct/Air sealing, Building Insulation, Insulation, Pool Pumps	11/10/16	N/A	N/A

(Database Of State Incentives For Renewables & Efficiency, North Carolina Clean Energy Technology Center, North Carolina State University, Accessed 11/29/17)

MAINE

Administrator	Name	Type	Technologies	Last Updated	Start Date	End Date
Programs administered locally or by Efficiency Maine Trust (determined locally)	Local Option - Property Assessed Clean Energy	PACE Financing	Solar Water Heat, Solar Space Heat, Solar Photovoltaics, Wind (All), Biomass, Geothermal Heat Pumps, Landfill Gas, Clothes Washers, Refrigerators/Freezers, Dehumidifiers, Ceiling Fan, Water Heaters, Lighting, Lighting Controls/Sensors, Furnaces, Boilers, Heat pumps, Air conditioners, Programmable Thermostats, Caulking/Weather-stripping, Duct/Air sealing, Building Insulation, Windows, Other EE, Yes; specific technologies not identified, Wind (Small), Geothermal Direct-Use, LED Lighting	11/3/16	4/1/10	N/A
AFC First Financial Corporation	Maine PACE Loans	PACE Financing	Solar Water Heat, Solar Space Heat, Solar Photovoltaics, Wind (All), Biomass, Geothermal Heat Pumps, Clothes Washers, Refrigerators/Freezers, Dehumidifiers, Ceiling Fan, Water Heaters, Lighting, Lighting Controls/Sensors, Furnaces, Boilers, Heat pumps, Air conditioners, Programmable Thermostats, Caulking/Weather-	11/3/16	4/4/11	N/A

			stripping, Duct/Air sealing, Building Insulation, Windows, Custom/Others pending approval, Other EE, Yes; specific technologies not identified, Wind (Small), LED Lighting			
Efficiency Maine Trust	Efficiency Maine Residential Home Energy Savings Program	Rebate Program	Biomass, Geothermal Heat Pumps, Furnaces, Boilers, Heat pumps, Duct/Air sealing, Building Insulation, Custom/Others pending approval, Other EE	10/20/16	9/11/13	N/A

(Database Of State Incentives For Renewables & Efficiency, North Carolina Clean Energy Technology Center, North Carolina State University, Accessed 11/29/17)

MARYLAND

Administrator	Name	Type	Technologies	Last Updated	Start Date	End Date
Maryland Energy Administration	Game Changer Competitive Grant Program	Grant Program	Solar Space Heat, Geothermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Biomass, Geothermal Heat Pumps, Combined Heat & Power	11/20/15	9/19/14	N/A
N/A	Maryland Smart Energy Communities Grant	Grant Program	Solar Water Heat, Geothermal Electric, Solar Photovoltaics, Biomass, Geothermal Heat Pumps, Boilers, Air conditioners, Energy Mgmt. Systems/Building Controls, Duct/Air sealing, Building Insulation, Comprehensive Measures/Whole Building, Custom/Others pending approval, Wind (Small), Hydroelectric (Small), Other Distributed Generation Technologies, Pool Pumps	11/20/15	7/1/15	N/A
Maryland Energy Administration	Parking Lot Solar PV with EV Charger Grant Program	Grant Program	Solar Photovoltaics	11/20/15	12/1/14	N/A
Baltimore City Energy Office	City of Baltimore-BEI Loan Program	Loan Program	Solar Photovoltaics, Combined Heat & Power, Clothes Washers, Dehumidifiers, Lighting, Heat pumps, Air conditioners, Combined Heat &	8/30/16	N/A	N/A

			Power, Energy Mgmt. Systems/Building Controls, Duct/Air sealing, Comprehensive Measures/Whole Building, Yes; specific technologies not identified, Insulation			
Maryland Energy Administration	Jane E. Lawton Conservation Loan Program	Loan Program	Solar Water Heat, Geothermal Electric, Geothermal Heat Pumps, Custom/Others pending approval, Geothermal Direct-Use	11/20/15	N/A	N/A
Maryland Energy Administration	State Agency Loan Program	Loan Program	Solar - Passive, Solar Water Heat, Solar Space Heat, Solar Photovoltaics, Wind (All), Geothermal Heat Pumps, Daylighting, Solar Pool Heating, Lighting, Lighting Controls/Sensors, Chillers, Boilers, Energy Mgmt. Systems/Building Controls, Custom/Others pending approval, Wind (Small)	11/20/15	N/A	N/A
Maryland Energy Administration	Clean Energy Production Tax Credit (Personal)	Personal Tax Credit	Geothermal Electric, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Municipal Solid Waste, Landfill Gas, Tidal, Wave, Ocean Thermal, Wind (Small), Anaerobic Digestion	6/2/16	1/1/06	12/31/18
Anne Arundel County Office of Finance	Anne Arundel County - High Performance Dwelling	Property Tax Incentive	Solar - Passive, Solar Water Heat, Solar Space Heat, Solar Photovoltaics, Wind (All), Biomass, Geothermal Heat Pumps, Daylighting,	7/28/15	7/1/10	N/A

	Property Tax Credit		Comprehensive Measures/Whole Building, Wind (Small), Hydroelectric (Small)			
Anne Arundel County Office of Finance	Anne Arundel County - Solar and Geothermal Equipment Property Tax Credits	Property Tax Incentive	Solar Water Heat, Solar Space Heat, Solar Photovoltaics, Geothermal Heat Pumps	5/13/15	N/A	N/A
Baltimore County Office of Budget and Finance	Baltimore County - Property Tax Credit for High Performance Buildings and Homes	Property Tax Incentive	Solar - Passive, Solar Water Heat, Solar Space Heat, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Geothermal Heat Pumps, Daylighting, Comprehensive Measures/Whole Building, Wind (Small)	7/28/15	N/A	N/A
Baltimore County Office of Budget and Finance	Baltimore County - Property Tax Credit for Solar and Geothermal Devices	Property Tax Incentive	Solar Water Heat, Solar Space Heat, Solar Photovoltaics, Geothermal Heat Pumps, Geothermal Direct-Use	5/13/15	N/A	N/A
Harford County Department of the Treasury	Harford County - Property Tax Credit for Solar and Geothermal Devices	Property Tax Incentive	Solar Water Heat, Solar Space Heat, Geothermal Electric, Solar Photovoltaics, Geothermal Heat Pumps, Geothermal Direct-Use	5/13/15	N/A	N/A
Programs locally administered	Local Option - Property Tax Credit for High Performance Buildings	Property Tax Incentive	Solar - Passive, Solar Water Heat, Solar Space Heat, Solar Photovoltaics, Wind (All), Biomass, Geothermal Heat Pumps, Daylighting, Comprehensive Measures/Whole Building, Wind (Small), Hydroelectric (Small)	7/28/15	N/A	N/A

Programs locally administered	Local Option - Property Tax Credit for Renewables and Energy Conservation Devices	Property Tax Incentive	Solar Water Heat, Solar Space Heat, Solar Thermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Geothermal Heat Pumps, Custom/Others pending approval	8/6/15	N/A	N/A
Department of Finance	Montgomery County - High Performance Building Property Tax Credit	Property Tax Incentive	Solar - Passive, Solar Water Heat, Solar Space Heat, Solar Photovoltaics, Wind (All), Biomass, Geothermal Heat Pumps, Daylighting, Custom/Others pending approval, Wind (Small), Hydroelectric (Small)	7/28/15	3/17/08	N/A
Prince George's County Office of Finance	Prince George's County - Solar and Geothermal Residential Property Tax Credit	Property Tax Incentive	Solar Water Heat, Solar Space Heat, Solar Photovoltaics, Geothermal Heat Pumps	5/13/15	N/A	N/A
Maryland Department of Assessments and Taxation	Property Tax Exemption for Solar and Wind Energy Systems	Property Tax Incentive	Solar Water Heat, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Wind (Small)	10/15/14	N/A	N/A
N/A	Baltimore Gas & Electric Company (Electric) - Commercial Energy Efficiency Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Dehumidifiers, Lighting, Lighting Controls/Sensors, Chillers, Heat pumps, Air conditioners, Combined Heat & Power, Programmable Thermostats, Energy Mgmt. Systems/Building Controls, Motor VFDs,	4/5/17	N/A	N/A

			Processing and Manufacturing Equipment, Custom/Others pending approval, Other EE, Food Service Equipment, Vending Machine Controls, LED Lighting, Commercial Refrigeration Equipment			
N/A	Baltimore Gas & Electric Company (Electric) - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Refrigerators/Freezers, Dehumidifiers, Water Heaters, Lighting, Heat pumps, Air conditioners, Other EE, Pool Pumps, LED Lighting	5/3/17	N/A	N/A
N/A	Baltimore Gas & Electric Company (Gas) - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Water Heaters, Furnaces, Heat pumps, Air conditioners, Pool Pumps	5/3/17	N/A	N/A
Maryland Energy Administration (MEA)	Clean-Burning Wood Stove Grant Program	Rebate Program	Biomass, Other EE	11/16/15	9/7/12	N/A
Maryland Energy Administration	Commercial Clean Energy Grant Program	Rebate Program	Solar Water Heat, Solar Photovoltaics, Geothermal Heat Pumps	6/24/15	11/6/09	N/A
Delmarva	Delmarva Power - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Refrigerators/Freezers, Water Heaters, Heat pumps, Air conditioners,	3/20/17	N/A	N/A

			Custom/Others pending approval, Other EE, Pool Pumps, LED Lighting			
FirstEnergy	FirstEnergy (Potomac Edison) - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Refrigerators/Freezers, Water Heaters, Lighting, Heat pumps, Air conditioners, Comprehensive Measures/Whole Building, Other EE, LED Lighting	3/16/17	N/A	N/A
Maryland Energy Administration	Geothermal Heat Pump Grant Program	Rebate Program	Geothermal Heat Pumps	10/16/14	1/26/15	N/A
PEPCO	PEPCO - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Refrigerators/Freezers, Water Heaters, Heat pumps, Air conditioners, Custom/Others pending approval, Other EE, Pool Pumps, LED Lighting	3/17/17	N/A	N/A
Maryland Energy Administration	Residential Clean Energy Grant Program	Rebate Program	Solar Water Heat, Solar Photovoltaics, Geothermal Heat Pumps	11/20/15	1/1/05	N/A
Southern Maryland Electric Cooperative	SMECO - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Refrigerators/Freezers, Water Heaters, Lighting, Heat pumps, Air conditioners, Programmable Thermostats, Duct/Air sealing, Building Insulation, Custom/Others pending approval,	3/17/17	N/A	N/A

			Other EE, Pool Pumps, LED Lighting			
Maryland Energy Administration	Windswept Grant Program	Rebate Program	Wind (All), Wind (Small)	6/24/15	N/A	N/A
Comptroller of Maryland	Sales and Use Tax Exemption for Renewable Energy Equipment	Sales Tax Incentive	Solar Water Heat, Solar Space Heat, Solar Thermal Electric, Solar Photovoltaics, Geothermal Heat Pumps, Wind (Small)	10/15/14	N/A	N/A
Comptroller of Maryland	Sales and Use Tax Exemption for Residential Solar and Wind Electricity Sales	Sales Tax Incentive	Solar Photovoltaics, Wind (Small)	10/15/14	N/A	N/A
Comptroller of Maryland	Sales Tax Holiday for Energy-Efficient Appliances	Sales Tax Incentive	Solar Water Heat, Geothermal Heat Pumps, Clothes Washers, Refrigerators/Freezers, Dehumidifiers, Lighting, Furnaces, Boilers, Heat pumps, Air conditioners, Programmable Thermostats, LED Lighting	10/15/14	1/26/15	N/A
N/A	Wood Heating Fuel Exemption	Sales Tax Incentive	Biomass	10/15/14	N/A	N/A
N/A	Solar Renewable Energy Certificates (SRECs)	Solar Renewable Energy Credit Program	Solar Water Heat, Solar Photovoltaics	4/27/15	N/A	N/A

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MASSACHUSETTS

Administrator	Name	Type	Technologies	Last Updated	Start Date	End Date
Massachusetts Department of Revenue	Excise Tax Deduction for Solar or Wind Powered Systems	Corporate Tax Deduction	Solar Water Heat, Solar Space Heat, Solar Thermal Process Heat, Wind (All)	5/24/17	N/A	N/A
Massachusetts Department of Revenue	Excise Tax Exemption for Solar or Wind Powered Systems	Corporate Tax Exemption	Solar Water Heat, Solar Space Heat, Solar Thermal Process Heat, Wind (All), Wind (Small)	5/24/17	N/A	N/A
Massachusetts Clean Energy Center	Commercial Biomass Heating Grant Program	Grant Program	Biomass	5/23/17	N/A	N/A
Massachusetts Clean Energy Center (MassCEC)	Commonwealth Hydropower Program	Grant Program	Hydroelectric, Hydroelectric (Small)	8/17/17	N/A	N/A
Massachusetts Clean Energy Center (MassCEC)	Commonwealth Organics-to-Energy Program	Grant Program	Biomass, Combined Heat & Power, Anaerobic Digestion	8/17/17	N/A	N/A
Massachusetts Clean Energy Center (MassCEC)	Commonwealth Wind Program	Grant Program	Wind (All)	5/22/17	N/A	N/A
Massachusetts Department of Energy Resources	Green Communities Grant Program	Grant Program	Solar Water Heat, Solar Space Heat, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Combined Heat & Power, Yes; specific technologies not identified, Wind (Small), Other Distributed Generation Technologies	5/30/17	N/A	N/A

Massachusetts Department of Revenue	Alternative Energy and Energy Conservation Patent Income Tax Deduction (Corporate)	Industry Recruitment /Support	Solar - Passive, Solar Water Heat, Solar Space Heat, Geothermal Electric, Solar Thermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Geothermal Heat Pumps, Municipal Solid Waste, Fuel Cells using Non-Renewable Fuels, Yes; specific technologies not identified, Wind (Small), Fuel Cells using Renewable Fuels	10/31/16	1/26/79	N/A
Massachusetts Department of Revenue	Alternative Energy and Energy Conservation Patent Income Tax Deduction (Personal)	Industry Recruitment /Support	Solar - Passive, Solar Water Heat, Solar Space Heat, Geothermal Electric, Solar Thermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Geothermal Heat Pumps, Municipal Solid Waste, Fuel Cells using Non-Renewable Fuels, Yes; specific technologies not identified, Wind (Small), Fuel Cells using Renewable Fuels	10/31/16	1/26/79	N/A
Holyoke Gas and Electric Department	Holyoke Gas & Electric - Commercial Energy	Loan Program	Solar Water Heat, Solar Photovoltaics, Equipment Insulation, Water Heaters, Lighting,	10/15/15	N/A	N/A

	Conservati on Loan Program		Furnaces, Boilers, Heat pumps, Air conditioners, Programmable Thermostats, Building Insulation, Windows, Doors, Processing and Manufacturing Equipment, Other EE, Insulation			
Customer Service	Holyoke Gas & Electric - Residential Energy Conservati on Loan Program	Loan Program	Solar Water Heat, Solar Photovoltaics, Equipment Insulation, Water Heaters, Furnaces, Boilers, Air conditioners, Programmable Thermostats, Building Insulation, Windows, Doors, Other EE, Insulation	10/15/15	N/A	N/A
MassSAVE	Mass Save - HEAT Loan Program	Loan Program	Solar Water Heat, Biomass, Geothermal Heat Pumps, Water Heaters, Furnaces, Boilers, Heat pumps, Duct/Air sealing, Building Insulation, Windows, Other EE, Tankless Water Heater	3/21/17	N/A	N/A
N/A	Mass Solar Loan Program	Loan Program	Solar Photovoltaics	3/20/17	N/A	N/A
Massachusetts Development Finance Agency	Local Option - Commerci al PACE Financing	PACE Financing	Solar - Passive, Solar Water Heat, Solar Space Heat, Solar Thermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Geothermal Heat Pumps, Daylighting, Lighting, Boilers, Heat pumps, Air	5/31/17	11/6/1 6	N/A

			conditioners, Energy Mgmt. Systems/Building Controls, Duct/Air sealing, Building Insulation, Comprehensive Measures/Whole Building, Custom/Others pending approval, Yes; specific technologies not identified, Wind (Small)			
Programs administered locally	Local Option - Energy Revolving Loan Fund	PACE Financing	Solar Water Heat, Solar Photovoltaics, Other EE	5/31/17	N/A	N/A
Massachusetts Department of Energy Resources (DOER)	Residential Renewabl e Energy Income Tax Credit	Personal Tax Credit	Solar Water Heat, Solar Space Heat, Solar Photovoltaics, Wind (All), Wind (Small)	10/25/16	1/26/7 9	N/A
Massachusetts Department of Revenue	Renewabl e Energy Property Tax Exemption	Property Tax Incentive	Solar Water Heat, Solar Space Heat, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Hydroelectric, Wind (Small)	8/15/17	1/26/7 5	N/A
N/A	Cape Light Compact-Residential Energy Efficiency Rebate Program	Rebate Program	Solar Water Heat, Refrigerators/Freeze rs, Dehumidifiers, Water Heaters, Lighting, Furnaces, Boilers, Heat pumps, Air conditioners, Programmable Thermostats, Building Insulation, Other EE, Personal Computing Equipment, LED Lighting	6/4/15	N/A	N/A
Chicopee Electric Light	Chicopee Electric Light -	Rebate Program	Solar Photovoltaics	8/8/17	N/A	N/A

	Residential Solar Rebate Program					
Massachusetts Clean Energy Center	Commercial Solar Hot Water Rebate Program	Rebate Program	Solar Water Heat	5/26/17	8/4/11	12/31/20
Concord Municipal Light Plant	Concord Municipal Light Plant - Solar Photovoltaic Rebate Program	Rebate Program	Solar Photovoltaics	8/8/17	N/A	N/A
Hudson Light & Power	Hudson Light & Power - Photovoltaic Incentive Program	Rebate Program	Solar Photovoltaics	5/27/15	N/A	N/A
Cape Light Compact, Unitil, National Grid, NSTAR, Western Massachusets Electric	MassSAVE (Electric) - Commercial New Construction/Major Renovation Program	Rebate Program	Geothermal Heat Pumps, Combined Heat & Power, Equipment Insulation, Lighting, Lighting Controls/Sensors, Chillers, Heat pumps, Air conditioners, Heat recovery, Compressed air, Programmable Thermostats, Energy Mgmt. Systems/Building Controls, Motors, Motor VFDs, Processing and Manufacturing Equipment, Custom/Others pending approval, Other EE, LED Lighting	7/1/15	N/A	N/A
MMWEC in collaboration	MuniHELPS - Offered	Rebate Program	Solar Photovoltaics, Clothes Washers,	6/19/15	N/A	N/A

with municipal utilities	by 17 Utilities through the MMWEC		Dishwasher, Refrigerators/Freezers, Dehumidifiers, Water Heaters, Lighting, Furnaces, Boilers, Heat pumps, Air conditioners, Duct/Air sealing, Building Insulation, Other EE, Tankless Water Heater			
Reading Municipal Light Department	Reading Municipal Light Department - Residential Renewable Energy Rebates	Rebate Program	Solar Photovoltaics, Wind (All), Combined Heat & Power, Wind (Small)	5/27/15	N/A	N/A
Massachusetts Clean Energy Center	Residential & Small-Scale Biomass Heating Program	Rebate Program	Biomass	5/23/17	11/24/14	N/A
Massachusetts Clean Energy Center	Residential & Small-Scale Ground-Source Heat Pump Program	Rebate Program	Geothermal Heat Pumps	5/23/17	N/A	N/A
Massachusetts Clean Energy Center (MassCEC)	Residential & Small-Scale Solar Hot Water Program	Rebate Program	Solar Water Heat, Solar Space Heat	8/17/17	2/7/11	12/31/20
Taunton Municipal Lighting Plant (TMLP)	Taunton Municipal Lighting Plant - Residential PV Rebate Program	Rebate Program	Solar Photovoltaics	8/8/17	1/1/10	N/A
Department of Revenue	Renewable Energy	Sales Tax Incentive	Solar Water Heat, Solar Space Heat,	5/25/17	N/A	N/A

	Equipment Sales Tax Exemption		Solar Photovoltaics, Wind (All), Geothermal Heat Pumps, Wind (Small)			
N/A	Solar Renewable Energy Certificates (SREC-II)	Solar Renewable Energy Credit Program	Solar Photovoltaics	5/25/17	N/A	N/A

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MICHIGAN

Administrator	Name	Type	Technologies	Last Updated	Start Date	End Date
NextEnergy	Michigan Accelerating Technologies (MATch) Energy Grant	Grant Program	Geothermal Electric, Solar Photovoltaics, Wind (All), Biomass, Combined Heat & Power, Custom/Others pending approval, Anaerobic Digestion, Fuel Cells using Renewable Fuels	11/30/15	12/1/12	N/A
N/A	Renewable Energy Program Grants	Grant Program	Solar Photovoltaics, Wind (All), Biomass	9/29/15	N/A	N/A
Michigan Economic Development Corporation	Nonrefundable Business Activity Tax Credit	Industry Recruitment/Support	Solar Water Heat, Solar Space Heat, Solar Thermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Wind (All), Biomass, Combined Heat & Power, Fuel Cells using Non-Renewable Fuels, Solar Pool Heating, Wind (Small), Fuel Cells using Renewable Fuels, Microturbines	7/9/15	10/17/02	N/A
Michigan Economic Development Corporation	Refundable Payroll Tax Credit	Industry Recruitment/Support	Solar Water Heat, Solar Space Heat, Solar Thermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Wind (All), Biomass, Combined Heat & Power, Fuel Cells using Non-Renewable Fuels, Solar Pool Heating, Wind (Small), Fuel Cells using Renewable Fuels, Microturbines	5/18/15	10/17/02	N/A
Michigan Economic	Renewable Energy	Industry Recruitment/Support	Solar Water Heat, Solar Space Heat,	7/16/15	7/12/06	N/A

Development Corporation	Renaissance Zones		Solar Thermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Wind (All), Biomass, Landfill Gas, Solar Pool Heating, Anaerobic Digestion			
The Economic Development Corporation	City of Detroit - SmartBuildings Detroit Green Fund Loan	Loan Program	Solar Water Heat, Solar Photovoltaics, Wind (All), Hydroelectric, Geothermal Heat Pumps, Lighting, Chillers, Furnaces, Boilers, Heat pumps, Air conditioners, Heat recovery, Steam-system upgrades, Caulking/Weather-stripping, Building Insulation, Windows, Doors, Roofs, Custom/Others pending approval, Geothermal Direct-Use, Other Distributed Generation Technologies	5/19/15	N/A	N/A
Michigan Saves	Michigan Saves - Business Energy Financing	Loan Program	Solar Water Heat, Solar Thermal Electric, Geothermal Heat Pumps, Equipment Insulation, Water Heaters, Lighting, Lighting Controls/Sensors, Chillers, Furnaces, Boilers, Heat pumps, Air conditioners, Steam-system upgrades, Programmable Thermostats, Caulking/Weather-stripping, Duct/Air sealing, Building Insulation, Windows, Siding, Roofs,	3/24/16	N/A	N/A

			Custom/Others pending approval, Yes; specific technologies not identified, Food Service Equipment, LED Lighting, Tankless Water Heater, Commercial Refrigeration Equipment			
Michigan Saves	Michigan Saves - Home Energy Loan Program	Loan Program	Solar Water Heat, Solar Thermal Electric, Solar Photovoltaics, Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Dehumidifiers, Ceiling Fan, Water Heaters, Furnaces, Boilers, Heat pumps, Air conditioners, Caulking/Weather-stripping, Duct/Air sealing, Building Insulation, Windows, Siding, Roofs, Custom/Others pending approval, Other EE, Yes; specific technologies not identified, Tankless Water Heater	3/24/16	N/A	N/A
N/A	City of Ann Arbor - PACE Financing	PACE Financing	Geothermal Electric, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Geothermal Heat Pumps, Landfill Gas, Clothes Washers, Dishwasher, Refrigerators/Freezers, Dehumidifiers, Ceiling Fan, Water Heaters, Lighting, Chillers, Furnaces, Boilers, Heat pumps, Air conditioners,	6/24/15	N/A	N/A

			Programmable Thermostats, Energy Mgmt. Systems/Building Controls, Caulking/Weather-stripping, Duct/Air sealing, Building Insulation, Windows, Roofs, Other EE, Wind (Small), Geothermal Direct-Use, Reflective Roofs			
Levin Energy Partners	Lean and Green Michigan PACE	PACE Financing	Solar Water Heat, Solar Space Heat, Solar Photovoltaics, Wind (All), Biomass, Geothermal Heat Pumps, Combined Heat & Power, Landfill Gas, Lighting, Chillers, Furnaces, Boilers, Heat pumps, Air conditioners, Heat recovery, Energy Mgmt. Systems/Building Controls, Caulking/Weather-stripping, Duct/Air sealing, Building Insulation, Windows, Roofs, Other EE, Wind (Small), Geothermal Direct-Use	3/7/16	N/A	N/A
N/A	Local Option - Property Assessed Clean Energy	PACE Financing	Solar Water Heat, Solar Space Heat, Solar Photovoltaics, Wind (All), Biomass, Geothermal Heat Pumps, Combined Heat & Power, Landfill Gas, Lighting, Chillers, Furnaces, Boilers, Heat pumps, Air conditioners, Heat recovery, Energy Mgmt. Systems/Building	5/19/15	N/A	N/A

			Controls, Caulking/Weather-stripping, Duct/Air sealing, Building Insulation, Windows, Roofs, Other EE, Wind (Small), Geothermal Direct-Use			
Michigan Department of Agriculture	Biomass Gasification and Methane Digester Property Tax Exemption	Property Tax Incentive	Biomass, Anaerobic Digestion	7/16/15	12/29/06	N/A
Efficiency Smart	Coldwater Board of Public Utilities - Commercial & Industrial Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Lighting, Lighting Controls/Sensors, Chillers, Air conditioners, Compressed air, Energy Mgmt. Systems/Building Controls, Motors, Motor VFDs, Custom/Others pending approval, Other EE, Food Service Equipment, Vending Machine Controls, Commercial Refrigeration Equipment	6/1/15	N/A	N/A
N/A	Consumers Energy (Electric) - Commercial Energy Efficiency Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Equipment Insulation, Lighting, Lighting Controls/Sensors, Chillers, Heat pumps, Air conditioners, Compressed air, Programmable Thermostats, Energy Mgmt. Systems/Building Controls, Windows, Motors, Motor VFDs, Processing and	7/16/15	N/A	N/A

			Manufacturing Equipment, Custom/Others pending approval, Other EE, Tankless Water Heater, Commercial Refrigeration Equipment			
CLEAResult Consulting	Consumers Energy (Electric) - Residential Energy Efficiency Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Refrigerators/Freezers, Dehumidifiers, Equipment Insulation, Lighting, Heat pumps, Air conditioners, Programmable Thermostats, Caulking/Weather-stripping, Duct/Air sealing, Building Insulation, Windows, Motor VFDs, Comprehensive Measures/Whole Building, Other EE, LED Lighting	7/16/15	N/A	N/A
Consumers Energy Business Solutions	Consumers Energy (Gas) - Commercial Energy Efficiency Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Equipment Insulation, Water Heaters, Chillers, Furnaces, Boilers, Steam-system upgrades, Programmable Thermostats, Energy Mgmt. Systems/Building Controls, Building Insulation, Windows, Motors, Motor VFDs, Processing and Manufacturing Equipment, Custom/Others pending approval, Other EE, Food	4/14/15	N/A	N/A

			Service Equipment, Commercial Refrigeration Equipment			
DTE Energy	DTE Energy (Electric) - Commercial and Industrial Energy Efficiency Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Refrigerators/Freezers, Equipment Insulation, Water Heaters, Lighting, Lighting Controls/Sensors, Chillers, Heat pumps, Air conditioners, Heat recovery, Steam-system upgrades, Compressed air, Programmable Thermostats, Energy Mgmt. Systems/Building Controls, Building Insulation, Windows, Roofs, Motor VFDs, Processing and Manufacturing Equipment, Agricultural Equipment, Custom/Others pending approval, Other EE, Food Service Equipment, Vending Machine Controls, Reflective Roofs, LED Lighting, Commercial Refrigeration Equipment	1/14/16	N/A	N/A
N/A	Energy Optimization (Electric) - Residential Efficiency Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Dehumidifiers, Ceiling Fan, Equipment Insulation, Water Heaters, Lighting, Lighting Controls/Sensors,	3/21/16	N/A	N/A

			Furnaces, Heat pumps, Air conditioners, Programmable Thermostats, Building Insulation, Motors, Other EE, Personal Computing Equipment, Pool Pumps			
Great Lakes Energy	Great Lakes Energy - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Heat pumps	4/14/15	N/A	N/A

(Database Of State Incentives For Renewables & Efficiency, North Carolina Clean Energy Technology Center, North Carolina State University, Accessed 11/29/17)

MINNESOTA

Administrator	Name	Type	Technologies	Last Updated	Start Date	End Date
Minnesota Power	Minnesota Power - Power Grant Program	Grant Program	Solar Water Heat, Geothermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Wind (All), Biomass, Combined Heat & Power, Landfill Gas, Custom/Others pending approval, Hydroelectric (Small), Anaerobic Digestion, Other Distributed Generation Technologies	1/12/16	N/A	N/A
Xcel Energy	Xcel Energy - Renewable Development Fund Grants	Grant Program	Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Hydrogen, Combined Heat & Power, Anaerobic Digestion, Fuel Cells using Renewable Fuels	3/5/15	1/26/99	N/A
Rural Finance Authority	Agricultural Improvement Loan Program	Loan Program	Wind (All), Biomass, Wind (Small), Anaerobic Digestion	3/11/15	N/A	N/A
Minnesota Department of Agriculture	Farm Opportunities Loan Program	Loan Program	Solar Water Heat, Solar Photovoltaics, Wind (All), Biomass, Yes; specific technologies not identified, Wind (Small), Hydroelectric (Small), Anaerobic Digestion	3/14/17	N/A	N/A
Minnesota Housing Finance Agency	Fix-Up Loan	Loan Program	Solar Thermal Electric, Solar Photovoltaics, Wind (All), Water Heaters, Furnaces, Boilers, Air conditioners, Caulking/Weather-stripping, Building Insulation, Windows,	6/1/16	N/A	N/A

			Doors, Roofs, Comprehensive Measures/Whole Building, Wind (Small), Other Distributed Generation Technologies			
Center for Energy and Environment	Home Energy Loan Program	Loan Program	Geothermal Heat Pumps, Water Heaters, Lighting, Furnaces, Boilers, Air conditioners, Duct/Air sealing, Building Insulation, Windows, Doors, Custom/Others pending approval	3/14/17	N/A	N/A
Minnesota Department of Agriculture	Methane Digester Loan Program	Loan Program	Biomass, Anaerobic Digestion	3/5/15	N/A	N/A
Minnesota Valley Electric Cooperative	Minnesota Valley Electric Cooperative - Residential Energy Resource Conservation Loan Program	Loan Program	Geothermal Heat Pumps, Equipment Insulation, Water Heaters, Heat pumps, Caulking/Weather-stripping, Building Insulation, Windows, Doors	5/19/16	N/A	N/A
Otter Tail Power Company	Otter Tail Power Company - DollarSmart Energy Efficiency Loan Program	Loan Program	Geothermal Heat Pumps, Water Heaters, Lighting, Chillers, Heat pumps, Air conditioners, Heat recovery, Motors, Motor VFDs, Agricultural Equipment, Food Service Equipment	3/29/17	N/A	N/A
Rural Finance Authority	Value-Added Stock Loan Participation Program	Loan Program	Solar Photovoltaics, Wind (All), Biomass, Wind (Small), Anaerobic Digestion	2/13/15	1/26/94	N/A
N/A	Rural Minnesota Energy Board PACE Program	PACE Financing	Solar Water Heat, Geothermal Electric, Solar Photovoltaics, Wind (All), Geothermal Heat Pumps, Yes; specific technologies not identified, Geothermal Direct-Use	5/1/15	N/A	N/A

N/A	Saint Paul Port Authority PACE Program	PACE Financing	Solar Water Heat, Geothermal Electric, Solar Photovoltaics, Wind (All), Geothermal Heat Pumps, Lighting, Furnaces, Boilers, Heat pumps, Air conditioners, Energy Mgmt. Systems/Building Controls, Caulking/Weather-stripping, Duct/Air sealing, Building Insulation, Windows, Custom/Others pending approval, Geothermal Direct-Use, Pool Pumps, LED Lighting	5/4/15	N/A	N/A
Minnesota Department of Commerce	Made in Minnesota Solar PV Incentive Program	Performance-Based Incentive	Solar Photovoltaics	9/15/16	1/1/14	12/31/23
Minnesota Department of Commerce	Renewable Energy Production Incentive	Performance-Based Incentive	Biomass, Anaerobic Digestion	1/7/15	N/A	N/A
Xcel Energy	Xcel Energy - Solar*Rewards Program	Performance-Based Incentive	Solar Photovoltaics	1/27/16	1/1/14	12/31/18
N/A	Wind and Solar-Electric (PV) Systems Exemption	Property Tax Incentive	Solar Photovoltaics, Wind (All), Wind (Small)	3/26/15	N/A	N/A
Alexandria Light and Power	Alexandria Light and Power - Commercial Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Water Heaters, Lighting, Lighting Controls/Sensors, Chillers, Heat pumps, Air conditioners, Compressed air, Programmable Thermostats, Energy Mgmt. Systems/Building	3/11/15	N/A	N/A

			Controls, Windows, Motors, Motor VFDs, Custom/Others pending approval, Other EE, Food Service Equipment, Personal Computing Equipment, LED Lighting, Commercial Refrigeration Equipment			
Alexandria Light and Power	Alexandria Light and Power - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Dehumidifiers, Water Heaters, Furnaces, Heat pumps, Air conditioners, Programmable Thermostats, Energy Mgmt. Systems/Building Controls, Other EE, LED Lighting	7/20/16	N/A	N/A
Austin Utilities	Austin Utilities - Solar Rebate Program	Rebate Program	Solar Water Heat, Solar Photovoltaics	7/6/16	N/A	N/A
Austin Utilities	Austin Utilities (Gas and Electric) - Commercial and Industrial Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Dehumidifiers, Water Heaters, Lighting, Lighting Controls/Sensors, Chillers, Furnaces, Boilers, Heat pumps, Air conditioners, Steam-system upgrades, Building Insulation, Motors, Motor VFDs, Custom/Others pending approval, Other EE, Food Service Equipment, Vending Machine Controls, Data Center Equipment,	3/11/15	N/A	N/A

			Commercial Refrigeration Equipment			
Austin Utilities	Austin Utilities (Gas and Electric) - Residential Conserve and Save Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Dehumidifiers, Water Heaters, Furnaces, Boilers, Heat pumps, Air conditioners, Programmable Thermostats, Duct/Air sealing, Windows, Motors, Custom/Others pending approval, Other EE, Insulation, LED Lighting, Tankless Water Heater	3/22/17	N/A	N/A
Blooming Prairie Public Utilities	Blooming Prairie Public Utilities - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Dehumidifiers, Lighting, Heat pumps, Air conditioners, Motors, Other EE, LED Lighting	2/23/17	N/A	N/A
Brainerd Public Utilities	Brainerd Public Utilities - Renewable Incentives Program	Rebate Program	Solar Photovoltaics	8/25/16	N/A	N/A
Connexus Energy	Connexus Energy - Commercial Energy Efficiency Rebate Programs	Rebate Program	Geothermal Heat Pumps, Lighting, Lighting Controls/Sensors, Chillers, Heat pumps, Air conditioners, Compressed air, Motors, Motor VFDs, Comprehensive Measures/Whole Building, Custom/Others pending approval, Other EE, Vending Machine Controls, LED	3/22/17	N/A	N/A

			Lighting, Commercial Refrigeration Equipment			
Connexus Energy	Connexus Energy - Residential Efficient HVAC Rebate Program	Rebate Program	Geothermal Heat Pumps, Water Heaters, Heat pumps, Programmable Thermostats, Pool Pumps	4/28/17	N/A	N/A
Crow Wing Power	Crow Wing Power - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Refrigerators/Freezers, Water Heaters, Boilers, Heat pumps, Air conditioners, Motors, Other EE, LED Lighting	3/14/17	N/A	N/A
Dakota Electric Service	Dakota Electric Association - Commercial and Industrial Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Lighting, Chillers, Heat pumps, Air conditioners, Compressed air, Energy Mgmt. Systems/Building Controls, Motors, Motor VFDs, Processing and Manufacturing Equipment, Agricultural Equipment, Comprehensive Measures/Whole Building, Custom/Others pending approval, Vending Machine Controls, Personal Computing Equipment, Data Center Equipment, LED Lighting	11/12/15	N/A	N/A
Dakota Electric Service	Dakota Electric Association - Residential Energy Efficiency	Rebate Program	Geothermal Heat Pumps, Refrigerators/Freezers, Dehumidifiers, Water Heaters, Lighting, Heat pumps, Air	3/13/17	N/A	N/A

	Rebate Program		conditioners, Motors, Other EE, LED Lighting			
East Central Energy	East Central Energy - Commercial Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Lighting, Lighting Controls/Sensors, Chillers, Heat pumps, Air conditioners, Energy Mgmt. Systems/Building Controls, Motors, Motor VFDs, Agricultural Equipment, Other EE, Vending Machine Controls, LED Lighting	7/21/16	N/A	N/A
East Central Energy	East Central Energy - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Refrigerators/Freezers, Dehumidifiers, Water Heaters, Lighting, Heat pumps, Air conditioners, Motors, Other EE, LED Lighting	7/21/16	N/A	N/A
Elk River Municipal Utilities	Elk River Municipal Utilities - Commercial Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Lighting, Lighting Controls/Sensors, Chillers, Heat pumps, Air conditioners, Compressed air, Energy Mgmt. Systems/Building Controls, Motors, Motor VFDs, Other EE, Vending Machine Controls, LED Lighting	8/25/16	N/A	N/A
Elk River Municipal Utilities	Elk River Municipal Utilities - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Dehumidifiers, Water Heaters, Furnaces, Heat pumps, Air conditioners, Motors, Other EE, Pool Pumps	3/14/17	N/A	N/A

Fairmont Public Utilities	Fairmont Public Utilities - Commercial & Industrial Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Dishwasher, Lighting, Lighting Controls/Sensors, Chillers, Heat pumps, Air conditioners, Energy Mgmt. Systems/Building Controls, Motors, Motor VFDs, Custom/Others pending approval, Other EE, Food Service Equipment, Vending Machine Controls, LED Lighting, Commercial Refrigeration Equipment	5/1/17	N/A	N/A
Fairmont Public Utilities	Fairmont Public Utilities - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Dehumidifiers, Lighting, Heat pumps, Air conditioners, Motor VFDs, Custom/Others pending approval, Other EE, Food Service Equipment, Vending Machine Controls	3/13/17	N/A	N/A
Grand Marais PUC	Grand Marais PUC - Commercial & Industrial Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Dishwasher, Lighting, Lighting Controls/Sensors, Chillers, Furnaces, Heat pumps, Air conditioners, Energy Mgmt. Systems/Building Controls, Motors, Motor VFDs, Custom/Others pending approval, Other EE, Food Service Equipment, Vending Machine Controls, LED Lighting,	4/24/17	N/A	N/A

			Commercial Refrigeration Equipment			
Grand Marais PUC	Grand Marais PUC - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Dehumidifiers, Lighting, Furnaces, Heat pumps, Air conditioners, Motors, Other EE, LED Lighting	4/5/17	N/A	N/A
Great River Energy Member Cooperatives	Great River Energy (28 Member Cooperatives) - Commercial and Industrial Efficiency Rebates	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Water Heaters, Lighting, Furnaces, Boilers, Heat pumps, Air conditioners, Motors, Motor VFDs, Yes; specific technologies not identified	3/20/17	N/A	N/A
Hutchinson Utilities Commission	Hutchinson Utilities Commission - Commercial Energy Efficiency Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Water Heaters, Lighting, Lighting Controls/Sensors, Chillers, Furnaces, Boilers, Heat pumps, Air conditioners, Programmable Thermostats, Motors, Motor VFDs, Custom/Others pending approval, Other EE, Food Service Equipment, LED Lighting, Commercial Refrigeration Equipment	6/27/16	N/A	N/A
Hutchinson Utilities Commission	Hutchinson Utilities Commission -	Rebate Program	Geothermal Heat Pumps, Clothes Washers,	3/20/17	N/A	N/A

	Residential Energy Efficiency Program		Refrigerators/Freezers, Dehumidifiers, Water Heaters, Furnaces, Boilers, Heat pumps, Air conditioners, Programmable Thermostats, Building Insulation, Other EE, LED Lighting, Tankless Water Heater			
Lake City Utilities	Lake City Utilities - Commercial & Industrial Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Dishwasher, Refrigerators/Freezers, Lighting, Furnaces, Heat pumps, Air conditioners, Energy Mgmt. Systems/Building Controls, Motors, Motor VFDs, Custom/Others pending approval, Other EE, Food Service Equipment, Vending Machine Controls, LED Lighting	4/14/17	N/A	N/A
Lake City Utilities	Lake City Utilities - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Dehumidifiers, Lighting, Heat pumps, Air conditioners, Motors, Other EE, LED Lighting	2/26/16	N/A	N/A
Lake Country Power	Lake Country Power - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Refrigerators/Freezers, Dehumidifiers, Water Heaters, Lighting, Heat pumps, Air conditioners, Motors, Other EE, LED Lighting	2/19/16	N/A	N/A
Lake Region Electric Cooperative	Lake Region Electric Cooperative - Residential Energy	Rebate Program	Geothermal Heat Pumps, Refrigerators/Freezers, Heat pumps, Air conditioners, Other EE	3/29/17	N/A	N/A

	Efficiency Rebate Program					
Litchfield Public Utilities	Litchfield Public Utilities - Commercial & Industrial Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Lighting, Lighting Controls/Sensors, Heat pumps, Air conditioners, Energy Mgmt. Systems/Building Controls, Motors, Motor VFDs, Custom/Others pending approval, Other EE, Food Service Equipment, Vending Machine Controls, Commercial Refrigeration Equipment	4/5/17	N/A	N/A
Litchfield Public Utilities	Litchfield Public Utilities - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Dehumidifiers, Lighting, Heat pumps, Air conditioners, Motors, Motor VFDs, Other EE, Food Service Equipment, Vending Machine Controls, LED Lighting	4/4/17	N/A	N/A
Minnesota Department of Commerce	Made in Minnesota Solar Thermal Rebate	Rebate Program	Solar Water Heat, Solar Thermal Electric, Solar Thermal Process Heat, Solar Pool Heating	1/8/16	1/1/14	12/31/23
Marshall Municipal Utilities/Missouri River Energy Services	Marshall Municipal Utilities - Commercial Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Dishwasher, Water Heaters, Lighting, Lighting Controls/Sensors, Furnaces, Heat pumps, Air conditioners, Compressed air, Programmable Thermostats, Energy	2/18/16	N/A	N/A

			Mgmt. Systems/Building Controls, Windows, Motors, Custom/Others pending approval, Other EE, LED Lighting, Commercial Refrigeration Equipment			
Marshall Municipal Utilities	Marshall Municipal Utilities - Residential Energy Efficiency Rebate Program	Rebate Program	Solar Water Heat, Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Dehumidifiers, Water Heaters, Lighting, Heat pumps, Air conditioners, Programmable Thermostats, Other EE, LED Lighting	3/13/17	N/A	N/A
Marshall Municipal Utilities	Marshall Municipal Utilities - Solar Thermal Water Heater Rebate Program	Rebate Program	Solar Water Heat	6/23/16	N/A	N/A
Minnesota Power	Minnesota Power - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Refrigerators/Freezers, Water Heaters, Lighting, Furnaces, Heat pumps, Air conditioners, Other EE, LED Lighting	1/7/16	N/A	N/A
Minnesota Power	Minnesota Power - Residential New Construction Rebate Program	Rebate Program	Solar Photovoltaics, Geothermal Heat Pumps, Clothes Washers, Refrigerators/Freezers, Dehumidifiers, Water Heaters, Heat pumps, Air conditioners, Windows, Comprehensive Measures/Whole Building, LED Lighting	1/7/16	N/A	N/A

Minnesota Power	Minnesota Power - SolarSense Solar Rebate Program	Rebate Program	Solar Photovoltaics	2/20/17	1/1/04	N/A
Minnesota Valley Electric Cooperative	Minnesota Valley Electric Cooperative - Commercial and Industrial Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Lighting, Lighting Controls/Sensors, Chillers, Heat pumps, Air conditioners, Compressed air, Energy Mgmt. Systems/Building Controls, Motors, Motor VFDs, Agricultural Equipment, Custom/Others pending approval, Other EE, Vending Machine Controls	2/19/16	N/A	N/A
Minnesota Valley Electric Cooperative	Minnesota Valley Electric Cooperative - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Boilers, Heat pumps, Air conditioners, Programmable Thermostats, Motors, Other EE	5/19/16	N/A	N/A
N/A	Minnkota Power Cooperative (17 Utilities) - PowerSavers Commercial Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Refrigerators/Freezers, Water Heaters, Lighting, Lighting Controls/Sensors, Chillers, Furnaces, Heat pumps, Air conditioners, Motor VFDs, Custom/Others pending approval, Food Service Equipment, Vending Machine Controls, LED Lighting, Commercial Refrigeration Equipment	5/4/16	N/A	N/A

N/A	Minnkota Power Cooperative (17 Utilities) - PowerSavers Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Refrigerators/Freezers, Water Heaters, Lighting, Furnaces, Heat pumps, Programmable Thermostats, Building Insulation, LED Lighting	5/4/16	N/A	N/A
Bright Energy Solutions/Missouri River Energy Services	Missouri River Energy Services (23 Member Cooperatives) - Business Energy Efficiency Rebate	Rebate Program	Geothermal Heat Pumps, Dishwasher, Water Heaters, Lighting, Lighting Controls/Sensors, Chillers, Furnaces, Boilers, Heat pumps, Air conditioners, Compressed air, Programmable Thermostats, Doors, Motors, Motor VFDs, Custom/Others pending approval, Other EE, Food Service Equipment, Commercial Cooking Equipment, LED Lighting, Commercial Refrigeration Equipment	2/5/16	N/A	N/A
Bright Energy Solutions/Missouri River Energy Services	Missouri River Energy Services (23 Member Cooperatives) - Residential Energy Efficiency Rebate	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Refrigerators/Freezers, Dehumidifiers, Water Heaters, Lighting, Furnaces, Heat pumps, Air conditioners, Programmable Thermostats, Other EE, LED Lighting	2/5/16	N/A	N/A
Moorhead Public Service/Bright Energy Solutions	Moorhead Public Service Utility - Commercial and Industrial	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Ceiling Fan, Water Heaters, Lighting,	6/23/16	N/A	N/A

	Energy Efficiency Rebate Program		Lighting Controls/Sensors, Chillers, Heat pumps, Air conditioners, Compressed air, Programmable Thermostats, Energy Mgmt. Systems/Building Controls, Motors, Motor VFDs, Comprehensive Measures/Whole Building, Custom/Others pending approval, Food Service Equipment, Vending Machine Controls, Commercial Cooking Equipment, Personal Computing Equipment, LED Lighting, Commercial Refrigeration Equipment			
Mora Municipal Utilities	Mora Municipal Utilities - Commercial & Industrial Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Dishwasher, Lighting, Lighting Controls/Sensors, Chillers, Heat pumps, Air conditioners, Motors, Motor VFDs, Custom/Others pending approval, Other EE, Food Service Equipment, Vending Machine Controls, LED Lighting, Commercial Refrigeration Equipment	8/26/16	N/A	N/A
Mora Municipal Utilities	Mora Municipal Utilities - Residential Energy Efficiency	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Dehumidifiers, Lighting, Heat pumps,	5/2/17	N/A	N/A

	Rebate Program		Air conditioners, Other EE, LED Lighting			
New Prague Utilities Commission	New Prague Utilities Commission - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Dehumidifiers, Lighting, Heat pumps, Air conditioners, Motors, Other EE, LED Lighting	8/26/16	N/A	N/A
New Ulm Public Utilities	New Ulm Public Utilities - Solar Electric Rebate Program	Rebate Program	Solar Photovoltaics	2/10/16	N/A	N/A
North Branch Municipal Water & Light	North Branch Municipal Water & Light - Commercial & Industrial Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Dishwasher, Refrigerators/Freezers, Lighting, Lighting Controls/Sensors, Chillers, Heat pumps, Air conditioners, Compressed air, Energy Mgmt. Systems/Building Controls, Motors, Motor VFDs, Custom/Others pending approval, Other EE, Food Service Equipment, Vending Machine Controls, LED Lighting, Commercial Refrigeration Equipment	3/2/17	N/A	N/A
North Branch Municipal Water & Light	North Branch Municipal Water & Light - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Dehumidifiers, Lighting, Heat pumps, Air conditioners, Other EE, LED Lighting	2/23/17	N/A	N/A
Northern Municipal Power Agency	Northern Municipal Power Agency - Commercial	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Refrigerators/Freezers,	7/6/16	N/A	N/A

	Energy Efficiency Rebate Program		Water Heaters, Lighting, Lighting Controls/Sensors, Chillers, Heat pumps, Air conditioners, Programmable Thermostats, Energy Mgmt. Systems/Building Controls, Motor VFDs, Custom/Others pending approval, Other EE, Food Service Equipment, Vending Machine Controls, LED Lighting, Commercial Refrigeration Equipment			
Wild Rice Electric	Northern Municipal Power Agency - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Refrigerators/Freezers, Water Heaters, Lighting, Furnaces, Heat pumps, Programmable Thermostats, Duct/Air sealing, Insulation, LED Lighting	5/23/16	N/A	N/A
Customer Service	Otter Tail Power Company - Commercial & Industrial Energy Efficiency Rebate Program	Rebate Program	Solar Photovoltaics, Geothermal Heat Pumps, Water Heaters, Lighting, Furnaces, Heat pumps, Air conditioners, Heat recovery, Building Insulation, Motors, Motor VFDs, Custom/Others pending approval, Other EE, LED Lighting, Commercial Refrigeration Equipment	3/28/17	N/A	N/A
Customer Service	Otter Tail Power Company -	Rebate Program	Geothermal Heat Pumps, Water Heaters, Lighting, Heat	3/29/17	N/A	N/A

	Residential Energy Efficiency Rebate Program		pumps, Programmable Thermostats, Building Insulation, Motors, Motor VFDs, Other EE			
Owatanna Public Utilities	Owatanna Public Utilities - Solar Rebate Program	Rebate Program	Solar Water Heat, Solar Photovoltaics	7/19/16	N/A	N/A
Owatonna Public Utilities/Conserve & $ave	Owatonna Public Utilities - Residential Conserve and Save Rebate Program	Rebate Program	Solar Water Heat, Solar Photovoltaics, Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Dehumidifiers, Water Heaters, Lighting, Furnaces, Boilers, Heat pumps, Air conditioners, Heat recovery, Programmable Thermostats, Duct/Air sealing, Building Insulation, Windows, Doors, Motors, Other EE, Insulation, LED Lighting, Tankless Water Heater	6/23/16	N/A	N/A
Preston Public Utilities	Preston Public Utilities - Commercial & Industrial Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Dishwasher, Lighting, Lighting Controls/Sensors, Chillers, Heat pumps, Air conditioners, Motors, Motor VFDs, Custom/Others pending approval, Other EE, Food Service Equipment, Vending Machine Controls, LED Lighting, Commercial Refrigeration Equipment	3/16/17	N/A	N/A
Preston Public Utilities	Preston Public Utilities - Residential Energy	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers,	3/16/17	N/A	N/A

	Efficiency Rebate Program		Dehumidifiers, Lighting, Furnaces, Heat pumps, Air conditioners, Motors, Motor VFDs, Custom/Others pending approval, Other EE, Food Service Equipment, Vending Machine Controls, LED Lighting			
Princeton PUC	Princeton PUC - Commercial & Industrial Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Dishwasher, Lighting, Lighting Controls/Sensors, Chillers, Heat pumps, Air conditioners, Motors, Custom/Others pending approval, Food Service Equipment, Vending Machine Controls, LED Lighting, Commercial Refrigeration Equipment	3/2/17	N/A	N/A
Princeton PUC	Princeton PUC - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Dehumidifiers, Lighting, Heat pumps, Air conditioners, Other EE, LED Lighting	3/2/17	N/A	N/A
Redwood Falls Public Utilities	Redwood Falls Public Utilities - Commercial & Industrial Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Dishwasher, Refrigerators/Freezers, Lighting, Lighting Controls/Sensors, Chillers, Furnaces, Heat pumps, Air conditioners, Energy Mgmt. Systems/Building Controls, Motors, Motor VFDs, Custom/Others pending approval, Other EE, Food	4/18/17	N/A	N/A

			Service Equipment, Vending Machine Controls, LED Lighting			
Redwood Falls Public Utilities	Redwood Falls Public Utilities - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Dehumidifiers, Lighting, Heat pumps, Air conditioners, Motors, Custom/Others pending approval, Other EE, Food Service Equipment, Vending Machine Controls, LED Lighting	3/14/17	N/A	N/A
Rochester Public Utilities	Rochester Public Utilities - Commercial and Industrial Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Lighting, Lighting Controls/Sensors, Chillers, Heat pumps, Air conditioners, Compressed air, Energy Mgmt. Systems/Building Controls, Motors, Motor VFDs, Custom/Others pending approval, Food Service Equipment, LED Lighting, Commercial Refrigeration Equipment	2/15/17	N/A	N/A
Rochester Public Utilities	Rochester Public Utilities - Residential Conserve and Save Rebate	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Dehumidifiers, Heat pumps, Air conditioners, Custom/Others pending approval, LED Lighting	2/15/17	N/A	N/A
Rochester Public Utilities	Rochester Public Utilities - Solar Rebate Program	Rebate Program	Solar Water Heat, Solar Photovoltaics	2/15/17	N/A	N/A

Saint Peter Municipal Utilities	Saint Peter Municipal Utilities - Commercial & Industrial Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Dishwasher, Dehumidifiers, Lighting, Lighting Controls/Sensors, Chillers, Heat pumps, Air conditioners, Compressed air, Energy Mgmt. Systems/Building Controls, Motors, Motor VFDs, Custom/Others pending approval, Food Service Equipment, Vending Machine Controls, LED Lighting, Commercial Refrigeration Equipment	5/24/16	N/A	N/A
Saint Peter Municipal Utilities	Saint Peter Municipal Utilities - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Dehumidifiers, Lighting, Heat pumps, Air conditioners, LED Lighting	5/24/16	N/A	N/A
Shakopee Public Utilities	Shakopee Public Utilities - Commercial and Industrial Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Lighting, Lighting Controls/Sensors, Chillers, Heat pumps, Air conditioners, Motor VFDs, Custom/Others pending approval, Other EE, LED Lighting	6/27/16	N/A	N/A
Spring Valley Public Utilities	Spring Valley Public Utilities - Commercial & Industrial Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Dishwasher, Lighting, Lighting Controls/Sensors, Chillers, Heat pumps, Air conditioners, Energy Mgmt. Systems/Building Controls, Motors, Motor VFDs, Custom/Others	4/6/17	N/A	N/A

			pending approval, Other EE, Food Service Equipment, Vending Machine Controls, Commercial Refrigeration Equipment			
Spring Valley Public Utilities	Spring Valley Public Utilities - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Dehumidifiers, Lighting, Heat pumps, Air conditioners, Energy Mgmt. Systems/Building Controls, Motors, Motor VFDs, Other EE, Vending Machine Controls, Commercial Cooking Equipment, LED Lighting	7/21/16	N/A	N/A
Stearns Electric Association	Stearns Electric Association - Commercial Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Lighting, Chillers, Heat pumps, Air conditioners, Compressed air, Motors, Motor VFDs, Agricultural Equipment, Other EE, Food Service Equipment, Vending Machine Controls, Commercial Cooking Equipment	3/22/17	N/A	N/A
Stearns Electric Association	Stearns Electric Association - Residential Energy Efficiency Rebate Program	Rebate Program	Solar Water Heat, Geothermal Heat Pumps, Refrigerators/Freezers, Water Heaters, Lighting, Heat pumps, Air conditioners, Motors, Motor VFDs, Pool Pumps	5/1/17	N/A	N/A
Waseca Utilities	Waseca Utilities - Commercial & Industrial Energy	Rebate Program	Geothermal Heat Pumps, Lighting, Lighting Controls/Sensors, Chillers, Furnaces,	4/18/17	N/A	N/A

	Efficiency Rebate Program		Heat pumps, Air conditioners, Compressed air, Energy Mgmt. Systems/Building Controls, Motors, Motor VFDs, Custom/Others pending approval, Other EE, Food Service Equipment, Vending Machine Controls, Commercial Refrigeration Equipment			
Waseca Utilities	Waseca Utilities - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Dehumidifiers, Lighting, Furnaces, Heat pumps, Air conditioners, Motors, Other EE, LED Lighting	2/5/16	N/A	N/A
Wells Public Utilities	Wells Public Utilities - Commercial & Industrial Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Dishwasher, Dehumidifiers, Lighting, Lighting Controls/Sensors, Chillers, Heat pumps, Air conditioners, Doors, Motors, Custom/Others pending approval, Other EE, Food Service Equipment, Vending Machine Controls, LED Lighting, Commercial Refrigeration Equipment	2/4/16	N/A	N/A
Wells Public Utilities	Wells Public Utilities - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Dehumidifiers, Lighting, Heat pumps,	2/4/16	N/A	N/A

			Air conditioners, Other EE, LED Lighting			
Willmar Municipal Utilities	Willmar Municipal Utilities - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Water Heaters, LED Lighting	3/13/17	N/A	N/A
Wright-Hennepin Cooperative Electric Association	Wright-Hennepin Cooperative Electric Association - Non-Residential Energy Efficient Rebate Program	Rebate Program	Geothermal Heat Pumps, Lighting, Lighting Controls/Sensors, Chillers, Heat pumps, Air conditioners, Motors, Motor VFDs, Custom/Others pending approval, LED Lighting	3/22/17	N/A	N/A
Wright-Hennepin Cooperative Electric Association	Wright-Hennepin Cooperative Electric Association - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Water Heaters, Heat pumps, Air conditioners, Motors, Pool Pumps	3/14/17	N/A	N/A
Xcel Energy	Xcel Energy (Electric) - Residential Energy Efficiency Rebate Programs	Rebate Program	Geothermal Heat Pumps, Refrigerators/Freezers, Lighting, Lighting Controls/Sensors, Furnaces, Heat pumps, Air conditioners, Programmable Thermostats, Duct/Air sealing, Building Insulation, Comprehensive Measures/Whole Building, Other EE, LED Lighting	1/7/16	N/A	N/A

Department of Revenue	Solar Energy Sales Tax Exemption	Sales Tax Incentive	Solar Water Heat, Solar Space Heat, Solar Thermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Solar Pool Heating	5/15/15	N/A	N/A
N/A	Wind Energy Sales Tax Exemption	Sales Tax Incentive	Wind (All), Wind (Small)	12/9/15	N/A	N/A

(Database Of State Incentives For Renewables & Efficiency, North Carolina Clean Energy Technology Center, North Carolina State University, Accessed 11/29/17)

MISSISSIPPI

Administrator	Name	Type	Technologies	Last Updated	Start Date	End Date
Mississippi Development Authority	Mississippi Clean Energy Initiative	Industry Recruitment/Support	Solar Water Heat, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Wind (Small)	6/15/15	7/1/10	N/A
N/A	Mississippi Power (Electric) - Residential Loan Program	Loan Program	Geothermal Heat Pumps, Equipment Insulation, Water Heaters, Heat pumps, Air conditioners, Programmable Thermostats, Duct/Air sealing, Building Insulation, Windows, Doors, Comprehensive Measures/Whole Building, Other EE	6/15/15	N/A	N/A
Tennessee Valley Authority	TVA Partner Utilities - Energy Right Heat Pump Program	Loan Program	Geothermal Heat Pumps, Heat pumps	6/17/15	N/A	N/A
Tennessee Valley Authority	TVA - Green Power Providers	Performance-Based Incentive	Solar Photovoltaics, Wind (All), Biomass, Wind (Small), Hydroelectric (Small)	6/2/15	10/1/12	N/A
Tennessee Valley Authority	TVA - Mid-Sized Renewable Standard Offer Program	Performance-Based Incentive	Solar Photovoltaics, Wind (All), Biomass, Landfill Gas	6/18/15	10/10/10	N/A
N/A	TVA - Solar Solutions Initiative	Performance-Based Incentive	Solar Photovoltaics	6/4/15	N/A	N/A
Coast Electric Power Association	Coast Electric Power Association - Comfort Advantage	Rebate Program	Geothermal Heat Pumps, Equipment Insulation, Heat pumps, Caulking/Weather-stripping, Building Insulation, Windows,	1/7/16	N/A	N/A

	Home Program		Comprehensive Measures/Whole Building			
Southern Company	Mississippi Power - EarthCents Commercial Incentives Program	Rebate Program	Geothermal Heat Pumps, Water Heaters, Chillers, Boilers, Heat pumps, Air conditioners, Energy Mgmt. Systems/Building Controls, Building Insulation, Custom/Others pending approval, Other EE, Food Service Equipment	6/16/15	N/A	N/A
Southern Company	Mississippi Power - EarthCents New Home Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Dehumidifiers, Water Heaters, Heat pumps, Air conditioners, Programmable Thermostats, Duct/Air sealing, Building Insulation, Windows, Comprehensive Measures/Whole Building, Other EE	6/16/15	N/A	N/A
N/A	Mississippi Power - Residential Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Water Heaters, Heat pumps, Air conditioners, Other EE	6/16/15	N/A	N/A
Pearl River Valley Electric Power Association	Pearl River Valley Electric Power Association - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Water Heaters, Heat pumps, Comprehensive Measures/Whole Building, Other EE	6/17/15	N/A	N/A
Singing River Electric	Singing River	Rebate Program	Geothermal Heat Pumps, Heat pumps,	12/2/15	N/A	N/A

Power Association	Electric Power Association - Comfort Advantage Home Program		Comprehensive Measures/Whole Building			
Southern Pine Electric Power Association	Southern Pine Electric Power Association - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Heat pumps, Comprehensive Measures/Whole Building	6/17/15	N/A	N/A
N/A	TVA Partner Utilities - eScore Program	Rebate Program	Geothermal Heat Pumps, Water Heaters, Heat pumps, Air conditioners, Duct/Air sealing, Windows, Doors, Insulation	8/31/17	N/A	N/A

(Database Of State Incentives For Renewables & Efficiency, North Carolina Clean Energy Technology Center, North Carolina State University, Accessed 11/29/17)

MISSOURI

Administrator	Name	Type	Technologies	Last Updated	Start Date	End Date
Division of Energy	Wood Energy Production Credit	Corporate Tax Credit	Biomass	5/13/15	1/1/97	6/30/20
N/A	Columbia Water & Light - Commercial Energy Efficiency Loans	Loan Program	Solar Water Heat, Solar Space Heat, Lighting, Furnaces, Heat pumps, Air conditioners, Other EE, LED Lighting	4/14/15	6/1/10	N/A
Columbia Water & Light	Columbia Water & Light - Home Performance with ENERGY STAR Loan	Loan Program	Solar Water Heat, Solar Space Heat, Water Heaters, Furnaces, Heat pumps, Air conditioners, Duct/Air sealing, Building Insulation, Windows, Doors, Comprehensive Measures/Whole Building, Other EE	4/14/15	N/A	N/A
Missouri Department of Economic Development	Energy Loan Program	Loan Program	Solar - Passive, Solar Water Heat, Solar Space Heat, Solar Photovoltaics, Wind (All), Biomass, Combined Heat & Power, Lighting, Chillers, Furnaces, Boilers, Heat pumps, Air conditioners, Programmable Thermostats, Building Insulation, Windows, Motors, Custom/Others pending approval, Other EE, Wind (Small)	9/4/15	1/26/89	N/A
N/A	Local Option - Clean Energy Development Boards	PACE Financing	Solar Water Heat, Solar Space Heat, Solar Photovoltaics, Wind (All), Biomass, Geothermal Heat Pumps, Daylighting,	5/5/16	N/A	N/A

			Equipment Insulation, Lighting, Furnaces, Boilers, Heat pumps, Air conditioners, Heat recovery, Energy Mgmt. Systems/Building Controls, Caulking/Weather-stripping, Building Insulation, Windows, Doors, Comprehensive Measures/Whole Building, Custom/Others pending approval, Wind (Small), Geothermal Direct-Use, Other Distributed Generation Technologies			
Missouri Clean Energy Funding, LLC	Missouri Clean Energy District	PACE Financing	Geothermal Electric, Solar Thermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Wind (All), Biomass, Geothermal Heat Pumps, Comprehensive Measures/Whole Building, Custom/Others pending approval, Yes; specific technologies not identified, Wind (Small)	3/17/16	1/1/11	N/A
Energy Equity Funding, LLC	Set the PACE St. Louis	PACE Financing	Solar Water Heat, Solar Photovoltaics, Ceiling Fan, Water Heaters, Lighting, Furnaces, Boilers, Heat pumps, Air conditioners, Programmable Thermostats, Caulking/Weather-	1/12/16	N/A	N/A

			stripping, Duct/Air sealing, Building Insulation, Windows, Doors, Comprehensive Measures/Whole Building, Other EE, Wind (Small), Pool Pumps, Tankless Water Heater			
Missouri Energy Initiative (MEI)	Show Me PACE	PACE Financing	Geothermal Electric, Solar Thermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Wind (All), Biomass, Geothermal Heat Pumps, Yes; specific technologies not identified	5/5/16	N/A	N/A
State Tax Commission of Missouri	Solar Property Tax Exemption	Property Tax Incentive	Solar Water Heat, Solar Space Heat, Solar Thermal Electric, Solar Thermal Process Heat, Solar Photovoltaics	5/13/15	8/28/13	N/A
N/A	Ameren Missouri (Electric) - Residential Heating and Cooling Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Heat pumps, Air conditioners, Motors	3/24/16	3/7/16	2/15/19
City Utilities of Springfield, Missouri	City Utilities of Springfield - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Furnaces, Heat pumps, Air conditioners, Programmable Thermostats, Building Insulation, Comprehensive Measures/Whole Building	10/23/15	N/A	N/A
Co-Mo Electric Cooperative	Co-Mo Electric Cooperative - Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Water Heaters, Heat pumps, Other EE	6/23/15	N/A	N/A

Columbia Water & Light	Columbia Water & Light - Solar Rebates	Rebate Program	Solar Water Heat, Solar Photovoltaics	4/14/15	N/A	N/A
Cuivre River Electric	Cuivre River Electric - Energy Efficiency Rebate Programs	Rebate Program	Geothermal Heat Pumps, Water Heaters, Heat pumps, Building Insulation, Other EE	7/30/15	N/A	N/A
N/A	Empire District Electric - Solar PV Rebates	Rebate Program	Solar Photovoltaics	3/15/17	1/1/10	6/30/20
Intercounty Electric Cooperative	Intercounty Electric Cooperative - Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Water Heaters, Heat pumps, Air conditioners, Building Insulation	7/30/15	N/A	N/A
N/A	Missouri Rural Electric Cooperative - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Water Heaters, Heat pumps, Air conditioners	10/12/15	N/A	N/A
Ozark Border Electric Cooperative	Ozark Border Electric Cooperative - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Water Heaters, Heat pumps, Air conditioners	7/29/15	N/A	N/A
Platte-Clay Electric Cooperative	Platte-Clay Electric Cooperative - Residential and Commercial Energy Efficiency Rebates	Rebate Program	Geothermal Heat Pumps, Lighting, Heat pumps, Air conditioners	1/11/16	N/A	N/A
Southwest Electric Cooperative	Southwest Electric Cooperative - Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Water Heaters, Heat pumps, Air conditioners, Building Insulation, Comprehensive Measures/Whole Building	7/30/15	N/A	N/A
White River Valley	White River Valley Electric	Rebate Program	Geothermal Heat Pumps, Water	8/5/15	1/1/13	N/A

Electric Cooperative	Cooperative - Energy Efficiency Rebate Program		Heaters, Lighting, Lighting Controls/Sensors, Heat pumps, Air conditioners, LED Lighting			

(Database Of State Incentives For Renewables & Efficiency, North Carolina Clean Energy Technology Center, North Carolina State University, Accessed 11/29/17)

MONTANA

Administrator	Name	Type	Technologies	Last Updated	Start Date	End Date
Montana Department of Revenue	Alternative Energy Investment Tax Credit	Industry Recruitment/Support	Geothermal Electric, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Landfill Gas, Wind (Small), Hydroelectric (Small), Fuel Cells using Renewable Fuels	10/27/16	1/1/02	N/A
Montana Department of Revenue	Property Tax Abatement for Production and Manufacturing Facilities	Industry Recruitment/Support	Solar Water Heat, Solar Space Heat, Geothermal Electric, Solar Thermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Wind (All), Biomass, Hydrogen, Municipal Solid Waste, Combined Heat & Power, Landfill Gas, Solar Pool Heating, Wind (Small), Anaerobic Digestion, Fuel Cells using Renewable Fuels	10/21/14	5/25/07	N/A
Montana Department of Environmental Quality	Alternative Energy Revolving Loan Program	Loan Program	Solar Water Heat, Solar Photovoltaics, Wind (All), Biomass, Geothermal Heat Pumps, Landfill Gas, Building Insulation, Windows, Doors, Other EE, Wind (Small), Hydroelectric (Small), Geothermal Direct-Use, Fuel Cells using Renewable Fuels	4/4/17	7/1/01	N/A
Montana Department of Environmental Quality	Residential Alternative Energy System Tax Credit	Personal Tax Credit	Solar - Passive, Solar Water Heat, Solar Space Heat, Geothermal Electric, Solar Photovoltaics,	10/27/16	1/1/02	N/A

			Wind (All), Biomass, Geothermal Heat Pumps, Wind (Small), Hydroelectric (Small), Geothermal Direct-Use, Fuel Cells using Renewable Fuels			
Montana Department of Environmental Quality	Residential Geothermal Systems Credit	Personal Tax Credit	Geothermal Heat Pumps, Geothermal Direct-Use	10/27/16	1/1/02	N/A
N/A	Corporate Property Tax Reduction for New/Expanded Generating Facilities	Property Tax Incentive	Geothermal Electric, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Landfill Gas, Wind (Small), Hydroelectric (Small), Fuel Cells using Renewable Fuels	10/22/14	N/A	N/A
N/A	Generation Facility Corporate Tax Exemptions	Property Tax Incentive	Geothermal Electric, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Landfill Gas, Wind (Small), Hydroelectric (Small), Fuel Cells using Renewable Fuels	10/22/14	N/A	N/A
N/A	Renewable Energy Systems Exemption	Property Tax Incentive	Solar - Passive, Solar Water Heat, Solar Space Heat, Geothermal Electric, Solar Thermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Wind (All), Biomass, Geothermal Heat Pumps, Municipal Solid Waste, Landfill Gas, Solar Pool Heating, Wind (Small), Hydroelectric (Small), Geothermal Direct-Use, Anaerobic Digestion, Fuel Cells	10/22/14	N/A	N/A

			using Renewable Fuels			
Flathead Electric Cooperative	Flathead Electric Cooperative - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Water Heaters, Heat pumps, Duct/Air sealing, Building Insulation, Windows	3/15/17	N/A	N/A
NorthWestern Energy	NorthWestern Energy - USB Renewable Energy Fund	Rebate Program	Solar Photovoltaics, Wind (Small)	7/1/16	N/A	N/A
Yellowstone Valley Electric Cooperative	Yellowstone Valley Electric Cooperative - Residential/Commercial Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Water Heaters, Heat pumps	7/22/15	N/A	N/A

(Database Of State Incentives For Renewables & Efficiency, North Carolina Clean Energy Technology Center, North Carolina State University, Accessed 11/29/17)

NEBRASKA

Administrator	Name	Type	Technologies	Last Updated	Start Date	End Date
Nebraska Energy Office	Dollar and Energy Savings Loans	Loan Program	Solar Water Heat, Solar Space Heat, Geothermal Electric, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Geothermal Heat Pumps, Municipal Solid Waste, Fuel Cells using Non-Renewable Fuels, Landfill Gas, Clothes Washers, Dishwasher, Refrigerators/Freezers, Dehumidifiers, Ceiling Fan, Equipment Insulation, Water Heaters, Lighting, Lighting Controls/Sensors, Furnaces, Boilers, Heat pumps, Air conditioners, Heat recovery, Programmable Thermostats, Caulking/Weather-stripping, Duct/Air sealing, Building Insulation, Windows, Roofs, Custom/Others pending approval, Other EE, Wind (Small), Personal Computing Equipment, Tankless Water Heater	10/5/15	N/A	N/A
N/A	Local Option - Property-Assessed Clean Energy Financing	PACE Financing	Solar - Passive, Solar Water Heat, Solar Space Heat, Geothermal Electric, Solar Thermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Wind (All), Biomass,	4/26/16	N/A	N/A

			Geothermal Heat Pumps, Combined Heat & Power, Landfill Gas, Daylighting, Solar Pool Heating, Lighting, Lighting Controls/Sensors, Heat pumps, Air conditioners, Heat recovery, Energy Mgmt. Systems/Building Controls, Caulking/Weather-stripping, Duct/Air sealing, Building Insulation, Windows, Doors, Yes; specific technologies not identified, Insulation, Wind (Small), Geothermal Direct-Use, Anaerobic Digestion, Fuel Cells using Renewable Fuels, Other Distributed Generation Technologies, Reflective Roofs, LED Lighting			
Nebraska Department of Revenue	Property Tax Exemption for Renewable Energy Generation Facilities	Property Tax Incentive	Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Landfill Gas, Wind (Small)	6/16/15	4/12/10	N/A
N/A	Lincoln Electric System - Renewable Energy Rebate	Rebate Program	Solar Photovoltaics, Biomass, Landfill Gas, Hydroelectric (Small), Anaerobic Digestion, Other Distributed Generation Technologies	3/15/17	N/A	N/A
Nebraska Public Power District	Nebraska Public Power District -	Rebate Program	Geothermal Heat Pumps, Lighting, Heat pumps, Air conditioners, Energy	8/26/15	N/A	N/A

	Commercial Energy Efficiency Rebate Programs		Mgmt. Systems/Building Controls, Motor VFDs, LED Lighting			
Nebraska Public Power District	Nebraska Public Power District - Residential Energy Efficiency Rebate Programs	Rebate Program	Geothermal Heat Pumps, Heat pumps, Air conditioners, Building Insulation, LED Lighting	7/22/15	N/A	N/A
N/A	Omaha Public Power District - Commercial Energy Efficiency Rebate Programs	Rebate Program	Geothermal Heat Pumps, Lighting, Lighting Controls/Sensors, Heat pumps, Energy Mgmt. Systems/Building Controls, Comprehensive Measures/Whole Building, Custom/Others pending approval, LED Lighting	7/22/15	N/A	N/A
N/A	Southern Power District - Residential Energy Efficiency Rebate Programs	Rebate Program	Geothermal Heat Pumps, Water Heaters, Heat pumps, Air conditioners, Building Insulation, LED Lighting	7/21/15	N/A	N/A
Nebraska Department of Revenue	Sales and Use Tax Exemption for Community Renewable Energy Projects	Sales Tax Incentive	Solar Photovoltaics, Wind (All), Biomass, Landfill Gas, Wind (Small)	8/24/15	10/1/08	N/A

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NEVADA

Administrator	Name	Type	Technologies	Last Updated	Start Date	End Date
Nevada State Office of Energy	Revolving Loan Program	Loan Program	Solar Water Heat, Geothermal Electric, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Geothermal Heat Pumps, Yes; specific technologies not identified, Hydroelectric (Small), Geothermal Direct-Use	10/28/16	N/A	N/A
Valley Electric Association	Valley Electric Association - Solar Water Heating Program	Loan Program	Solar Water Heat	3/1/16	N/A	N/A
Programs administered locally	Local Option - Special Improvement Districts	PACE Financing	Solar Water Heat, Solar Space Heat, Geothermal Electric, Solar Thermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Geothermal Heat Pumps, Solar Pool Heating, Yes; specific technologies not identified, Wind (Small), Hydroelectric (Small)	3/30/16	5/28/09	N/A
Public Utilities	Portfolio Energy Credits	Performance-Based Incentive	Solar - Passive, Solar Water Heat, Solar Space Heat,	1/22/16	2/23/06	N/A

Commission of Nevada			Geothermal Electric, Solar Thermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Municipal Solid Waste, Landfill Gas, Solar Pool Heating, Yes; specific technologies not identified, Wind (Small), Anaerobic Digestion			
Nevada State Office of Energy	Large Scale Renewable Energy Property Tax Abatement (Nevada State Office of Energy)	Property Tax Incentive	Geothermal Electric, Solar Thermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Municipal Solid Waste, Fuel Cells using Non-Renewable Fuels, Landfill Gas, Wind (Small), Anaerobic Digestion, Fuel Cells using Renewable Fuels	5/19/16	7/1/09	6/30/49
Nevada State Office of Energy	Property Tax Abatement for Green Buildings	Property Tax Incentive	Solar - Passive, Solar Water Heat, Geothermal Electric, Solar Photovoltaics, Wind (All), Biomass, Landfill Gas, Daylighting, Comprehensive Measures/Whole Building, Wind	10/21/14	12/4/07	N/A

			(Small), Hydroelectric (Small), Anaerobic Digestion			
NV Department of Taxation	Renewable Energy Systems Property Tax Exemption	Property Tax Incentive	Solar - Passive, Solar Water Heat, Solar Space Heat, Geothermal Electric, Solar Photovoltaics, Wind (All), Hydroelectric, Geothermal Heat Pumps, Municipal Solid Waste, Wind (Small), Hydroelectric (Small), Geothermal Direct-Use	5/1/17	7/1/83	N/A
NV Energy	NV Energy - RenewableGenerations Rebate Program	Rebate Program	Solar Photovoltaics, Wind (All), Wind (Small), Hydroelectric (Small)	9/3/15	N/A	N/A
NV Energy	NV Energy (Northern Nevada) - SolarGenerations Solar Heating	Rebate Program	Solar Water Heat, Solar Space Heat, Solar Pool Heating	3/24/15	2/1/11	N/A
NV Energy	NV Energy (Southern Nevada) - SolarGenerations Solar Heating	Rebate Program	Solar Water Heat	3/24/15	12/1/10	N/A
Southwest Gas Corporation	Southwest Gas Corporation - Smarter Greener Better Solar Water Heating Program	Rebate Program	Solar Water Heat	2/12/16	N/A	N/A
Nevada State Office of Energy	Renewable Energy Sales and Use Tax Abatement	Sales Tax Incentive	Geothermal Electric, Solar Thermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric,	5/19/16	7/1/09	6/30/49

			Municipal Solid Waste, Fuel Cells using Non-Renewable Fuels, Landfill Gas, Wind (Small), Anaerobic Digestion, Fuel Cells using Renewable Fuels			

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NEW HAMPSHIRE

Administrator	Name	Type	Technologies	Last Updated	Start Date	End Date
New Hampshire Public Utilities Commission	Commercial & Industrial Renewable Energy Grants	Grant Program	Solar Water Heat, Solar Space Heat, Solar Thermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Hydrogen, Geothermal Heat Pumps, Landfill Gas, Tidal, Wave, Ocean Thermal, Wind (Small), Hydroelectric (Small), Anaerobic Digestion, Fuel Cells using Renewable Fuels	6/7/17	N/A	N/A
New Hampshire Community Development Finance Authority	Enterprise Energy Fund Loans	Loan Program	Solar Water Heat, Solar Space Heat, Solar Photovoltaics, Wind (All), Biomass, Combined Heat & Power, Refrigerators/Freezers, Equipment Insulation, Water Heaters, Lighting, Lighting Controls/Sensors, Chillers, Furnaces, Boilers, Heat pumps, Air conditioners, Heat recovery, Steam-system upgrades, Compressed air, Programmable Thermostats, Energy Mgmt. Systems/Building Controls, Caulking/Weather-stripping, Duct/Air sealing, Building Insulation, Windows, Doors, Siding, Roofs, Comprehensive	5/22/17	N/A	N/A

			Measures/Whole Building, Custom/Others pending approval, Other EE, Yes; specific technologies not identified, Wind (Small), Food Service Equipment, Other Distributed Generation Technologies, Personal Computing Equipment, Data Center Equipment, Reflective Roofs, Commercial Refrigeration Equipment			
N/A	Liberty Utilities (Electric) - Commercial Energy Efficiency Loan Program	Loan Program	Geothermal Heat Pumps, Lighting, Lighting Controls/Sensors, Chillers, Heat pumps, Air conditioners, Compressed air, Motors, Motor VFDs, Custom/Others pending approval	10/13/15	N/A	N/A
Local community	Local Option - Energy Efficiency & Clean Energy Districts	PACE Financing	Solar Water Heat, Solar Space Heat, Solar Thermal Process Heat, Solar Photovoltaics, Wind (All), Biomass, Geothermal Heat Pumps, Combined Heat & Power, Daylighting, Lighting, Chillers, Furnaces, Boilers, Heat pumps, Air conditioners, Energy Mgmt. Systems/Building Controls, Duct/Air sealing, Building Insulation, Windows, Comprehensive Measures/Whole Building,	5/25/17	8/27/10	N/A

			Custom/Others pending approval, Wind (Small), Geothermal Direct-Use			
Office of Energy and Planning	Local Option - Property Tax Exemption for Renewable Energy	Property Tax Incentive	Solar Water Heat, Solar Space Heat, Solar Photovoltaics, Wind (All), Biomass, Wind (Small)	11/8/16	1/1/76	N/A
New Hampshire Public Utilities Commission	Commercial & Industrial Solar Rebate Program	Rebate Program	Solar Water Heat, Solar Space Heat, Solar Thermal Process Heat, Solar Photovoltaics	5/30/17	11/1/10	N/A
N/A	Eversource - New Equipment & Construction Schools Program	Rebate Program	Geothermal Heat Pumps, Lighting, Lighting Controls/Sensors, Chillers, Heat pumps, Air conditioners, Compressed air, Motors, Motor VFDs, Custom/Others pending approval, LED Lighting	8/24/17	1/1/15	N/A
Public Service of New Hampshire	Eversource - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Refrigerators/Freezers, Dehumidifiers, Equipment Insulation, Water Heaters, Lighting, Boilers, Heat pumps, Air conditioners, Programmable Thermostats, Duct/Air sealing, Building Insulation, Windows, Comprehensive Measures/Whole Building, Other EE, Pool Pumps, LED Lighting	8/24/17	N/A	N/A
New Hampshire	New Hampshire Electric Co-	Rebate Program	Geothermal Heat Pumps, Lighting, Lighting	1/31/17	N/A	N/A

Electric Co-Op	Op - Commercial and Municipal New Equipment and Construction Program		Controls/Sensors, Chillers, Heat pumps, Air conditioners, Compressed air, Energy Mgmt. Systems/Building Controls, Motors, Motor VFDs, Custom/Others pending approval, Other EE, LED Lighting			
NH Public Utilities Commission	Residential Bulk-Fed Wood-Pellet Central Boilers and Furnace Rebate Program	Rebate Program	Biomass, Furnaces, Boilers	6/7/17	4/14/10	N/A
New Hampshire Public Utilities Commission	Residential Small Renewable Energy Rebate Program	Rebate Program	Solar Photovoltaics, Wind (All), Wind (Small)	6/7/17	10/1/09	N/A
New Hampshire Public Utilities Commission	Residential Solar Water Heating Rebates	Rebate Program	Solar Water Heat, Solar Space Heat	6/7/17	4/21/10	N/A

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NEW JERSEY

Administrator	Name	Type	Technologies	Last Updated	Start Date	End Date
New Jersey Economic Development Authority	Edison Innovation Clean Energy Manufacturing Fund - Grants and Loans	Industry Recruitment/Support	Geothermal Electric, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Landfill Gas, Tidal, Wave, Lighting, Furnaces, Boilers, Air conditioners, Energy Mgmt. Systems/Building Controls, Other EE, Wind (Small), Anaerobic Digestion, Fuel Cells using Renewable Fuels	1/20/16	N/A	N/A
New Jersey Economic Development Authority	Edison Innovation Green Growth Fund Loans	Industry Recruitment/Support	Solar Photovoltaics, Wind (All), Biomass, Landfill Gas, Tidal, Wave, Lighting, Furnaces, Boilers, Air conditioners, Energy Mgmt. Systems/Building Controls, Other EE, Wind (Small), Fuel Cells using Renewable Fuels	1/20/16	5/23/11	N/A
Public Service Electric and Gas (PSE&G)	PSE&G - Solar Loan Program	Other Incentive	Solar Photovoltaics	2/27/17	5/29/13	N/A
N/A	Assessment of Farmland Hosting Renewable Energy Systems	Property Tax Incentive	Solar Water Heat, Solar Space Heat, Solar Thermal Process Heat, Solar Photovoltaics, Wind (All), Biomass, Wind (Small), Anaerobic Digestion	10/1/14	7/1/10	N/A
New Jersey Department of the Treasury	Property Tax Exemption for Renewable Energy Systems	Property Tax Incentive	Solar Water Heat, Solar Space Heat, Geothermal Electric, Solar Thermal Process Heat, Solar	10/1/14	10/1/08	N/A

			Photovoltaics, Wind (All), Biomass, Hydroelectric, Geothermal Heat Pumps, Fuel Cells using Non-Renewable Fuels, Landfill Gas, Tidal, Wave, Wind (Small), Geothermal Direct-Use, Fuel Cells using Renewable Fuels			
New Jersey Board of Public Utilities, Office of Clean Energy	COOLAdvantage Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Refrigerators/Freezers, Heat pumps, Air conditioners	12/6/16	N/A	N/A
New Jersey Board of Public Utilities, Office of Clean Energy	New Jersey Renewable Energy Incentive Program (Sustainable Biopower)	Rebate Program	Biomass, Combined Heat & Power, Landfill Gas, Anaerobic Digestion, Fuel Cells using Renewable Fuels	3/23/15	N/A	N/A
New Jersey Board of Public Utilities, Office of Clean Energy	New Jersey SmartStart Buildings - New Construction and Retrofits	Rebate Program	Geothermal Heat Pumps, Water Heaters, Lighting, Lighting Controls/Sensors, Chillers, Furnaces, Boilers, Heat pumps, Air conditioners, Compressed air, Energy Mgmt. Systems/Building Controls, Motors, Motor VFDs, Custom/Others pending approval, Food Service Equipment, LED Lighting, Tankless Water Heater, Commercial Refrigeration Equipment	12/2/16	N/A	N/A

New Jersey Board of Public Utilities, Office of Clean Energy	NJ Clean Energy-WARMAdvantage Program (Electric and Gas)	Rebate Program	Solar Water Heat, Water Heaters, Furnaces, Boilers, Other EE	12/2/16	7/1/16	N/A
New Jersey Division of Taxation	Solar Energy Sales Tax Exemption	Sales Tax Incentive	Solar - Passive, Solar Water Heat, Solar Space Heat, Solar Thermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Solar Pool Heating	10/1/14	N/A	N/A
N/A	Solar Renewable Energy Certificates (SRECs) Registration Program	Solar Renewable Energy Credit Program	Solar Photovoltaics	2/27/17	3/1/04	N/A

(Database Of State Incentives For Renewables & Efficiency, North Carolina Clean Energy Technology Center, North Carolina State University, Accessed 11/29/17)

NEW MEXICO

Administrator	Name	Type	Technologies	Last Updated	Start Date	End Date
New Mexico Finance Authority	Clean Energy Revenue Bond Program	Bond Program	Solar - Passive, Solar Water Heat, Solar Space Heat, Solar Photovoltaics, Wind (All), Biomass, Combined Heat & Power, Fuel Cells using Non-Renewable Fuels, Daylighting, Lighting, Energy Mgmt. Systems/Building Controls, Caulking/Weather-stripping, Building Insulation, Windows, Doors, Custom/Others pending approval, Other EE, Wind (Small), Fuel Cells using Renewable Fuels	5/25/17	N/A	N/A
Taxation and Revenue Department	Agricultural Biomass Income Tax Credit (Corporate)	Corporate Tax Credit	Biomass	3/22/17	1/1/11	12/31/19
New Mexico Energy, Minerals and Natural Resources Department	Geothermal Heat Pump Tax Credit (Corporate)	Corporate Tax Credit	Geothermal Heat Pumps	11/1/16	1/1/10	12/31/20
New Mexico Taxation & Revenue Department	Sustainable Building Tax Credit (Corporate)	Corporate Tax Credit	Solar - Passive, Solar Water Heat, Solar Space Heat, Solar Photovoltaics, Wind (All), Daylighting, Comprehensive Measures/Whole Building, Wind (Small)	11/9/16	1/1/07	12/31/26

New Mexico Energy, Minerals and Natural Resources Department	Alternative Energy Product Manufacturers Tax Credit	Industry Recruitment/Support	Geothermal Electric, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Municipal Solid Waste, Fuel Cells using Non-Renewable Fuels, Landfill Gas, Wind (Small), Anaerobic Digestion, Fuel Cells using Renewable Fuels	5/25/17	7/1/06	N/A
New Mexico Finance Authority	Drinking Water State Revolving Loan Fund	Loan Program	Solar Photovoltaics, Yes; specific technologies not identified, Other Distributed Generation Technologies	3/22/17	1/26/97	N/A
Programs administered locally	Local Option - Renewable Energy Financing District/Solar Energy Improvement Special Assessments	PACE Financing	Solar Water Heat, Solar Space Heat, Geothermal Electric, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Geothermal Heat Pumps, Wind (Small)	5/25/17	7/1/09	N/A
El Paso Electric Company	El Paso Electric Company - Small and Medium System Renewable Energy Certificate Purchase Program	Performance-Based Incentive	Solar Photovoltaics, Wind (All), Wind (Small)	11/10/16	3/1/09	N/A
PNM	PNM - Performance-Based Solar Program	Performance-Based Incentive	Solar Thermal Electric, Solar Photovoltaics	5/26/17	3/1/06	12/31/19
N/A	Agricultural Biomass Income Tax	Personal Tax Credit	Biomass	3/22/17	1/1/11	12/31/19

	Credit (Personal)					
New Mexico Energy, Minerals and Natural Resources Department	Geothermal Heat Pump Tax Credit (Personal)	Personal Tax Credit	Geothermal Heat Pumps	11/1/16	1/1/10	12/31/20
New Mexico Taxation & Revenue Department	Sustainable Building Tax Credit (Personal)	Personal Tax Credit	Solar - Passive, Solar Water Heat, Solar Space Heat, Solar Photovoltaics, Wind (All), Daylighting, Comprehensive Measures/Whole Building, Wind (Small)	11/9/16	1/1/07	12/31/26
New Mexico Energy, Minerals and Natural Resources Department	Property Tax Exemption for Residential Solar Systems	Property Tax Incentive	Solar Water Heat, Solar Space Heat, Solar Photovoltaics	11/2/16	1/1/10	N/A
El Paso Electric Company	El Paso Electric Company - Residential Efficiency Program	Rebate Program	Geothermal Heat Pumps, Lighting, Heat pumps, Air conditioners, Duct/Air sealing, Building Insulation, Comprehensive Measures/Whole Building, Other EE, Pool Pumps	7/19/17	N/A	N/A
Taxation and Revenue Department	Advanced Energy Gross Receipts Tax Deduction	Sales Tax Incentive	Geothermal Electric, Solar Thermal Electric, Solar Photovoltaics	5/25/17	7/1/10	N/A
New Mexico Taxation & Revenue Department	Biomass Equipment & Materials Compensating Tax Deduction	Sales Tax Incentive	Biomass, Hydrogen, Municipal Solid Waste, Combined Heat & Power, Landfill Gas, Anaerobic Digestion, Microturbines	11/8/16	6/17/05	N/A
New Mexico Taxation & Revenue Department	Gross Receipts Tax Exemption for Sales of Wind	Sales Tax Incentive	Solar Thermal Electric, Solar Photovoltaics, Wind (All), Wind (Small)	5/26/17	N/A	N/A

	and Solar Systems to Government Entities					
New Mexico Energy, Minerals and Natural Resources Department	Solar Energy Gross Receipts Tax Deduction	Sales Tax Incentive	Solar - Passive, Solar Water Heat, Solar Space Heat, Solar Thermal Electric, Solar Photovoltaics	11/8/16	7/1/07	N/A

(Database Of State Incentives For Renewables & Efficiency, North Carolina Clean Energy Technology Center, North Carolina State University, Accessed 11/29/17)

NEW YORK

Administrator	Name	Type	Technologies	Last Updated	Start Date	End Date
PSEG	PSEG Long Island- Commercial Solar PV Feed-in Tariff	Feed-in Tariff	Solar Photovoltaics	2/24/17	N/A	N/A
PSEG Long Island	PSEG Long Island- Fuel Cell Resource Feed-in Tariff	Feed-in Tariff	Fuel Cells using Non-Renewable Fuels, Fuel Cells using Renewable Fuels	2/24/17	N/A	N/A
New York State Energy Research and Development Authority	NY-Sun Commercial and Industrial Incentive Program	Grant Program	Solar Photovoltaics	8/24/17	5/4/15	12/29/23
Riverhead Building Department	City of Riverhead - Energy Conservation Device Permitting Fees	Green Building Incentive	Solar Water Heat, Solar Photovoltaics, Yes; specific technologies not identified	2/4/16	N/A	N/A
New York State Energy Research and Development Authority (NYSERDA)	Home Performance with ENERGY STAR	Loan Program	Solar Water Heat, Solar Photovoltaics, Refrigerators/Freezers, Dehumidifiers, Equipment Insulation, Water Heaters, Lighting, Furnaces, Boilers, Heat pumps, Air conditioners, Programmable Thermostats, Duct/Air sealing, Building Insulation, Custom/Others pending approval, Other EE, LED Lighting	12/2/16	N/A	N/A
N/A	NY-Sun Loan Program	Loan Program	Solar Thermal Process Heat, Solar Photovoltaics	10/12/15	N/A	N/A
NY Green Bank	NY Green Bank	Other Incentive	Solar Water Heat, Solar Thermal Electric, Solar Photovoltaics,	1/21/16	12/19/13	N/A

			Wind (All), Biomass, Hydroelectric, Combined Heat & Power, Fuel Cells using Non-Renewable Fuels, Wave, Other EE, Hydroelectric (Small), Anaerobic Digestion			
Programs administered locally	Local Option - Municipal Sustainable Energy Programs	PACE Financing	Solar Water Heat, Solar Space Heat, Geothermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Wind (All), Biomass, Geothermal Heat Pumps, Fuel Cells using Non-Renewable Fuels, Lighting, Furnaces, Boilers, Air conditioners, Caulking/Weather-stripping, Building Insulation, Windows, Custom/Others pending approval, Wind (Small), Geothermal Direct-Use, Anaerobic Digestion, Fuel Cells using Renewable Fuels	7/10/15	N/A	N/A
New York State Energy Research and Development Authority	Anaerobic Digester Gas-to-Electricity Rebate and Performance Incentive	Performance-Based Incentive	Anaerobic Digestion	9/25/14	N/A	N/A
New York State Department of Taxation and Finance	Residential Solar Tax Credit	Personal Tax Credit	Solar Water Heat, Solar Space Heat, Solar Photovoltaics	4/20/15	N/A	N/A
New York State Office of Real Property Tax Services	Energy Conservation Improvements Property Tax Exemption	Property Tax Incentive	Solar Water Heat, Solar Photovoltaics, Wind (All), Biomass, Geothermal Heat Pumps, Equipment	4/30/15	N/A	N/A

			Insulation, Water Heaters, Furnaces, Boilers, Heat pumps, Air conditioners, Programmable Thermostats, Energy Mgmt. Systems/Building Controls, Caulking/Weather-stripping, Duct/Air sealing, Building Insulation, Windows, Doors, Wind (Small)			
Administered locally	Local Option - Real Property Tax Exemption for Green Buildings	Property Tax Incentive	Solar - Passive, Solar Space Heat, Solar Photovoltaics, Wind (All), Biomass, Geothermal Heat Pumps, Daylighting, Comprehensive Measures/Whole Building, Hydroelectric (Small), Anaerobic Digestion	4/30/15	1/1/13	N/A
N/A	Local Option - Solar, Wind & Biomass Energy Systems Exemption	Property Tax Incentive	Solar - Passive, Solar Water Heat, Solar Space Heat, Solar Thermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Wind (All), Biomass, Daylighting, Solar Pool Heating, Wind (Small), Anaerobic Digestion	4/30/15	N/A	1/1/25
New York City Department of Buildings	New York City - Property Tax Abatement for Photovoltaic (PV) Equipment Expenditures	Property Tax Incentive	Solar Photovoltaics	10/7/16	8/5/08	12/31/18
N/A	New York Power Authority - Energy Services Programs for Public Entities	Rebate Program	Solar Water Heat, Solar Photovoltaics, Biomass, Geothermal Heat Pumps, Lighting, Chillers, Furnaces, Boilers, Heat pumps, Air conditioners, Heat	7/7/15	N/A	N/A

			recovery, Steam-system upgrades, Compressed air, Duct/Air sealing, Motors, Motor VFDs, Custom/Others pending approval			
New York State Energy Research and Development Authority	NY-Sun PV Incentive Program (Residential, Low-Income, and Small Business)	Rebate Program	Solar Photovoltaics	9/18/17	8/12/10	12/29/23
New York State Energy Research and Development Authority	On-Site Wind Incentive Program	Rebate Program	Wind (All), Wind (Small)	4/30/15	N/A	N/A
Long Island Power Authority	PSEG Long Island - Commercial Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Lighting, Chillers, Heat pumps, Air conditioners, Compressed air, Energy Mgmt. Systems/Building Controls, Roofs, Motors, Motor VFDs, Comprehensive Measures/Whole Building, Custom/Others pending approval, Other EE, Food Service Equipment, Vending Machine Controls, Reflective Roofs, LED Lighting	6/25/15	N/A	N/A
NYSERDA	Renewable Heat NY	Rebate Program	Biomass	8/13/15	7/29/14	N/A
N/A	Local Option - Solar Sales Tax Exemption	Sales Tax Incentive	Solar - Passive, Solar Water Heat, Solar Space Heat, Solar Photovoltaics	4/14/15	N/A	N/A
N/A	New York City - Residential Solar Sales	Sales Tax Incentive	Solar - Passive, Solar Water Heat, Solar Space Heat, Solar Photovoltaics	9/18/14	12/1/05	N/A

	Tax Exemption					
New York State Department of Taxation and Finance	Residential Wood Heating Fuel Exemption	Sales Tax Incentive	Biomass	4/30/15	N/A	N/A
New York State Department of Taxation and Finance	Solar Sales Tax Exemption	Sales Tax Incentive	Solar - Passive, Solar Water Heat, Solar Space Heat, Solar Photovoltaics, Solar Pool Heating	12/3/15	N/A	N/A

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NORTH CAROLINA

Administrator	Name	Type	Technologies	Last Updated	Start Date	End Date
Catawba County Utilities & Engineering	Catawba County - Green Construction Permitting Incentive Program	Green Building Incentive	Solar Water Heat, Solar Photovoltaics, Geothermal Heat Pumps, Comprehensive Measures/Whole Building	5/26/15	N/A	N/A
Building Safety Department	City of Asheville - Building Permit Fee Rebates	Green Building Incentive	Solar Water Heat, Solar Photovoltaics, Wind (All), Geothermal Heat Pumps, Other EE	12/4/15	7/1/09	N/A
N/A	Local Option - Green Building Incentives	Green Building Incentive	Solar - Passive, Solar Water Heat, Solar Space Heat, Solar Photovoltaics, Wind (All), Biomass, Geothermal Heat Pumps, Daylighting, Comprehensive Measures/Whole Building, Wind (Small), Hydroelectric (Small)	12/4/15	N/A	N/A
N/A	Local Option - Financing Program for Renewable Energy and Energy Efficiency	Loan Program	Solar Water Heat, Solar Space Heat, Geothermal Electric, Solar Thermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Wind (All), Biomass, Hydrogen, Combined Heat & Power, Landfill Gas, Tidal, Wave, Yes; specific technologies not identified, Wind (Small), Hydroelectric (Small), Anaerobic Digestion	3/15/17	8/26/09	N/A
Lumbee River Electric Membership Corporation	Lumbee River EMC - Residential Weatherization Loan Program	Loan Program	Geothermal Heat Pumps, Water Heaters, Furnaces, Heat pumps, Air conditioners, Duct/Air sealing, Building	5/20/15	N/A	N/A

			Insulation, Windows, Doors			
Lumbee River EMC	Lumbee River EMC - Solar Water Heating Loan Program	Loan Program	Solar Water Heat	12/3/15	N/A	N/A
Piedmont EMC	Piedmont EMC - Residential Energy Efficiency Loan Program	Loan Program	Solar Water Heat, Solar Photovoltaics, Heat pumps, Air conditioners, Building Insulation, Windows, Doors	12/3/15	N/A	N/A
Piedmont EMC	Piedmont EMC - Residential Solar Loan Program	Loan Program	Solar Water Heat, Solar Photovoltaics, Heat pumps, Air conditioners, Building Insulation, Windows, Doors	8/8/15	N/A	N/A
Town of Carrboro	Town of Carrboro - Worthwhile Investments Save Energy (WISE) Homes and Buildings Program	Loan Program	Solar Water Heat, Solar Photovoltaics, Water Heaters, Lighting, Lighting Controls/Sensors, Heat pumps, Air conditioners, Programmable Thermostats, Building Insulation, Motors, Motor VFDs, Custom/Others pending approval, Food Service Equipment, Vending Machine Controls, Commercial Refrigeration Equipment	12/3/15	N/A	N/A
Tennessee Valley Authority	TVA Partner Utilities - Energy Right Heat Pump Program	Loan Program	Geothermal Heat Pumps, Heat pumps	9/25/15	N/A	N/A
N/A	NC GreenPower Production Incentive	Performance-Based Incentive	Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Landfill Gas, Wind (Small), Anaerobic Digestion	4/1/15	N/A	N/A

Tennessee Valley Authority	TVA - Green Power Providers	Performance-Based Incentive	Solar Photovoltaics, Wind (All), Biomass, Wind (Small), Hydroelectric (Small)	6/2/15	10/1/12	N/A
Tennessee Valley Authority	TVA - Mid-Sized Renewable Standard Offer Program	Performance-Based Incentive	Solar Photovoltaics, Wind (All), Biomass, Landfill Gas, Anaerobic Digestion	6/18/15	10/10/10	N/A
N/A	TVA - Solar Solutions Initiative	Performance-Based Incentive	Solar Photovoltaics	6/4/15	N/A	N/A
North Carolina Solar Center	Active Solar Heating and Cooling Systems Exemption	Property Tax Incentive	Solar Water Heat, Solar Space Heat	12/4/15	N/A	N/A
N.C. Department of Revenue	Property Tax Abatement for Solar Electric Systems	Property Tax Incentive	Solar Thermal Electric, Solar Photovoltaics	12/4/15	7/1/08	N/A
Carteret Craven Electric Cooperative	Carteret-Craven Electric Cooperative - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Water Heaters, Heat pumps	6/21/16	N/A	N/A
Customer Service	Duke Energy (Electric) - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Equipment Insulation, Water Heaters, Heat pumps, Air conditioners, Duct/Air sealing, Building Insulation, Pool Pumps	6/30/15	N/A	N/A
Progress Energy Carolinas	Duke Energy Progress - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Water Heaters, Heat pumps, Air conditioners, Duct/Air sealing, Insulation, Pool Pumps	5/2/17	N/A	N/A
Four County EMC	Four-County EMC - Residential Energy	Rebate Program	Solar Water Heat, Clothes Washers, Dishwasher,	6/21/16	N/A	N/A

	Efficiency Appliance Rebate Program		Refrigerators/Freezers, Other EE			
N/A	Jones-Onslow EMC - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Refrigerators/Freezers, Dehumidifiers, Ceiling Fan, Heat pumps, Air conditioners	12/3/15	N/A	N/A
Lumbee River Electric Membership Corporation	Lumbee River EMC - Residential Energy Efficiency Program	Rebate Program	Geothermal Heat Pumps, Refrigerators/Freezers, Water Heaters, Heat pumps, Air conditioners, Duct/Air sealing, Building Insulation	7/22/15	N/A	N/A
South River EMC	South River EMC - Energy Efficiency Rebate Program	Rebate Program	Solar Water Heat, Geothermal Heat Pumps, Clothes Washers, Refrigerators/Freezers, Dehumidifiers, Water Heaters, Lighting, Heat pumps, Air conditioners, Duct/Air sealing, Building Insulation, Comprehensive Measures/Whole Building, Pool Pumps, LED Lighting	6/23/16	N/A	N/A
South River EMC	South River EMC - Solar Water Heating Rebate Program	Rebate Program	Solar Water Heat, Solar Pool Heating	12/4/15	N/A	N/A
N/A	TVA Partner Utilities - eScore Program	Rebate Program	Geothermal Heat Pumps, Equipment Insulation, Water Heaters, Heat pumps, Air conditioners, Duct/Air sealing, Building Insulation, Windows, Doors	8/31/17	N/A	N/A
PSNC Energy	PSNC Energy (Gas) - Green	Utility Rate Discount	Solar - Passive, Solar Water Heat, Solar	10/5/15	N/A	N/A

	Building Rate Discount		Space Heat, Solar Photovoltaics, Wind (All), Daylighting, Comprehensive Measures/Whole Building, Wind (Small)			

(Database Of State Incentives For Renewables & Efficiency, North Carolina Clean Energy Technology Center, North Carolina State University, Accessed 11/29/17)

NORTH DAKOTA

Administrator	Name	Type	Technologies	Last Updated	Start Date	End Date
Northern Plains Electric Cooperative	Northern Plains EC - Commercial Energy Efficiency Loan Program	Loan Program	Geothermal Heat Pumps, Water Heaters, Heat pumps, Air conditioners, Caulking/Weather-stripping, Duct/Air sealing, Building Insulation, Windows, Doors	8/10/17	N/A	N/A
Otter Trail Power Company	Otter Tail Power Company - Dollar Smart Financing Program	Loan Program	Geothermal Heat Pumps, Water Heaters, Lighting, Furnaces, Heat pumps, Heat recovery, Motors, Motor VFDs, Custom/Others pending approval, Other EE, Yes; specific technologies not identified, Commercial Refrigeration Equipment	3/29/17	N/A	N/A
North Dakota Department of Commerce	Renewable Energy Property Tax Exemption	Property Tax Incentive	Solar - Passive, Solar Water Heat, Solar Space Heat, Geothermal Electric, Solar Thermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Wind (All), Geothermal Heat Pumps, Wind (Small), Geothermal Direct-Use	10/28/16	7/1/07	N/A
Bright Energy Solutions/Missouri River Energy Services	Business Energy Efficiency Rebates (Offered by 5 Utilities)	Rebate Program	Geothermal Heat Pumps, Equipment Insulation, Water Heaters, Lighting, Lighting Controls/Sensors, Boilers, Heat pumps, Air conditioners, Compressed air, Programmable Thermostats, Energy Mgmt.	4/16/15	N/A	N/A

			Systems/Building Controls, Windows, Motor VFDs, Custom/Others pending approval, Other EE, LED Lighting, Commercial Refrigeration Equipment			
Otter Trail Power Company	Otter Tail Power Company - Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Water Heaters, Heat pumps, Energy Mgmt. Systems/Building Controls, Other EE	3/29/17	N/A	N/A
Bright Energy Solutions/Missouri River Energy Services	Residential Energy Efficiency Rebates (Offered by 5 Utilities)	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Refrigerators/Freezers, Dehumidifiers, Water Heaters, Lighting, Furnaces, Heat pumps, Air conditioners, Programmable Thermostats, Other EE, LED Lighting	8/10/17	N/A	N/A
Office of State Tax Commissioner	Sales and Use Tax Exemption for Electrical Generating Facilities	Sales Tax Incentive	Geothermal Electric, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Municipal Solid Waste, Combined Heat & Power, Fuel Cells using Non-Renewable Fuels, Landfill Gas, Anaerobic Digestion	10/28/16	N/A	N/A
Office of State Tax Commissioner	Sales and Use Tax Exemption for Gas Processing Facilities	Sales Tax Incentive	Landfill Gas	10/28/16	N/A	N/A
Office of State Tax Commissioner	Sales Tax Exemption for Hydrogen	Sales Tax Incentive	Hydrogen, Fuel Cells using Renewable Fuels	10/28/16	N/A	N/A

	Generation Facilities					

(Database Of State Incentives For Renewables & Efficiency, North Carolina Clean Energy Technology Center, North Carolina State University, Accessed 11/29/17)

OHIO

Administrator	Name	Type	Technologies	Last Updated	Start Date	End Date
Butler Rural Electric Cooperative, Inc.	Butler Rural Electric Cooperative - Energy Efficiency Improvement Loan Program	Loan Program	Geothermal Heat Pumps, Water Heaters, Heat pumps, Air conditioners, Caulking/Weather-stripping, Duct/Air sealing, Building Insulation, Windows, Doors	5/19/16	N/A	N/A
Ohio Treasurer of State	Energy Conservation for Ohioans (ECO-Link) Program	Loan Program	Solar Water Heat, Solar Photovoltaics, Wind (All), Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Dehumidifiers, Ceiling Fan, Water Heaters, Furnaces, Boilers, Heat pumps, Air conditioners, Caulking/Weather-stripping, Duct/Air sealing, Building Insulation, Windows, Doors, Siding, Roofs, Custom/Others pending approval, Other EE, Wind (Small)	3/15/17	9/9/09	N/A
Ohio Development Services Agency	Energy Loan Fund	Loan Program	Solar Photovoltaics, Hydroelectric, Landfill Gas, Other EE	3/15/17	12/15/11	N/A
Hamilton County Department of Community Development	Hamilton County - Home Improvement Program	Loan Program	Solar - Passive, Solar Water Heat, Solar Photovoltaics, Wind (All), Daylighting, Furnaces, Heat pumps, Air conditioners, Building Insulation, Windows, Doors, Siding, Roofs, Wind (Small)	12/3/15	N/A	N/A

Ohio Department of Development	Air-Quality Improvement Tax Incentives	Other Incentive	Solar Water Heat, Solar Space Heat, Solar Thermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Wind (All), Biomass, Combined Heat & Power, Landfill Gas, Lighting, Chillers, Boilers, Air conditioners, Processing and Manufacturing Equipment, Custom/Others pending approval, Wind (Small)	4/30/15	N/A	N/A
N/A	Local Option - Special Energy Improvement Districts	PACE Financing	Solar Water Heat, Solar Thermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Wind (All), Biomass, Geothermal Heat Pumps, Other EE, Yes; specific technologies not identified, Wind (Small), Geothermal Direct-Use, Anaerobic Digestion	8/27/14	10/16/09	N/A
Navigant Consulting	First Energy Ohio - Renewable Energy Credit Procurements	Performance-Based Incentive	Geothermal Electric, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Municipal Solid Waste, Fuel Cells using Non-Renewable Fuels, Landfill Gas, Fuel Cells using Renewable Fuels	10/3/14	7/1/10	N/A
Cincinnati Dept. of Community Development	City of Cincinnati - Property Tax Abatement for Green Buildings	Property Tax Incentive	Solar - Passive, Solar Water Heat, Solar Space Heat, Solar Photovoltaics, Wind (All), Daylighting, Comprehensive	4/30/15	N/A	N/A

			Measures/Whole Building, Wind (Small)			
Division of Neighborhood Services, Department of Community Development	City of Cleveland - Residential Property Tax Abatement for Green Buildings	Property Tax Incentive	Solar - Passive, Solar Water Heat, Solar Space Heat, Solar Photovoltaics, Wind (All), Geothermal Heat Pumps, Daylighting, Comprehensive Measures/Whole Building, Wind (Small)	5/11/15	1/1/10	N/A
Ohio Development Services Agency	Qualified Energy Property Tax Exemption for Projects 250 kW or Less	Property Tax Incentive	Geothermal Electric, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Combined Heat & Power, Fuel Cells using Non-Renewable Fuels, Wind (Small), Hydroelectric (Small), Anaerobic Digestion, Fuel Cells using Renewable Fuels	4/30/15	1/1/10	N/A
Ohio Development Services Agency and local county commissioners	Qualified Energy Property Tax Exemption for Projects over 250 kW (Payment in Lieu)	Property Tax Incentive	Geothermal Electric, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Municipal Solid Waste, Combined Heat & Power, Fuel Cells using Non-Renewable Fuels, Landfill Gas, Anaerobic Digestion, Fuel Cells using Renewable Fuels	5/12/16	1/1/10	12/31/21
AEP Ohio	AEP Ohio - Commercial New Construction Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Equipment Insulation, Water Heaters, Lighting, Lighting Controls/Sensors, Chillers, Heat pumps, Air conditioners, Compressed air, Programmable Thermostats, Energy Mgmt.	6/16/16	N/A	N/A

			Systems/Building Controls, Motors, Motor VFDs, Agricultural Equipment, Comprehensive Measures/Whole Building, Custom/Others pending approval, Other EE, Food Service Equipment, Vending Machine Controls, Commercial Cooking Equipment, Data Center Equipment, LED Lighting, Commercial Refrigeration Equipment			
AEP Ohio gridSMART	AEP Ohio (Electric) - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Refrigerators/Freezers, Dehumidifiers, Water Heaters, Heat pumps, Air conditioners, Programmable Thermostats, Duct/Air sealing, Building Insulation	6/17/15	N/A	N/A
Butler Rural Electric Cooperative, Inc.	Butler Rural Electric Cooperative - Residential Rebate Program	Rebate Program	Geothermal Heat Pumps, Heat pumps, Duct/Air sealing, Building Insulation	5/19/16	N/A	N/A
Consolidated Electric Cooperative, Inc.	Consolidated Electric Cooperative - Heat Pump and Water Heating Rebates	Rebate Program	Geothermal Heat Pumps, Water Heaters, Furnaces, Heat pumps	5/11/15	N/A	N/A
Dayton Power and Light	Dayton Power and Light - Business and Government	Rebate Program	Geothermal Heat Pumps, Water Heaters, Lighting, Lighting Controls/Sensors,	5/12/15	N/A	N/A

	Energy Efficiency Rebate Program		Chillers, Heat pumps, Air conditioners, Combined Heat & Power, Compressed air, Energy Mgmt. Systems/Building Controls, Motors, Motor VFDs, Processing and Manufacturing Equipment, Custom/Others pending approval, Other EE			
N/A	Dayton Power and Light - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Heat pumps, Air conditioners, Programmable Thermostats, Other EE	5/12/15	N/A	N/A
Duke Energy - Smart $aver Residential Rebate Program	Duke Energy (Gas & Electric) - Residential Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Water Heaters, Heat pumps, Air conditioners, Duct/Air sealing, Comprehensive Measures/Whole Building, Other EE, Insulation, Pool Pumps	6/10/15	N/A	N/A
Firelands Electric Cooperative	Firelands Electric Cooperative - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Water Heaters, Heat pumps, Comprehensive Measures/Whole Building, Other EE	12/3/15	N/A	N/A
Green Energy Ohio	Green Energy Ohio - GEO Solar Thermal Rebate Program	Rebate Program	Solar Water Heat	3/15/17	4/1/09	N/A
The Energy Cooperative	The Energy Cooperative - Residential Energy	Rebate Program	Geothermal Heat Pumps, Water Heaters, Furnaces, Heat pumps, Other EE	5/11/15	N/A	N/A

	Efficiency Rebate Program					
Ohio Department of Taxation	Energy Conversion and Thermal Efficiency Sales Tax Exemption	Sales Tax Incentive	Geothermal Electric, Solar Thermal Process Heat, Wind (All), Biomass, Hydroelectric, Municipal Solid Waste, Combined Heat & Power, Fuel Cells using Non-Renewable Fuels, Landfill Gas, Heat recovery, Anaerobic Digestion, Fuel Cells using Renewable Fuels, Microturbines	4/30/15	N/A	N/A
N/A	Solar Renewable Energy Certificates Program (SRECs)	Solar Renewable Energy Credit Program	Solar Photovoltaics	2/5/15	1/1/09	N/A

(Database Of State Incentives For Renewables & Efficiency, North Carolina Clean Energy Technology Center, North Carolina State University, Accessed 11/29/17)

OKLAHOMA

Administrator	Name	Type	Technologies	Last Updated	Start Date	End Date
Oklahoma Tax Commission	Zero-Emission Facilities Production Tax Credit	Corporate Tax Credit	Geothermal Electric, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Hydroelectric, Wind (Small)	5/12/15	1/1/03	12/31/20
Oklahoma Department of Commerce	Community Energy Education Management Program	Loan Program	Solar - Passive, Solar Water Heat, Solar Space Heat, Solar Photovoltaics, Wind (All), Biomass, Combined Heat & Power, Equipment Insulation, Water Heaters, Lighting, Lighting Controls/Sensors, Chillers, Furnaces, Boilers, Heat pumps, Air conditioners, Heat recovery, Programmable Thermostats, Energy Mgmt. Systems/Building Controls, Caulking/Weather-stripping, Duct/Air sealing, Building Insulation, Windows, Doors, Roofs, Other EE	8/24/15	N/A	N/A
Oklahoma Department of Commerce	Energy Loan Fund for Schools	Loan Program	Solar - Passive, Solar Water Heat, Solar Space Heat, Solar Photovoltaics, Wind (All), Biomass, Yes; specific technologies not identified	12/3/15	N/A	N/A
Oklahoma Department of Commerce	Higher Education Energy Loan Program	Loan Program	Solar - Passive, Solar Water Heat, Solar Space Heat, Solar Photovoltaics, Wind (All), Yes; specific	12/3/15	N/A	N/A

			technologies not identified			
Community Action Agency of Oklahoma City	Oklahoma City - Green Home Loan Program	Loan Program	Geothermal Heat Pumps, Water Heaters, Lighting, Furnaces, Heat pumps, Air conditioners, Duct/Air sealing, Building Insulation, Windows, Doors, Roofs, Other EE, Yes; specific technologies not identified, Reflective Roofs	12/11/15	1/26/15	N/A
N/A	Oklahoma Municipal Power Authority - WISE Energy Efficiency Loan Program	Loan Program	Geothermal Heat Pumps, Ceiling Fan, Equipment Insulation, Water Heaters, Lighting, Heat pumps, Air conditioners, Programmable Thermostats, Caulking/Weather-stripping, Duct/Air sealing, Building Insulation, Windows, LED Lighting	10/13/15	N/A	N/A
Red River Valley Rural Electric Cooperative	Red River Valley REA - Heat Pump Loan Program	Loan Program	Geothermal Heat Pumps, Heat pumps	6/23/15	N/A	N/A
N/A	East Central Electric Cooperative - Residential Rebate Program	Rebate Program	Geothermal Heat Pumps, Water Heaters, Air conditioners	10/26/15	N/A	N/A
City of Edmond Utility Office	Edmond Electric - Residential Heat Pump Rebate Program	Rebate Program	Geothermal Heat Pumps, Heat pumps, Air conditioners	7/19/16	N/A	N/A
OGE Energy	OG&E - Commercial Energy Efficiency	Rebate Program	Geothermal Heat Pumps, Lighting, Lighting Controls/Sensors,	10/26/15	N/A	N/A

	Rebate Programs		Furnaces, Boilers, Heat pumps, Air conditioners, Compressed air, Motors, Custom/Others pending approval, LED Lighting			
Oklahoma Electric Cooperative	Oklahoma Electric Cooperative - Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Water Heaters, Heat pumps, LED Lighting	3/2/17	N/A	N/A
N/A	Oklahoma Municipal Power Authority - Commercial and Industrial Energy Efficiency Program	Rebate Program	Geothermal Heat Pumps, Lighting, Lighting Controls/Sensors, Chillers, Heat pumps, Air conditioners, Heat recovery, Compressed air, Programmable Thermostats, Motors, Motor VFDs, Processing and Manufacturing Equipment, Custom/Others pending approval, Food Service Equipment, LED Lighting, Commercial Refrigeration Equipment	10/13/15	N/A	N/A
N/A	Oklahoma Municipal Power Authority - WISE Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Heat pumps, Air conditioners, Building Insulation	10/26/15	1/1/11	N/A
Verdigris Valley	Verdigris Valley Electric	Rebate Program	Geothermal Heat Pumps, Water	7/30/15	N/A	N/A

Electric Cooperative	Cooperative - Residential Energy Efficiency Rebate Program		Heaters, Heat pumps, Air conditioners			

(Database Of State Incentives For Renewables & Efficiency, North Carolina Clean Energy Technology Center, North Carolina State University, Accessed 11/29/17)

OREGON

Administrator	Name	Type	Technologies	Last Updated	Start Date	End Date
Oregon Department of Energy	Energy Conservation Tax Credits - Competitively-Selected Projects (Corporate)	Corporate Tax Credit	Solar Water Heat, Geothermal Electric, Solar Thermal Electric, Biomass, Geothermal Heat Pumps, Water Heaters, Chillers, Furnaces, Boilers, Heat pumps, Air conditioners, Compressed air, Caulking/Weather-stripping, Duct/Air sealing, Building Insulation, Windows, Doors, Siding, Roofs, Processing and Manufacturing Equipment, Agricultural Equipment, Comprehensive Measures/Whole Building, Custom/Others pending approval, Yes; specific technologies not identified	9/1/16	N/A	N/A
Energy Trust of Oregon	Custom Renewable Energy Projects	Grant Program	Geothermal Electric, Wind (All), Biomass, Hydroelectric, Anaerobic Digestion, Fuel Cells using Renewable Fuels	10/8/15	5/1/02	N/A
Lane Electric Cooperative	Lane Electric Cooperative - Residential and Commercial Weatherization & Energy Efficiency Program	Grant Program	Solar Water Heat, Clothes Washers, Lighting, Heat pumps, Air conditioners, Caulking/Weather-stripping, Duct/Air sealing, Building Insulation, Windows, Doors, Comprehensive Measures/Whole Building	3/26/15	N/A	N/A

Pacific Power	Pacific Power - Blue Sky Community Project Funds	Grant Program	Geothermal Electric, Solar Photovoltaics, Wind (All), Biomass, Tidal, Wave, Hydroelectric (Small), Anaerobic Digestion	6/6/16	N/A	N/A
Portland General Electric Co	PGE Renewable Development Fund	Grant Program	Geothermal Electric, Solar Photovoltaics, Wind (All), Biomass, Tidal, Wave, Hydroelectric (Small), Anaerobic Digestion	10/25/16	N/A	N/A
Oregon Department of Energy	Renewable Energy Development Grant Program	Grant Program	Geothermal Electric, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Geothermal Heat Pumps, Landfill Gas, Tidal, Wave, Ocean Thermal, Wind (Small), Hydroelectric (Small), Geothermal Direct-Use, Anaerobic Digestion	1/6/16	1/1/12	N/A
Ashland Electric Utilities Department	City of Ashland - Green Building Incentive	Green Building Incentive	Solar - Passive, Daylighting, Comprehensive Measures/Whole Building, Custom/Others pending approval	11/24/14	N/A	N/A
City of Ashland	Ashland Electric Utility - Residential Energy Efficiency Loan Program	Loan Program	Solar Water Heat, Heat pumps, Caulking/Weather-stripping, Duct/Air sealing, Building Insulation, Windows	5/24/16	N/A	N/A
Ashland Electric Utilities Department	Ashland Electric Utility - Solar Water Heater Loan	Loan Program	Solar Water Heat	7/12/16	N/A	N/A
Lane Electric Cooperative	Lane Electric Cooperative - Residential Energy Efficiency Loan Programs	Loan Program	Solar Photovoltaics, Heat pumps, Air conditioners, Caulking/Weather-stripping, Duct/Air sealing, Building	3/26/15	N/A	N/A

			Insulation, Windows, Doors			
Oregon Department of Energy	State Energy Loan Program	Loan Program	Solar - Passive, Solar Water Heat, Solar Space Heat, Geothermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Wind (All), Biomass, Geothermal Heat Pumps, Combined Heat & Power, Water Heaters, Lighting, Chillers, Boilers, Heat pumps, Air conditioners, Heat recovery, Programmable Thermostats, Energy Mgmt. Systems/Building Controls, Caulking/Weather-stripping, Duct/Air sealing, Building Insulation, Windows, Motors, Comprehensive Measures/Whole Building, Custom/Others pending approval, Other EE, Wind (Small), Hydroelectric (Small), Geothermal Direct-Use	3/15/17	N/A	N/A
Oregon Business Development Department	Utility Scale Solar Incentive Program	Performance-Based Incentive	Solar Photovoltaics	3/18/16	N/A	1/2/23
Oregon Department of Energy	Energy Conservation Tax Credits - Competitively-Selected Projects (Personal)	Personal Tax Credit	Solar Water Heat, Geothermal Electric, Solar Thermal Electric, Biomass, Geothermal Heat Pumps, Water Heaters, Chillers, Furnaces, Boilers, Heat pumps, Air	9/1/16	1/26/15	N/A

			conditioners, Compressed air, Caulking/Weather-stripping, Duct/Air sealing, Building Insulation, Windows, Doors, Siding, Roofs, Processing and Manufacturing Equipment, Agricultural Equipment, Comprehensive Measures/Whole Building, Custom/Others pending approval, Yes; specific technologies not identified			
The Oregon Business Development Commission	Local Option - Rural Renewable Energy Development Zones	Property Tax Incentive	Geothermal Electric, Solar Photovoltaics, Wind (All), Biomass, Wave, Hydroelectric (Small)	11/6/14	N/A	N/A
Oregon Department of Energy	Renewable Energy Systems Exemption	Property Tax Incentive	Solar - Passive, Solar Water Heat, Solar Space Heat, Geothermal Electric, Solar Thermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Wind (All), Hydroelectric, Geothermal Heat Pumps, Fuel Cells using Non-Renewable Fuels, Landfill Gas, Solar Pool Heating, Wind (Small), Geothermal Direct-Use, Fuel Cells using Renewable Fuels	6/20/14	N/A	7/1/18
Ashland Electric Utilities Department	Ashland Electric Utility - Bright Way to Heat Water Rebate	Rebate Program	Solar Water Heat	6/22/15	N/A	N/A

Ashland Electric Utilities Department	Ashland Electric Utility - Photovoltaic Rebate Program	Rebate Program	Solar Photovoltaics	5/1/17	N/A	N/A
City of Ashland	Ashland Electric Utility - Residential Conservation Rebate Program	Rebate Program	Solar Water Heat, Refrigerators/Freezers, Heat pumps, Building Insulation, Windows, Insulation	8/25/16	N/A	N/A
Central Lincoln People's Utility District	Central Lincoln People's Utility District - Renewable Energy Incentive Program	Rebate Program	Solar Water Heat, Solar Photovoltaics, Wind (All), Wind (Small), Hydroelectric (Small)	3/2/17	N/A	N/A
Central Lincoln People's Utility District	Central Lincoln People's Utility District - Residential Energy Efficiency Rebate Programs	Rebate Program	Solar Thermal Electric, Solar Photovoltaics, Clothes Washers, Water Heaters, Heat pumps, Duct/Air sealing, Building Insulation, Windows, Doors, Comprehensive Measures/Whole Building, Wind (Small), Hydroelectric (Small), LED Lighting	3/2/17	N/A	N/A
Energy Trust of Oregon	Commercial Energy Efficiency Rebate for Existing Buildings	Rebate Program	Solar Photovoltaics, Geothermal Heat Pumps, Clothes Washers, Dishwasher, Equipment Insulation, Water Heaters, Lighting, Lighting Controls/Sensors, Furnaces, Boilers, Heat pumps, Steam-system upgrades, Compressed air, Energy Mgmt. Systems/Building Controls, Building Insulation, Custom/Others pending approval, Other EE, Food	1/31/17	N/A	N/A

			Service Equipment, Commercial Cooking Equipment, Personal Computing Equipment, Data Center Equipment, LED Lighting, Tankless Water Heater, Commercial Refrigeration Equipment			
Consumers Power, Inc.	Consumers Power, Inc - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Refrigerators/Freezers, Water Heaters, Heat pumps, Duct/Air sealing, Building Insulation, Windows, Comprehensive Measures/Whole Building, Other EE, LED Lighting	1/7/16	N/A	N/A
N/A	Emerald PUD - Solar Electric Program	Rebate Program	Solar Photovoltaics	5/1/17	N/A	N/A
Eugene Water & Electric Board	EWEB - Solar Electric Program (Rebate)	Rebate Program	Solar Photovoltaics	2/11/16	1/25/08	N/A
Energy Trust of Oregon	Home Energy Solutions for Existing Homes	Rebate Program	Solar Photovoltaics, Clothes Washers, Equipment Insulation, Water Heaters, Boilers, Heat pumps, Programmable Thermostats, Building Insulation, Windows, Other EE, Pool Pumps	1/31/17	N/A	N/A
Lane Electric Cooperative	Lane Electric Cooperative - Residential Efficiency Rebate Program	Rebate Program	Solar Water Heat, Solar Photovoltaics, Geothermal Heat Pumps, Clothes Washers, Heat pumps, Duct/Air sealing, Comprehensive Measures/Whole Building	2/11/16	N/A	N/A

Midstate Electric Cooperative	Midstate Electric Cooperative - Residential Conservation Rebates	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Refrigerators/Freezers, Water Heaters, Heat pumps, Duct/Air sealing, Windows, Comprehensive Measures/Whole Building	2/11/16	N/A	N/A
Energy Trust of Oregon	New Homes Incentive Program	Rebate Program	Solar Water Heat, Solar Photovoltaics, Geothermal Heat Pumps, Water Heaters, Lighting, Furnaces, Heat pumps, Duct/Air sealing, Building Insulation, Windows, Comprehensive Measures/Whole Building	1/31/17	N/A	N/A
Oregon Trail Electric Cooperative	OTEC - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Refrigerators/Freezers, Water Heaters, Heat pumps, Caulking/Weather-stripping, Building Insulation, Windows, Doors, Siding, Roofs, Comprehensive Measures/Whole Building, Insulation, Reflective Roofs	6/29/15	N/A	N/A
Portland General Electric	Portland General Electric - Heat Pump Rebate Program	Rebate Program	Geothermal Heat Pumps, Heat pumps	7/28/15	N/A	N/A
Salem Electric	Salem Electric - Photovoltaic Rebate Program	Rebate Program	Solar Photovoltaics	5/1/17	N/A	N/A
Salem Electric	Salem Electric - Solar Water Heater Rebate	Rebate Program	Solar Water Heat	6/23/15	1/26/97	N/A

Energy Trust of Oregon	Small Wind Incentive Program	Rebate Program	Wind (All), Wind (Small)	1/31/17	N/A	N/A
Energy Trust of Oregon	Solar Electric Incentive Program	Rebate Program	Solar Photovoltaics	8/29/17	5/1/03	N/A

(Database Of State Incentives For Renewables & Efficiency, North Carolina Clean Energy Technology Center, North Carolina State University, Accessed 11/29/17)

PENNSYLVANIA

Administrator	Name	Type	Technologies	Last Updated	Start Date	End Date
Department of Community and Economic Development	Alternative and Clean Energy Program	Grant Program	Geothermal Electric, Wind (All), Biomass, Hydroelectric, Geothermal Heat Pumps, Municipal Solid Waste, Combined Heat & Power, Fuel Cells using Non-Renewable Fuels, Landfill Gas, Daylighting, Clothes Washers, Dishwasher, Refrigerators/Freezers, Dehumidifiers, Ceiling Fan, Water Heaters, Lighting, Lighting Controls/Sensors, Chillers, Furnaces, Boilers, Heat pumps, Air conditioners, Energy Mgmt. Systems/Building Controls, Comprehensive Measures/Whole Building, Other EE, Wind (Small), Hydroelectric (Small), Geothermal Direct-Use, Anaerobic Digestion, Fuel Cells using Renewable Fuels	5/4/15	5/1/09	N/A
Department of Community and Economic Development	High Performance Building Incentives Program	Grant Program	Solar - Passive, Solar Water Heat, Solar Space Heat, Solar Photovoltaics, Wind (All), Biomass, Geothermal Heat Pumps, Daylighting, Comprehensive Measures/Whole Building, Wind (Small), Hydroelectric (Small)	5/4/15	4/1/09	N/A

Berks County Community Foundation	Metropolitan Edison Company SEF Grants (FirstEnergy Territory)	Grant Program	Solar - Passive, Solar Water Heat, Solar Space Heat, Solar Thermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Municipal Solid Waste, Combined Heat & Power, Fuel Cells using Non-Renewable Fuels, Landfill Gas, Yes; specific technologies not identified, Wind (Small), Fuel Cells using Renewable Fuels	11/24/14	N/A	N/A
Community Foundation of the Alleghenies	Penelec SEF of the Community Foundation for the Alleghenies Grant Program (FirstEnergy Territory)	Grant Program	Solar - Passive, Solar Water Heat, Solar Space Heat, Solar Thermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Combined Heat & Power, Fuel Cells using Non-Renewable Fuels, Landfill Gas, Yes; specific technologies not identified, Wind (Small), Fuel Cells using Renewable Fuels	11/24/14	N/A	N/A
Department of Environmental Protection	Small Business Advantage Grant Program	Grant Program	Wind (All), Geothermal Heat Pumps, Water Heaters, Lighting, Lighting Controls/Sensors, Chillers, Furnaces, Boilers, Air conditioners, Heat recovery, Steam-system upgrades, Compressed air, Building Insulation,	1/8/16	N/A	N/A

			Motor VFDs, Processing and Manufacturing Equipment, Custom/Others pending approval, Wind (Small), Food Service Equipment, Commercial Refrigeration Equipment			
The EMS Energy Institute of Pennsylvania State University	West Penn Power SEF Grant Program	Grant Program	Solar Water Heat, Solar Space Heat, Solar Thermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Combined Heat & Power, Fuel Cells using Non-Renewable Fuels, Landfill Gas, Yes; specific technologies not identified, Wind (Small), Fuel Cells using Renewable Fuels, Other Distributed Generation Technologies	11/24/14	N/A	N/A
Department of Community and Economic Development	Wind and Geothermal Incentives Program	Grant Program	Geothermal Electric, Wind (All), Geothermal Heat Pumps, Wind (Small), Geothermal Direct-Use	11/21/14	1/1/09	N/A
N/A	City of Philadelphia - Streamlined Solar Permitting and Fee Reduction	Green Building Incentive	Solar Photovoltaics	11/19/14	N/A	N/A
Department of Community and Economic Development	Alternative and Clean Energy Program	Industry Recruitment/Support	Geothermal Electric, Wind (All), Biomass, Hydroelectric, Geothermal Heat Pumps, Municipal	11/20/14	5/1/09	N/A

			Solid Waste, Combined Heat & Power, Fuel Cells using Non-Renewable Fuels, Landfill Gas, Clothes Washers, Dishwasher, Refrigerators/Freezers, Dehumidifiers, Ceiling Fan, Water Heaters, Lighting, Lighting Controls/Sensors, Chillers, Furnaces, Boilers, Heat pumps, Air conditioners, Energy Mgmt. Systems/Building Controls, Comprehensive Measures/Whole Building, Other EE, Wind (Small), Hydroelectric (Small), Geothermal Direct-Use, Anaerobic Digestion, Fuel Cells using Renewable Fuels, LED Lighting			
Department of Community and Economic Development	Wind and Geothermal Incentives Program	Industry Recruitment/Support	Geothermal Electric, Wind (All), Geothermal Heat Pumps, Wind (Small), Geothermal Direct-Use	11/21/14	1/1/09	N/A
N/A	Wind and Geothermal Industry Incentives Program	Industry Recruitment/Support	Geothermal Electric, Wind (All), Geothermal Heat Pumps, Wind (Small), Geothermal Direct-Use	5/4/15	1/1/09	N/A
Adams Electric Cooperative	Adams Electric Cooperative - Energy Efficiency Loan Program	Loan Program	Geothermal Heat Pumps, Equipment Insulation, Heat pumps, Air conditioners, Caulking/Weather-stripping, Building Insulation, Windows, Doors, Other EE	5/19/16	N/A	N/A
Department of Community	Alternative and Clean	Loan Program	Geothermal Electric, Wind (All), Biomass,	11/21/14	5/1/09	N/A

and Economic Development	Energy Program		Hydroelectric, Geothermal Heat Pumps, Municipal Solid Waste, Combined Heat & Power, Fuel Cells using Non-Renewable Fuels, Landfill Gas, Daylighting, Clothes Washers, Dishwasher, Refrigerators/Freezers, Dehumidifiers, Ceiling Fan, Water Heaters, Lighting, Lighting Controls/Sensors, Chillers, Furnaces, Boilers, Heat pumps, Air conditioners, Energy Mgmt. Systems/Building Controls, Comprehensive Measures/Whole Building, Other EE, Wind (Small), Hydroelectric (Small), Geothermal Direct-Use, Anaerobic Digestion, Fuel Cells using Renewable Fuels			
Department of Community and Economic Development	High Performance Buildings Incentive Program	Loan Program	Solar - Passive, Solar Water Heat, Solar Space Heat, Solar Photovoltaics, Wind (All), Biomass, Geothermal Heat Pumps, Daylighting, Comprehensive Measures/Whole Building	11/25/14	4/1/09	N/A
Berks County Community Foundation	Metropolitan Edison Company SEF Loans (FirstEnergy Territory)	Loan Program	Solar - Passive, Solar Water Heat, Solar Space Heat, Solar Thermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric,	11/21/14	N/A	N/A

			Municipal Solid Waste, Combined Heat & Power, Fuel Cells using Non-Renewable Fuels, Landfill Gas, Yes; specific technologies not identified, Wind (Small), Fuel Cells using Renewable Fuels			
Community Foundation of the Alleghenies	Penelec SEF of the Community Foundation for the Alleghenies Loan Program (FirstEnergy Territory)	Loan Program	Solar - Passive, Solar Water Heat, Solar Space Heat, Solar Thermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Combined Heat & Power, Fuel Cells using Non-Renewable Fuels, Landfill Gas, Yes; specific technologies not identified, Wind (Small), Fuel Cells using Renewable Fuels	11/24/14	N/A	N/A
Department of Community and Economic Development (DCED) and the Department of Environmental Protection (DEP)	Solar Energy Loan Program	Loan Program	Solar Water Heat, Solar Thermal Electric, Solar Photovoltaics	11/22/16	11/2/16	N/A
TRF Sustainable Development Fund	Sustainable Development Fund Financing Program (PECO Territory)	Loan Program	Solar - Passive, Solar Water Heat, Solar Space Heat, Solar Thermal Process Heat, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Geothermal Heat Pumps, Combined Heat & Power, Fuel	11/24/14	N/A	N/A

			Cells using Non-Renewable Fuels, Landfill Gas, Lighting, Chillers, Boilers, Heat pumps, Air conditioners, Comprehensive Measures/Whole Building, Custom/Others pending approval, Yes; specific technologies not identified, Wind (Small), Fuel Cells using Renewable Fuels			
Sustainable Energy Fund of Central Eastern PA	Sustainable Energy Fund (SEF) Loan Program (PPL Territory)	Loan Program	Solar Water Heat, Solar Space Heat, Geothermal Electric, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Geothermal Heat Pumps, Combined Heat & Power, Fuel Cells using Non-Renewable Fuels, Landfill Gas, Lighting, Energy Mgmt. Systems/Building Controls, Other EE, Wind (Small), Fuel Cells using Renewable Fuels, Other Distributed Generation Technologies	10/14/15	N/A	N/A
The EMS Energy Institute of Pennsylvania State University	West Penn Power SEF Commercial Loan Program	Loan Program	Solar Water Heat, Solar Space Heat, Solar Thermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Combined Heat & Power, Fuel Cells using Non-Renewable Fuels, Landfill Gas, Yes; specific	11/24/14	N/A	N/A

			technologies not identified, Wind (Small), Fuel Cells using Renewable Fuels, Other Distributed Generation Technologies			
Department of Community and Economic Development	Wind and Geothermal Incentives Program	Loan Program	Geothermal Electric, Wind (All), Geothermal Heat Pumps, Wind (Small), Geothermal Direct-Use	11/21/14	1/1/09	N/A
Administered at county level	Property Tax Assessment for Commercial Wind Farms	Property Tax Incentive	Wind (All)	11/25/14	N/A	N/A
N/A	Duquesne Light Company - Residential Solar Water Heating Program	Rebate Program	Solar Water Heat	3/15/17	N/A	N/A
Honeywell	FirstEnergy (MetEdison, Penelec, Penn Power, West Penn Power) - Residential Energy Efficiency Programs	Rebate Program	Solar Water Heat, Geothermal Heat Pumps, Clothes Washers, Refrigerators/Freezers, Dehumidifiers, Water Heaters, Lighting, Heat pumps, Air conditioners, Other EE	1/9/16	10/29/09	N/A
N/A	Solar Alternative Energy Credits	Solar Renewable Energy Credit Program	Solar Photovoltaics	5/5/15	N/A	N/A

(Database Of State Incentives For Renewables & Efficiency, North Carolina Clean Energy Technology Center, North Carolina State University, Accessed 11/29/17)

RHODE ISLAND

Administrator	Name	Type	Technologies	Last Updated	Start Date	End Date
Rhode Island Office of Energy Resources	Residential Renewable Energy Tax Credit (Corporate)	Corporate Tax Credit	Solar Water Heat, Solar Space Heat, Solar Photovoltaics, Wind (All), Geothermal Heat Pumps, Wind (Small)	8/2/17	N/A	N/A
Rhode Island Conservation & Development Area Council	Agricultural Energy Program	Grant Program	Solar Thermal Process Heat, Solar Photovoltaics, Geothermal Heat Pumps, Lighting, Heat pumps, Building Insulation, Windows, Doors, Motor VFDs, Agricultural Equipment, Wind (Small), Commercial Refrigeration Equipment, HVAC	2/3/17	N/A	N/A
Commerce RI	Commercial Scale Renewable Energy Grants (Commerce RI)	Grant Program	Geothermal Electric, Solar Thermal Electric, Solar Photovoltaics, Biomass, Combined Heat & Power, Fuel Cells using Non-Renewable Fuels, Landfill Gas, Wind (Small), Hydroelectric (Small)	2/2/17	1/1/13	N/A
Commerce RI	Small Scale Solar Grants (Commerce RI)	Grant Program	Solar Water Heat, Solar Photovoltaics	2/2/17	1/1/13	N/A
Commerce RI	Energy Revolving Loan Fund	Loan Program	Solar Thermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Biomass, Geothermal Heat Pumps, Combined Heat & Power, Clothes Washers, Refrigerators/Freezers, Ceiling Fan, Lighting,	12/10/14	N/A	N/A

			Boilers, Building Insulation, Processing and Manufacturing Equipment, Other EE, Wind (Small)			
N/A	National Grid EnergyWise Financing program	Loan Program	Solar Water Heat, Water Heaters, Furnaces, Boilers, Heat pumps, Building Insulation	5/11/15	N/A	N/A
N/A	Local Option - Property-Assessed Clean Energy Financing	PACE Financing	Solar Photovoltaics, Wind (All), Yes; specific technologies not identified, Wind (Small), Fuel Cells using Renewable Fuels	7/13/15	N/A	N/A
National Grid	Renewable Energy Growth Program	Performance-Based Incentive	Solar Photovoltaics, Wind (All), Wave, Wind (Small), Hydroelectric (Small), Anaerobic Digestion	7/13/17	4/1/16	12/31/29
Rhode Island Office of Energy Resources	Local Option - Property Tax Exemption for Renewable Energy Systems	Property Tax Incentive	Solar Water Heat, Solar Space Heat, Solar Photovoltaics, Wind (All), Biomass, Geothermal Heat Pumps, Wind (Small), Hydroelectric (Small)	8/2/16	N/A	N/A
http://www.tax.ri.gov/	Property Tax Exemption for Renewable Energy Equipment	Property Tax Incentive	Solar - Passive, Solar Water Heat, Geothermal Electric, Solar Photovoltaics, Wind (All), Biomass, Geothermal Heat Pumps, Tidal, Wave, Ocean Thermal, Solar Pool Heating, Hydroelectric (Small), Anaerobic Digestion, Fuel Cells using Renewable Fuels	8/2/16	6/27/16	N/A
Rhode Island Office of Energy Resources	Residential Solar Energy Property	Property Tax Incentive	Solar Water Heat, Solar Space Heat, Solar Photovoltaics	8/2/16	1/1/01	N/A

	Tax Reduction						
N/A	Renewable Energy Products Sales and Use Tax Exemption	Sales Tax Incentive	Solar Water Heat, Solar Space Heat, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Geothermal Heat Pumps, Solar Pool Heating, Wind (Small)	5/6/15	7/15/05	N/A	

(Database Of State Incentives For Renewables & Efficiency, North Carolina Clean Energy Technology Center, North Carolina State University, Accessed 11/29/17)

SOUTH CAROLINA

Administrator	Name	Type	Technologies	Last Updated	Start Date	End Date
South Carolina Department of Revenue	Biomass Energy Tax Credit (Corporate)	Corporate Tax Credit	Biomass, Combined Heat & Power, Landfill Gas, Anaerobic Digestion	5/4/15	1/1/07	N/A
South Carolina Department of Revenue	Solar Energy, Small Hydropower, and Geothermal Tax Credit (Corporate)	Corporate Tax Credit	Solar Water Heat, Solar Space Heat, Geothermal Electric, Solar Photovoltaics, Geothermal Heat Pumps, Hydroelectric (Small), Tankless Water Heater	3/28/16	1/1/06	N/A
Berkeley Electric Cooperative	Berkeley Electric Cooperative - Energy Efficiency Loan Programs	Loan Program	Geothermal Heat Pumps, Water Heaters, Heat pumps, Air conditioners, Caulking/Weather-stripping, Duct/Air sealing, Building Insulation, Windows, Doors, Custom/Others pending approval	7/16/15	N/A	N/A
Blue Ridge Electric Cooperative	Blue Ridge Electric Cooperative - Heat Pump Loan Program	Loan Program	Geothermal Heat Pumps, Heat pumps	7/1/15	N/A	N/A
South Carolina Energy Office	ConserFund Loan Program	Loan Program	Solar Photovoltaics, Biomass, Geothermal Heat Pumps, Combined Heat & Power, Lighting, Lighting Controls/Sensors, Chillers, Furnaces, Boilers, Heat pumps, Air conditioners, Heat recovery, Programmable Thermostats, Energy Mgmt. Systems/Building Controls, Caulking/Weather-stripping, Duct/Air sealing, Building	1/29/16	N/A	N/A

			Insulation, Windows, Doors, Roofs, Custom/Others pending approval			
Pee Dee Electric Cooperative	Pee Dee Electric Cooperative - Energy Resource Conservation Loan Program	Loan Program	Geothermal Heat Pumps, Heat pumps, Programmable Thermostats, Caulking/Weather-stripping, Building Insulation, Windows, Doors	7/1/15	N/A	N/A
Santee Cooper	Santee Cooper - Renewable Energy Resource Loans	Loan Program	Solar Water Heat, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric (Small)	2/2/17	10/1/07	N/A
South Carolina Jobs-Economic Development Authority	SouthCarolinaSaves Green Community Loan Program	Loan Program	Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Combined Heat & Power, Lighting, Lighting Controls/Sensors, Furnaces, Air conditioners, Building Insulation, Comprehensive Measures/Whole Building, Custom/Others pending approval, Other EE	3/15/17	N/A	N/A
South Carolina Energy Office	Biomass Energy Production Incentive	Performance-Based Incentive	Biomass, Combined Heat & Power, Landfill Gas, Anaerobic Digestion	6/2/15	5/29/08	6/30/18
South Carolina Energy Office	Palmetto Clean Energy (PaCE) Program	Performance-Based Incentive	Geothermal Electric, Solar Photovoltaics, Wind (All), Biomass, Municipal Solid Waste, Landfill Gas, Wind (Small), Hydroelectric (Small), Anaerobic Digestion	6/2/15	N/A	N/A
South Carolina Department of Revenue	Biomass Energy Tax Credit (Personal)	Personal Tax Credit	Biomass, Combined Heat & Power, Landfill Gas, Anaerobic Digestion	6/8/15	1/1/07	N/A

South Carolina Department of Revenue	Solar Energy, Small Hydropower, and Geothermal Tax Credit (Personal)	Personal Tax Credit	Solar Water Heat, Solar Space Heat, Solar Photovoltaics, Geothermal Heat Pumps, Hydroelectric (Small)	11/9/16	1/1/06	N/A
Berkeley Electric Cooperative	Berkeley Electric Cooperative - Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Water Heaters	7/28/15	N/A	N/A
Duke Energy	Duke Energy (Electric) - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Heat pumps, Air conditioners, Duct/Air sealing, Building Insulation, Other EE, Pool Pumps	9/21/15	N/A	N/A
Progress Energy Carolinas	Duke Energy Progress - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Water Heaters, Lighting, Heat pumps, Air conditioners, Duct/Air sealing, Building Insulation, Windows, Other EE	8/31/15	N/A	N/A
N/A	Duke Energy Progress Customer Scale Solar Rebate Program	Rebate Program	Solar Photovoltaics	10/12/16	N/A	N/A
Palmetto Electric Cooperative	Palmetto Electric Cooperative - Buried Treasure Rebate Program	Rebate Program	Geothermal Heat Pumps, Heat pumps	9/21/15	N/A	N/A
Pee Dee Electric Cooperative	Pee Dee Electric Cooperative - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Water Heaters, Heat pumps	6/30/15	N/A	N/A
Santee Cooper	Santee Cooper - Residential Energy Efficiency Existing Homes Rebate Program	Rebate Program	Solar Water Heat, Refrigerators/Freezers, Water Heaters, Lighting, Heat pumps, Programmable Thermostats, Duct/Air sealing, Building Insulation, Comprehensive Measures/Whole Building, Other EE, Insulation	1/25/16	N/A	N/A

Santee Cooper	Santee Cooper - Rooftop Solar Rebate Program	Rebate Program	Solar Photovoltaics	2/2/17	11/30/16	N/A
South Carolina Energy Office	Sales Tax Exemption for Hydrogen Fuel Cells	Sales Tax Incentive	Hydrogen, Fuel Cells using Non-Renewable Fuels, Fuel Cells using Renewable Fuels	1/29/16	10/1/07	N/A

(Database Of State Incentives For Renewables & Efficiency, North Carolina Clean Energy Technology Center, North Carolina State University, Accessed 11/29/17)

SOUTH DAKOTA

Administrator	Name	Type	Technologies	Last Updated	Start Date	End Date
Otter Tail Power Company	Otter Tail Power Company - Dollar Smart Financing Program	Loan Program	Geothermal Heat Pumps, Water Heaters, Lighting, Heat pumps, Air conditioners, Heat recovery, Motors, Motor VFDs, Other EE, Commercial Refrigeration Equipment	3/21/17	N/A	N/A
Southeastern Electric Cooperative	Southeastern Electric Cooperative - Electric Equipment Loan Program	Loan Program	Geothermal Electric, Geothermal Heat Pumps, Heat pumps, Caulking/Weather-stripping, Duct/Air sealing, Building Insulation, Windows, Doors	8/10/17	N/A	N/A
S.D. Department of Revenue and Regulation	Large Commercial Wind and Solar Alternative Taxes	Property Tax Incentive	Solar Photovoltaics, Wind (All)	5/25/17	N/A	N/A
S.D. Department of Revenue and Regulation	Renewable Energy System Exemption	Property Tax Incentive	Solar Water Heat, Solar Space Heat, Geothermal Electric, Solar Thermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Hydrogen, Geothermal Heat Pumps, Municipal Solid Waste, Combined Heat & Power, Landfill Gas, Solar Pool Heating, Wind (Small), Hydroelectric (Small), Geothermal Direct-Use, Anaerobic Digestion	5/25/17	N/A	N/A
Black Hills Energy	Black Hills Energy -	Rebate Program	Geothermal Heat Pumps, Lighting,	5/16/17	N/A	N/A

	Commercial Energy Efficiency Programs		Lighting Controls/Sensors, Air conditioners, Motors, Motor VFDs, Custom/Others pending approval, LED Lighting			
Black Hills Energy	Black Hills Energy - Residential Customer Rebate Program	Rebate Program	Geothermal Heat Pumps, Water Heaters, Lighting, Heat pumps, LED Lighting	5/16/17	N/A	N/A
Bright Energy Solutions/Missouri River Energy Services	Business Energy Efficiency Rebate (Offered by 11 Utilities)	Rebate Program	Geothermal Heat Pumps, Water Heaters, Lighting, Lighting Controls/Sensors, Chillers, Furnaces, Boilers, Heat pumps, Air conditioners, Compressed air, Programmable Thermostats, Motor VFDs, Custom/Others pending approval, Other EE, Food Service Equipment, LED Lighting, Commercial Refrigeration Equipment	4/16/15	N/A	N/A
MidAmerican Energy Company	MidAmerican Energy (Electric) - Residential Energy Efficiency Rebate Programs	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Water Heaters, Heat pumps, Air conditioners, Programmable Thermostats, Other EE	4/16/15	1/1/14	N/A
Otter Tail Power Company	Otter Tail Power Company - Commercial Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Water Heaters, Lighting, Lighting Controls/Sensors, Heat pumps, Motors, Other EE	3/29/17	N/A	N/A
Otter Tail Power Company	Otter Tail Power Company - Residential Energy	Rebate Program	Geothermal Heat Pumps, Water Heaters, Heat pumps, Energy Mgmt.	3/29/17	N/A	N/A

	Efficiency Rebate Program		Systems/Building Controls, Other EE			
Bright Energy Solutions/Missouri River Energy Services	Residential Energy Efficiency Rebates (Offered by 11 Utilities)	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Dehumidifiers, Ceiling Fan, Water Heaters, Lighting, Furnaces, Heat pumps, Air conditioners, Programmable Thermostats, Energy Mgmt. Systems/Building Controls, Windows, Other EE, LED Lighting	4/16/15	N/A	N/A
Southeastern Electric Cooperative	Southeastern Electric - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Heat pumps	4/16/15	N/A	N/A
Governor's Office of Economic Development	Renewable Energy Facility Sales and Use Tax Reimbursement	Sales Tax Incentive	Geothermal Electric, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Hydrogen, Municipal Solid Waste, Combined Heat & Power, Landfill Gas, Hydroelectric (Small), Anaerobic Digestion	10/31/16	4/1/13	N/A

(Database Of State Incentives For Renewables & Efficiency, North Carolina Clean Energy Technology Center, North Carolina State University, Accessed 11/29/17)

TENNESSEE

Administrator	Name	Type	Technologies	Last Updated	Start Date	End Date
Energy Efficient Schools Initiative	Energy Efficient Schools Initiative - Grants	Grant Program	Geothermal Heat Pumps, Lighting, Lighting Controls/Sensors, Chillers, Furnaces, Boilers, Heat pumps, Air conditioners, Programmable Thermostats, Energy Mgmt. Systems/Building Controls, Motors, Motor VFDs, Custom/Others pending approval, Other EE, Food Service Equipment, Commercial Refrigeration Equipment	7/13/16	7/1/08	N/A
Energy Efficient Schools Initiative	Energy Efficient Schools Initiative - Loans	Loan Program	Geothermal Heat Pumps, Lighting, Lighting Controls/Sensors, Chillers, Furnaces, Boilers, Heat pumps, Air conditioners, Programmable Thermostats, Energy Mgmt. Systems/Building Controls, Motors, Motor VFDs, Comprehensive Measures/Whole Building, Custom/Others pending approval, Yes; specific technologies not identified, Food Service Equipment	7/13/16	N/A	N/A
Pathway Lending Community	Pathway Energy Efficiency	Loan Program	Solar Photovoltaics, Combined Heat & Power, Lighting,	7/13/16	8/1/10	N/A

Development Financial Institution	Loan Program		Heat pumps, Air conditioners, Processing and Manufacturing Equipment, Comprehensive Measures/Whole Building, Custom/Others pending approval			
Tennessee Valley Authority	TVA Partner Utilities - Energy Right Heat Pump Program	Loan Program	Geothermal Heat Pumps, Heat pumps	9/25/15	N/A	N/A
Tennessee Valley Authority	TVA - Green Power Providers	Performance-Based Incentive	Solar Photovoltaics, Wind (All), Biomass, Wind (Small), Hydroelectric (Small)	6/2/15	10/1/12	N/A
Tennessee Valley Authority	TVA - Mid-Sized Renewable Standard Offer Program	Performance-Based Incentive	Solar Photovoltaics, Wind (All), Biomass, Landfill Gas, Anaerobic Digestion	6/18/15	10/10/10	N/A
N/A	TVA - Solar Solutions Initiative	Performance-Based Incentive	Solar Photovoltaics	6/4/15	N/A	N/A
Tennessee Comptroller of the Treasury	Green Energy Property Tax Assessment	Property Tax Incentive	Geothermal Electric, Solar Photovoltaics, Wind (All), Hydrogen, Wind (Small)	7/31/15	6/30/10	N/A
N/A	TVA Partner Utilities - eScore Program	Rebate Program	Geothermal Heat Pumps, Water Heaters, Heat pumps, Air conditioners, Duct/Air sealing, Windows, Doors, Insulation	8/31/17	N/A	N/A
Tennessee Department of Revenue	Sales Tax Credit for Clean Energy Technology	Sales Tax Incentive	Geothermal Electric, Solar Photovoltaics, Wind (All), Biomass, Wind (Small)	7/29/15	6/30/10	N/A

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TEXAS

Administrator	Name	Type	Technologies	Last Updated	Start Date	End Date
Comptroller of Public Accounts	Solar and Wind Energy Device Franchise Tax Deduction	Corporate Tax Deduction	Solar Water Heat, Solar Space Heat, Solar Thermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Wind (All)	4/27/15	1/26/82	N/A
Comptroller of Public Accounts	Solar and Wind Energy Business Franchise Tax Exemption	Industry Recruitment/Support	Solar Water Heat, Solar Space Heat, Solar Thermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Wind (All)	4/27/15	1/26/82	N/A
City of Plano, Credit Union of Texas	City of Plano - Smart Energy Loan Program	Loan Program	Solar Water Heat, Solar Photovoltaics, Wind (All), Geothermal Heat Pumps, Solar Pool Heating, Clothes Washers, Dishwasher, Refrigerators/Freezers, Dehumidifiers, Water Heaters, Lighting, Chillers, Furnaces, Heat pumps, Air conditioners, Programmable Thermostats, Duct/Air sealing, Building Insulation, Windows, Custom/Others pending approval, Wind (Small)	4/17/15	N/A	N/A
Comptroller of Public Accounts State Energy Conservation Office (SECO)	LoanSTAR Revolving Loan Program	Loan Program	Solar - Passive, Solar Water Heat, Solar Space Heat, Solar Photovoltaics, Wind (All), Geothermal Heat	4/27/15	1/26/89	N/A

			Pumps, Lighting, Lighting Controls/Sensors, Chillers, Furnaces, Boilers, Heat pumps, Air conditioners, Heat recovery, Programmable Thermostats, Energy Mgmt. Systems/Building Controls, Building Insulation, Motors, Motor VFDs, Custom/Others pending approval, Other EE, Wind (Small)			
Austin Energy	Austin Energy - Commercial Solar PV Incentive Program	Performance-Based Incentive	Solar Photovoltaics	4/27/15	N/A	N/A
Economic Development Division of the City Finance Department	City of Houston - Property Tax Abatement for Green Commercial Buildings	Property Tax Incentive	Solar - Passive, Solar Water Heat, Solar Space Heat, Solar Photovoltaics, Wind (All), Biomass, Geothermal Heat Pumps, Daylighting, Comprehensive Measures/Whole Building, Hydroelectric (Small)	6/29/16	N/A	3/30/18
Comptroller of Public Accounts	Renewable Energy Systems Property Tax Exemption	Property Tax Incentive	Solar - Passive, Solar Water Heat, Solar Space Heat, Solar Thermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Wind (All), Biomass, Solar Pool Heating, Wind (Small), Anaerobic Digestion	4/29/16	N/A	N/A

CLEAResult Consulting	AEP (Central and North) - Residential Energy Efficiency Programs	Rebate Program	Solar Photovoltaics, Clothes Washers, Dishwasher, Refrigerators/Freezers, Water Heaters, Heat pumps, Air conditioners, Caulking/Weather-stripping, Duct/Air sealing, Building Insulation, Windows, Motor VFDs, Comprehensive Measures/Whole Building, Custom/Others pending approval, Yes; specific technologies not identified, Other Distributed Generation Technologies	6/10/15	N/A	N/A
Frontier Associates and Clean Energy Associates	AEP Texas Central Company - SMART Source Solar PV Rebate Program	Rebate Program	Solar Photovoltaics	4/27/15	8/1/09	N/A
Frontier Associates and Clean Energy Associates	AEP Texas North Company - SMART Source Solar PV Rebate Program	Rebate Program	Solar Photovoltaics	6/11/15	8/1/09	N/A
Austin Energy	Austin Energy - Commercial Energy Management Rebate Program	Rebate Program	Solar Photovoltaics, Water Heaters, Lighting, Heat pumps, Air conditioners, Programmable Thermostats, Building Insulation, Windows,	2/23/17	N/A	N/A

			Custom/Others pending approval, Other EE, Reflective Roofs, LED Lighting			
Austin Energy	Austin Energy - Multi-Family Energy Efficiency Rebate Program	Rebate Program	Solar Water Heat, Solar Photovoltaics, Water Heaters, Lighting, Furnaces, Heat pumps, Air conditioners, Duct/Air sealing, Building Insulation, Windows, Roofs, Other EE, Reflective Roofs	2/23/17	N/A	N/A
Austin Energy	Austin Energy - Residential Energy Efficiency Rebate Program	Rebate Program	Solar Photovoltaics, Geothermal Heat Pumps, Water Heaters, Heat pumps, Air conditioners, Programmable Thermostats, Caulking/Weather-stripping, Duct/Air sealing, Building Insulation, Windows, Other EE, Pool Pumps	2/23/17	N/A	N/A
Austin Energy	Austin Energy - Residential Solar PV Rebate Program	Rebate Program	Solar Photovoltaics	3/15/17	6/1/04	N/A
Austin Energy	Austin Energy - Small Business Energy Efficiency Rebate Program	Rebate Program	Solar Photovoltaics, Lighting, Air conditioners, Programmable Thermostats, Building Insulation, Windows, Roofs, Custom/Others pending approval, Other EE	2/23/17	N/A	N/A
Austin Energy	Austin Energy - Solar	Rebate Program	Solar Water Heat	4/20/15	N/A	N/A

	Water Heating Rebate					
CenterPoint Energy	CenterPoint Energy - Commercial and Industrial Energy Efficiency Programs	Rebate Program	Geothermal Heat Pumps, Lighting, Chillers, Heat pumps, Air conditioners, Programmable Thermostats, Energy Mgmt. Systems/Building Controls, Windows, Roofs, Motors, Motor VFDs, Custom/Others pending approval, Other EE, Reflective Roofs, LED Lighting	4/28/15	N/A	N/A
City of San Marcos Electric Utility	City of San Marcos - Distributed Generation Rebate Program	Rebate Program	Solar Photovoltaics, Wind (All), Wind (Small)	4/17/15	10/14/11	N/A
City of Sunset Valley	City of Sunset Valley - PV Rebate Program	Rebate Program	Solar Photovoltaics	4/17/15	N/A	N/A
City of Sunset Valley	City of Sunset Valley - Solar Water Heating Rebate Program	Rebate Program	Solar Water Heat	4/17/15	N/A	N/A
College Station Utilities	College Station Utilities - Residential Energy Back II Rebate Program	Rebate Program	Geothermal Heat Pumps, Heat pumps, Air conditioners	4/18/17	N/A	N/A
CoServ	CoServ - Solar	Rebate Program	Solar Photovoltaics	4/20/15	1/1/11	N/A

	Energy Rebate					
CoServe Electric Cooperative	CoServ Electric Cooperative - Residential Energy Efficiency Rebate Program	Rebate Program	Solar Photovoltaics, Dishwasher, Water Heaters, Lighting, Heat pumps, Air conditioners, Programmable Thermostats, Comprehensive Measures/Whole Building, Other EE, Pool Pumps, LED Lighting	6/8/15	9/1/09	N/A
CPS Energy	CPS Energy - Solar Hot Water Rebate Program	Rebate Program	Solar Water Heat	3/15/17	N/A	N/A
CPS Energy	CPS Energy - Solar PV Rebate Program	Rebate Program	Solar Photovoltaics	2/1/17	N/A	N/A
Denton Municipal Electric	Denton Municipal Electric - GreenSense Solar PV/Thermal Rebate Program	Rebate Program	Solar Water Heat, Solar Photovoltaics	1/31/17	N/A	N/A
Denton Municipal Electric	Denton Municipal Electric - Residential GreenSense Energy Efficiency Rebate Program	Rebate Program	Solar Water Heat, Solar Photovoltaics, Geothermal Heat Pumps, Water Heaters, Heat pumps, Air conditioners, Programmable Thermostats, Duct/Air sealing, Windows, Comprehensive Measures/Whole Building, Other EE, Insulation	1/31/17	N/A	N/A

Farmers Electric Cooperative	Farmers Electric Cooperative - Residential Energy Efficiency Rebate Program	Rebate Program	Solar Photovoltaics, Wind (All), Geothermal Heat Pumps, Water Heaters, Caulking/Weather-stripping, Building Insulation, Windows	1/26/17	N/A	N/A
Garland Power & Light	Garland Power & Light - Solar Rebate Program	Rebate Program	Solar Photovoltaics	2/8/16	N/A	N/A
Guadalupe Valley Electric Cooperative	Guadalupe Valley Electric Cooperative - Renewable Energy Rebates	Rebate Program	Solar Water Heat, Solar Photovoltaics, Wind (All), Wind (Small)	4/20/15	N/A	N/A
Guadalupe Valley Electric Cooperative	Guadalupe Valley Electric Cooperative - Residential Energy Efficiency Rebate Programs	Rebate Program	Solar Photovoltaics, Water Heaters, Heat pumps, Duct/Air sealing, Building Insulation, Windows, Comprehensive Measures/Whole Building, Other EE	6/9/15	N/A	N/A
New Braunfels Utilities	New Braunfels Utilities - Energy Efficiency and Water Conservation Rebate Programs	Rebate Program	Solar Water Heat, Clothes Washers, Heat pumps, Air conditioners, Other EE, LED Lighting	1/31/17	N/A	N/A
New Braunfels Utilities	New Braunfels Utilities - Residential Solar Water Heater	Rebate Program	Solar Water Heat	4/17/15	N/A	N/A

	Rebate Program					
Oncor Electric Delivery	Oncor Electric Delivery - Commercial and Industrial Rebate Program	Rebate Program	Solar Photovoltaics, Biomass, Geothermal Heat Pumps, Lighting, Lighting Controls/Sensors, Chillers, Heat pumps, Air conditioners, Compressed air, Energy Mgmt. Systems/Building Controls, Windows, Roofs, Motor VFDs, Processing and Manufacturing Equipment, Comprehensive Measures/Whole Building, Custom/Others pending approval, Other EE, Reflective Roofs, LED Lighting	4/20/15	N/A	N/A
Oncor Electric Delivery	Oncor Electric Delivery - Solar Photovoltaic Standard Offer Program	Rebate Program	Solar Photovoltaics	6/13/16	N/A	N/A
Pedernales Electric Cooperative	Pedernales Electric Cooperative - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Heat pumps, Air conditioners	1/31/17	N/A	N/A
Texas Gas Service	Texas Gas Service - Residential Energy Efficiency	Rebate Program	Solar Water Heat, Water Heaters, Furnaces, Caulking/Weather-stripping, Duct/Air	6/2/15	N/A	N/A

	Rebate Program		sealing, Building Insulation, Windows, Other EE, Tankless Water Heater			
Texas Gas Service	Texas Gas Service - Residential Solar Water Heating Rebate Program	Rebate Program	Solar Water Heat	4/16/15	N/A	N/A
Texas-New Mexico Power Company	Texas-New Mexico Power Company - SCORE/CitySmart, Commercial Solutions, and Small Business Programs	Rebate Program	Solar Photovoltaics, Lighting, Heat pumps, Air conditioners, Roofs, Comprehensive Measures/Whole Building, Custom/Others pending approval, Other EE, LED Lighting	11/21/16	1/1/14	N/A
N/A	TXU - Commercial Energy Efficiency Program	Rebate Program	Solar Photovoltaics, Water Heaters, Lighting, Lighting Controls/Sensors, Heat pumps, Air conditioners, Compressed air, Programmable Thermostats, Energy Mgmt. Systems/Building Controls, Roofs, Motor VFDs, Custom/Others pending approval, Other EE, Vending Machine Controls, Reflective Roofs, Tankless Water Heater	6/3/15	N/A	N/A
United Cooperative Services	United Cooperative Services -	Rebate Program	Geothermal Heat Pumps, Water Heaters, Heat pumps, Heat	6/2/15	N/A	N/A

	Residential Energy Efficiency Rebate Program		recovery, Programmable Thermostats, Caulking/Weather-stripping, Building Insulation, Windows, Comprehensive Measures/Whole Building, Custom/Others pending approval, Other EE			
Xcel Energy	Xcel Energy - Residential and Hard-to-Reach Standard Offer Program	Rebate Program	Solar Water Heat, Solar Photovoltaics, Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Equipment Insulation, Water Heaters, Lighting, Heat pumps, Air conditioners, Duct/Air sealing, Building Insulation, Windows, Custom/Others pending approval, Other EE	4/27/15	N/A	N/A

(Database Of State Incentives For Renewables & Efficiency, North Carolina Clean Energy Technology Center, North Carolina State University, Accessed 11/29/17)

UTAH

Administrator	Name	Type	Technologies	Last Updated	Start Date	End Date
Programs are administered at the local level	Local Option - Industrial Facilities and Development Bonds	Bond Program	Solar Water Heat, Geothermal Electric, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Hydroelectric, Geothermal Heat Pumps, Combined Heat & Power, Daylighting, Equipment Insulation, Lighting, Chillers, Furnaces, Boilers, Heat pumps, Air conditioners, Heat recovery, Compressed air, Energy Mgmt. Systems/Building Controls, Caulking/Weather-stripping, Building Insulation, Windows, Doors, Other EE, Wind (Small), Hydroelectric (Small), Geothermal Direct-Use, LED Lighting	5/9/16	N/A	N/A
Utah Governor's Office of Energy Development	Alternative Energy Development Incentive (Corporate)	Corporate Tax Credit	Geothermal Electric, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Combined Heat & Power, Landfill Gas, Wind	3/9/16	5/12/09	N/A

			(Small), Hydroelectric (Small)			
State Energy Program, State Tax Commission	Renewable Energy Systems Tax Credit (Corporate)	Corporate Tax Credit	Solar - Passive, Solar Water Heat, Solar Space Heat, Geothermal Electric, Solar Thermal Electric, Solar Thermal Process Heat, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Geothermal Heat Pumps, Landfill Gas, Solar Pool Heating, Wind (Small), Geothermal Direct-Use, Anaerobic Digestion	5/31/17	N/A	N/A
Utah Governor's Office of Economic Development	Alternative Energy Manufacturing Tax Credit	Industry Recruitment/Support	Geothermal Electric, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Wind (Small), Hydroelectric (Small)	3/23/16	5/12/09	N/A
N/A	Commercial PACE Financing	PACE Financing	Solar Water Heat, Geothermal Electric, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Geothermal Heat Pumps, Daylighting, Equipment Insulation,	5/31/17	N/A	N/A

			Lighting, Chillers, Furnaces, Boilers, Heat pumps, Air conditioners, Heat recovery, Programmable Thermostats, Energy Mgmt. Systems/Building Controls, Caulking/Weather-stripping, Building Insulation, Windows, Doors, Roofs, Custom/Others pending approval, Wind (Small), Hydroelectric (Small), Geothermal Direct-Use, Other Distributed Generation Technologies			
Utah Governor's Office of Energy Development	Alternative Energy Development Incentive (Personal)	Personal Tax Credit	Geothermal Electric, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Combined Heat & Power, Landfill Gas, Wind (Small), Hydroelectric (Small)	3/9/16	5/12/09	N/A
State Energy Program, State Tax Commission	Renewable Energy Systems Tax Credit (Personal)	Personal Tax Credit	Solar - Passive, Solar Water Heat, Solar Space Heat, Geothermal Electric, Solar Thermal Electric, Solar Thermal Process Heat, Solar Photovoltaics,	5/31/17	N/A	N/A

			Wind (All), Biomass, Hydroelectric, Geothermal Heat Pumps, Landfill Gas, Solar Pool Heating, Wind (Small), Geothermal Direct-Use			
Questar Gas	Questar Gas - Residential Energy Efficiency Rebate Programs	Rebate Program	Solar Water Heat, Solar Pool Heating, Clothes Washers, Water Heaters, Furnaces, Boilers, Programmable Thermostats, Duct/Air sealing, Building Insulation, Windows, Other EE, Tankless Water Heater	2/2/16	N/A	N/A
Questar Gas	Questar Gas - Residential Solar Assisted Water Heating Rebate Program	Rebate Program	Solar Water Heat, Solar Pool Heating	5/27/16	N/A	N/A
Rocky Mountain Power	Rocky Mountain Power - wattsmart New Homes Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Lighting, Heat pumps, Air conditioners, Duct/Air sealing, Windows, Comprehensive Measures/Whole Building, Custom/Others pending approval, Other EE, LED Lighting	8/21/15	N/A	N/A

Utah State Tax Commission	Alternative Energy Sales Tax Exemption	Sales Tax Incentive	Geothermal Electric, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Municipal Solid Waste, Fuel Cells using Non-Renewable Fuels, Wind (Small), Fuel Cells using Renewable Fuels	3/9/16	7/1/04	6/30/27

(Database Of State Incentives For Renewables & Efficiency, North Carolina Clean Energy Technology Center, North Carolina State University, Accessed 11/29/17)

VERMONT

Administrator	Name	Type	Technologies	Last Updated	Start Date	End Date
Vermont Electric Power Producers (VEPP) Inc.	Standard Offer Program	Feed-in Tariff	Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Municipal Solid Waste, Landfill Gas, Hydroelectric (Small), Anaerobic Digestion	5/19/16	9/30/09	N/A
Vermont Agricultural Credit Corporation (VACC)	Agricultural Energy Loan Program	Loan Program	Geothermal Electric, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Combined Heat & Power, Landfill Gas, Equipment Insulation, Lighting, Lighting Controls/Sensors, Chillers, Furnaces, Boilers, Heat pumps, Air conditioners, Heat recovery, Steam-system upgrades, Compressed air, Programmable Thermostats, Caulking/Weather-stripping, Duct/Air sealing, Building Insulation, Windows, Doors, Siding, Roofs, Agricultural Equipment, Geothermal Direct-Use, Anaerobic Digestion, Fuel Cells using Renewable Fuels, Reflective Roofs, LED Lighting	10/28/16	N/A	N/A
Vermont Economic Development Authority (VEDA)	Commercial Energy Loan Program	Loan Program	Geothermal Electric, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Combined Heat & Power, Landfill Gas,	10/28/16	N/A	N/A

			Equipment Insulation, Lighting, Lighting Controls/Sensors, Chillers, Furnaces, Boilers, Heat pumps, Air conditioners, Heat recovery, Steam-system upgrades, Compressed air, Programmable Thermostats, Caulking/Weather-stripping, Duct/Air sealing, Building Insulation, Windows, Doors, Siding, Roofs, Geothermal Direct-Use, Anaerobic Digestion, Fuel Cells using Renewable Fuels, Reflective Roofs, LED Lighting			
Vermont Economic Development Authority (VEDA)	Small Business Energy Loan Program	Loan Program	Geothermal Electric, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Combined Heat & Power, Landfill Gas, Equipment Insulation, Lighting, Lighting Controls/Sensors, Chillers, Furnaces, Boilers, Heat pumps, Air conditioners, Heat recovery, Steam-system upgrades, Compressed air, Programmable Thermostats, Caulking/Weather-stripping, Duct/Air sealing, Building Insulation, Windows, Doors, Siding, Roofs, Geothermal Direct-Use, Anaerobic Digestion, Fuel Cells using Renewable	10/28/16	N/A	N/A

			Fuels, Reflective Roofs, LED Lighting			
Programs administered locally	Local Option - Property Assessed Clean Energy	PACE Financing	Solar Water Heat, Solar Space Heat, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Daylighting, Ceiling Fan, Water Heaters, Lighting, Furnaces, Boilers, Heat recovery, Programmable Thermostats, Energy Mgmt. Systems/Building Controls, Duct/Air sealing, Building Insulation, Windows, Doors, Motors, Motor VFDs, Comprehensive Measures/Whole Building, Other EE, Wind (Small), Hydroelectric (Small)	11/4/16	N/A	N/A
Green Mountain Power Corporation	GMP Cow Power	Performance-Based Incentive	Anaerobic Digestion	8/23/17	N/A	N/A
Green Mountain Power	GMP Solar Power	Performance-Based Incentive	Solar Photovoltaics	10/27/16	7/1/08	N/A
Vermont Department of Taxes	Investment Tax Credit	Personal Tax Credit	Solar Water Heat, Solar Space Heat, Geothermal Electric, Solar Thermal Electric, Solar Thermal Process Heat, Solar Photovoltaics	3/16/17	1/1/09	N/A
N/A	Local Option - Property Tax Exemption	Property Tax Incentive	Solar Water Heat, Solar Space Heat, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Combined Heat & Power, Landfill Gas, Wind (Small), Hydroelectric (Small), Anaerobic Digestion,	5/23/17	N/A	N/A

			Fuel Cells using Renewable Fuels			
Department of Taxes	Uniform Capacity Tax and Exemption for Solar	Property Tax Incentive	Solar Photovoltaics	5/23/17	1/1/13	N/A
Burlington Electric Department	Burlington Electric Department - Energy Efficiency Rebate Program	Rebate Program	Solar Water Heat, Clothes Washers, Refrigerators/Freezers, Dehumidifiers, Water Heaters, Furnaces, Boilers, Heat pumps, Programmable Thermostats, Other EE, Pool Pumps	4/25/17	N/A	N/A
Efficiency Vermont	HVAC Equipment Rebate Program	Rebate Program	Biomass, Furnaces, Boilers, Heat pumps, Energy Mgmt. Systems/Building Controls, Motor VFDs, Other EE	8/23/17	N/A	N/A
Efficiency Vermont	Residential Heating Systems Rebate Program	Rebate Program	Biomass, Furnaces, Boilers, Heat pumps	8/24/17	N/A	N/A
Renewable Energy Resource Center	Small-Scale Renewable Energy Incentive Program	Rebate Program	Solar Water Heat, Biomass	5/26/17	N/A	N/A
N/A	Renewable Energy Systems Sales Tax Exemption	Sales Tax Incentive	Solar Water Heat, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Combined Heat & Power, Landfill Gas, Wind (Small), Anaerobic Digestion, Fuel Cells using Renewable Fuels	11/10/16	1/26/99	N/A

(Database Of State Incentives For Renewables & Efficiency, North Carolina Clean Energy Technology Center, North Carolina State University, Accessed 11/29/17)

VIRGINIA

Administrator	Name	Type	Technologies	Last Updated	Start Date	End Date
Arlington County	Arlington County - Green Building Incentive Program	Green Building Incentive	Solar - Passive, Solar Water Heat, Solar Space Heat, Solar Photovoltaics, Wind (All), Biomass, Geothermal Heat Pumps, Daylighting, Comprehensive Measures/Whole Building, Wind (Small), Hydroelectric (Small)	11/22/16	N/A	N/A
Virginia Department of Treasury	Commonwealth's Energy Leasing Program	Leasing Program	Solar Water Heat, Geothermal Electric, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Geothermal Heat Pumps, Combined Heat & Power, Equipment Insulation, Lighting, Energy Mgmt. Systems/Building Controls, Caulking/Weather-stripping, Duct/Air sealing, Building Insulation, Windows, Doors, Siding, Motors, Custom/Others pending approval, Wind (Small), Geothermal Direct-Use, Other Distributed Generation Technologies	11/6/14	N/A	N/A
Virginia Resource Authority	Energy Project and Equipment Financing	Loan Program	Solar Water Heat, Solar Space Heat, Geothermal Electric, Solar Thermal	11/7/14	N/A	N/A

			Electric, Solar Thermal Process Heat, Solar Photovoltaics, Wind (All), Biomass, Geothermal Heat Pumps, Municipal Solid Waste, Combined Heat & Power, Landfill Gas, Custom/Others pending approval, Yes; specific technologies not identified, Wind (Small), Geothermal Direct-Use			
N/A	Small Business & Non-Profit Loan Program	Loan Program	Solar Photovoltaics, Wind (All)	7/7/14	N/A	N/A
N/A	TVA Partner Utilities - Energy Right Heat Pump Program	Loan Program	Geothermal Heat Pumps, Heat pumps	5/9/17	N/A	N/A
N/A	VirginiaSAVES Green Community Loan Program	Loan Program	Solar - Passive, Solar Water Heat, Geothermal Electric, Solar Photovoltaics, Wind (All), Biomass, Geothermal Heat Pumps, Municipal Solid Waste, Combined Heat & Power, Landfill Gas, Tidal, Wave, Ocean Thermal, Clothes Washers, Dehumidifiers, Ceiling Fan, Chillers, Furnaces, Boilers, Heat pumps, Air conditioners, Combined Heat & Power, Compressed air, Caulking/Weather-stripping, Building Insulation,	11/2/15	9/2/15	N/A

			Agricultural Equipment, Comprehensive Measures/Whole Building, Custom/Others pending approval, Yes; specific technologies not identified, Insulation, Hydroelectric (Small), Food Service Equipment, Anaerobic Digestion, Other Distributed Generation Technologies, Commercial Cooking Equipment, Data Center Equipment, Commercial Refrigeration Equipment			
Domion Virginia Power	Dominion Virginia Power - Solar Purchase Program	Performance-Based Incentive	Solar Photovoltaics	3/12/15	6/20/13	6/20/18
Tennessee Valley Authority	TVA - Green Power Providers	Performance-Based Incentive	Solar Photovoltaics, Wind (All), Biomass, Wind (Small), Hydroelectric (Small)	6/2/15	10/1/12	N/A
Tennessee Valley Authority	TVA - Mid-Sized Renewable Standard Offer Program	Performance-Based Incentive	Solar Photovoltaics, Wind (All), Biomass, Landfill Gas, Anaerobic Digestion	6/18/15	10/10/10	N/A
Tennessee Valley Authority	TVA - Solar Solutions Initiative	Performance-Based Incentive	Solar Photovoltaics	6/4/15	N/A	N/A
Virginia Department of Mines, Minerals, and Energy	Commercial Solar Property Tax Exemption	Property Tax Incentive	Solar - Passive, Solar Water Heat, Solar Space Heat, Solar Thermal Electric, Solar Photovoltaics, Solar Pool Heating	3/18/16	N/A	N/A

Virginia Department of Mines, Minerals, and Energy	Local Option - Residential Property Tax Exemption for Solar	Property Tax Incentive	Solar - Passive, Solar Water Heat, Solar Space Heat, Solar Thermal Electric, Solar Photovoltaics	11/7/14	N/A	N/A
N/A	Local Option- Renewable Energy Machinery and Tools Property Tax Exemption	Property Tax Incentive	Geothermal Electric, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Municipal Solid Waste, Combined Heat & Power, Landfill Gas, Tidal, Wave, Anaerobic Digestion, Microturbines	4/9/15	7/1/15	N/A
Dominion	Dominion Virginia Power - Non-Residential Energy Efficiency Programs	Rebate Program	Geothermal Heat Pumps, Lighting, Lighting Controls/Sensors, Chillers, Heat pumps, Air conditioners, Energy Mgmt. Systems/Building Controls, Duct/Air sealing, Windows, Motor VFDs, Comprehensive Measures/Whole Building, Other EE, Vending Machine Controls, Commercial Refrigeration Equipment	3/25/15	N/A	N/A
N/A	TVA Partner Utilities - eScore Program	Rebate Program	Geothermal Heat Pumps, Water Heaters, Heat pumps, Air conditioners, Duct/Air sealing, Windows, Doors, Insulation	8/31/17	N/A	N/A

(Database Of State Incentives For Renewables & Efficiency, North Carolina Clean Energy Technology Center, North Carolina State University, Accessed 11/29/17)

WASHINGTON

Administrator	Name	Type	Technologies	Last Updated	Start Date	End Date
N/A	Renewable Energy Cost Recovery Incentive Payment	Feed-in Tariff	Solar Thermal Electric, Solar Photovoltaics, Wind (All), Wind (Small), Anaerobic Digestion	5/18/17	8/31/06	6/30/20
Washington State Department of Commerce	Energy Efficiency and Solar Grants	Grant Program	Solar Water Heat, Solar Space Heat, Solar Photovoltaics, Lighting, Custom/Others pending approval, Other EE, LED Lighting	8/25/16	N/A	N/A
Pacific Power	Pacific Power - Blue Sky Community Project Funds	Grant Program	Geothermal Electric, Solar Photovoltaics, Wind (All), Biomass, Tidal, Wave, Hydroelectric (Small), Anaerobic Digestion	3/16/16	N/A	N/A
Washington Department of Commerce	Evergreen Sustainable Development Standard for Affordable Housing	Green Building Incentive	Solar Water Heat, Solar Photovoltaics, Clothes Washers, Dishwasher, Refrigerators/Freezers, Water Heaters, Lighting, Furnaces, Boilers, Heat pumps, Air conditioners, Caulking/Weather-stripping, Duct/Air sealing, Building Insulation, Comprehensive Measures/Whole Building	12/3/15	N/A	N/A
Washington Economic Development Finance Authority and Department of Commerce	Renewable Energy Manufacturing Program	Industry Recruitment/Support	Geothermal Electric, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Hydroelectric, Municipal Solid Waste, Landfill Gas, Tidal, Wave, Ocean Thermal, Geothermal Direct-Use, Anaerobic	5/20/16	N/A	N/A

			Digestion, Other Distributed Generation Technologies			
Clark PUD	Clark Public Utilities - Solar Energy Equipment Loan	Loan Program	Solar Water Heat, Solar Photovoltaics, Solar Pool Heating	2/5/16	N/A	N/A
Okanogon County PUD Conservation Department	Okanogan PUD - Conservation Loan Program	Loan Program	Solar Photovoltaics, Wind (All), Lighting, Heat pumps, Compressed air, Duct/Air sealing, Building Insulation, Windows, Doors, Motors, Other EE, LED Lighting	5/12/15	N/A	N/A
N/A	WSHFC Sustainable Energy Program	Loan Program	Solar Water Heat, Geothermal Electric, Solar Photovoltaics, Geothermal Heat Pumps, Combined Heat & Power, Comprehensive Measures/Whole Building, Custom/Others pending approval, Wind (Small), Other Distributed Generation Technologies	3/15/17	N/A	N/A
Chelan County Public Utility District	Chelan County PUD - Sustainable Natural Alternative Power Producers Program	Performance-Based Incentive	Geothermal Electric, Solar Photovoltaics, Wind (All), Biomass, Landfill Gas, Tidal, Wave, Wind (Small), Hydroelectric (Small)	6/19/15	N/A	N/A
Orcas Power & Light Cooperative	Orcas Power & Light - MORE Green Power Program	Performance-Based Incentive	Solar Photovoltaics, Wind (All), Wind (Small), Hydroelectric (Small)	6/19/15	7/1/11	N/A
Clark Public Utilities	Clark Public Utilities - Residential Energy Efficiency	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Water Heaters, Heat pumps, Duct/Air sealing,	1/6/16	N/A	N/A

	Rebate Program		Building Insulation, Windows, Comprehensive Measures/Whole Building, Other EE			
Clark PUD	Clark Public Utilities - Solar Water Heater Rebate	Rebate Program	Solar Water Heat	2/5/16	N/A	N/A
Cowlitz County Public Utility District	Cowlitz County PUD - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Refrigerators/Freezers, Water Heaters, Lighting, Heat pumps, Windows, Insulation, LED Lighting	7/8/15	N/A	N/A
Inland Power & Light Company	Inland Power & Light Company - Residential Energy Efficiency Rebate Programs	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Refrigerators/Freezers, Water Heaters, Lighting, Heat pumps, Duct/Air sealing, Building Insulation, Windows, Comprehensive Measures/Whole Building, LED Lighting	1/14/16	N/A	N/A
Pacific Power	Pacific Power - wattsmart Business Program	Rebate Program	Geothermal Heat Pumps, Lighting, Chillers, Heat pumps, Air conditioners, Compressed air, Building Insulation, Windows, Motors, Motor VFDs, Custom/Others pending approval, Food Service Equipment, Personal Computing Equipment, Commercial Refrigeration Equipment	8/26/15	N/A	N/A
Puget Sound Energy	Puget Sound Energy - Residential	Rebate Program	Geothermal Heat Pumps, Clothes Washers,	3/24/17	N/A	N/A

	Energy Efficiency Rebate Programs		Refrigerators/Freezers, Water Heaters, Furnaces, Boilers, Heat pumps, Programmable Thermostats, Duct/Air sealing, Building Insulation, Windows, Other EE, LED Lighting			
Snohomish County PUD	Snohomish County PUD No 1 - Build with Energy Star Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Refrigerators/Freezers, Water Heaters, Heat pumps	4/22/16	N/A	N/A
Snohomish County PUD	Snohomish County PUD No 1 - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Lighting, Heat pumps, Duct/Air sealing, Building Insulation, Windows, Other EE, LED Lighting	5/16/16	N/A	N/A
Snohomish County Public Utility District	Snohomish County PUD No 1 - Solar Express Rebate Program	Rebate Program	Solar Water Heat, Solar Photovoltaics	6/18/15	N/A	N/A
Washington State Department of Revenue	Renewable Energy Sales and Use Tax Exemption	Sales Tax Incentive	Solar Water Heat, Geothermal Electric, Solar Photovoltaics, Wind (All), Biomass, Landfill Gas, Tidal, Wave, Wind (Small), Anaerobic Digestion	5/18/17	7/1/09	N/A

(Database Of State Incentives For Renewables & Efficiency, North Carolina Clean Energy Technology Center, North Carolina State University, Accessed 11/29/17)

WEST VIRGINIA

Administrator	Name	Type	Technologies	Last Updated	Start Date	End Date
West Virginia Division of Energy	Tax Exemption for Wind Energy Generation	Corporate Tax Exemption	Wind (All), Wind (Small)	5/29/15	N/A	N/A
West Virginia Division of Energy	Special Assessment for Wind Energy Systems	Property Tax Incentive	Wind (All), Wind (Small)	5/29/15	N/A	N/A

(Database Of State Incentives For Renewables & Efficiency, North Carolina Clean Energy Technology Center, North Carolina State University, Accessed 11/29/17)

WISCONSIN

Administrator	Name	Type	Technologies	Last Updated	Start Date	End Date
Chicago Bridge & Iron	Renewable Energy Competitive Incentive Program	Grant Program	Solar Water Heat, Geothermal Electric, Solar Thermal Electric, Solar Photovoltaics, Wind (All), Biomass, Geothermal Heat Pumps, Anaerobic Digestion	3/15/17	N/A	N/A
Summit Credit Union	City of Milwaukee - Milwaukee Shines Solar Financing	Loan Program	Solar Water Heat, Solar Photovoltaics	4/1/15	7/28/11	N/A
The Wisconsin Economic Development Corporation and The Wisconsin Department of Administration	Clean Energy Manufacturing Revolving Loan Fund	Loan Program	Biomass, Other EE, Anaerobic Digestion	4/3/15	N/A	N/A
River Falls Municipal Utilities	River Falls Municipal Utilities - Renewable Energy Finance Program	PACE Financing	Solar Water Heat, Solar Space Heat, Geothermal Electric, Solar Photovoltaics, Wind (All), Geothermal Heat Pumps, Custom/Others pending approval, Other EE, Wind (Small)	6/25/15	N/A	N/A
Madison Gas & Electric	Madison Gas & Electric - Clean Power Partner Solar Buyback Program	Performance-Based Incentive	Solar Photovoltaics	7/13/15	N/A	N/A
River Falls Municipal Utilities	River Falls Municipal Utilities - Distributed Solar Tariff	Performance-Based Incentive	Solar Photovoltaics	7/8/15	N/A	N/A
Wisconsin Department of Revenue	Biogas, Solar, and Wind Energy	Property Tax Incentive	Solar Water Heat, Solar Space Heat, Solar Thermal Electric,	12/15/15	N/A	N/A

	Equipment Exemption		Solar Photovoltaics, Wind (All), Biomass, Solar Pool Heating, Wind (Small), Anaerobic Digestion			
Barron Electric Cooperative	Barron Electric Cooperative - ENERGY STAR Appliance and Energy Efficient Lighting Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Dehumidifiers, Lighting, Lighting Controls/Sensors, Heat pumps, Air conditioners, Other EE, LED Lighting	3/30/15	N/A	N/A
Eau Claire Energy Cooperative	Eau Claire Energy Cooperative - Non-Residential Energy Efficiency Rebate Programs	Rebate Program	Solar Water Heat, Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Dehumidifiers, Ceiling Fan, Water Heaters, Lighting, Heat pumps, Air conditioners, Heat recovery, Motor VFDs, Agricultural Equipment, Other EE, LED Lighting	4/6/15	N/A	N/A
Eau Claire Energy Cooperative	Eau Claire Energy Cooperative - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Dehumidifiers, Lighting, Lighting Controls/Sensors, Heat pumps, Air conditioners, Compressed air, Motor VFDs, Other EE, LED Lighting	3/30/15	N/A	N/A
Marshfield Reward	Marshfield Utilities - Heat Pump Rebate Program	Rebate Program	Geothermal Heat Pumps, Heat pumps	3/30/15	N/A	N/A
N/A	Multifamily Energy Savings Program (Existing	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Dehumidifiers,	3/15/17	N/A	N/A

	Buildings and New Construction)		Equipment Insulation, Water Heaters, Lighting, Lighting Controls/Sensors, Chillers, Furnaces, Boilers, Heat pumps, Air conditioners, Heat recovery, Energy Mgmt. Systems/Building Controls, Building Insulation, Motor VFDs, Custom/Others pending approval, Other EE, Vending Machine Controls, LED Lighting, Tankless Water Heater			
Chicago Bridge & Iron	Renewable Rewards Program	Rebate Program	Solar Photovoltaics, Geothermal Heat Pumps	3/20/17	1/1/17	N/A
Riverland Energy Cooperative	Riverland Energy Cooperative - Commercial and Industrial Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Dehumidifiers, Water Heaters, Lighting, Lighting Controls/Sensors, Boilers, Heat pumps, Air conditioners, Compressed air, Energy Mgmt. Systems/Building Controls, Motor VFDs, Agricultural Equipment, Other EE, LED Lighting	6/25/15	N/A	N/A
Riverland Energy Cooperative	Riverland Energy Cooperative - Residential Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Dishwasher, Refrigerators/Freezers, Dehumidifiers, Water Heaters, Lighting, Lighting Controls/Sensors, Heat pumps, Air conditioners, Energy Mgmt.	7/7/15	N/A	N/A

			Systems/Building Controls, Other EE, LED Lighting			
Wisconsin Department of Revenue	Renewable Energy Sales Tax Exemptions	Sales Tax Incentive	Solar Water Heat, Solar Space Heat, Solar Thermal Process Heat, Solar Photovoltaics, Wind (All), Biomass, Landfill Gas, Solar Pool Heating, Wind (Small), Anaerobic Digestion	7/13/15	N/A	N/A

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WYOMING

Administrator	Name	Type	Technologies	Last Updated	Start Date	End Date
Black Hills Energy	Black Hills Energy - Commercial Energy Efficiency Programs	Rebate Program	Geothermal Heat Pumps, Water Heaters, Lighting, Lighting Controls/Sensors, Heat pumps, Air conditioners, Motors, Motor VFDs, Custom/Others pending approval, LED Lighting	4/7/16	N/A	N/A
Black Hills Energy	Black Hills Energy - Residential Customer Rebate Program	Rebate Program	Geothermal Heat Pumps, Water Heaters, Lighting, Heat pumps, Air conditioners, Energy Mgmt. Systems/Building Controls, Other EE	4/6/16	N/A	N/A
Carbon Power & Light, Inc.	Carbon Power & Light - Residential and Commercial Energy Efficiency Rebate Program	Rebate Program	Geothermal Heat Pumps, Water Heaters, Heat pumps, Motors, Other EE	10/26/15	N/A	N/A
Questar Gas	Questar Gas - Residential Energy Efficiency Rebate Programs	Rebate Program	Solar Water Heat, Solar Pool Heating, Clothes Washers, Water Heaters, Furnaces, Boilers, Programmable Thermostats, Duct/Air sealing, Building Insulation, Windows, Other EE, Tankless Water Heater	2/2/16	N/A	N/A
Rocky Mountain Power	Rocky Mountain Power - wattsmart	Rebate Program	Geothermal Heat Pumps, Clothes Washers, Refrigerators/Freezers, Water Heaters,	8/21/15	N/A	N/A

	Business Program		Lighting, Lighting Controls/Sensors, Chillers, Heat pumps, Air conditioners, Heat recovery, Programmable Thermostats, Energy Mgmt. Systems/Building Controls, Building Insulation, Windows, Roofs, Motors, Motor VFDs, Agricultural Equipment, Custom/Others pending approval, Other EE, Food Service Equipment, Vending Machine Controls, Reflective Roofs, LED Lighting, Commercial Refrigeration Equipment			

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REPORT: MASSIVE SUBSIDIES BEING SHELLED OUT FOR RENEWABLE ENERGY

3:31 PM 04/13/2018 | ENERGY | Jason Hopkins | Energy Investigator

A new report reveals the billions of dollars in subsidies being quietly shelled out to renewable energy technologies, all on the back of the American taxpayer.

The renewable industry's dependence on government subsidies has been well documented, but a recent American Rising Squared investigation painted a more clear picture of just how much state and federal taxpayer money is being spent to prop up solar and wind energy companies. Among the key findings: billions in financial aid from the federal government and a burgeoning number of programs at the state level to keep otherwise-noncompetitive renewable energy companies afloat.

At the national level, U.S. taxpayers were charged over $13 billion through federal expenditures relating to renewable energy and energy efficiency in 2016 alone.

Policy aimed at supporting renewable energy production has proliferated in recent time. Eight states have established renewable goals and nearly 30 have renewable portfolio standards. Minnesota tops the list when it comes to subsidy programs for renewable energy technologies, having more than any other state in the country. Additionally, there are a total of 86 different programs offering financial incentives for solar energy, with California managing 25 programs alone.

"Billions in federal and state spending for this elaborate tapestry of mismatched, ineffective, redundant, and short-sighted programs continue to move forward without critical or objective review. The plain fact is that America's bureaucrats continue to throw billions of taxpayer dollars toward renewable energy without asking the hard and inconvenient questions," an America Rising Squared Friday statement noted about the findings.

The investigation also dives into the process required to operate "clean" energy. For example, the manufacturing of many renewable energy products requires the extraction of rare earth metals such as Gallium, Indium and Tellurium. The process to extract and refine rare earth materials — elements necessary in the construction of electric vehicle batteries, solar panels and wind turbines — is extremely energy intensive.

"The process of shaping America's energy policy, particularly when it comes to renewable energy and their connection to critical materials like rare earth, lacks the essential simplicity for average Americans to understand. The government's objectives appear primarily political, with neither clear ‘big picture’ goals nor the strong leadership needed to chart a logical path forward,” the America Rising Squared statement continued.

The findings come as more reports indicate the hidden costs of renewable energy.

A 2017 study initiated by the Montana legislature revealed net metering customers in the state were being overcompensated for their solar energy by about three times the market value — that price falling on the backs of non-net metering customers.

The New Jersey legislature overwhelmingly passed a bill on Thursday allocating more money into the renewable energy industry, with a goal of making solar, wind and other renewables account for 50 percent of the state’s total energy use by 2030.

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If Solar Panels Are So Clean, Why Do They Produce So Much Toxic Waste?

Michael Shellenberger Energy I write about energy and the environment Contributor
Bell Labs, 1954. Solar Panel Waste, 2014 BELL LABS & PV CYCLE

The last few years have seen growing concern over what happens to solar panels at the end of their life. Consider the following statements:

- The problem of solar panel disposal "will explode with full force in two or three decades and wreck the environment" because it "is a huge amount of waste and they are not easy to recycle."
- "The reality is that there is a problem now, and it's only going to get larger, expanding as rapidly as the PV industry expanded 10 years ago."
- "Contrary to previous assumptions, pollutants such as lead or carcinogenic cadmium can be almost completely washed out of the fragments of solar modules over a period of several months, for example by rainwater."

Were these statements made by the right-wing Heritage Foundation? Koch-funded global warming deniers? The editorial board of the *Wall Street Journal*?

None of the above. Rather, the quotes come from a senior Chinese solar official, a 40-year veteran of the U.S. solar industry, and research scientists with the German Stuttgart Institute for Photovoltaics.

With few environmental journalists willing to report on much of anything other than the good news about renewables, it's been left to environmental scientists and solar industry leaders to raise the alarm.

"I've been working in solar since 1976 and that's part of my guilt," the veteran solar developer told *Solar Power World* last year. "I've been involved with millions of solar panels going into the field, and now they're getting old."

The Trouble With Solar Waste

The International Renewable Energy Agency (IRENA) in 2016 estimated there was about 250,000 metric tonnes of solar panel waste in the world at the end of that year. IRENA projected that this amount could reach 78 *million* metric tonnes by 2050.

Solar panels often contain lead, cadmium, and other toxic chemicals that cannot be removed without breaking apart the entire panel. "Approximately 90% of most PV modules are made up of glass," notes San Jose State environmental studies professor Dustin Mulvaney. "However, this glass often cannot be recycled as float glass due to impurities. Common problematic impurities in glass include plastics, lead, cadmium and antimony."

Researchers with the Electric Power Research Institute (EPRI) undertook a study for U.S. solar-owning utilities to plan for end-of-life and concluded that solar panel “disposal in “regular landfills [is] not recommended in case modules break and toxic materials leach into the soil” and so “disposal is potentially a major issue.”

California is in the process of determining how to divert solar panels from landfills, which is where they currently go, at the end of their life.

California's Department of Toxic Substances Control (DTSC), which is implementing the new regulations, held a meeting last August with solar and waste industry representatives to discuss how to deal with the issue of solar waste. At the meeting, the representatives from industry and DTSC all acknowledged how difficult it would be to test to determine whether a solar panel being removed would be classified as hazardous waste or not.

The DTSC described building a database where solar panels and their toxicity could be tracked by their model numbers, but it's not clear DTSC will do this.

"The theory behind the regulations is to make [disposal] less burdensome," explained Rick Brausch of DTSC. "Putting it as universal waste eliminates the testing requirement."

The fact that cadmium can be washed out of solar modules by rainwater is increasingly a concern for local environmentalists like the Concerned Citizens of Fawn Lake in Virginia, where a 6,350 acre solar farm to partly power Microsoft data centers is being proposed.

“We estimate there are 100,000 pounds of cadmium contained in the 1.8 million panels,” Sean Fogarty of the group told me. “Leaching from broken panels damaged during natural events — hail storms, tornadoes, hurricanes, earthquakes, etc. — and at decommissioning is a big concern.”

There is real-world precedent for this concern. A tornado in 2015 broke 200,000 solar modules at southern California solar farm Desert Sunlight.

"Any modules that were broken into small bits of glass had to be swept from the ground," Mulvaney explained, "so lots of rocks and dirt got mixed in that would not work in recycling plants that are designed to take modules. These were the cadmium-based modules that failed [hazardous] waste tests, so were treated at a [hazardous] waste facility. But about 70 percent of the modules were actually sent to recycling, and the recycled metals are in new panels today."

And when Hurricane Maria hit Puerto Rico last September, the nation’s second largest solar farm, responsible for 40 percent of the island’s solar energy, lost a majority of its panels.

Many experts urge mandatory recycling. The main finding promoted by IRENA's in its 2016 report was that, “If fully injected back into the economy, the value of the recovered material [from used solar panels] could exceed USD 15 billion by 2050.”

But IRENA's study did not compare the value of recovered material to the cost of new materials and admitted that "Recent studies agree that PV material availability is not a major concern in the near term, but critical materials might impose limitations in the long term."

They might, but today recycling costs more than the economic value of the materials recovered, which is why most solar panels end up in landfills. "The absence of valuable metals/materials produces economic losses," wrote a team of scientists in the *International Journal of Photoenergy* in their study of solar panel recycling last year, and "Results are coherent with the literature."

Chinese and Japanese experts agree. "If a recycling plant carries out every step by the book," a Chinese expert told *The South China Morning Post*, "their products can end up being more expensive than new raw materials."

Toshiba Environmental Solutions told Nikkei Asian Review last year that,

Low demand for scrap and the high cost of employing workers to disassemble the aluminum frames and other components will make it difficult to create a profitable business unless recycling companies can charge several times more than the target set by [Japan's environment ministry].

Can Solar Producers Take Responsibility?

In 2012, First Solar stopped putting a share of its revenues into a fund for long-term waste management. "Customers have the option to use our services when the panels get to the end of life stage," a spokesperson told *Solar Power World*. "We'll do the recycling, and they'll pay the price at that time."

Or they won't. "Either it becomes economical or it gets mandated." said EPRI's Cara Libby. "But I've heard that it will have to be mandated because it won't ever be economical."

Last July, Washington became the first U.S. state to require manufacturers selling solar panels to have a plan to recycle. But the legislature did not require manufacturers to pay a fee for disposal. "Washington-based solar panel manufacturer Itek Energy assisted with the bill's writing," noted Solar Power World.

The problem with putting the responsibility for recycling or long-term storage of solar panels on manufacturers, says the insurance actuary Milliman, is that it increases the risk of more financial failures like the kinds that afflicted the solar industry over the last decade.

[A]ny mechanism that finances the cost of recycling PV modules with current revenues is not sustainable. This method raises the possibility of bankruptcy down the road by shifting today's greater burden of 'caused' costs into the future. When growth levels off then PV producers would face rapidly increasing recycling costs as a percentage of revenues.

Since 2016, Sungevity, Beamreach, Verengo Solar, SunEdison, Yingli Green Energy, Solar World, and Suniva have gone bankrupt.

The result of such bankruptcies is that the cost of managing or recycling PV waste will be born by the public. “In the event of company bankruptcies, PV module producers would no longer contribute to the recycling cost of their products,” notes Milliman, “leaving governments to decide how to deal with cleanup.”

Governments of poor and developing nations are often not equipped to deal with an influx of toxic solar waste, experts say. German researchers at the Stuttgart Institute for Photovoltaics warned that poor and developing nations are at higher risk of suffering the consequences.

Dangers and hazards of toxins in photovoltaic modules appear particularly large in countries where there are no orderly waste management systems… Especially in less developed countries in the so-called global south, which are particularly predestined for the use of photovoltaics because of the high solar radiation, it seems highly problematic to use modules that contain pollutants.

The attitude of some solar recyclers in China appears to feed this concern. “A sales manager of a solar power recycling company,” the *South China Morning News* reported, “believes there could be a way to dispose of China’s solar junk, nonetheless.”

“We can sell them to Middle East… Our customers there make it very clear that they don’t want perfect or brand new panels. They just want them cheap… There, there is lots of land to install a large amount of panels to make up for their low performance. Everyone is happy with the result.”

In other words, there are firms that may advertise themselves as "solar panel recyclers" but instead sell panels to a secondary markets in nations with less developed waste disposal systems. In the past, communities living near electronic waste dumps in Ghana, Nigeria, Vietnam, Bangladesh, Pakistan, and India have been primary e-waste destinations.

According to a 2015 United Nations Environment Program (UNEP) report, somewhere between 60 and 90 percent of electronic waste is illegally traded and dumped in poor nations. Writes UNEP:

[T]housands of tonnes of e-waste are falsely declared as second-hand goods and exported from developed to developing countries, including waste batteries falsely described as plastic or mixed metal scrap, and cathode ray tubes and computer monitors declared as metal scrap.

Unlike other forms of imported e-waste, used solar panels can enter nations legally before eventually entering e-waste streams. As the United Nation Environment Program notes, “loopholes in the current Waste Electrical and Electronic Equipment (WEEE) Directives allow the export of e-waste from developed to developing countries (70% of the collected WEEE ends up in unreported and largely unknown destinations).”

A Path Forward on Solar Panel Waste

Perhaps the biggest problem with solar panel waste is that there is so much of it, and that's not going to change any time soon, for a basic physical reason: sunlight is dilute and diffuse and thus require large collectors to capture and convert the sun's rays into electricity. Those large surface areas, in turn, require an order of magnitude more in materials — whether today's toxic combination of glass, heavy metals, and rare earth elements, or some new material in the future — than other energy sources.

All of that waste creates a large quantity of material to track, which in turn requires coordinated, overlapping, and different responses at the international, national, state, and local levels.

The local level is where action to dispose of electronic and toxic waste takes place, often under state mandates. In the past, differing state laws have motivated the U.S. Congress to put in place national regulations. Industry often prefers to comply with a single national standard rather than multiple different state standards. And as the problem of the secondary market for solar shows, ultimately there needs to be some kind of international regulation.

The first step is a fee on solar panel purchases to make sure that the cost of safely removing, recycling or storing solar panel waste is internalized into the price of solar panels and not externalized onto future taxpayers. An obvious solution would be to impose a new fee on solar panels that would go into a federal disposal and decommissioning fund. The funds would then, in the future, be dispensed to state and local governments to pay for the removal and recycling or long-term storage of solar panel waste. The advantage of this fund over extended producer responsibility is that it would insure that solar panels are safely decommissioned, recycled, or stored over the long-term, even after solar manufacturers go bankrupt.

Second, the federal government should encourage citizen enforcement of laws to decommission, store, or recycle solar panels so that they do not end up in landfills. Currently, citizens have the right to file lawsuits against government agencies and corporations to force them to abide by various environmental laws, including ones that protect the public from toxic waste. Solar should be no different. Given the decentralized nature of solar energy production, and lack of technical expertise at the local level, it is especially important that the whole society be involved in protecting itself from exposure to dangerous toxins.

“We have a County and State approval process over the next couple months,” Fogarty of Concerned Citizens of Fawn Lake told me, “but it has become clear that local authorities have very little technical breadth to analyze the impacts of such a massive solar power plant.”

Lack of technical expertise can be a problem when solar developers like Sustainable Power Group, or sPower, incorrectly claim that the cadmium in its panels is not water soluble. That claim has been contradicted by the previously-mentioned Stuttgart research scientists who found cadmium from solar panels “can be almost completely washed out...over a period of several months...by rainwater.”

Third, the United Nations Environment Programme’s Global Partnership for Waste Management, as part of its International Environmental Partnership Center, should more strictly monitor e-waste shipments and encourage nations importing used solar panels into secondary markets to impose a fee to cover the cost of recycling or long-term management. Such a recycling and waste management fund could help nations address their other e-waste problems while supporting the development of a new, high-tech industry in recycling solar panels.

None of this will come quickly, or easily, and some solar industry executives will resist internalizing the cost of safely storing, or recycling, solar panel waste, perhaps for understandable reasons. They will rightly note that there are other kinds of electronic waste in the world. But it is notable that some new forms of electronic waste, namely smartphones like the iPhone, have in many cases replaced things like stereo systems, GPS devices, and alarm clocks and thus reduced their contribution to the e-waste stream. And no other electronics industry makes being “clean” its main selling point.

Wise solar industry leaders can learn from the past and be proactive in seeking stricter regulation in accordance with growing scientific evidence that solar panels pose a risk of toxic chemical contamination. “If waste issues are not preemptively addressed,” warns Mulvaney, “the industry risks repeating the disastrous environmental mistakes of the electronics industry.”

If the industry responds with foresight, Mulvaney notes, it could end up sparking clean innovation including “developing PV modules without hazardous inputs and recycled rare metals." And that's something everyone can get powered up about.

Michael Shellenberger, President, Environmental Progress. Time Magazine "Hero of the Environment."

ENVIRONMENTALIST SOUNDS ALARM ON COMING WAVE OF TOXIC SOLAR PANEL WASTE

2:31 PM 05/24/2018 | ENERGY
Jason Hopkins | Energy Investigator

A leading activist has raised concerns over the ecological impact of solar panels — a renewable energy technology widely considered to be harmless to the environment.

Michael Shellenberger — the president of Environmental Progress, a nonprofit organization working to promote clean energy — detailed the real life impacts of discarded solar installation. Solar technology typically contains cadmium, lead and other toxic chemicals that can't be extracted without taking apart the whole panel, resulting in entire solar panels being considered hazardous, Shellenberger noted in a Wednesday Forbes article.

More specifically, these toxic chemicals become an environmental threat when solar panels reach their end-of-life stage and need to be disposed. Panels left in landfills may break apart and release toxic waste into the ground or even enter bodies of water. Solar panel disposal in "regular landfills [is] not recommended in case modules break and toxic materials leach into the soil," Electric Power Research Institute determined in a 2016 study.

There is growing concern over the possibility of rainwater washing cadmium out of panels and into the environment. In Virginia, for example, a group of locals are pushing back against a proposal to construct a 6,350 acre solar farm in Spotsylvania County.

"We estimate there are 100,000 pounds of cadmium contained in the 1.8 million panels," Sean Fogarty of Concerned Citizens of Fawn Lake stated to Shellenberger. "Leaching from broken panels damaged during natural events — hail storms, tornadoes, hurricanes, earthquakes, etc. — and at decommissioning is a big concern."

Instances can occur where severe weather — such as a tornado in California and a hurricane through Puerto Rico — decimate solar panel farms, potentially leaking chemicals into the ground.

Virtually no one in media cares to discuss the solar industry's negative effects on the environment, Shellenberger also noted. "With few environmental journalists willing to report on much of anything other than the good news about renewables, it's been left to environmental scientists and solar industry leaders to raise the alarm."

As a suggested solution, Shellenberger entertained the idea of an added fee with solar panel purchases that can go toward the recycling and disposing of decommissioned panels. He also encouraged greater government involvement as to avoid the placement of solar installation into landfills.

Previous studies have examined the solar industries' effect on the environment. The process it takes to build renewable energy technology is extremely intensive, an April America Rising Squared report determined. The production of solar panels and wind turbines, America Rising found, requires the extraction of rare earth metals such as Indium, Gallium and Tellurium. Refining these rare minerals is extremely energy intensive.

Issues relating to solar panel waste will only worsen as more Americans utilize the technology. Lured with promises of long-term financial gains and environmental benefits, a growing number of U.S. households are purchasing rooftop solar installations. On May 9, California became the first state in the U.S. to mandate every new household have a solar panel. Environmental activists, like billionaire Tom Steyer, are funding national campaigns to promote renewable energy use. Such campaigns and government mandates are increasing renewable portfolio standards across the country.

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Newport smelter hearing draws skeptical crowd

UPDATED: Tue., Sept. 18, 2018, 11:09 p.m.

Thubten Semkye, a Buddhist nun from Sravasti Abbey near Newport, Washington, speaks out against the proposed silicon smelter while testifying Tuesday, Sept. 18, 2018 at a public meeting held by the Washington Department of Ecology at the Spokane Convention Center. (Jesse Tinsley / The Spokesman-Review)

By Becky Kramer beckyk@spokesman.com(509) 459-5466

Buddhist nuns from Sravasti Abbey traveled to Spokane on Tuesday evening to testify about a silicon smelter proposed south of Newport.

"We're deeply concerned about the emissions the smelter will pump into the atmosphere and the effect on people and the environment," said Thubten Samten, one of the nuns.

Heavy fog and air inversions are already common around Newport, said Thubten Semkye, another member of the abbey.

"We've got some of the most beautiful air in the country, and EPA will give them a lot of room to pollute," Semkye told state officials.

About 100 people attended the meeting at the Spokane Convention Center, which gave area residents a chance to tell the state Department of Ecology what they think should be included in its environmental review of the smelter.

The first draft of the review is expected to be released next year, with a final version out in late 2019.

The review will provide details about the smelter's effect on the environment and nearby communities, including possible mitigation, said Brook Beeler, an Ecology Department spokeswoman. The state's review must be completed before the smelter can get air quality and water discharge permits.

The proposed smelter is a project of PacWest Silicon, a subsidiary of HiTest Sands, of Alberta. The company would ship silica mined in British Columbia to the smelter, where it would be combined with wood chips, coal and charcoal at high temperatures to produce the metal.

Low electricity prices attracted the company to Northeast Washington. PacWest plans to build the smelter on 188 acres south of Newport, adjacent to the Washington-Idaho border.

PacWest expects to produce about 73,000 tons of silicon annually for solar panels and other uses. The smelter proposal qualified as a "project of statewide significance" and the company received $300,000 in state money to defray design costs.

PacWest officials say the smelter will create about 400 construction jobs and employ up to 150 people once it's operating.

Scott Holstrom, business manager for Laborers' International Union of North America Local 238, spoke in favor of the smelter. The union represents about 1,000 Eastern Washington residents who work in trades.

“This is viable jobs for the Newport area,” Holstrom said. “We’re interested in the jobs going union so we can uphold strong safety standards and prevailing wages.”

“This is the first review,” he added. “When they do the ecological study, the science will come out about the impact of the smelter.”

But the crowd was mostly skeptical. A number of speakers expressed concern about the smelter’s effect on property values, withdrawal of groundwater from the Little Spokane River watershed for the plant and air emissions.

According to a consultant’s report, the smelter could emit up to 766,000 tons of greenhouse gases annually, which would rank the smelter among the state’s top 15 carbon emitters. Company officials, however, say the silicon’s eventual use in solar panels would offset the greenhouse gas emissions. The smelter would also release nitrogen oxides, carbon monoxide and sulfur dioxide – components in smog and acid rain.

“I’m not someone who comes out to protest things, but it’s not a good situation,” said Dr. Renata Moon, a Spokane pediatrician.

Industrial pollutants have an outsized effect on children, the elderly and people with chronic lung and heart conditions, she said. With kids, “their lungs are still developing,” she said.

The Kalispel Tribe also opposes the smelter. Last year, the tribe’s council asked Gov. Jay Inslee to rescind the $300,000 state grant and work with the Kalispels on other types of economic development for the area.

“If Ecology chooses to move forward, you must do a very robust (environmental review),” Deane Osterman, executive director for the tribe’s natural resources department, told state officials.

The smelter proposal is “ill-defined,” lacking critical information that would allow the tribe and the public to provide meaningful input, he said.

The review must address human health, the deposit of air pollutants on the forest and local lakes, and the smelter’s effect on tourism in northeast Washington, Osterman said.

Public meetings on the smelter continue this week in Newport and Priest River.

Written comments will be accepted through Oct. 26.

Report to the Joint Standing Committee on the Environment and Natural Resources

Annual Product Stewardship Report

January 2019

Contacts

Paula Clark
Director, Division of Materials Management
207-287-7718
paula.m.clark@maine.gov

Carole Cifrino
Supervisor, Recycling Programs
207-485-8160
carole.a.cifrino@maine.gov

MAINE DEPARTMENT OF ENVIRONMENTAL PROTECTION
17 State House Station | Augusta, Maine 04333-0017
www.maine.gov/dep

https://www.maine.gov/dep/contact/staff-directory.html

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I. Introduction

This is a report on the current implementation of product stewardship laws in the State of Maine, and opportunities for new product stewardship initiatives and improvements to existing programs to help achieve Maine's waste reduction and recycling goals. Product stewardship is a policy approach that can be used by governments and businesses to minimize the negative impacts of products and packaging throughout their lifecycle. Manufacturers (a.k.a. producers) have the greatest ability to affect the life-cycle impacts of products, with distributors, retailers and consumers also having a role. Extended producer responsibility (EPR) is the term used to describe laws that mandate responsiblities for manufacturers in the end-of-life managment of their products.

Maine currently has 9 laws related to the end-of-life management of specific consumer products that may be considered to be product stewardship laws. Additionally, in 2009 Maine enacted 38 M.R. S. Chapter 18, *Product Stewardship*, which sets a framework of elements to be included in new product stewardship programs (as well as the requirements for this annual report to the Joint Standing Committee on the Environment and Natural Resources). The Department is recommending statutory changes to the *Product Stewardship* framework law and to 4 of the product-specific laws to improve program performance and/or create efficiencies in implementation:

- **Framework law.** 38 M.R.S. Chapter 18, Maine's *Product Stewardship* "framework law" delineates required components for new EPR programs at *38 M.R.S. § 1776, Product Stewardship Program Requirements*. Based on Maine's experience in implementing its great variety of EPR laws, it is now apparent the framework law does not include adequate provisions to ensure implementation of effective programs. The department is proposing additions to the framework law to address these deficiencies.

- **Mercury lamps**. 38 M.R.S. § 1672, Maine's *Mercury-added lamps* law, requires manufacturers to establish and operate a recycling program for mercury-added lamps (fluorescents and HIDs) generated by households (see section 4 of the law). This law was enacted prior to the program component requirements in the *Product Stewardship* framework law. The resulting program has consistently underperformed, with recycling rates never exceeding 13%. Revising this law to address all required components for new product stewardship programs will help drive better program performance.

- **Beverage containers**. Maine's Bottle Bill, 38 M.R.S. Chapter 33, *Manufacturers, Distributors, and Dealers of Beverage Containers*, (originally enacted in Title 22 in 1976) establishes responsibilities for the collection and recycling of most plastic, metal and glass beverage containers sold in the state. During 2018, the Legislature's Office of Program Evaluation and Government Accountability (OPEGA) completed a review of this program. The report resulting from this review (http://legislature.maine.gov/doc/2316) includes a number of recommendations requiring legislative consideration. These include: comprehensive data reporting to assess program performance and inform policymaking; clarification of BABLO's commingling status and expectations for unredeemed deposits; opportunities to improve program design; and clarification of the intended benefits of commingling and updates to maximize its impact. The

Department is recommending changes to address many of the issues identified in the OPEGA report.

- **Dry-cell mercuric oxide, rechargeable nickel-cadmium, and rechargeable sealed lead acid batteries**. 38 M.R.S. § 2165, *Regulation of certain dry-cell batteries* (enacted in 1991) requires manufacturers of certain battery types to provide a system for the recycling of their batteries from certain users. The Department recommends that this law be repealed and replaced with an EPR law covering all consumer battery types.

- **Cellular telephones**. 38 M.R.S. § 2143 Maine's Cellular telephone recycling law requires retailers to accept, at no cost, used cell phones at retail locations, and annual reporting by cellular telephone service providers on their recycling efforts in Maine. The Department recommends repeal of the reporting requirement as the data reported reflects only a portion of cell phone recycling so is not useful for assessing program performance.

The department is not recommending statutory changes to these other currently-implemented programs:

- **Electronic waste (e-waste)**. 38 M.R.S. § 1610, Maine's *Electronic Waste* law, was initially enacted in 2003 to manage TVs and other electronics with video displays greater than 4" diagonally from households only. It was subsequently amended to add game consoles and desktop printers and to manage the covered electronics from small businesses (100 or fewer employees) and K-12 schools.

- **Mercury auto-switches**. 38 M.R.S. § 1665-A, Maine's *Motor Vehicle Components* law, set up a system by-which motor vehicle manufacturers pay for the collection and proper disposal of mercury auto-switches as the vehicles containing them are removed from service.

- **Mercury thermostats**. 38 M.R.S. § 1665-B, Maine's *Mercury-added Thermostats* law requires that manufacturers that sold mercury-added thermostats into the state pay for the collection and disposal of mercury-added thermostats and to provide a financial incentive with a minimum value of $5 for the return of each mercury-added thermostat to an established recycling collection point.

- **Architectural paint**. 38 M.R.S. § 2144, Maine's *Stewardship Program for Architectural Paint* law requires that manufacturers establish and maintain a statewide system to collect, transport, recycle and process post-consumer paint.

- **Plastic bags.** 38 M.R.S. § 1605, *Plastic bags; recycling* law requires retailers that use plastic bags to have a receptacle within 20 feet of their store entrance to collect used plastic bags and to ensure the bags are collected.

Additionally, the report includes discussion of other products that may warrant future legislative consideration as candidates for new EPR programs, including:

- Packaging
- Pharmaceuticals
- Mattresses
- Carpet
- Solar panels

II. Background

Product stewardship is a policy approach that can be used by governments and businesses to minimize the negative impacts of products throughout their lifecycle. Manufacturers (a.k.a. producers) have the greatest ability to affect the life-cycle impacts of products, with distributors, retailers and consumers also having a role. Extended producer responsibility (EPR) is the term used to describe laws that mandate responsiblities for manufacturers in the end-of-life managment of their products.

A. Basic components included in Maine's Framework law

38 M.R.S. § 1776, *Product Stewardship Program Requirements* delineates the basic components for new EPR programs. These include:

- Identification of participating entities, and their roles and responsibilities
- Identification of covered product(s)
- Convenient and adequate collection system, including no fee at collection
- Effective education and outreach
- A sales ban on products from non-compliant manufacturers
- Immunity from antitrust liability for participating manufacturers
- Requirements for the program plan, including management standards and submittal of the plan for review and approval by the Department
- Program performance goals
- Program performance monitoring and assessment
- A financing mechanism to fund "collection, transportation and reuse, recycling or disposition of the relevant product"
- A mechanism for amending the approved program

Based on the Department's experience with implementing EPR programs to date, a program plan designed only to meet the basic requirements in the *Product Stewardship* framework law will not be guaranteed to be successful, i.e., it has a good likelihood of not achieving substantial collection rates. Most notably, the *Product Stewardship* framework law does not include meaningful standards for program performance, any mechanism for the Department to require program improvements or improved program performance, nor any reporting or oversight agency review of annual program budgets.

B. Additional elements of successful EPR programs

Based on experience in Maine and elsewhere, there are certain elements that contribute to an EPR program achieving high rates of diversion from disposal. The following elements are key to achieving high collection rates but currently are not included in Maine's *Product Stewardship* framework law.

1) Minimum standards for producers' or stewardship organization staffing, e.g., a minimum ½-fulltime equivalent (FTE) to recruit, train and monitor collection sites. For example, the PaintCare program has employed 1-FTE to perform these functions for its program in Maine and Vermont since the inception of their program. This level of staffing has ensured that collection sites receive the support they need to safely and adequately implement the program as confirmed by Department staff field visits.

2) Adequate financing for implementation and operations, including funding for regulatory oversight. Payment into the system to finance end-of-life management must be sufficient to cover materials management costs, consumer and collection site education, a minimum ½-FTE per stewardship program assigned to implement the program in Maine, on-going program evaluation and reporting, government oversight, and any incentives for collection.

3) Minimum program standards for education and outreach to collection sites and to consumers, and on-going evaluation of the effectiveness of education and outreach efforts. No program can be successful without collection site staff and consumers knowing about the program and how it works. Staff turnover at collection sites (often retailers and/or solid waste facilities) is ongoing, as are changes in residents in Maine. Evaluation of education and outreach efforts identifies which initiatives are most effective, and where additional focus is needed. Manufacturers can use the information gained to achieve cost-effective continuous improvement in their programs.

4) Measurable, enforceable goals (e.g., recycling rate, consumer awareness, convenient collection), and defined consequences for non-compliance. When manufacturers are responsible for paying for the recycling of collected products, they have a disincentive to collect or to promote the existence or ease of use of a collection system. Minimum standards for locations of collection sites along with a ban on fees at collection are critical to counteracting the financial incentive manufacturers have to discourage consumer participation. Repercussions for insufficient performance or non-participation on the part of manufacturers must be practical to implement. The Department must have the authority to direct program changes if the program fails to make sufficient progress toward achieving program goals.

5) Financial incentives for collection site participation and for consumers to return products to collection sites. Successful programs provide an incentive for collection to either consumers or third-party collection agents or both. Collections in Maine's mercury thermostat recycling program increased significantly when the $5 incentive was implemented, and again when a $10 incentive was offered for a limited period of time. A similar jump in collections was

achieved in Maine's mercury auto switch recycling program when the $4 incentive to collection sites was implemented. Maine's Bottle Bill program consistently achieves the highest return rate, with consumers motivated by the deposit/return payment system.

III. Recommendations for changes to existing EPR laws

Based on reviews of Maine's 10 product stewardship laws, the performance of each of the implemented programs and the staffing resources needed to provide adequate oversight, the Department is recommending changes to 5 of these laws.

A. Framework law – 38 M.R.S. chapter 18

As discussed in section II.B above, there are significant deficiencies in the framework law that would allow for approval of a manufacturer program plan which would not result in an effective program. The framework law does not include adequate program performance standards and does not provide the department with the authority to require changes in programs that fail to achieve adequate progress toward the program goals. Legislation to address these deficiencies is included as Appendix A.

B. Mercury lamps – 38 M.R.S. § 1672

Program description: The manufacturer requirements for recycling of mercury-added lamps (fluorescent, neon, black lights, UV, and high intensity discharge - HID) from households are implemented by the National Electrical Manufacturers Association (NEMA) on behalf of the manufacturers. NEMA's program provides free containers, shipping and recycling services to voluntarily participating retail and municipal collection sites. The program also does some outreach to let consumers know about the program.

Figure 1:
NEMA's Household Mercury-added Lamp Recycling Rates

	# NEMA collection sites	# Lamps recycled by NEMA	# Lamps available for recycling	NEMA recycling rate
2011	149	6,634	688,000	0.96%
2012	263	50,492	708,889	7.12%
2013	293	97,743	844,576	11.57%
2014	300	109,337	1,042,750	10.49%
2015	307	135,035	1,127,500	12.00%
2016	270*	151,434	1,344,991	11.26%
2017	244*	181,255	1,456,902	12.44%
Total		**731,930**	**7,213,608**	**10.15%**

*Approximately 150 sites sent lamps for recycling in 2016 and 2017

Current performance: Through its product stewardship program, NEMA collected and recycled 181,255 mercury-added lamps out of the estimated 1,456,902 mercury-added lamps available for collection in Maine in 2017. The recycling rate, i.e., the percentage recycled of lamps estimated to be at end of life, has been consistently low for the duration of the program, with an average recycling rate of 10.15%[1].

NEMA's methodology to determine the number of lamps expiring each year utilizes national sales data and lamp life averages for HID, linear fluorescent and compact fluorescent lamps. This information provides a denominator used to calculate an overall recycling rate. NEMA does not provide the actual numerical data for these calculations, which could be used to calculate separate recycling rates for each type of lamp and determine if certain lamps are being recycled at lower rates than others, allowing for more targeted outreach. In addition, NEMA does not provide the Department with the estimated amounts of mercury recovered or available for recovery each year. Lamp mercury content varies significantly, ranging from 0.01 milligrams to 1,000 milligrams.

Figure 2: Amount of mercury collected by the NEMA program compared to that which was not collected

	Low end mercury estimates (lbs.)		**High end mercury estimates (lbs.)**	
Year	NEMA collections	Available to collect	NEMA collections	Available to collect
2015	3.03	25.22	10.27	85.55
2016	2.79	24.89	8.40	72.59
2017	3.54	29.11	10.72	88.16
Total	**9.36**	**79.22**	**29.39**	**246.30**

Lamp companies selling in Maine report data on their mercury per unit and total mercury amounts to the Interstate Mercury Education & Reduction Clearinghouse (IMERC). The IMERC database provides the best available data to estimate lamp mercury content, with ranges for average mercury content in lamps sold by type as well as the percent of lamps that contain a specified range of mercury. For example, 27 percent of fluorescent lamps contain more than 10 but fewer than 50 milligrams of mercury. This data allows the Department to calculate low and high end estimates of how much mercury is recovered. If one assumes that lamps are returned through the NEMA program in the percentages in which they are available in the waste stream, it is also possible to estimate potential mercury recovery. While the Department does not have data on the NEMA lamp collections by lamp type prior to 2015, recent data highlights the significant amount of mercury not being recovered from waste lamps.

NEMA has failed to consistently implement the approved plan or take timely actions to improve program performance as proposed in its annual reports. The Department has noted multiple instances of poorly handled program operations, characterized by a lack of communication with participating collection sites and the Department, a lack of effort to make any substantial program improvements in response to Department requests, and a marked lack of resource allocation to ensure the program functions successfully. The lamp law requires that NEMA provide "effective education and outreach, including, but not limited to, point-of-purchase signs and other materials provided to retail establishments without cost." Beginning in 2016, NEMA eliminated their budget allocation for staff, and in 2017 NEMA reduced "Program and Administration" costs by 43%. As the entity that must pay for each bulb recycled, NEMA has an economic disincentive to effectively

[1] If 2011 data is excluded due to lower collections during program implementation, the average recycling rate is 10.81%

advertise the recycling program. Recovery of mercury-added lamps could be increased through improved public education and outreach and through ensuring convenient collection.

Recommendations: Title 38 § 1672, Maine's *Mercury-added lamp* law, was passed prior to Maine's Product Stewardship Framework law and is, in many ways, inconsistent with the framework. This statute should be revised to better align with the Framework and with more recent, successful product stewardship programs implemented in Maine. Included as Appendix B is legislation that if enacted would accomplish the following:

1. Incorporate the standard definition of "covered entities" rather than limiting participation to households. All references limiting participation to "households" and "residents" would change to "covered entities" and the definition of "covered entities" consistent with that in §1672(1)(E).
2. Establish convenience standards with distribution goals to ensure access to collection sites in rural and urban geographic areas throughout the State.
3. Establish a minimum standard for producer or stewardship organization staffing of ½-FTE to ensure adequate personnel resources to recruit, train and provide on-going in-person technical assistance to collection sites.
4. Strengthen requirements for education and outreach.
5. Establish goals for consumer awareness of key program information.
6. Strengthen data requirements for annual reporting.

C. Consumer batteries – 38 M.R.S. § 2165

In 1991, Maine enacted Title 38 § 2165, *Regulation of certain dry cell batteries*, which requires manufacturers of nickel cadmium and small sealed lead acid batteries to provide recycling services for these batteries at no cost to government agencies, and industrial, communications and medical facilities. In response to this and similar laws enacted by other states in the early 1990's, U.S. battery manufacturers established the Rechargeable Battery Recycling Corporation (RBRC) in 1996. This program, now known as Call2Recycle, offered a free rechargeable battery recycling program to any interested business, government entity and retail location interested in acting as a collection location until mid-2017. Due to increases in "free riders", i.e., collection of batteries from primary (single-use) and rechargeable battery manufacturers that do not financially support Call2Recycle, Call2Recycle now limits participation in its free rechargeable battery recycling program to municipal collection sites and businesses only as required by state laws. The Call2Recycle program is also incurring new operational costs for redesigning their collection boxes with fire retarding properties and for training of collection site staff in management to prevent fires caused by improper management of lithium and lithium-ion batteries. Note that Maine's current rechargeable battery recycling law does not include lithium or lithium-ion batteries, new chemistries placed into the market subsequent to the law's enactment.

Lithium ion batteries improperly disposed of in the household trash or recycling pose a significant fire risk. The batteries are prone to short circuit and explode if dropped, punctured, or dented, any of which can easily happen during collection or processing at a traditional waste and recycling facility[2]. This danger has been made evident by the increasing number of Materials Recovery Facility (MRF) fires in recent years attributed to lithium ion batteries, including two at ecomaine's Portland facility in 2017[3]. Lithium ion battery use is growing at a rate of 1.63 batteries per person, per year[4]. Estimated costs to a MRF from such a fire depends on damages, but some have reported costs ranging from $8 to $10 million from a single lithium ion battery fire[5].

In 2016, Senator Saviello introduced an amendment to LD 1578, *An Act to Update Maine's Solid Waste Management Laws*, to establish an EPR program for small primary and rechargeable batteries of all chemistries. This proposal was developed by the battery industry[6], and supported by Call2Recycle, Duracell, and other representatives of battery manufacturers. Requiring all manufacturers of covered batteries to participate in a stewardship program would level the playing field by making all suppliers pay their fair share for the recycling of collected batteries. LD 1578 included several other sections affecting other aspects of solid waste management in Maine, and ultimately did not pass the Legislature.

Consumer batteries are a growing problem in Maine's waste stream. The battery industry estimates more than 28 million consumer batteries (single-use and rechargeable) are sold in Maine annually. Maine consumers frequently contact DEP staff asking how they can recycle their batteries. Fires caused by batteries in the waste stream are increasing, and the risk of fires continues to increase as the number of batteries discarded by consumers increases. For these reasons, the Department is proposing the Legislature consider the draft legislation included as Appendix C to establish an expanded product stewardship program for small primary and rechargeable batteries. Along with addressing the elements required in Maine's *Product Stewardship* framework law, this draft includes provisions from the industry-developed model presented in Sen. Saviello's 2016 amendment to LD 1578 as amended through the committee process as well as provisions added to address Maine retailers' concerns with the original proposal. The Department estimates that 0.5 new FTE would be needed to implement the proposed expanded program.

D. Container redemption ("Bottle bill") law – 38 M.R.S. chapter 33

Maine's *Manufacturers, Distributors, and Dealers of Beverage Containers*, a.k.a. the "Bottle Bill" law was enacted in Title 22 in 1976, with the resulting beverage container redemption program initially implemented in 1978 under the purview of the Department of Agriculture. The Legislature transferred responsibility for the program to the Department effective November 1, 2015. The Bottle Bill has resulted in a very successful collection program. Estimated recovery rates fall in the

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[2] See EPA: *Lithium Ion batteries in the solid waste system*. Michael Timpane, RRS.
[3] See Kennebec Journal: *Ecomaine fire shows why putting lithium-ion batteries in trash is a really bad idea.* December 21, 2017
[4] Ibid.
[5] See *How industry pros deal with fires at MRFs*, December 22, 2016: https://www.waste360.com/mrfs/how-industry-pros-deal-fires-mrfs and *Battery fires an 'existential' threat for industry*, April 10, 2018: https://resource-recycling.com/recycling/2018/04/10/battery-fires-an-existential-threat-for-industry/
[6] See *Testimony of Richard Abramowitz, Director of Communications and Government Relations, Duracell Before the Joint Standing Committee on Environment and Natural Resources,* February 17, 2016.

75 to 87% range[7] which, when compared to the national, overall recycling rate of 34%, is outstanding.

In May 2018, the Office of Program Evaluation and Government Accountability (OPEGA) completed a review of and report on the Bottle Bill program. The purpose of the review as stated in the report was to assess: "whether the program was operating as intended; the costs and offsets of the program for both the State and the initiators of deposit (IoDs); the degree to which risks of non-compliance, fraud, and abuse were mitigated in the program; and how the program compared to the management of beverage containers in other states."

The OPEGA report includes several recommendations for departmental and Legislative consideration to improve program implementation. In response to the recommendation that the department can implement without legislative action (Recommendation #3), the department has refined and documented its procedures for removing non-compliant products from sale and completed work with Maine Revenue Services (MRS) to better integrate the agencies' responses to instances of non-compliance. Additionally, in 2018 the Department focused on other initiatives to improve administrative processes, including the continued development and implementation of an on-line portal for manufacturers and distributors to register the labels on all products subject to the law. The information collected through product registrations is critical to apportioning responsibilities for recycling as well as handling fee and deposits payments to redemption centers.

Recommendation #1 in the OPEGA report provides the Department with responsibility for initiating legislation to require data reporting by all IoDs and by third party pick-up agents. Quality data can help improve effectiveness and efficiency in program administration, allow accurate quantitative assessment of program outcomes, and inform policymakers when making decisions about the program. Appendix D contains proposed legislation which would require IoDs to report the number of non-refillable beverage containers sold in the state and the number of non-refillable beverage containers returned by redemption value. Along with proposing new reporting requirements, this draft legislation also seeks to respond to additional issues noted in the OPEGA report and by the department during its 3 years of program oversight as follows:

- Reporting by third party pick-up agents on redemptions by IoD so that the department and MRS can verify self-reported redemptions by IoDs (see OPEGA Recommendation #1). This issue may be addressed by enacting a new subparagraph, § 3113 sub-6, as shown in Appendix D.

- The Bureau of Alcoholic Beverages and Lottery Operations (BABLO) is the IoD for all spirits sold in Maine, efficiently handing all spirits containers collected by redemption centers as a commingled group. However, the statutory criteria for approval inappropriately precludes BABLO from being categorized as a qualified commingling group (see OPEGA Recommendation #4). This issue may be addressed by enactment of the changes proposed in the last sentence of paragraph § 3106.7(C) as shown in Appendix D.

[7] Office of Program Evaluation and Government Accountability Report No. SR-BOTTLE -17, *Maine's Beverage Container Redemption Program–Lack of Data Hinders Evaluation of Program and Alternatives; Program Design Not Fully Aligned with Intended Goals; Compliance, Program Administration, and Commingling Issues Noted*, May 2018 (http://legislature.maine.gov/doc/2316)

- OPEGA identified several aspects of the law that impact redemption centers and/or retailers and that are outdated or of limited relevance to current program operations (see OPEGA Recommendation #5).

  When the Bottle Bill law was enacted, it required all beverage retailers (a.k.a. "dealers") to allow customers to redeem beverage containers of the brands, types and sizes sold by that retailer. Since that time, a network of redemption centers independent of retailers has developed across the state to manage all brands, types and sizes of containers. To reflect this reality and prevent circumvention of the limit to the number of redemption centers established in Title 38 § 3113 sub- 3, the Department is proposing to eliminate the required redemption responsibility for retailers with less than 5000 square feet of retail space as well as the limitations on the kind, size and brand of containers that must be accepted by retailers with more than 5000 square feet of retail space, and also to eliminate the exemption for food establishments from the limit on the number of redemption centers (which will be moot if the 5000 square foot exemption is enacted) [see proposed amendments to § 3106 sub- 1 and sub- 2, and § 3113(4)(B) respectively, as shown in Appendix D].

  Removal of provisions of the law which indicate redemption centers must have agreements to provide redemption services for dealers and only need accept containers of the kind, size and brand sold by those dealers eliminates the administrative burden on redemption centers and retailers of maintaining written agreements. It also addresses the issue of limitations on where consumers can redeem containers by eliminating these limitations. The end result of enacting these proposed changes will be that establishments that sell beverages but have less than 5000 square feet of retail space will not be required to redeem containers. Additionally, stand-alone redemption centers and dealers with 5000 or more square feet of retail space without an agreement with a stand-alone redemption center within 1 mile will be required to redeem all beverage containers included in the deposit/redemption program.

- The OPEGA report identifies on-going concerns by Bottle Bill program participants that the Department does not have a formal role or authority to impose consequences on redemption centers that routinely present bags holding fewer than the required number of containers to pick-up agents. In response to OPEGA's Recommendation #7, included in the proposed legislation in Appendix D, the Department is proposing an additional subsection in Title 38 § 3109 that adds an affirmative responsibility for redemption centers to package containers for pick up in a manner that ensures accurate unit counts of eligible containers. In addition, the Department is proposing to change the criteria in Title 38 § 3113 sub-2 from criteria for rule-making to criteria for licensing. These changes will enable the Department to implement standard compliance and enforcement procedures to check unit counts of containers readied for pick-up by redemption centers, and to refuse to renew the license of a redemption center based on its record of compliance.

- OPEGA's Recommendation #8 describes how the current commingling provisions in statute have become too restrictive to meet their original intent of minimizing the number of sorts that must be implemented by redemption centers. Due to the explosion of sizes and container types for beverages other than soda, beer, wine, and water, redemption centers must employ significant labor and maintain large storage areas to properly sort and store containers that are not included in commingling groups. To fully realize the efficiency benefits of commingling, the department recommends that the Legislature provide all IoDs with the opportunity to become part of a "catch-all" commingling group administered by a third party as delineated in proposed § 3107 sub-5 included in Appendix D. The third-party program could allow redemption centers to commingle containers by material type and allow assignment of responsibility by share of marketed weight, thus eliminating scores of sorts. In this system, manufacturers would pay redemption centers for an assigned portion of that container type proportional to their share of sales based on container weights. Such a system will significantly reduce redemption center costs for labor, as well as costs associated with the delay in receiving deposit reimbursements from the IoDs that results from the need to store containers of non-commingled brands for long lengths of time after paying out the deposits to consumers.

It is important to note that under the current law, only IoDs that do not participate in a commingling group are required to remit unclaimed deposits to the State. Recommendation #4 includes the suggestion that the Legislature consider amending the statute "to specify how unredeemed deposit funds should be processed and used by the State." This recommendation will become moot if the recommendation to create a "catch-all" commingling group is enacted and all IoDs opt to participate in a commingling group.

- Additionally, this draft legislation includes amendments to consolidate the rule-making provisions, to integrate the redemption center licensing fees into Title 38 subchapter 2, *Maine Environmental Protection Fund*, and to set the licensing fee at $100 consistent with the standards Title 38 § 352, *Fees* (see Section 1 of the proposed legislation in Appendix D). The current annual licensing fee is $50, which is not adequate to cover costs incurred by the department for application review and processing.

The department also recommends that the Legislature review Recommendation #6 in the OPEGA report to determine how the Legislature and the department should proceed to address the issues of program scope, deposit value, performance measurement, final disposition of redeemed materials and maximizing commodity values as identified by OPEGA.

E. Cell phones - 38 M.R.S. § 2143

Maine's cellular telephone recycling law (38 M.R.S. § 2143) requires retailers to accept, at no cost, used cell phones at retail locations, and annual reporting by cellular telephone service providers (i.e., carriers including Verizon, T-Mobile, USCellular, AT&T) on their recycling efforts in Maine. The Department recommends repeal of the reporting requirement as it does not provide useful data (see Appendix E for proposed statutory change). Many consumers return cell phones to entities that pay for them, so the data from the service providers cannot be used to assess program performance or determine a recycling rate. Also, each of the carriers provides information to their customers on the recycling programs they offer, often in support of social welfare causes. This information is readily available on their web sites.

IV. Candidate products for new EPR programs

Maine's Product Stewardship Framework law identifies the following criteria for evaluating product stewardship as a mechanism to facilitate recycling:

A. The product or product category is found to contain toxics that pose the risk of an adverse impact to the environment or public health and safety;

B. A product stewardship program for the product will increase the recovery of materials for reuse and recycling;

C. A product stewardship program will reduce the costs of waste management to local governments and taxpayers;

D. There is success in collecting and processing similar products in programs in other states or countries; and

E. Existing voluntary product stewardship programs for the product in the State are not effective in achieving the policy of this chapter.

Recycling is defined as "the transforming or remanufacturing of an unwanted product or the unwanted product's components and by-products into usable or marketable materials. 'Recycling' does not include landfill disposal, incineration or energy recovery or energy generation by means of combusting unwanted products, components and by-products with or without other waste."

Included here are several products that may be good candidates for EPR programs in Maine in the future. Some of these are products that previously have been the subject of some discussion in Maine, and EPR programs have been established for each of these products in other jurisdictions.

A. Product stewardship for packaging

A large portion of the current municipal waste stream is comprised of various types of consumer packaging. Much of it is not recyclable. Packaging that is readily recyclable has historically been managed to some extent through Maine's existing recycling system, which is a combination of public and private enterprises. However, shifts in international markets for recyclables during 2018 have shown the vulnerability of these programs to commodity price changes and the need for investment in recycling infrastructure. Stable funding provided by extended producer responsibility can prevent high municipal costs and diversion of these resources to disposal when material values drop, as occurred during 2018. [8] An EPR program for packaging also can provide incentives for producers to increase the recyclability of their packaging and to use packaging that is more valuable at end of

[8] The average value of a ton of single stream recycling in Maine, as tracked by the Maine Resource Recovery Association, fluctuated between a value of $20/ton to a cost of $30/ton between 2007 and 2017 before dropping to cost of more than $100/ton in 2018.

life, galvanize investment in Maine's recycling infrastructure, and relieve municipalities of much of the financial burden of dealing with this waste stream.

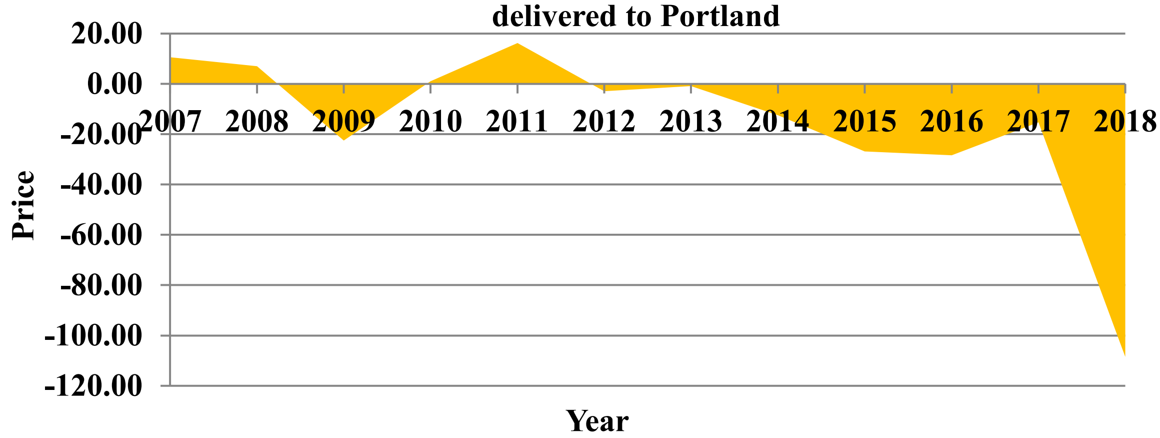
1) Packaging meets four candidate criteria for stewardship program

Product stewardship for packaging meets four of the five criteria outlined in the Framework Law – all but criteria A, products containing toxics.[9]

Criteria B: Increase the recovery of materials. Alleviating economic pressure on municipalities would prevent moves away from recycling caused by market downturns like that experienced during 2018. In addition, the incentives provided by product stewardship can help change the make-up of this stream. Currently, much packaging is not readily recyclable and therefore is destined for disposal. Examples of packages that are not practical to recycle include plastic pouches, multilayered materials, and packages made from commonly recycled materials like PET that can't be processed by the recycling system because of issues with their wrappers or shapes and sizes[10]. To support the development of a sustainable "circular economy", there is a need to design packaging with recycling in mind.[11]

Criteria C: Reduce the costs of waste management to local governments and taxpayers. Packaging is a large material stream, only part of which is readily recyclable. Packaging that is not readily recyclable is being disposed of as municipal solid waste. The portion of the stream that is readily recyclable can also be problematic. Although recycling of some packaging streams has long been promoted as a way to lessen the burden of waste management costs on municipalities or even as a money maker, recycling costs for packaging rose sharply in 2018 when China stopped accepting

Figure 3 - Average annual value of one ton of single stream recyclables delivered to Portland



[9] Nineteen states, including Maine, have laws governing toxics in packaging. For more information, see the Toxics in Packaging Clearinghouse website at https://toxicsinpackaging.org/ and Title 32 Chapter 26-A, Reduction of Toxics in Packaging.

[10] "APR Design Guide for Plastics Recyclability", The Association of Plastics Recyclers, https://plasticsrecycling.org/apr-design-guide/apr-design-guide-home

[11] *The New Plastics Economy – Catalysing Action*, Ellen Macarthur Foundation, 2017 https://www.ellenmacarthurfoundation.org/assets/downloads/New-Plastics-Economy_Catalysing-Action_13-1-17.pdf

bales of plastic and fiber recyclables due to contamination. Municipal transfer stations and the companies that manage these materials found themselves unable to move some materials or only able to do so at a cost. Single-stream programs increased their fees, [12] while source separated programs stopped recycling certain material types. The lack of data on packaging generation and municipal recycling and disposal costs makes price estimates of the amount of municipal resources spent handling packaging difficult to come by. That said, triangulating a variety of imperfect estimates can provide a rough idea of the amount of money spent.

- Using Maine tons of municipal solid waste generated in 2017[13] and applying percentages of packaging materials found in the University of Maine's 2011 study[14] characterizing the makeup of Maine municipal solid waste provides an estimate of the amount of packaging disposed of as waste in 2017. This method yields an estimated 177,000 tons of material. If Maine municipalities spent an average of $90/ton[15] to transport and dispose of this material during 2018, they spent approximately $16 million. This $16 million estimate understates the actual cost to municipalities of managing packaging because it does not include the cost of separated recyclables, i.e., it is only the cost of managing packaging material that is thrown out with household trash.

- Using statistics on average per capita generation of packaging from Europe[16] and subtracting the amount of material handled through Maine's Bottle Bill[17] provides an estimate of approximately 194,000 tons of packaging handled through Maine municipalities annually. Once again, assuming Maine municipalities paid $90/ton to handle packaging either as trash or as recycling

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[12] Data for Figure 3 courtesy of Victor Horton, Maine Resource Recovery Association, October 29, 2018, "Single stream spot market pricing paid in Maine delivered to Portland; for contract pricing add $2-5/ton"

[13] Maine Department of Environmental Protection, "Maine Solid Waste Generation and Disposal Capacity Report for Calendar Year 2017", January 2019, shows 721,646 tons of municipal solid waste generate in Maine in 2017.

[14] Criner, George; Blackmer, Travis; "2011 Maine Residential Waste Characterization Study School of Economics Staff Paper #601", available here: https://umaine.edu/wp-content/uploads/sites/2/2017/04/2011-Maine-Residential-Waste-Characterization-Study.pdf, studied samples of municipal solid waste in Maine and identified the components, by material type. Using the total percentage of plastics other than "durable plastic items"; the percentages of "tin/steel containers", "redeemable aluminum beverage containers", "non-redeemable aluminum beverage containers" in the metals category; the total percentage of glass other than the "remainder/composite glass" and "flat glass"; and the percentages of "uncoated corrugated cardboard/kraft paper" and "remainder/composite paper", and half of the percentage of "other recyclable" paper, we obtained an estimate of the percentage of Maine's municipal waste stream composed of packaging waste of 24.5%.

[15] There is not good data to support this number; tonnages of packaging resulting from each method have been provided so that municipalities can easily adjust estimates to reflect their costs. The Maine Department of Environmental Protection, "Maine Solid Waste Generation and Disposal Capacity Report for Calendar Year 2017", January 2019, reports that tipping fees for municipal solid waste were between $40 and $85 during 2017, which does not include the cost of transportation. Figure 3 of this report shows the average cost of single stream recycling delivered to Portland at over $100/ton in 2018.

[16] Eurostat, "Packaging Waste Statistics", https://ec.europa.eu/eurostat/statistics-explained/index.php/Packaging_waste_statistics show the average European generated 166.3 kg or 366.6 pounds of packaging in 2015.

[17] 51,808 tons of material or 77.3 pounds per person were recycled through Maine's Bottle Bill program in 2017, which would leave approximately 290 pounds of packaging per person handled through the municipal waste stream.

in 2018, the cost to Maine municipalities of managing packaging in 2018 was approximately $17.5 million.

- Using estimated costs in the Canadian province of Saskatchewan (which has 1.17 million people in 700 municipalities, 600 of which have fewer than 1000 residents), where the cost of handling packaging is around $14.5 million, annually[18] and prorating this cost for a population of 1.34 million yields an annual municipal cost of $16.6 million.

Criteria D: There has been success in other states or countries. **M**any European Union countries and five of Canada's provinces manage packaging through product stewardship programs. Years of successful implementation, per capita results, and municipal savings for each of the Canadian stewardship programs are presented below. Movement toward more sustainable packaging is hard to quantify based on available information, but there is an on-going pilot program in British Columbia testing the recyclability of flexible packaging collected at drop-off locations and there have been significant decreases in the use of plastic bags in Manitoba since the initiation of a government effort that has been facilitated by the Manitoba packaging stewardship organization.

Figure 4
Per capita results of Canada's five EPR for Packaging and Printed Paper Programs

PROVINCE	PROGRAM DURATION	PER CAPITA RESULTS	MUNI. SAVINGS	BOTTLE BILL MATERIAL*
Ontario	15 years	65 kg *recycled (2016)* **	Reimbursed 50% of recycling costs	Alcohol
Manitoba	9 years	71 kg collected (2017)	Reimbursed 80% of recycling costs	Beer
British Columbia	7 years	38 kg collected (2017)	Municipalities don't recycle	Non-milk
Quebec	5 years	93 kg collected (2017)	Reimbursed 100% of recycling costs	Beer and carbonated beverages
Saskatchewan	3 years	49 kg collected (2017)	Reimbursed 75% of recycling costs	Non-milk, non-nutritional supplements

*Bottle bill material is not collected through these programs so the breadth of a province's bottle bill influences the amount of material available for collection.
** Ontario's program reports on kg recycled per person, as opposed to kg collected; more material is collected than can be recycled. Ontario's most recent data is from 2016, not 2017.

Criteria E: Voluntary efforts are insufficient. Industry efforts to assist with the management of packaging include the Closed Loop Fund and The Recycling Partnership, which invest in recycling infrastructure and education at the national level. The city of Portland received a grant of $175,000 from The Recycling Partnership to help pay for new recycling carts in 2017.[19] The department is unaware of any other direct contributions by these organizations to recycling programs in Maine.

[18] Steven Dribnenki, Saskatchewan Recycling, November 28, 2018: Saskatchewan recently studied program costs and updated payments to municipalities, increasing them to $8.7 million, which covers approximately 60% of the cost of a "reasonably run" program.
[19] Harry, David, *The Forecaster*, "Portland set to roll out covered recycling carts", July 31,2017, http://www.theforecaster.net/portland-set-to-roll-out-covered-recycling-carts/

The Department estimates that 1 new FTE would be needed at the Department to oversee implementation of the program.

2) Key considerations in design of a packaging stewardship program

Maine's *Product Stewardship* framework law provides minimum requirements for new product stewardship programs. Review of the Canadian provinces' EPR programs for packaging reveals additional key aspects that should be considered when formulating legislation to establish a new packaging stewardship program. These include a) whether manufacturers are given complete financial and operational responsibility for establishing and maintaining recycling systems (full manufacturer responsibility) or share that responsibility with municipalities, and b) whether the enabling legislation includes incentives for the use of recyclable packaging and/or disincentives for the use of non-recyclable packaging.

a) Division of responsibilities between manufacturers and municipalities

Whether there is a division of responsibilities between municipalities and producers in packaging stewardship programs provides incentives for effective and efficient collection and recycling, streamlining of operations, and the free market economics of the recycling industry. Canada's existing product stewardship laws governing packaging differ in the level of financial and operational responsibility given to each group. For example, British Columbia assigns manufacturers full responsibility while Province Quebec implements a program of shared responsibility. If responsibilities are shared, legislation establishing the EPR system must delineate the division of financial and operational responsibilities.

Proponents of a system in which a producer organization has full financial and operational responsibility for recycling point to the opportunity for efficiencies that such a system provides. If one entity manages the recycling of all packaging (including control of the collection system), the collection system and educational programs can be standardized; fewer, larger contracts can be written to reduce administrative costs; and the single entity managing recycling has much more control over market price than do a larger number of smaller entities[20]. If managed well, the streamlining afforded by full producer responsibility for operations could lead to lower system costs, though the limited available data from North America does not show this to be the case.[21]

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[20] Recycle BC runs the only North American packaging stewardship program that gives producers responsibility for recycling operations. A common comment from local government stakeholders during the revision of Recycle BC's stewardship plan is that incentive payments made by the stewardship organization to collectors are insufficient. For instance, the City of Vancouver receives an incentive of $66 per ton for recycling collected for Recycle BC at its depots, while Recycle BC's own cost study pegs the per ton cost of recycling through a depot at $301 per ton. Because Recycle BC is the only buyer, it has a lot of power to influence the price. Data from, Recycle BC, "Consultation Report on Revised Packaging and Paper Product Extended Producer Responsibility Plan", October 2018.

[21] Recycle BC performed a cost comparison of pre-program costs (2012 data) and costs 5 years into the program (2017). This cost study uses a limited sample size but is the best data available to compare costs under a free-market vs. stewardship run recycling system. Results show that the range of kilograms of packaging diverted for recycling per household has shifted downward for both curbside and multifamily collections (from 48-270kg/household to 42-200kg/household using curbside and from 73-136 kg/household to 67-91kg/household using multifamily collection);

Proponents of a shared responsibility system cite the advantages of maintaining diverse recycling systems as the maintenance of free market forces in the industry and the avoidance of stranded investments in the existing system. Competition in a free market correctly sets prices, leads to innovation, and drives efficiency and effectiveness elsewhere in the economy. Distributed end-of-life management of post-consumer packaging also ensures that, once recycled, these resources are available at market prices rather than having the price controlled by a single entity.

Maintaining municipal control of recycling also minimizes disruption of current waste management, allowing municipalities to continue collecting and sorting material as they see fit and avoiding the stranding of investments and excessive consolidation in the recycling industry that may be experienced if operational responsibility for recycling of packaging was removed from municipal MSW management systems. This type of system design dovetails with Maine law that assigns each municipality responsibility for providing for management of MSW generated within the municipality (see 38 M.R.S. § 1305.1). However, in such a shared responsibility system, municipalities and their recycling service providers must be willing to share information with producers to ensure transparency in costs and accountability for ensuring materials are recycled.

Division of financial responsibilities: incentives for *efficient* collection and recycling. Careful division of financial responsibility in legislative design can promote efficient collection and recycling systems. If producers are financially responsible for the recycling of packaging yet municipalities have operational control of their recycling programs (i.e., producers pay municipalities for their costs of recycling packaging), system requirements should include incentives for municipalities to operate efficiently. Existing Canadian programs in which municipalities have operational control over recycling do this by tying municipal costs to producer costs, defining what constitutes an efficient program, and providing municipalities with extensive producer assistance. For example, defining reimbursable municipal costs as the average regional cost of municipal recycling rather than each municipality's actual costs results in municipalities with higher-than average costs bearing the cost of their premium operations. Conversely, municipalities with lower-than-average costs receive a premium for their efficient operations. This incentivizes cost-efficient municipal operations and dis-incentivizes premium operations.

The legislative design of a shared responsibility system can also promote efficiency by giving producers the ability to lower their program costs by managing their own recycling plans. Producers want, and should have, the opportunity to provide new or improved recycling options for their packaging (some producers already provide for recycling of their packaging). [22]

the change in quantity collected using depots is not reported. Cost data shows a 6% increase in cost per household for curbside collection, a 11% increase in cost per household for multifamily collection, and a 79% increase in cost per ton at depots. Cost savings were realized in the areas of education and administration (39% and 62%, respectively), but these costs make up a much lower percentage of total program costs than do the costs of collection ($1.50/household on education, $1.60/household on administration, $43/household on curbside collection, $23/household on multifamily collection, and $301/ton on depot collection). Data from, Recycle BC "Packaging and Paper Product Collection Costs Five Year Cost Study Refresh", June 8, 2018.

[22] Letter to Elena Bertocci, Maine DEP, from Calla Farna, Vice President Corporate Affairs, Canadian Stewardship Services Alliance, December 11, 2018.

Legislation can support the creation of new, and maintenance of current, producer recycling operations by providing producers the ability to offset their financial responsibility for material they place on the market by collecting and recycling that material through their own programs. For instance, every pound of plastic bags a producer collects may offset a pound of plastic bags it marketed and the amount the producer would pay into the system. If a producer collects as many pounds of plastic bags as it markets, it would not need to pay into the system. With this design, if a material is not being handled efficiently by municipal recycling programs, producers have the incentive and the ability to create an alternative management system.

Division of operational responsibilities: incentives for *effective* collection and recycling. In systems where municipalities are operationally responsible for recycling, when a municipality recycles more, it pays less for trash disposal. When combined with a system that incentivizes municipalities to recycle better as described above, municipalities have strong incentives to recycle as much material as possible, as well as possible.[23] Conversely, in systems where a producer or group of producers operate the only collection system, they pay more as their collection increases (other than when the material is worth more than the cost of processing and transportation). [24] In this case, the responsible entity (producer) has an incentive to collect as little recycling as is allowable under the law and to recycle only to the extent the law requires. A legislative design that maintains municipal control over municipal recycling operations incentivizes effective collection for recycling.

b) Incentives and disincentives to support the use of readily-recyclable packaging

Legislation establishing EPR for packaging should include incentives that promote the design and use of packaging that can be efficiently collected and reused or recycled. Whether the legislation requires full producer responsibility or establishes a shared responsibility system, it can incentivize the use of readily recyclable packaging by calibrating financial responsibility based on the cost to recycle the packaging material as well as the amount of packaging a producer sells into Maine. Producer costs for packaging that has a positive recycling value (taking into account the cost of processing and transportation) could be limited to simply providing support for consumer recycling education.

A shared responsibility system can be designed to provide producers with additional incentives to create new opportunities for recycling materials that currently are not readily recyclable. One

[23] Recycle BC runs the only North American packaging stewardship program that gives producers responsibility for recycling operations. The Recycle BC program is criticized for its extensive limitations on eligibility for participation. Local governments and First Nations note that collection could be expanded if Recycle BC would loosen population and process restrictions that prevent many smaller, more rural communities from participating. Complaints include an inability to drop off recycling even if a community that is not served by Recycle BC is willing to pay a hauler to bring its material to an existing Recycle BC depot. Recycle BC, "Consultation Report on Revised Packaging and Paper Product Extended Producer Responsibility Plan", October 2018.

[24] Recycle BC runs the only North American packaging stewardship program that gives producers responsibility for recycling operations. According to page 9 of its 2018 Packaging and Paper Product Extended Producer Responsibility Plan, "Recycle BC offers financial incentives to qualified collectors. These incentives are designed to provide collectors near-by with sufficient incentive to collect the amount of PPP required by Recycle BC to meet its targets." "Packaging and Paper Product Extended Producer Responsibility Plan", Recycle BC, October 2018 revision. As could be anticipated, considering the incentives and this statement, the program's recovery rate dropped in 2017 after passing the mandated minimum in 2016.

mechanism to accomplish this is to require producers to reimburse municipalities their costs of disposal for packaging materials that are not readily recyclable in Maine. This eliminates any incentive to switch recyclable materials packaging, which may carry a cost in the system, to non-recyclable. It also creates a financial incentive for producers to develop recycling processes and/or infrastructure to increase the types of packaging that are readily recyclable. For example, although systems do not exist today for recycling multi-laminate pouches, producers may help support the development of new recycling processes and the subsequent establishment of nearby infrastructure to make multi-laminate packaging readily recyclable in Maine.

B. Pharmaceuticals

A pharmaceutical product stewardship program meets four of the five criteria listed in the framework law – all but the criterion of increasing recovery of material for reuse and recycling. The most compelling of the criterion as relates to pharmaceuticals is the increasing evidence that, when not managed properly, they adversely impact the environment and public health and safety.

The public health argument for proper disposal of pharmaceuticals is strong. A 2015 study published in the U.S. National Library of Medicine, National Institutes of Health estimates that 2 of 3 prescriptions dispensed go unused.[25] Unused medications may be left sitting in medicine cabinets, where they contribute to accidental poisonings of children[26] and are available to potential abusers – in 2013, 18% of Maine high school students reported having misused a prescription drug during their lifetime and more than 1 in 3 Maine parents felt their teen would be able to access prescription medications at home without parental knowledge.[27]

Common disposal options like sending unused meds to landfills or through waste water treatment systems result in the release of these chemicals into the environment. A study of Seattle area seafood performed during the spring of 2018 detected opiates, antibiotics, anti-depressants, chemotherapy drugs and heart medications. Because shellfish lack the ability to metabolize these chemicals, they can be passed on to humans that consume them.[28] In addition, an Associated Press investigation found pharmaceuticals including antibiotics, anti-convulsants, mood stabilizers and sex

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[25] Law A.V., Sakharkar P., Zargarzadeh A., Tai B.W., Hess K., Hata M., Mireles R., Ha C., Park T.J. (2014, Oct 17). "Taking stock of medication wastage: Unused medications in the U.S." U.S. National Library of Medicine, National Institutes of Health.https://calpsc.org/mobius/cpsc-content/uploads/2015/08/Study-Taking-Stock-of-Medication-Wastage-Unused-Medicines-in-US-Households-2015.pdf

[26] Centers for Disease Control and Prevention, "Protect the Ones You Love: Childhood Injuries are Preventable", https://www.cdc.gov/safechild/poisoning/index.html

[27]Diomede, Tim. Maine Department of Health and Human Services. "SEOW Special Report: Heroin, Opioids, and Other Drugs in Maine". October 2015. https://www.maine.gov/dhhs/samhs/osa/data/cesn/Heroin_Opioids_and_Other_Drugs_in_Maine_SEOW_Report.pdf

[28] NPR. "Traces of opioids found in Seattle area mussels", May 25, 2018.

hormones in the drinking water supplies of at least 41 million Americans.[29] It is known that pharmaceuticals in the environment are having toxic effects on marine animals[30] and fish.[31]

The case for pharmaceutical takeback has been strengthened by the connection between prescription opioids and opioid abuse. This link led the legislature to enact, "An Act to Prevent Opiate Abuse by Strengthening the Controlled Substances Prescription Monitoring Program" in March of 2017. Since 2016, four states have enacted product stewardship laws for pharmaceuticals: Massachusetts and Vermont included extended producer responsibility requirements for pharmaceutical takeback as part of comprehensive legislation for the prevention of opioid abuse, while New York and Washington passed stand-alone product stewardship laws to fight prescription drug abuse.

In response to the opioid epidemic, a number of Maine entities have begun pharmaceutical takeback programs. Although these appear to be doing a good job and are free,[32] collection sites and events are limited, as is money to cover the costs of education, outreach, and collection. Establishing an EPR law for pharmaceuticals could guarantee on-going funding and provide for safe, convenient collection from consumers, extended care facilities, and medical service providers.

C. Mattresses

Mattresses meet all 5 criteria established in Maine's *Product Stewardship* framework law for evaluating products to determine whether mandated product stewardship will facilitate recycling (see criteria above and at 38 M.R.S. § 1772.2).

First, many mattresses contain organohalogen flame retardants (OFRs), including brominated flame retardants (BFRs). In September 2017, the Consumer Products Safety Commission (CPSC) issued a guidance document recommending producers to stop manufacturing mattresses containing OFRs and warning consumers to avoid products containing OFRs,[33] due to their potential toxicity. Maine law (38 M.R.S. § 1609) banned the sale of mattresses and mattress pads made with the "deca" mixture of polybrominated diphenyl ethers beginning January 1, 2008. Given these and similar governmental actions, the risk to public health and the environment from flame retardants in mattresses should decrease over time.

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29 Granite State Analytical Services, June 2018 Newsletter "Pharmaceuticals in Drinking Water"
30 Hernando M.D., Mezcua M., Fernandez-Alba A.R., Barcelo D. (2006). "Environmental risk assessment of pharmaceutical residues in wastewater effluents, surface waters and sediments." Talanta 69: 334-342.
31 Corcoran, J., Winter, M.J. and Tyler, C.R. (2010). "Pharmaceuticals in the aquatic environment: A critical review of the evidence for health effects in fish." Critical Reviews in Toxicology 40,4: 287-304
32 Current efforts include 59 permanent sites for collection from households only (medical and residential care facilities cannot utilize the current system). The permanent collection sites are located at police offices or sheriff's stations; they offer continuous collection then store pharmaceuticals until they can access free disposal provided by the USDEA National Takeback Days. Although Maine has just 0.4% of the country's population, Maine collected 3% by weight of total drugs turned in during the most recent national one-day USDEA event, including unwanted pharmaceuticals collected at 157 temporary collection sites.
33 *Guidance Document on Hazardous Additive, Non-Polymeric Organohalogen Flame Retardants in Certain Consumer Products*, Consumer Product Safety Commission, Federal Register / Vol. 82, No. 187 / Thursday, September 28, 2017 / Notices, (available at https://www.govinfo.gov/content/pkg/FR-2017-09-28/pdf/2017-20733.pdf)

Mattress recycling currently occurs in Maine on an ad hoc basis at a few solid waste facilities. In these cases, facility staff deconstruct mattresses into their wood, metal, foam and fabric components, then recycle the metal, manage the wood with other clean wood wastes, and send the foam and fabric for disposal. Although there are a few businesses that dismantle mattresses in southern New England, there are no such businesses in Maine.

Currently in Maine the vast majority of discarded mattresses are sent for disposal. The costs to municipalities for handling and transportation are relatively high compared to other waste streams due to their bulk; municipalities also bear the cost of disposal fees. Mattresses cause operational challenges for landfills in that they do not compress and have a tendency to "float" to the surface, potentially compromising cover systems.

Connecticut, Rhode Island and California have all enacted EPR laws for mattresses. The mattress recycling programs in these three states are administered by an industry-led nonprofit, the Mattress Recycling Council (MRC), with state government oversight. The program is funded by a visible fee that is levied on new mattress purchases, which is established based upon population distribution, geographic considerations, and other factors. MRC recently announced it has recycled more than 3 million mattresses in California. During the most recent fiscal year (July 1, 2017 – June 30, 2018), MRC recycled more than 180,000 mattresses, bring the total recycled in Connecticut since the program began in 2015 to almost ½ million. In its second year of operation in Rhode Island, the MRC program (known as "Bye Bye Mattress") collected 83,762 mattresses and recycled 1,645 tons of material.[34]

There are no existing voluntary stewardship programs for mattresses in Maine.

The Connecticut, Rhode Island, and California EPR programs all have significantly increased the diversion of mattresses from disposal to recycling. However, the fee per unit (a mattress and a box spring are 2 separate units) at sale in Rhode Island jumped from $11 to $16 within 2 years of program implementation (currently the fee is $9 in Connecticut and $10.50 in California). Given Maine's geographic size, low population, and lack of businesses to deconstruct mattresses, enacting a law with the same financing mechanism likely would result in a per unit fee at sale even higher than the $16 fee in Rhode Island. When the Legislature considered the bill to establish an EPR program for architectural paint, concerns were raised that a fee at sale may drive consumers to purchase products outside of Maine rather than in Maine. The higher the fee at sale, the more likely this consumer reaction may happen. Additionally, financing an EPR program fully on revenues collected from a fee-at-sale provides little incentive for manufacturers to design their products for recycling. Given these dynamics, an EPR system for mattresses funded at least partially through cost internalization may be most appropriate for Maine.

D. Carpet

Carpet meets four of the five criteria listed in the framework law for identifying stewardship candidate products – all but the criterion of toxics in the product. However, it is worth noting that

[34] This data and additional information on the 3 state programs are available through the Mattress Recycling Council's website at https://mattressrecyclingcouncil.org/programs/.

although carpets generally do not meet the toxin criterion, research shows that some carpets may contain brominated flame retardants,[35] which pose health concerns related to endocrine disruption, immunotoxicity, reproductive toxicity, and neurotoxicity.[36]

In 2002, the carpet industry, several non-governmental organizations (NGOs), the EPA, and 21 states including Maine signed onto a ten-year Memorandum of Understanding for Carpet Stewardship ("MOU") intended to support recycling of end-of-life carpet.[37] This MOU resulted in the establishment of the Carpet America Recovery Effort (CARE), which was formed to implement the MOU. Barriers to the implementation of a voluntary, market-driven carpet recycling program included a shrinking market share for the carpet industry in the flooring market and decreasing value of carpet due to substitution of lower-value materials such as PET (Polyethylene Terephthalate) for higher-value materials such as nylon.

The 2011 Product Stewardship report observed that "industry has not achieved the diversion and recycling goals set by the MOU," and although a stewardship program was not proposed at that time, the report was clear that "the need for product stewardship legislation may change if significant progress is not made by the industry to establish affordable carpet recycling in Maine." Since that time, minimal progress has been made with voluntary efforts to recycle carpet in Maine. Several states that signed the MOU have enacted or are considering carpet stewardship legislation; California became the first state[38] to enact a carpet stewardship law in 2010[39] and the New York Legislature is currently considering a carpet EPR bill.[40]

CARE acknowledges the lack of recycling availability on their website, which states, "There is no simple, routine method in place today to recycle old carpet. Each case is individual since there is no infrastructure to handle old carpet at this time."[41] A contributing challenge to widespread carpet recycling is that some types of carpet currently on the market are readily recyclable and some are not.[42] EPR has the opportunity to influence design by encouraging use of readily recyclable materials over those destined for disposal at end-of-life. While a real challenge exists for recycling low-value carpet made from materials that are not easy to recycle, the design of the carpet is a key factor. Manufacturers tasked with ensuring their products are recycled may be more likely to use high-value recyclable materials over low-value non-recyclable materials.

A product stewardship program for carpet will increase the recovery of materials for reuse and recycling and reduce the costs of waste management to local governments and taxpayers. For a

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[35] *Environmental concentrations and consumer exposure data for selected flame retardants (TBB, TBPH, TBBPA, ATO),* Consumer Product Safety Commission, 2015

[36] Gosavi RA, Knudsen GA, Birnbaum LS, Pedersen LC. 2013. Mimicking of estradiol binding by flame retardants and their metabolites: a crystallographic analysis. *Environ Health Perspect 121*(10):1194-1199.

[37] Other states include New Hampshire, Vermont, Massachusetts, Connecticut, Rhode Island, New York, New Jersey, Pennsylvania, Delaware, North Carolina, Tennessee, South Carolina, Georgia, Florida, Minnesota, Wisconsin, Iowa, Washington, Oregon, and California.

[38] *Carpet stewardship law*, California Department of Resources Recycling and Recovery (CalRecycle).

[39] *Chapter 20. Product Stewardship for Carpets,* California Legislative Information.

[40] *Bill Summary for S07147*, New York State Assembly.

[41] *FAQs, How can I recycle my old carpet?,* Carpet America Recovery Effort.

[42] *Carpet Fiber Types,* California Department of Resources Recycling and Recovery (CalRecycle).

successful program, it is important to incentivize reuse and recycling as well as the use of recycled content.

Adequate funding and resource allocation is essential to establish a functional and lasting program. California's EPR program is funded by a consumer fee upon sale, which has increased steadily over time from $0.05 per square yard to $0.25 per square yard[43] and will increase again to $0.35 per square yard as of January 2019.[44] During the public comment period for review and approval of CARE's 2017 carpet stewardship plan, dozens of negative comments were submitted over continued fee increases, many from flooring businesses concerned with the impact consumer fee increases were having on their carpet sales, business, or livelihood.[45] As with mattresses, Maine's large geographic size, low population, and lack of businesses to recycle carpet make it likely that enacting a law with the same financing mechanism would result in a per square yard fee at sale even higher than the $0.35 fee in California. Additionally, financing an EPR program fully on revenues collected from a fee-at-sale provides little incentive for manufacturers to design their products for recycling. Given these dynamics, an EPR system for carpet funded at least partially through cost internalization may be most appropriate for Maine.

E. Solar panels

Product stewardship for photovoltaic (PV) solar panels meets all five criteria outlined in the Framework Law. There are no federal regulations to require solar panel recycling, nor are there any third-party or public recycling programs aside from "limited manufacturer take-back programs."[46] Recycling is generally motivated by either the value of raw materials or regulations that mandate recycling. Current technology makes it possible to extract or reuse approximately 80% of the solar panel materials.[47] By 2030, estimates suggest it will be technically possible to recover raw materials from waste solar panels sufficient to "produce approximately 60 million new panels, or 18 GW of power-generation capacity" with an estimated value of "up to USD 450 million (in 2016 terms)" and "by 2050, the recoverable value could cumulatively exceed USD 15 billion, equivalent to 2 billion panels, or 630 GW."[48] However, on an individual basis, there isn't "a large amount of money-making salvageable parts on any type of solar panel,"[49] and it is unlikely that sufficient economic motivation exists to support voluntary development of a robust collection and recycling network.

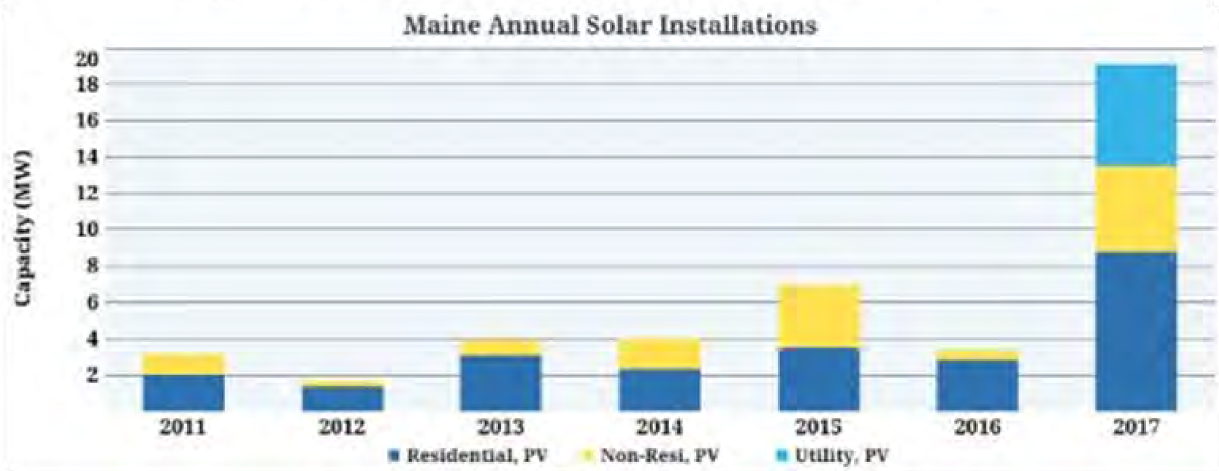
Approximately two-thirds of solar panels are crystalline-silicon (c-Si), made from 90% glass, polymer, and aluminum and silver, tin, and lead.[50] The remaining one-third of panels are thin-film, made from 98% glass, polymer, and aluminum with 2% copper and zinc and silicon semiconductor and may include indium, gallium, selenium, lead, and cadmium and tellurium in the form of

[43] *Public Notice: Consideration of Carpet America Recovery Effort's California Carpet Stewardship Plan 2018-2022.* California Department of Resources Recycling and Recovery (CalRecycle).
[44] *California Carpet Stewardship Assessment to Increase on January 1, 2019*, Carpet America Recovery Effort (CARE).
[45] *Public Notice: Consideration of Carpet America Recovery Effort's California Carpet Stewardship Plan 2018-2022.* California Department of Resources Recycling and Recovery (CalRecycle).
[46] Enbar, N. *PV life cycle analysis: Managing PV assets over an uncertain lifetime.* Electronic Power Research Institute, 2016
[47] *Ibid.*
[48] *End-of-life management: Solar photovoltaic panels.* IEA-PVPS Report Number: T12-06:2016
[49] "*It's time to plan for solar panel recycling in the United States*," April 2018, Solar Power World.
[50] *End-of-life management: Solar photovoltaic panels.* IEA-PVPS Report Number: T12-06:2016

cadmium telluride (CdTe).[51] Heavy metals in solar panels including lead, tin, and cadmium can pollute the environment and pose threats to human health when panels are not properly managed.[52] Landfill disposal poses risks as the panels may break and leach toxics into the soil[53] A recent PV life cycle analysis noted that decommissioning plans for solar sites are meant to include information on safe disposal for all materials, but plans "often don't specify what to do or how to do it."[54]

Solar panels have an average lifetime of 25-30 years.[55] Recycling of solar panels "was not a concern during their first 25 years of development," but early installations are now entering the waste stream in "considerable numbers."[56] Research modeling projects solar panel waste in the US may increase to between 170,000 to 1 million metric tons cumulatively by 2030 and to between "7.5-10 million tons in 2050."[57] The overall proportion of waste to new installations is expected to increase over time from an estimated 4-14% in 2030 and up to more than 80% in 2050.[58]

Figure 5: New installation of solar capacity in Maine over time



Currently, there are approximately 4,268 solar installations powering 6,568 homes in Maine.[59] Prices for solar installation have decreased by an estimated 43% over the last five years in Maine, and the number of installations increased sharply in 2017.[60] Solar panel-specific treatment standards and collection and recycling regulations are "crucial to consistently, efficiently and profitably deal with increasing waste volumes."[61] Given the lack of any solar panel-specific recycling program in Maine, municipalities are likely to face an increasing financial burden as solar panel waste increases. In the

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51 *Ibid.*
52 Xu, Y., Li, J., Tan, Q., Peters, A. and Yang, C. (2018). Global status of recycling waste solar panels: A review. *Waste Management,* 75, pp.450-458.
53 *Ibid.*
54 Enbar, N. *PV life cycle analysis: Managing PV assets over an uncertain lifetime.* Electronic Power Research Institute, 2016
55 Solar Energy Industry Association, *PV Recycling:* https://www.seia.org/initiatives/pv-recycling
56 *End-of-life management: Solar photovoltaic panels.* IEA-PVPS Report Number: T12-06:2016
57 *Ibid.*
58 *Ibid.*
59 Installations and table from "Maine solar data current through Q3 2018," Solar Energy Industries Association, 2018.
60 Installations and table from "Maine solar data current through Q3 2018," Solar Energy Industries Association, 2018.
61 *End-of-life management: Solar photovoltaic panels.* IEA-PVPS Report Number: T12-06:2016

US, the State of Washington has passed EPR legislation for solar panels. The legislation, passed in 2017, requires manufacturers to "finance the takeback and recycling system at no cost to the owner of the PV module" by 2021.[62] The law requires that the manufacturers' plan includes performance goals for "combined reuse and recycling of collected photovoltaic modules as a percentage of the total weight of photovoltaic modules collected, which rate must be no less than eighty-five percent."[63] The regulation was part of a larger solar incentives package and is expected to generate new jobs and businesses in solar panel recycling. New York's Legislature is currently considering a solar panel EPR bill.[64]

Proactively establishing EPR for solar panels will allow companies to internalize recovery costs into current production and sales. In addition, the increasing volume of PV waste may improve economies of scale over time.[65] Including incentives for design can also help minimize impacts on the environment and increase efficient use of resources for production, collection, and recycling.

V. Implementation status for Maine's other EPR programs

A. Electronic waste - [38 M.R.S. § 1610]

This law was amended by Maine's 128th Legislature to increase efficiency by reducing brand-sorting. These amendments required changes to the Department's rule governing electronics recycling; law and rule changes went into effect in August.

Because of these changes:
- historic manufacturers no longer register with the Department and are no longer billed for recycling costs;
- all recycling costs are distributed among current manufacturers according to a department determined recycling share that is based on national market share and adjusted to exempt small manufacturers and provide credit to manufacturers with environmentally preferable products and takeback programs;
- program payment structure no longer discourages refurbishment; and
- 3D printers have been added as covered products.

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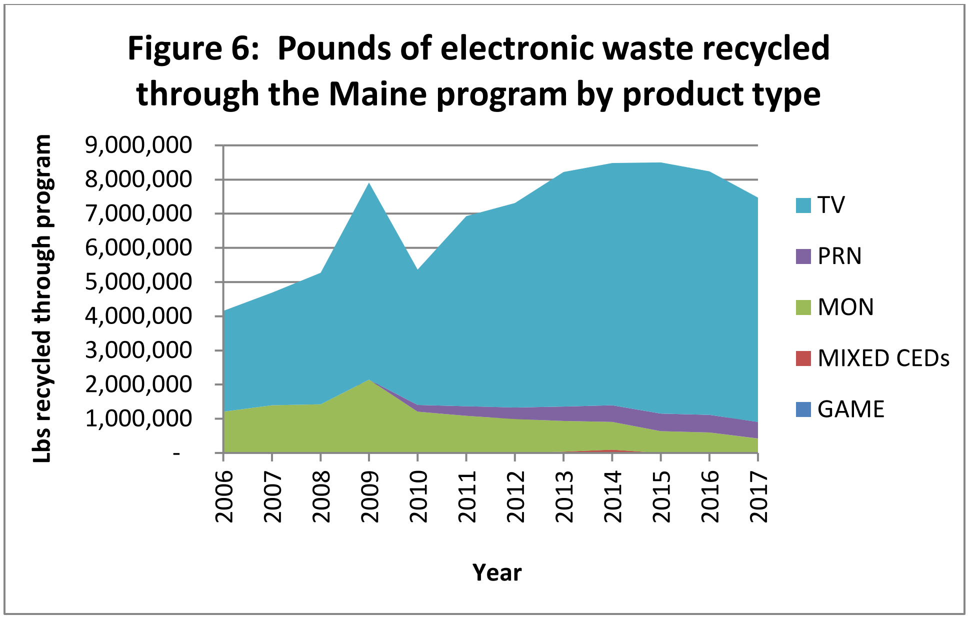
62 *'Information for manufacturers of PV modules'* Department of Ecology, State of Washington.
63 Chapter 70.355 RCW, *Photovoltaic Module Stewardship and Takeback Program*, Washington State Legislature
64 *Senate Bill S2837A*, The New York State Senate.
65 *End-of-life management: Solar photovoltaic panels.* IEA-PVPS Report Number: T12-06:2016



The question of appropriate product scope was also discussed during the legislative work session and was largely unaddressed by the change. Another change that was not made, though it was suggested by program consolidators during both the legislative work session and department rulemaking, was the increase or removal of the per pound cap of recycling costs that can be approved by the Department.

The department is undertaking an evaluation of the effectiveness of credits feeding into recycling share calculations and payments to consolidators for refurbishment, and gathering information on appropriate product scope and the sufficiency of the per pound cap on recycling payments set by department rule. Overall, e-waste collections continue to level off, likely due to light-weighting in the electronics industry.

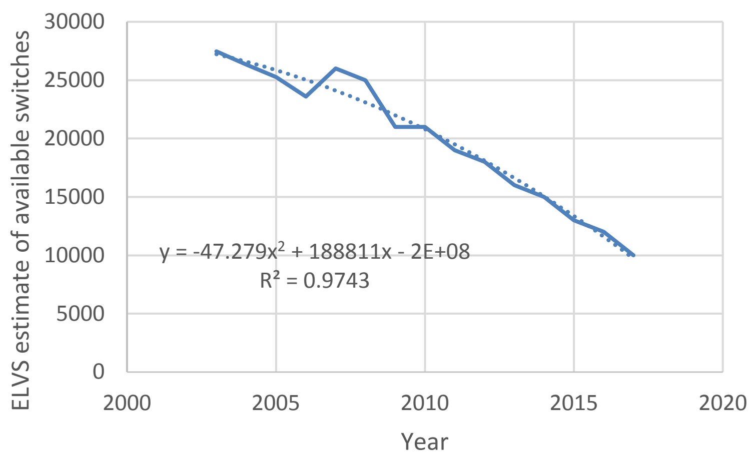
B. Mercury auto switches – 38 M.R.S. § 1665-A

There were no major changes in the implementation of this law in 2018. This program has been in place since 2003, so Department work mainly consists of telephone contact with previous participants to remind them of the need to collect switches and ensure they have materials and information they need to do so. Some work is still done to identify new participants using DMV Car Recycler records.

During 2017, Maine auto-recyclers collected 4448 switches containing approximately 9.8 pounds of mercury. This represents 44% of switches estimated to be available for collection and a more than 200% increase from 2016 collections.

The subsection of Chapter 16-B *Mercury-added products and services* that created this stewardship program also banned the sale of new vehicles with mercury-auto switches. As a result, the number of a switches available for collection is decreasing. Statute directs the department to recommend repeal of the program once the commissioner determines that the number of mercury switches available for collection is too small to warrant continued collection. The department is not recommending this action at this point.

Figure 7: Estimated switches available with trendlines for future calculation



Extrapolation of available switches using best fit trendline	
Year	Polynomic (best fit) trendline extrapolation of available switches
2018	8,000
2019	6,000
2020	4,000
2021	1,000
2022	-

End of Life Vehicle Solutions (ELVS), the non-profit entity that runs mercury auto-switch collection programs for auto manufacturers nationally, currently plans to end collection in states where switches are collected voluntarily in 2021. There are no available estimates of the number of switches available for recycling after 2017, but extrapolation of the estimates of switches available for collection in Maine from previous years suggest that after 2021, the number of available switches will be negligible. Actual collection amounts and information from automobile recyclers in the coming years can better inform the decision of when Maine's law should sunset but, barring the development of additional information to the contrary, 2021 may be the year.

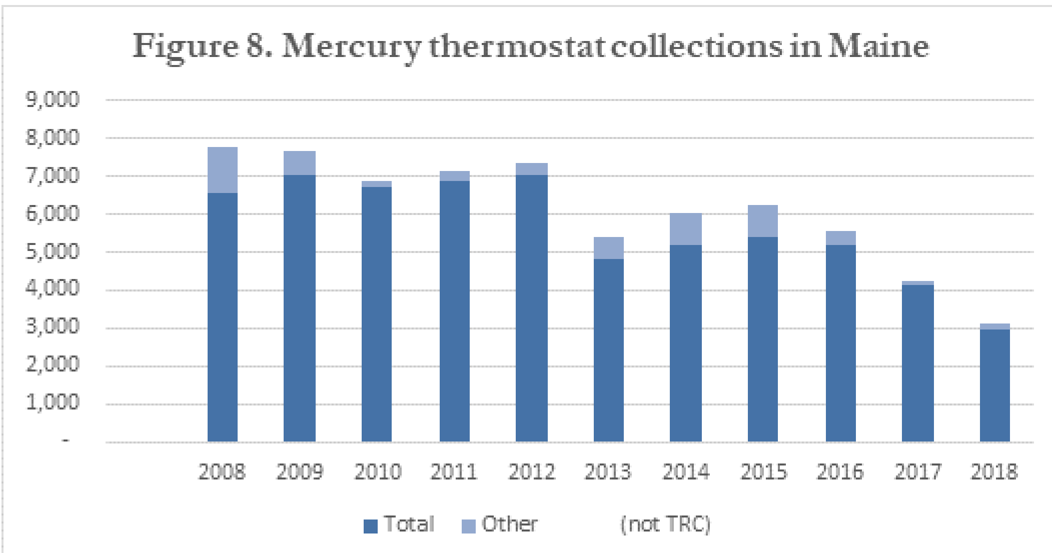
C. Mercury thermostats - [38 M.R.S. § 1665-B]

Program description: Maine's *Mercury-added Thermostats* law, 38 M.R.S. § 1665-B, enacted in 2005, established extended producer responsibility for the collection and recycling of mercury-added thermostats, and beginning in 2007 required a five-dollar ($5.00) incentive payment for each mercury thermostat returned.

Current performance: A total of 4,112 mercury thermostats were collected in 2017 (by TRC and through universal waste management), down from 5,190 in 2016 (3,973 by TRC and 139 through universal waste management). Preliminary data suggests TRC collections dropped to just under

3,000 mercury thermostats in 2018[66]. Since 2001, approximately 534 pounds of mercury has been recovered through thermostat recycling efforts in Maine, 86% of which was recovered through TRC's program.[67]

As was recommended in the *Implementing Product Stewardship in Maine* report submitted to the Legislature in February 2016, TRC simplified the manufacturers' financial incentive payment system for wholesaler and contractor locations. This new process was implemented throughout 2016 and 2017, and has received many positive comments from collection locations. Subsequent to the Department's 2016 report, TRC also made significant improvements to data access with a real-time reporting system that provides public access to TRC's current and historic mercury thermostat recycling data. TRC has been waiving its standard one-time $25 fee for a mercury thermostat bin to encourage participation, and has provided the Department with new promotional materials focused on the $5 incentive to distribute. In addition, TRC has conducted an annual round of site visits to 35-45 Maine collection locations that had not returned their mercury thermostat bin within the past year.



From 2007-2016, collections averaged roughly 5,200 thermostats per year, consistently at least 40% higher than rates achieved before the $5 incentive was implemented. However, collections declined over the past two years; by 18% in 2017 and by 25% in 2018[68].

TRC conducted national and regional advertising campaigns 2017, but campaign efforts that may have reached Maine residents did not contain information about Maine's program and the $5 incentive. However, TRC is currently ramping up its Maine-specific efforts and has been working with the Department to improve its education and outreach campaign in Maine. Statute requires that TRC provide an "analysis of program effectiveness" in its annual report. TRC provides a record

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66 Preliminary 2018 data is based on TRC's real-time reporting as of 12/28/2018.
67 Department staff recently reviewed all historic data provided by TRC. An average of 3.18 grams of mercury per thermostat was found and used in calculations for this year's report. In previous reports, an estimate of 4 grams per thermostat was used to calculate the total amount of mercury collected.
68 Preliminary 2018 data is based on TRC's real-time reporting as of 12/28/2018.

of year-to-year collections in Maine and nationwide as well as comparisons between state collections. These numbers do not account for the estimated number of thermostats available for collection, nor do they compare annual collections to the statutory performance goal of 160 pounds of mercury per year (equivalent to roughly 22,822 thermostats). TRC reported in 2017 that declines in mercury thermostat collections can be explained by the fact that production was phased out by 2007. However, mercury thermostats have a life expectancy of 30-50 years, although increasing options for energy-saving thermostats may result in early replacement.

The data show that millions of mercury thermostats were still being sold annually until the mid-2000s. In 2017, TRC reported collections of approximately 2.1 million mercury thermostats in its 20 years of operation, equivalent to 0.00002% of the mercury contained in thermostats sold in just the selective six years shown in the table below, which represent the time period during which mercury thermostats were phased out and sales were dwindling. It is unknown how many mercury thermostats have been collected through other programs or remain in use.

Without data upon which to base the claim that collections are dropping due to lack of available mercury thermostats, TRC and the Department do not have adequate information to assess the program's performance. The Department continues to recommend that TRC contract an independent third-party study to determine the expected annual outflow of mercury-added thermostats from Maine. The results of such a study would allow the Department to achieve a more accurate quantitative evaluation of program performance and better target efforts to improve collection rates, and could serve as a basis for adjusting statutory goals as appropriate.

Figure 9 - Total mercury sold in thermostats (pounds)[69]

Year	Pounds mercury	Estimated thermostats
2001	29,253	4,172,659
2004	28,901	4,122,449
2007	7,485	1,067,663
2010	32	4,564
2013	102	14,549
2016	0	0

D. Architectural paint. 38 M.R.S. § 2144

Program description: PaintCare is a non-profit third-party organization established by the paint manufacturers to fulfill their responsibilities under EPR laws in effect in 8 states and the District of Columbia. The costs of operating the PaintCare program are funded by a fee levied at the point of sale on paint.

Consumers may return unwanted architectural paint at no cost to participating retail and municipal collection sites, and to municipally-offered household hazardous waste (HHW) collection events that partner with PaintCare. PaintCare provides the collection sites with gaylords (boxes that are approximately one cubic yard in size) for collection and shipping of the paint, in-person training and a training manual, and education and outreach materials for customers. In addition, PaintCare's Program Manager visits each collection location throughout the state at least once annually.

[69] Table data is based on fact sheet: IMERC Mercury Use in Thermostats, 2015.

Current performance: PaintCare reports on a fiscal year (July 1 – June 30) basis. In FY 2018 (July 1, 2017 – June 30, 2018), PaintCare collected and processed 129,907 gallons of postconsumer paint, 76% of which was latex and 24% of which was oil-based. The program had a recycling rate of approximately 59% in 2017, an increase over the 2016 recycling rate of 50%.[70] 90% of the oil-based paint was used as fuel and 10% was recycled into new paint; the percentages of oil-based paint recycled was slightly higher than in the previous reporting period. 83% of the collected latex was made into recycle-content paint and 1% was used as fuel; 16% was unrecyclable and sent to landfills for disposal. These percentages were unchanged from the previous reporting period. In addition, 105 tons of consumer packaging, i.e., metal and plastic containers, were recycled.

PaintCare's analysis shows that its collection network provides a permanent collection site within 15 miles of 94.2% of Maine's population, exceeding the 90% goal set in statute. The current fees at sale are adequate to fund the program going forward in 2018, PaintCare established a separate subsidiary to operate the Maine program, keeping all funds collected in Maine for Maine program activity only.

In FY 2018, PaintCare reached out to housing authorities in Maine, ran Facebook online advertisements, conducted a print newspaper advertisement campaign, and provided pamphlets, posters, brochures, and other materials for collection sites. This advertising effort was noted to be limited due to budget constraints as PaintCare sought to make up costs incurred prior to program implementation. The program ended the fiscal year with a surplus of $270,717, and PaintCare has indicated that it will employ a variety of media activities to grow public awareness of the program, including television, radio, online and newspaper advertising, as program's financial health improves.

E. Plastic bags. 38 M.R.S. § 1605

Maine's "Plastic bags; recycling" law requires retailers that use plastic bags to have a receptacle within 20 feet of their store entrance to collect used plastic bags and to ensure the bags are collected. Rates of compliance with this "self-implementing" law are unknown. The Department does not have the resources to inspect retailers to assess compliance, but does provide technical assistance when complaints are received.

VI. Conclusion

Over the past 2 decades Maine and other jurisdictions in the U.S. and Canada have gained significant experience implementing mandatory product stewardship programs. In this report, the Department has applied lessons learned from this experience to recommend amendments to Maine's current laws to improve the effectiveness of existing programs in ensuring the safe handling of products containing toxics and in diverting materials from disposal. These "lessons learned" also can be used to inform discussions as Maine develops legislative proposals for new EPR programs. Given recent upheavals in recycling markets, an EPR program for packaging can help address the financial burden that municipalities bear in fulfilling their responsibilities for managing MSW while ensuring materials continue to be recycled. Additionally, pharmaceuticals, mattresses, carpet and solar panels are other products that present end-of-life management challenges that may be addressed by carefully-constructed EPR programs.

[70] Based on the estimate that approximately 10% of paint sold each year is left over.

Appendices

Appendix A – Proposed changes to Maine's Product Stewardship law

An Act to Improve Maine's Product Stewardship Law

Be it enacted by the People of the State of Maine as follows:

Sec. 1. 38 M.R.S. §1776, is amended to read:

A product stewardship program established for a product or product category designated by the Legislature for inclusion in a product stewardship program must be established and implemented in accordance with the provisions of this section.

1. Program. A producer selling a product in the State that is a designated product or that is in a designated product category is responsible individually, collectively or through a stewardship organization for the implementation and financing of a product stewardship program to manage the product at the end of the product's life in accordance with the priorities in section 2101.

A. The program must include a collection system that is convenient and adequate to serve the needs of covered entities in both rural and urban areas, including a permanent collection site within 15 miles of 90% of Maine residents within 1 year of the start of product collections unless the commissioner determines the 90% requirement is not practicable due to geographical constraints or that an alternative collection system will result in equivalent and more efficient collection.

B. The program must provide for effective education and outreach to promote the use of the program and to ensure that collection options are understood by covered entities.

C. A producer or stewardship organization, including a producer's or stewardship organization's officers, members, employees and agents that organize a product stewardship program under this chapter, is immune from liability for the producer's or stewardship organization's conduct under state laws relating to antitrust, restraint of trade, unfair trade practices and other regulation of trade or commerce only to the extent necessary to plan and implement the producer's or stewardship organization's chosen organized collection or recycling system.

D. The program must provide for a minimum ½-time emplouee of esch producer or stewardship organization dedicated to implementing the program in Maine.

2. Requirement for sale. One hundred eighty days after a product stewardship plan under subsection 5 is approved in accordance with subsection 8, a producer may not sell or offer for sale in the State the relevant product, unless the producer of the product participates individually, collectively or through a product stewardship program in accordance with an approved product stewardship plan.

3. No fee. A product stewardship program may not charge a fee at the time an unwanted product is delivered or collected for recycling or disposal.

4. Costs. Producers in a product stewardship program shall finance the collection, transportation~~, and~~ reuse, recycling or disposition of the relevant product, effective education and outreach, program assessment, reporting, any incentives necessary to achieve program collection goals, reasonable fees to the department for review of the program plan and any proposed amendments, and an annual fee to cover the actual costs for annual report review, oversight, administration and enforcement. The annual fee may not exceed $100,000 per year per stewardship program.

5. Requirement to submit a plan. Within one year of a product's or product category's being designated for inclusion in a product stewardship program, the relevant producer or stewardship organization shall submit a product stewardship plan to the department for approval. The plan must include:

A. Identification and contact information for:

(1) The individual or entity submitting the plan;

(2) All producers participating in the product stewardship program;

(3) The owners of the brands covered by the program; and

(4) If using a stewardship organization, the stewardship organization, including a description of the organization and the tasks to be performed by the organization. The description must include information on how the organization is organized, including administration of the organization and management of the organization;

B. A description of the collection system, including:

(1) The types of sites or other collection services to be used;

(2) How all products covered under the product stewardship program will be collected in all counties of the State; and

(3) How the collection system will be convenient and adequate to serve the needs of all entities;

C. The names and locations of recyclers, processors and disposal facilities that may be used by the product stewardship program;

D. Information on how the product and product components will be safely and securely transported, tracked and handled from collection through final disposition;

E. ~~If possible, a~~ A description of the methods to be used to reuse, deconstruct ~~or~~ and recycle the unwanted product to ensure that the product components are transformed or remanufactured to the extent feasible;

F. A description of how the convenience and adequacy of the collection system will be monitored and maintained;

G. A description of how the amount of product and product components collected, recycled, processed, reused and disposed of will be measured;

H. A description of the education and outreach methods that will be used to recruit, train and monitor collection sites, and to encourage participation by collection sites and consumers throughout the state on an on-going basis;

I. A description of how education and outreach methods will be evaluated, including at a minimum an annual consumer awareness survey to assess consumer knowledge about product management options and collection locations. The survey questions and methodology must be approved by the Department and the survey must be administered by a third party;

J. ~~Any~~ A description of how program performance will be assessed, including performance goals ~~established by producers or a stewardship organization~~ to show success of the program. When the performance goal is expressed as a recycling or diversion from disposal rate, the plan must include a description of the methodology and the relevant historic sales data used to develop the rate. The department shall keep sales information submitted pursuant to this paragraph confidential as provided under section 1310-B. The performance goals must include at least 50% of Maine residents having awareness in the third year of program implementation, or a recycling rate of at least 50% in the third year of program implementation and 80% in the sixth year of program implementation unless sufficient evidence is provided to justify alternative performance goals; ~~and~~

K. A description of how the program will be financed. If the program is financed by a per unit assessment paid by the ~~producer to a stewardship organization~~ consumer at the point of sale, a plan for an annual 3rd-party audit to ensure revenue from the assessment does not exceed the cost of implementing the product stewardship program must be included~~.~~, and

L. An anticipated budget for the program, broken down into administrative, collection, transportation, disposition, and communication costs. The annual budget must be sufficient to fund a minimum ½-time employee of each producer or stewardship organization dedicated to implementing the program in Maine, and funds to reimburse the department for its costs incurred in implementing the program. The budget must not include costs for legal fees or costs related to legislative efforts.

6. **Plan amendments.** Changes to an approved product stewardship plan may be initiated by the responsible manufacturers or by the department.

A. A change to an approved product stewardship plan by a manufacturer must be submitted to the department for review prior to the implementation of that change. If a change is not substantive, such as the addition of or a change to collection locations, or if an additional producer joins the product stewardship program, approval is not needed, but the producer or stewardship organization operating the program must inform the department of the change within 14 days of implementing the change. The department shall review plan amendments in accordance with subsection 8.

B. When the department determines that a product stewardship program has failed to make adequate progress toward achieving program goals, the department shall notify the responsible entities in writing of its findings and may direct the manufacturer to implement specific changes to the program plan within 6 months of the written notification. This may include the implementation of financial incentives or a deposit/refund system if appropriate for the product.

7. **Annual reporting.** By ~~February~~ March 1st of the calendar year after the calendar year in which an approved product stewardship program is implemented, and annually thereafter, the producer or stewardship organization operating the program shall submit to the department a report on the program for the previous calendar year. The report must include, at a minimum:

A. The amount of each product collected by collection site ~~per county~~;

B. A description of the methods used to collect, transport and process the product;

C. An evaluation of the program performance, including, if possible, diversion and recycling rates together with certificates of recycling or similar confirmations and an evaluation of the convenience of collection;

D. A description of the methods used for education and outreach efforts ~~and an evaluation of the convenience of collection~~ and the effectiveness of outreach and education. Every 2 years, the report must include the results of an assessment of the methods used for and effectiveness of education and outreach efforts. The assessment must be completed by a 3rd party;

E. If applicable, the report of the 3rd-party audit conducted to ensure that revenue collected from the assessment does not exceed implementation costs pursuant to subsection 5, paragraph K; ~~and~~

F. Any recommendations for changes to the product stewardship program to improve convenience of collection, consumer education and program evaluation; and

G. A financial report on the program, including: the total cost of implementing the program, as determined by an independent financial audit, including a breakdown of administrative, collection, transportation, disposition and communication costs; and an anticipated budget for the next program year.

8. **Department review and approval.** Within ~~20 business~~ 120 days after receipt of a proposed product stewardship plan, the department shall determine whether the plan complies with ~~subsection 5~~ this section. If the plan is approved, the department shall notify the submitter in writing. If the department rejects the plan, the department shall notify the submitter in writing stating the reason for rejecting the plan. ~~A submitter whose plan is rejected must submit a revised plan to the department within 60 days of receiving a notice of rejection.~~

Appendix B – Proposed changes to Maine's Mercury-added Lamp law

Be it enacted by the People of the State of Maine as follows:

Sec. 1. 38 M.R.S. §1672, is amended to read:

1. Definitions. As used in this section, unless the context otherwise indicates, the following terms have the following meanings.

…

E. Covered entity. "Covered entity" means a household in this State, a business or nonprofit organization in this State exempt from taxation under the United States Internal Revenue Code of 1986, Section 501(c)(3) that employs 100 or fewer individuals, an elementary school in this State or a secondary school in this State.

F. Proprietary information. "Proprietary information" means information that is a trade secret or production, commercial or financial information the disclosure of which would impair the competitive position of the submitter and which is not otherwise publicly available.

G. "Population center" means an urbanized area or urban cluster as defined by the United States Department of Commerce, Bureau of the Census to identify areas of high population density and urban land use with a population of 2,500 or greater.

Sec. 2. 38 M.R.S. §1672, is amended to read:

4. Manufacturer recycling programs for ~~household~~ mercury-added lamps. Effective January 1, 2011, each manufacturer of mercury-added lamps sold or distributed for ~~household~~ use by covered entities in the State on or after January 1, 2001 shall individually or collectively implement a department-approved program for the recycling of mercury-added lamps from ~~households~~ covered entities.

A. The recycling program required under this subsection must include, but is not limited to, the following:

(1) Convenient collection locations adequate to serve the needs of covered entities in both rural and urban areas ~~located~~ throughout the State where ~~residents~~ covered entities can drop off their ~~household~~ mercury-added lamps without cost, including but not limited to municipal collection sites and participating retail establishments;

(a) A method to determine the number and geographic distribution of lamp collection sites based on the use of geographic information modeling. By January 1, 2020 the program must provide that at least 90% of state residents have a permanent lamp collection site within a 15-mile radius of their residences, unless the commissioner determines that the 90% requirement is not practicable due to geographical constraints. If the commissioner determines the 90% requirement is not practicable, the commissioner may approve a plan that includes a geographic distribution of lamp collection sites that is practicable. The distribution of lamp collection sites must include at least one additional lamp collection site for each 30,000 residents in a population center that is located to provide convenient and reasonably equitable access for residents within the population center unless otherwise approved by the commissioner;

(b) Identification of the ways in which the program will coordinate with existing solid waste collection programs and events, including strategies to reach the State's residents who do not have a permanent lamp collection site within a 15-mile radius of their residences and to ensure adequate coverage of service center communities as defined in Title 30-A, section 4301, subsection 14-A;

(2) Handling and recycling equipment and practices in compliance with the universal waste rules adopted pursuant to section 1319-O, subsection 1, paragraph F, with subsection 6 if a crushing device is used and with all other applicable requirements;

(3) Provision of education and outreach efforts by the manufacturer to promote the program. The education and outreach efforts must include strategies for reaching consumers in all areas of the State and must ensure that collection options are understood by covered entities;

~~Effective~~ The education and outreach program~~, including, but not limited to,~~ shall, at a minimum, include posters, window clings, and point-of-purchase signs ~~and other materials~~ provided to ~~retail establishments~~ collection locations without cost~~; and~~ that can be prominently displayed and will be easily visible to the consumer, and outreach to the general public including annual web, print, and radio media campaigns in both rural and urban areas throughout the State.

(4) Goals for consumer awareness of the requirement to recycle mercury-added lamps and lamp collection locations, provisions for routinely evaluating the effectiveness of education and outreach efforts; and procedures for improving education and outreach efforts if goals are not achieved;

(5) A minimum ½-time employee of one or more manufacturers dedicated to implementing the program in Maine; and

~~(4)~~ (6) An annual report to the department which must, at a minimum, include the following information:

(a) ~~on t~~The number of mercury-added lamps recycled under the manufacturer's program and recommendations for program modifications to increase the percentage of discarded lamps recycled under the recycling program;

(b)~~, t~~The estimated percentage of mercury-added lamps available for recycling that were recycled under the program;

(c) ~~and t~~The methodology for estimating the number of mercury-added lamps available for recycling, which must include an assumption of the average life span by type of mercury-added lamp and number of lamps sold by type in the years on which the recycling calculation is based. If the manufacturer may designates this as proprietary information, the department shall handle this information in the same manner as confidential information is handled under section 1310-B ;

(d) A description of the methods used for education and outreach efforts and an evaluation of the effectiveness of ~~the recycling program, recommendations for increasing the number of lamps recycled under the recycling program~~ education and outreach. This must include a description of the methods used for measuring consumer awareness of the requirement to recycle mercury-added lamps, and every 2 years the results of an assessment of consumer awareness of the program completed by an independent third party;

(e) The location of and contact information for each collection point established under the program, and an assessment of the convenience of collection;

(f) Any recommendations for changes to the product stewardship program to improve convenience of collection, consumer education and program evaluation; and

(g) ~~and a~~An accounting of the costs associated with administering and implementing the recycling program;

…

~~F. The department may determine that a manufacturer's recycling program is in compliance with paragraph A, subparagraphs (1), (2) and (4) for the collection of compact fluorescent mercury-added lamps from households covered entities if the manufacturer provides adequate financial support for the collection and recycling of such lamps to municipalities and a conservation program established pursuant to Title 35-A, section 10110 and implemented by the Efficiency Maine Trust.~~

Appendix C – Proposed replacement for Maine's rechargeable battery recycling law

An Act to Establish Comprehensive Consumer Battery Recycling

Be it enacted by the People of the State of Maine as follows:

Sec. 1. 38 MRSA §1611 is enacted to read:

§ 1611. Stewardship program for small batteries

1. Purpose. It is the intent of the legislature that the cost associated with the handling, recycling, and disposal of used batteries be the responsibility of the producers and consumers of batteries, not the local government or their service providers, state government, or tax payers. These costs should be internalized at or before the point of sale.

Further, it is the intent of the legislature that materials in batteries be made available for use in new products and, therefore, that they should be recycled to the greatest extent possible. Battery stewardship in this state should incentivize the design and marketing of batteries and battery-containing products that are more recyclable, less hazardous, and, in general, more environmentally sound.

2. Definitions. As used in this section, unless the context otherwise indicates, the following terms have the following meanings.

A. "Approved product" means:

(1) A covered battery or a covered battery-containing product the producer of which participates in a battery stewardship program approved by the department; or

(2) A covered battery-containing product that has been listed in accordance with subsection 9 as the product of a participant in a covered battery stewardship program.

B. "Battery stewardship plan" means a plan submitted to the commissioner in accordance with subsection 3 by a producer or a battery stewardship organization.

C. "Battery stewardship program" means a system implemented for the collection, transportation, recycling, and disposal of covered batteries and/or covered battery-containing products in accordance with a battery stewardship plan approved by the Department.

D. "Brand" means a trademark, including both a registered and an unregistered trademark, a logo, a name, a symbol, a word, an identifier or a traceable mark that identifies a covered battery or covered battery-containing product and identifies as the producer of the battery or product the owner or licensee of the brand.

E. "Covered battery" means a new or unused primary battery or a small rechargeable battery.

F. "Covered battery-containing product" means a new or unused primary battery-containing product or a rechargeable battery-containing product, or a product containing a covered battery that is not easily removed from the product using common household tools.

(1) a product subject to section 1610 from which a primary battery or a rechargeable battery is not easily removed or is not intended or designed to be removed from the product other than by the manufacturer;

(2) a medical device, as described in the Federal Food, Drug and Cosmetic Act, 21 United States Code, Section 321(h) (2012), if, when the device or battery within the device is discarded, it must be treated as biomedical waste or if changing the supplier of the battery contained in the medical device would trigger the need for premarket review of the device with the United Staes Food and Drug Administration pursuant to the Federal Food, Drug and Cosmetic Act, 21 United States Code, Section 360 (2012), unless such device is listed as an exempt device under 21 united States Code, Section 360 (m)(2012) or other applicable provisions of law.

G. "Discarded battery" means a covered battery that a user discarded, abandoned or sent for recycling.

H. "Operator" means a producer or covered battery stewardship organization that implements and administers a covered battery stewardship program.

I. "Participant" means a producer that establishes or participates in a covered battery stewardship program individually or by appointing and having that appointment accepted by a covered battery stewardship organization to operate the program on the producer's behalf.

J. "Primary battery" means a nonrechargeable battery that weighs 2 kilograms or less, including, but not limited to, nonrechargeable alkaline, carbon-zinc and lithium metal batteries.

K. "Producer" means, with respect to a covered battery or covered battery-containing product that is sold, offered for sale or distributed for sale in the State, the following:

(1) The person that manufactures the covered battery or covered battery-containing product and sells or offers for sale in the State that battery or product under the person's own brand;

(2) If there is no person to which subparagraph (1) applies, the owner or licensee of a brand under which the covered battery or covered battery-containing product is sold or distributed in the State; or

(3) If there is no person to which subparagraph (1) or (2) applies, a person, including, but not limited to, a wholesaler or retailer, that imports the covered battery or covered battery-containing product into the United States for sale or distribution in the State.

L. "Proprietary information" means information that is a trade secret or production, commercial or financial information the disclosure of which would impair the competitive position of the submitter and would make available information not otherwise publicly available.

M. "Rechargeable battery" means a battery that contains one or more voltaic or galvanic cells, electrically connected to produce electric energy, that weighs less than 5 kilograms and that is designed to be recharged and to provide less than 40 volts direct current. "Rechargeable battery" does not include:

(1) A battery that contains electrolyte as a free liquid; or

(2) A battery or battery pack that employs lead-acid technology, unless the battery or battery pack is sealed, contains no liquid electrolyte and is intended by its manufacturer to power a handheld device or to provide uninterrupted backup electrical power protection for consumer covered battery-containing products or stationary office equipment.

N. "Recycling" means any process through which a discarded covered battery or its components or by-products is transformed from its original identity or form into new usable or marketable material. "Recycling" does not include the incineration of a discarded covered battery or its components or by-products for energy recovery.

O. "Retailer" means a person that sells or offers a covered battery or covered battery-containing product for retail sale, as defined in Title 36, section 1752, subsection 11, in the State, including through a remote offering for sale, such as a sales outlet or sales catalog or via the Internet.

P. "Stewardship organization" means an organization appointed by more than one producer to design, submit a plan for, implement, and administer a battery stewardship program in accordance with this section.

Q. "Wholesaler" means a person that offers for sale or sells in the State a covered battery or covered battery-containing product in a sale that is not a retail sale, as defined in Title 36, section 1752, subsection 11, with the intention that the battery or product be resold.

2. Product labeling. By January 1, 2020, a producer that sells, offers for sale or distributes for sale in the State a covered battery, either as a replacement battery or packaged with or contained in a covered battery-containing product, shall, to the extent feasible, ensure that the covered battery is labeled in a manner identifying the chemistry employed in storing energy in the battery to facilitate sorting of discarded batteries by recyclers.

3. Submission of plan. No later than 6 months after the effective date of this section, except as specified in subsection 6 or 10, each producer of a covered battery or covered battery-containing product, individually or through a battery stewardship organization, shall submit a plan for the establishment of a battery stewardship program to the commissioner for approval. The plan must include, at a minimum and where applicable:

A. Identification and contact information for:

(1) The individual or entity submitting the plan;

(2) All producers participating in the battery stewardship program;

(3) A listing of the brands and the owners of the brands covered by the program; and

(4) If a stewardship organization, a description of the organization and the tasks to be performed by the organization. The description must include information on how the organization is organized, including administration and management of the organization;

B. A description of the collection system, including:

(1) The types of sites or other collection services to be used, including as applicable a description of how the program may use covered battery collection points that are established through other battery collection services;

(2) A description of how the program will provide convenient, free statewide collection opportunities for discarded batteries adequate to serve the needs of all entities;

(3) The criteria to be used by the program in determining whether an entity may serve as a collection location for covered batteries under the program. The plan must allow all retailers, wholesalers, municipalities, solid waste management facilities and other entities that meet such criteria to voluntarily serve as a collection location; and

(4) A description of how the convenience and adequacy of the collection system will be monitored and maintained;

C. Information on how discarded covered batteries will be safely and securely transported, tracked and handled from collection through final disposition;

D. The names and locations of recyclers, processors and disposal facilities that may be used by the product stewardship program, and a description of the methods that will be used to ensure that the components of the discarded batteries are recycled to the maximum extent practicable or otherwise responsibly managed;

E. A description of how the amount of product and product components collected, recycled, processed, reused and disposed of will be measured;

F. A description of the education and outreach methods that will be used to establish, train and monitor collection sites, and to encourage participation by collection sites and consumers throughout the state on an on-going basis;

G. A description of how program performance will be assessed, including performance goals that include, at a minimum, at least 50% of Maine residents knowing how to recycle their covered batteries in the third year of program implementation and 80% in the sixth year of program implementation;

H. An anticipated budget for the program, broken down into administrative, collection, transportation, disposition, and communication costs. The annual budget must fund a minimum ½-time person dedicated to implementing the program in Maine, and funds to reimburse the department for its costs incurred in implementing the program. The budget must not include costs for legal fees or costs related to legislative efforts.

I. If the plan is submitted by an organization, a description of the financing method through which implementation of the plan will be funded. The financing method must:

(1) Allocate to producers of primary batteries and primary battery-containing products costs that are directly attributable to the collection, transportation and recycling of primary batteries, such as reclamation costs;

(2) Allocate to producers of small rechargeable batteries and rechargeable battery-containing products costs that are directly attributable to the collection, transportation and recycling of rechargeable batteries, such as reclamation costs; and

(3) Allocate all other costs on the basis of the weights of types of batteries collected or some other nondiscriminatory basis acceptable to participating producers of primary batteries, small rechargeable batteries, primary battery-containing products and rechargeable battery-containing products.

4. Approval of plan. The commissioner shall review a plan submitted under subsection 3 and make a determination of whether to approve the plan within 90 days of receipt of the plan. In conducting a review of a submitted plan, the commissioner may consult with producers, associations representing producers, covered battery stewardship organizations, retailers and recyclers.

A. If the commissioner determines that a submitted plan fails to meet all applicable requirements of subsection 3, the commissioner shall provide to the producer or organization that submitted the plan a written notice of determination describing the reasons for rejecting the plan. No later than 45 days after receiving a written notice of determination from the commissioner rejecting a submitted plan, the producer or organization may amend the plan and resubmit the plan to the commissioner for reconsideration. The commissioner shall review an amended plan, make a determination of whether to approve the amended plan and provide a written notice of determination notifying the producer or organization of the commissioner's decision within 45 days of receipt of the amended plan. A producer or organization whose amended plan is rejected by the commissioner may appeal the commissioner's decision in accordance with section 346.

B. If the commissioner approves a submitted plan, the commissioner shall provide to the producer or organization that submitted the plan a written notice of determination of the plan's approval. No later than 30 days after receiving a written notice of determination from the commissioner approving a submitted plan, the producer or organization shall make the approved plan available on its publicly accessible website, but is not required to make available any information contained in the approved plan protected under the Uniform Trade Secrets Act.

C. No later than 45 days after the commissioner's approval of a submitted plan, the department shall make available on its publicly accessible website a list of participants in and brands of covered batteries and covered battery-containing products included under the approved plan or provide instructions on how to obtain such information as provided by the producer or organization that submitted the approved plan.

5. Implementation of plan. A producer or organization that submitted a plan approved by the commissioner under subsection 4 shall implement the plan no later than the first day of the next calendar quarter after the date the plan is approved by the commissioner, except that if the period of time between the date the plan is approved and the first day of the next calendar quarter is less than 60 days, the producer or organization shall implement the plan within 60 days after the date the plan is approved.

6. Amendment of plan and termination of program. This subsection governs amendment of a plan approved under subsection 4 and termination of a program established under an approved plan.

A. An approved plan under subsection 4 may be amended at the discretion of the producer or organization that submitted the plan without approval from the commissioner if the proposed amendments are non-substantive and do not significantly alter the likelihood that the plan will result in the successful collection and recycling of discarded batteries. The producer or organization shall at the beginning of each calendar quarter notify the department of any amendments made to the approved plan in the previous calendar quarter that are non-substantive and do not significantly alter the likelihood that the plan will result in the successful collection and recycling of discarded batteries.

B. If proposed amendments to an approved plan are substantive and would significantly alter the likelihood that the plan will result in the successful collection and recycling of discarded batteries, including, but not limited to, amendments eliminating a substantial number of retail collection locations, adding or deleting battery chemistries to be collected, addressing threats to the financial viability of the organization or addressing disruption in transportation or service affecting the ability of the producer or organization or any service providers to collect or process covered batteries or covered battery-containing products, the producer or organization shall submit to the commissioner a revised plan describing the proposed amendments. The commissioner shall review the revised plan and make a determination of whether to approve the proposed amendments, in whole or in part, within 90 days of receipt of the revised plan. If the commissioner determines that the revised plan fails to meet all applicable requirements of subsection 3, the commissioner shall provide to the producer or organization a written notice of determination describing the reasons for rejecting the revised plan. No later than 45 days after receiving a written notice of determination from the commissioner rejecting a revised plan, the producer or organization may amend and resubmit the revised plan to the commissioner for reconsideration. The commissioner shall review an amended revised plan, make a determination of whether to approve the amended revised plan and provide a written notice of determination notifying the producer or organization of the commissioner's decision within 45 days of receipt of the amended revised plan. Review and consideration by the commissioner of a revised plan under this paragraph, including whether the commissioner will hold a hearing on the revised plan, shall be conducted in accordance with the department's rules concerning the processing of applications and other administrative matters. A producer or organization whose revised plan is rejected by the commissioner may appeal the commissioner's decision in accordance with section 346.

C. A producer or organization that submitted a plan approved under subsection 4 may terminate the program implementing that plan no earlier than 90 days after providing notice to the commissioner and to program participants of the program's termination. Prior to the termination of a program, each producer included in the program shall, individually or through a covered battery stewardship organization that has agreed to act on the producer's behalf, submit a plan for the establishment of a covered battery stewardship program to the commissioner for approval consistent with subsection 3 or join an existing organization.

D. A plan approved under subsection 4 remains in effect until a revised plan is adopted in accordance with paragraph B or the program implementing that plan is terminated in accordance with paragraph C by the producer or organization that submitted the plan.

7. Collection locations. This subsection applies to collection locations.

A. A retailer, a wholesaler, a municipality, a solid waste management facility and any other private or public entity may voluntarily serve as a collection location for discarded batteries under an approved and implemented program, so long as the operator of the program determines that the collection location meets the criteria for collection locations established under the program's approved plan.

B. The participants in a program must fully underwrite the costs of battery collection containers provided to each collection location established under the program, including the costs of all materials necessary to comply with the safe collection requirements of subsection 12, as well as the costs of pickup and transportation of discarded batteries from each collection location, and may not charge a collection location for such items or services.

C. An entity serving as a collection location shall not be required to make available more than one battery collection container at a single location.

D. An entity serving as a collection location may not refuse collection of batteries based on the brand or brands of the batteries. The operator of the program may not refuse the pickup or transfer of collected batteries from a collection location based on the brand or brands of the batteries collected.

E. An entity serving as a collection location may not charge consumers any fee relating to the collection of discarded batteries at the collection point. An entity serving as a collection location may not impose any fee on the operator of the program as a condition of voluntarily agreeing to serve as a collection location.

8. Sales prohibition. This subsection governs the sale of covered batteries and covered battery-containing products in the State.

A. Beginning July 1, 2020, a manufacturer, distributor, wholesaler or retailer may not sell, offer for sale, distribute for sale or offer for promotional purposes in the State a covered battery or covered battery-containing product unless the producer of the battery or product has joined an existing covered battery stewardship organization or submitted a plan for the establishment of a covered battery stewardship program that has been approved by the commissioner.

B. Notwithstanding paragraph A, a manufacturer, distributor, wholesaler or retailer may continue to sell, distribute for sale, offer for sale or offer for promotional purposes in the State a covered battery or covered battery-containing product manufactured prior to July 1, 2020, but shall:

(1) By October 1, 2020, sell or otherwise divest or dispose of its remaining stock of covered batteries manufactured prior to July 1, 2020 by a producer that has not joined an existing covered battery stewardship organization or submitted a plan for the establishment of a covered battery stewardship program that has been approved by the commissioner; and

(2) By October 1, 2021, sell or otherwise divest or dispose of its remaining stock of covered battery-containing products manufactured prior to July 1, 2020 by a producer that has not joined an existing covered battery stewardship organization or submitted a plan for the establishment of a covered battery stewardship program that has been approved by the commissioner.

C. Notwithstanding paragraphs A and B, beginning July 1, 2021 , a manufacturer, distributor, wholesaler or retailer of medical devices, as described in the Federal Food, Drug and Cosmetic Act, 21 United States Code, Section 321(h) (2012), may not sell, offer for sale, distribute for sale or offer for promotional purposes in the State a medical device containing batteries not included in a plan approved under subsection 4, except that a manufacturer, distributor, wholesaler or retailer may continue to sell, distribute for sale, offer for sale or offer for promotional purposes in the State a medical device manufactured prior to July 1, 2021, but shall, by October 1, 2022, sell or otherwise divest or dispose of its remaining stock of medical devices containing batteries manufactured prior to July 1, 2021 by a producer that has not joined an existing covered battery stewardship organization or submitted a plan for the establishment of a covered battery stewardship program that has been approved by the commissioner. Notwithstanding subsection 1, paragraph L, prior to July 1, 2022, a manufacturer, distributor, wholesaler or retailer of medical devices shall not be considered a producer under this section.

D. Notwithstanding paragraphs A, B or C, a hospital or other health care provider may until July 1, 2027 continue to sell or otherwise exhaust its existing inventory of medical devices containing batteries manufactured prior to July 1, 2020 and not included in a plan approved under subsection 4.

9. Producer exclusions. Notwithstanding subsection 1, paragraph K, a person that manufactures, sells, offers for sale or imports for sale in the State a covered battery-containing product is not considered a producer under this section if, no later than 45 days after receiving a request from the commissioner or an operator, the person:

A. Verifies to the commissioner or the operator that the product only contains batteries with visible, permanent labels clearly identifying the producer or brand of the batteries, that the battery is easily removed and that the producer or brand is a participant in or covered under the operator's program; and

B. Identifies the chemistry type of the batteries contained in the product and provides data on the estimated weight of batteries contained in the products sold in the State. In January of each year thereafter, the person shall notify the commissioner or the operator as to any changes to the chemistry type of the batteries contained in the product or the estimated weights of batteries contained in the products sold in the State.

An operator of a covered battery stewardship program that includes the covered battery contained in the person's covered battery-containing product shall list the person as a participant in and the product as covered under the operator's program. If the producer of the covered battery contained in the person's covered battery-containing product subsequently terminates its participation in a covered battery stewardship program in the State, or if the person ceases to use covered batteries in its covered battery-containing product that are produced by a participant in or are covered under an existing covered battery stewardship program in the State, the person shall be considered a producer under subsection 1, paragraph L, and must join an existing covered battery stewardship organization or submit a plan for the establishment of a covered battery stewardship program and have that plan approved by the commissioner.

10. New producers. A producer who seeks to sell, offer for sale or distribute for promotional purposes in the State a covered battery or covered battery-containing product not sold or offered for sale in the State prior to July 1, 2020 must notify the commissioner prior to the sale, offer for sale or distribution of the covered battery or covered battery-containing product in the State.

A. Upon receiving notification under this subsection from a new producer, the commissioner shall list the producer as a new producer on the department's publicly accessible website.

B. No later than 90 days following a new producer's notification to the commissioner, the producer shall submit a plan to the commissioner in accordance with subsection 3 or join an existing organization operating under a plan approved under subsection 4.

C. If a new producer fails to submit a plan or join an existing organization within the 90-day period under paragraph B, the producer may not sell a covered battery or covered battery-containing product in the State after the expiration of the 90-day period and a retailer may not sell that producer's battery or product in the State after 120 days following the expiration of the 90-day period.

D. Notwithstanding paragraph C, if a new producer submits a plan within the 90-day period under paragraph B and that plan is ultimately rejected by the commissioner under subsection 4 after the expiration of the 90-day period, the producer may not sell the covered battery or covered battery-containing product in the State after 45 days following the commissioner's final determination rejecting the submitted plan and a retailer may not sell the producer's battery or product in the State after 120 days following the commissioner's final determination rejecting the submitted plan.

A new producer that fails to submit a plan that is approved by the commissioner under subsection 4 or to join an existing organization within the time limits described in this subsection may not sell, offer for sale or distribute for promotional purposes a covered battery or covered battery-containing product not sold or offered for sale in the State prior to July 1, 2020 until the producer submits a plan for approval consistent with subsection 3 that is subsequently approved by the commissioner or joins an existing organization.

11. Return of noncompliant products. If a plan approved under subsection 4 is subsequently determined by the commissioner not to be in compliance with this section, a producer who sells, offers for sale or distributes for sale in the State a covered battery or covered battery-containing product included in that plan shall, upon request by a retailer, designate a location to which the retailer may ship the battery or product for further handling and shall reimburse the retailer for costs incurred in shipping the battery or product to the designated location.

12. Safe collection. Any entity that collects covered batteries in the State, has a physical presence in the State and is operating under or in cooperation with a covered battery stewardship program shall ensure that all discarded covered batteries placed in its collection containers are protected from short-circuiting in accordance with applicable regulations of the federal Department of Transportation, 49 Code of Federal Regulations, Subtitle B (2015) and other applicable laws or regulations and take reasonable steps to prevent the placement of materials other than properly protected discarded covered batteries into its collection containers.

13. Reporting. By March 1st of the calendar year after the calendar year in which an approved product stewardship program is implemented, and annually thereafter, the producer or stewardship organization operating the program shall submit to the department a report describing activities carried out by the program pursuant to the plan during the previous calendar year. The report must include, at a minimum:

A. Updated contact information for the program operator and all participating producers, a list of the brands of covered batteries and covered battery containing devices for which it is responsible.

B. The weight of covered batteries collected by the program in the previous calendar year, reported to the extent feasible by:

(1) amount by county or by collection site;

(2) amount of primary batteries and amount of rechargeable batteries by chemistry type; and

(3) amount of battery-containing products.

C. The location of and contact information for each collection point established under the program, and an assessment of the convenience of collection;

D. A description of the manner in which collected covered batteries and covered battery-containing products were sorted, consolidated and processed by the program;

E. A description of the methods and materials used for education and outreach, and an evaluation of the effectiveness of education and outreach efforts. Every 2 years, the report must include the results of an assessment of consumer awareness of the program completed by an independent 3rd party;

F. A financial report on the program, including: the total cost of implementing the program, as determined by an independent financial audit, including a breakdown of administrative, collection, transportation, disposition and communication costs; and an anticipated budget for the next program year; and

G. Any recommendations for changes to the product stewardship program to improve convenience of collection, consumer education and program evaluation.

14. Proprietary information. Proprietary information submitted to the department in a covered battery stewardship plan, in an amendment to a plan or pursuant to the reporting requirements of this section that is identified by the submittor as proprietary information is confidential and must be handled by the department in the same manner as confidential information is handled under section 1310-B.

15. Administration and enforcement of program. The department shall enforce this section and may adopt rules consistent with this section as necessary for the purpose of implementing, administering and enforcing this section. Rules adopted pursuant to this subsection are routine technical rules as defined in Title 5, chapter 375, subchapter 2-A.

A. The department shall charge a reasonable fee to be paid by an applicant for review and approval of a covered battery stewardship plan. Fees established under this paragraph must be based on the actual costs to the department of reviewing and approving a covered battery stewardship plan and may not exceed $25,000.

B. The department may establish a reasonable annual fee, to be paid by the operator of each covered battery stewardship program, to cover the department's costs for annual report review, oversight, administration and enforcement of the program. Fees established under this paragraph must be based on the actual costs to the department of annual report review, oversight, administration and enforcement of the program and may not exceed $50,000 per year.

16. Limited private right of action. Except as provided in paragraph D, a nonprofit covered battery stewardship organization recognized by the United States Internal Revenue Service as exempt from taxation under Section 501 of the United States Internal Revenue Code, as amended, that has spent at least $250,000 transporting, collecting and recycling covered batteries in the State in the previous calendar year, may maintain a civil action in Superior Court against one or more producers not participating in the organization's program to recover a portion of the organization's costs and additional sums, as set forth in this subsection.

A. Damages recoverable under this subsection shall be a fair share of the actual costs incurred by the plaintiff organization in collecting covered batteries of a defendant producer discarded in the State for which the defendant producer was required under this section to submit and implement a covered battery stewardship plan or join an existing covered battery stewardship program, as well as the plaintiff organization's costs incurred in handling, transporting and recycling or properly disposing of such batteries. Additional amounts recoverable under this subsection shall include an award of reasonable attorney's fees and court costs, including expert witness fees, and, if a defendant producer did not operate or participate in a covered battery stewardship program established under this section during the time period in which covered batteries of the defendant producer were collected in the State, transported and recycled by the plaintiff organization, a punitive sum of 3 times the damages award shall be assessed.

B. In an action by a plaintiff organization against a defendant producer that did not operate or participate in a covered battery stewardship program established under this section during the time period in which covered batteries of the defendant producer were collected, transported and recycled by the plaintiff, the plaintiff may establish the defendant's fair share of the plaintiff's actual costs by:

(1) Providing the court with market share data that the court finds reasonably represents the percentage of sales by the defendant into the State;

(2) Providing the court with data generated from discarded battery sorts involving a minimum of 500 pounds of discarded covered batteries collected at each of 3 or more collection locations in the State that are found by the court to have been collected in an unbiased manner and to be reasonably representative of the population of the State; or

(3) Through any other method that the court finds reliable in establishing the defendant's fair share of the plaintiff's actual costs.

C. In an action by a plaintiff organization against a defendant producer that operated or participated in a covered battery stewardship program established under this section during the time period in which covered batteries of the defendant producer were collected, transported and recycled by the plaintiff, the plaintiff may establish the defendant's fair share of the plaintiff's actual costs by providing the court with data establishing the relative weight of discarded covered batteries collected by the plaintiff for which the defendant was required under this section to collect, transport and recycle under a covered battery stewardship program compared to the weight of other discarded covered batteries collected by the plaintiff. This data may be generated by the plaintiff:

(1) Through the collection of data from discarded battery sorts involving a minimum of 500 pounds of discarded covered batteries collected at each of 3 or more collection locations in the State that are found by the court to have been collected in an unbiased manner and to be reasonably representative of the population of the State;

(2) Through an analysis of actual collections by the organization that is found by the court to be reasonably representative of total actual collections in the State; or

(3) Through any other method that the court finds reliable in establishing the defendant's fair share of the plaintiff's actual costs.

D. An action may not be commenced under this subsection against any potential defendant until 60 days after a plaintiff provides to all potential defendants a written notice of the claim setting forth the amount of the claim and the basis for the calculation of that amount.

E. No action may be brought under this subsection against a retailer or franchisor of retail outlets that was operating or participating in a covered battery stewardship program established under this section, individually or on behalf of its franchisees, to recover costs or additional sums incurred during a time period in which covered batteries were collected, transported and recycled by the retailer or franchisor.

F. The department shall not be a party to or be required to provide assistance or otherwise participate in a civil action authorized under this subsection unless subject to a subpoena before a court of jurisdiction.

17. Preemption. The State intends to occupy and preempt the entire field of legislation concerning the regulation of the stewardship of covered batteries and covered battery-containing products. Any existing or future order, ordinance, rule or regulation in this field of any political subdivision of the State is void.

18. Antitrust exclusions. A producer, a group of producers and a covered battery stewardship organization, and an agent, officer, director and employee of such entities, preparing, submitting a plan for, implementing or administering a covered battery stewardship program in accordance with this section, and a wholesaler and retailer that engages in conduct authorized by this section, are granted immunity, individually and jointly, from all applicable antitrust laws of the State for the limited purpose of establishing, implementing and administering a covered battery stewardship program and otherwise complying with the requirements of this section, and any activity undertaken by these entities in accordance with and authorized under this section is not an unlawful restraint of trade, a conspiracy or other violation of any provision of any applicable antitrust law of the State.

An action taken by a producer, a group of producers or an organization to increase the recycling of covered batteries in accordance with this section that affects the types or quantities of batteries recycled or the cost and structure of any covered battery stewardship program is not a violation of any provision of Title 10, chapter 201, except when such action constitutes an agreement establishing or affecting the price of covered batteries or the output or production of covered batteries or restricting the geographic area in which covered batteries will be sold or the customers to whom covered batteries will be sold.

Sec. 2. 38 MRSA §2165 sub-4 is repealed: Repealed.

~~**4. Manufacturer responsibility.** A manufacturer of dry cell mercuric oxide or rechargeable batteries that are subject to subsection 1 shall:~~

~~A. Establish and maintain a system for the proper collection, transportation and processing of waste dry cell mercuric oxide and rechargeable batteries for purchasers in this State;~~

~~B. Clearly inform each purchaser that intends to use these batteries of the prohibition on disposal of dry cell mercuric oxide and rechargeable batteries and of the available systems for proper collection, transportation and processing of these batteries;~~

~~C. Identify a collection system through which mercuric oxide and rechargeable batteries must be returned to the manufacturer or to a manufacturer-designated collection site; and~~

~~D. Include the cost of proper collection, transportation and processing of the waste batteries in the sales transaction or agreement between the manufacturer and any purchaser.~~

Appendix D – Proposed changes to Maine's Bottle Bill law

An Act to Improve Maine's Container Redemption Law

Be it enacted by the People of the State of Maine as follows:

Sec. 1. 38 MRSA § 352. Fees Table II is amended to read:

3109, Redemption centers	Annual Processing Fee	Annual Licensing Fee
	$0	$100

Sec. 2. 38 MRSA §3102 sub-13 is amended, and subs- 16-A and 17-A are enacted to read**:**

13. **Manufacturer.** "Manufacturer" means a person who ~~bottles, cans or otherwise places beverages in beverage containers for sale to distributors or dealers.~~: offers beverages for sale in or into Maine under its brand or label or licenses other entities to offer beverages for sale in or into Maine under its brand or label, or imports a beverage into the United States that is manufactured by a person without a presence in the United States; and an out-of-state wholesaler of liquor that holds a certificate of approval in accordance with Maine law under Title 28-A.

16-A. Pick-up agent. "Pick-up agent" means the initiator of deposit, distributor, or contracted agent that receives and transports redeemed beverage containers from licensed redemption centers to recycling.

17-A. Proprietary information. "Proprietary information" means information that is a trade secret or production, commercial or financial information the disclosure of which would impair the competitive position of the submitter and which is not otherwise publicly available.

Sec. 3. 38 MRSA §3105 sub-5 is amended to read:

5. **Label registration.** An initiator of deposit shall register the container label of any beverage offered for sale in the State on which it initiates a deposit. Registration must be on forms or in an electronic format provided by the department and must include the universal product code for each combination of beverage and container manufactured. The initiator of deposit shall renew a label registration annually and whenever that label is revised by altering the universal product code or whenever the container on which it appears is changed in size, composition or glass color. The initiator of deposit shall also include as part of the registration the method of collection for that type of container, identification of a collection agent, identification of all of the parties to a commingling agreement that applies to the container and proof of the collection agreement. The department may charge a fee for registration and registration renewals under this subsection. ~~Rules adopted pursuant to this subsection that establish fees are major substantive rules as defined in Title 5, chapter 375, subchapter 2-A and subject to review by the joint standing committee of the Legislature having jurisdiction over environmental and natural resources matters.~~

Sec. 4. 38 MRSA §3106 sub-5 is amended to read:

1. **Dealer acceptance.** Except as provided in this section, a dealer operating a retail space of 5000 square feet or more may not refuse to accept from any consumer or other person not a dealer any empty, unbroken and reasonably clean beverage container ~~of the kind, size and brand sold by the dealer~~, or refuse to pay in cash the refund value of the returned beverage container as established by section 3103 unless that dealer has a written agreement with a local redemption center within 1 roadway mile to provide redemption services on behalf of that dealer . This section does not require an operator of a vending machine to maintain a person to accept returned beverage containers on the premises where the vending machine is located.

~~**2. Permissive refusal by dealer.** A dealer may refuse to accept from a consumer or other person and to pay the refund value on any beverage container, if the place of business of the dealer and the kind, size and brand of beverage container are included in an order of the department approving a redemption center under section 3109.~~

…

6. Obligation to preserve recycling value. Notwithstanding subsection 8, a distributor or its agent may refuse to accept, or pay the refund value and handling costs to a dealer, redemption center or other person for, a beverage container that has been processed by a reverse vending machine in a way that has reduced the recycling value of the container below current market value. This subsection may not be interpreted to prohibit a written processing agreement between a distributor and a dealer or redemption center and does not relieve a distributor of its obligation under subsection 8 to accept empty, unbroken and reasonably clean beverage containers. The department shall adopt rules to establish the recycling value of beverage containers under this subsection and the rules may authorize the use of a 3rd-party vendor to determine if a beverage container has been processed by a reverse vending machine in a manner that has reduced the recycling value below current market value. The rules must outline the method of allocating among the parties involved the payment for 3rd-party vendor costs. ~~Rules adopted under this subsection are routine technical rules pursuant to Title 5, chapter 375, subchapter 2-A.~~

7. Reimbursement of handling costs. Reimbursement of handling costs is governed by this subsection.

A. In addition to the payment of the refund value, the initiator of the deposit under section 3103, subsections 1, 2 and 4 shall reimburse the dealer or local redemption center for the cost of handling beverage containers subject to section 3103, in an amount that equals at least 3¢ per returned container for containers picked up by the initiator before March 1, 2004, at least 3 1/2¢ for containers picked up on or after March 1, 2004 and before March 1, 2010 and at least 4¢ for containers picked up on or after March 1, 2010. The initiator of the deposit may reimburse the dealer or local redemption center directly or indirectly through a party with which it has entered into a commingling agreement.

B. In addition to the payment of the refund value, the initiator of the deposit under section 3103, subsection 3 shall reimburse the dealer or local redemption center for the cost of handling beverage containers subject to section 3103 in an amount that equals at least 3¢ per returned container for containers picked up by the initiator before March 1, 2004, at least 3 1/2¢ for containers picked up on or after March 1, 2004 and before March 1, 2010 and at least 4¢ for containers picked up on or after March 1, 2010. The initiator of the deposit may reimburse the dealer or local redemption center directly or indirectly through a contracted agent or through a party with which it has entered into a commingling agreement.

C. The reimbursement that the initiator of the deposit is obligated to pay the dealer or redemption center pursuant to paragraph A or B must be reduced by 1/2¢ for any returned container that is ~~subject to~~ <u>managed in accordance with</u> a qualified commingling agreement that allows the dealer or redemption center to commingle beverage containers of like ~~product group,~~ material ~~and size~~. ~~A commingling agreement is qualified for purposes of this paragraph if the department determines that 50% or more of the beverage containers of like product group, material and size for which the deposits are being initiated in the State are covered by the commingling agreement or that the initiators of deposit covered by the commingling agreement are initiators of deposit for wine containers who each sell no more than 100,000 gallons of wine or 500,000 beverage containers that contain wine in a calendar year. Once the initiator of deposit has established a qualified commingling agreement for containers of a like product group, material and size, the department shall allow additional brands to be included from a different product group if they are of like material.~~ The State, through the Department of Administrative and Financial Services, Bureau of Alcoholic Beverages and Lottery Operations, ~~shall make every reasonable effort to enter into~~ <u>may operate as</u> a qualified commingling agreement under this paragraph ~~with every other initiator of deposit for~~ <u>provided it allows the commingling of</u> beverage containers that are of like ~~product group, size and~~ material ~~as the beverage containers for which the State is the initiator of deposit~~.

D. Paragraphs A, B and C do not apply to a brewer who annually produces no more than 50,000 gallons of its product or a bottler of water who annually sells no more than 250,000 containers each containing no more than one gallon of its product. In addition to the payment of the refund value, an initiator of deposit under section 3103, subsections 1 to 4 who is also a brewer who annually produces no more than 50,000 gallons of its product or a bottler of water who annually sells no more than 250,000 containers each containing no more than one gallon of its product shall reimburse the dealer or local redemption center for the cost of handling beverage containers subject to section 3103 in an amount that equals at least 3 1/2¢ per returned container.

8. **Obligation to pick up and recycle containers.** The obligation to pick up and recycle beverage containers subject to this chapter is determined as follows.

A. A distributor that initiates the deposit under section 3103, subsection 2 or 4 has the obligation to pick up and recycle any empty, unbroken and reasonably clean beverage containers of the particular kind, size and brand sold by the distributor from dealers to whom that distributor has sold those beverages and from licensed redemption centers ~~designated to serve those dealers pursuant to an order entered under section 3109~~. A distributor that, within this State, sells beverages under a particular label exclusively to one dealer, which dealer offers those labeled beverages for sale at retail exclusively at the dealer's establishment, shall pick up any empty, unbroken and reasonably clean beverage containers of the kind, size and brand sold by the distributor to the dealer only from those licensed redemption centers that enter into a written agreement to provide redemption services for ~~serve the various establishments of~~ the dealer~~, under an order entered under section 3109~~. A dealer that manufactures its own beverages for exclusive sale by that dealer at retail has the obligation of a distributor under this section. The commissioner may establish by rule, in accordance with the Maine Administrative Procedure Act, criteria prescribing the manner in which distributors shall fulfill the obligations imposed by this paragraph. The rules may establish a minimum number or value of containers below which a distributor is not required to respond to a request to pick up empty containers. Any rules adopted under this paragraph must allocate the burdens associated with the handling, storage and transportation of empty containers to prevent unreasonable financial or other hardship.

B. The initiator of the deposit under section 3103, subsection 3 has the obligation to pick up any empty, unbroken and reasonably clean beverage containers of the particular kind, size and brand sold by the initiator from dealers to whom a distributor has sold those beverages and from licensed redemption centers designated to serve those dealers pursuant to an order entered under section 3109 and to ensure the containers are recycled. The obligation may be fulfilled by the initiator directly or indirectly through a contracted agent.

C. An initiator of the deposit under section 3103, subsection 2, 3 or 4 has the obligation to pick up and recycle any empty, unbroken and reasonably clean beverage containers that are commingled pursuant to a commingling agreement along with any beverage containers that the initiator is otherwise obligated to pick up pursuant to paragraphs A and B.

D. The initiator of deposit or initiators of deposit who are members of a commingling agreement have the obligation under this subsection to pick up and recycle empty, unbroken and reasonably clean beverage containers of the particular kind, size and brand sold by the initiator from dealers to whom a distributor has sold those beverages and from licensed redemption centers ~~designated to serve those dealers~~ every 15 days. The initiator of deposit or initiators of deposit who are members of a commingling agreement have the obligation to make additional pickups when a redemption center has collected 10,000 beverage containers from that initiator of deposit or from the initiators of deposit who are members of a commingling agreement.

The obligations of the initiator of the deposit under this subsection may be fulfilled by the initiator directly or through a party with which it has entered into a commingling agreement. A contracted agent hired to pick up beverage containers for one or more initiators of deposit is deemed to have made a pickup at a redemption center for those initiators of deposit when it picks up beverage containers belonging to those initiators of deposit.

9. **Plastic bags.** A dealer or redemption center has an obligation to pick up plastic bags that are used by that dealer or redemption center to contain beverage containers. Plastic bags used by a dealer or redemption center and the cost allocation of these bags must conform to rules adopted by the department concerning size and gauge. ~~Rules adopted pursuant to this subsection are routine technical rules as defined in Title 5, chapter 375, subchapter 2-A.~~

Sec. 5. 38 MRSA §3107 is amended to read:

Notwithstanding any other provision of this chapter to the contrary, 2 or more initiators of deposit may enter into a commingling agreement through which some or all of the beverage containers for which the initiators have initiated deposits may be commingled by dealers and operators of redemption centers as provided in this section.

The department shall determine that a commingling agreement is qualified for purposes of this chapter when: 50% or more of the beverage containers of like product group, material and size for which the deposits are being initiated in the State are covered by the commingling agreement; the initiators of deposit covered by the commingling agreement are initiators of deposit for wine containers who each sell no more than 100,000 gallons of wine or 500,000 beverage containers that contain wine in a calendar year; or commingling is implemented under the terms of a plan submitted and approved in accordance with paragraph 5.

An initiator of deposit that enters into a commingling agreement pursuant to this section shall permit any other initiator of deposit to become a party to that agreement on the same terms and conditions as the original agreement. Once the initiator of deposit has established a qualified commingling agreement, the department shall allow additional brands to be included from a different product group if they are of like material.

1. **Commingling requirement.** If initiators of deposit enter into a commingling agreement pursuant to this section, commingling of beverage containers must be by all containers of like product group, material and size. An initiator of deposit required pursuant to section 3106, subsection 8 to pick up beverage containers subject to a commingling agreement also shall pick up all other beverage containers subject to the same agreement. The initiator of deposit may not require beverage containers that are subject to a commingling agreement to be sorted separately by a dealer or redemption center.

2. **Commingling of like materials.** For purposes of this section, containers are considered to be of like materials if made up of one of the following:

A. Plastic;

B. Aluminum;

C. Metal other than aluminum; and

D. Glass.

3. **Commingling of like products.** For purposes of this section, like products are those that are made up of one of the following:

A. Beer, ale or other beverage produced by fermenting malt, wine and wine coolers;

B. Spirits;

C. Soda;

D. Noncarbonated water; and

E. All other beverages.

4. **Registration of commingling agreements.** Not later than 48 hours following the execution or amendment of a commingling agreement, including an amendment that adds an additional party to an existing agreement, the parties shall file a copy of the commingling agreement or amendment with the department.

5. Commingling by a third party or stewardship organization. An initiator of deposit may enter into an agreement for its beverage containers to be managed in a commingling program administered by a third party or through a stewardship organization as defined in chapter 18, section 1771. The third party or stewardship organization shall submit a plan to operate a commingling program to the department for review and approval as a qualified commingling agreement.

The commingling program must require redemption centers to commingle all containers of participating manufacturers by like material, and shall establish containerizing standards to provide for fair apportionment of costs among participating manufacturers, either on the basis of the total weight of containers marketed or by unit count. An initiator of deposit shall report by the 20th day of the month following the end of March, June, September and December to the administrator of the commingling program its sales of beverages into Maine for the previous three months by brand and number of nonrefillable containers sold by product size and material type, and the average container weight by material type and size. The third party or stewardship organization shall assign financial responsibility to participating initiators of deposit based on each initiator of deposit's proportion of the total weight of beverage containers marketed in Maine by material type or on actual unit counts.

The third party or stewardship organization may require a participating initiator of deposit to provide financial assurance in the form of a deposit of no greater than the cost of beverage container deposits, container handling fees for redemption centers and any contractual fees for up to 4 months of anticipated sales in Maine. The third party or stewardship organization shall retain the deposit funds in a separate account and may use the funds to pay program costs in the event the initiator of deposit fails to pay the third party or stewardship organization for incurred costs within 90 days of invoicing.

Sec. 6. 38 MRSA §3109 is amended to read:

1. **Establishment.** Local redemption centers may be established and operated by any person or municipality, agency or regional association as defined in section 1303-C, subsection 24, subject to the approval of the commissioner, to serve local dealers and consumers, at which consumers may return empty beverage containers as provided under section 3106.

2. **Application for approval.** Application for approval of a local redemption center must be filed with the department. The application must state the name and address of the person responsible for the establishment and operation of the center, ~~the kinds, sizes and brand names of beverage containers that will be accepted and~~ the names and addresses of each dealer~~s~~ with whom the redemption center has entered into a written agreement to provide redemption services in accordance with section 3106 sub-5 ~~be served~~ and their distances from the local redemption center, and a statement that the local redemption center will accept and manage all beverage containers registered in accordance with section 3105.

3. **Approval.** The commissioner may approve the licensing of a local redemption center if the redemption center complies with the requirements established under section 3113. The order approving a local redemption center license must state the dealers to be served and the kinds, sizes and brand names of empty beverage containers that the center accepts.

4. **Redemption center acceptance refund account.** A ~~local~~ licensed redemption center may not refuse to accept from any consumer or other person not a dealer any empty, unbroken and reasonably clean beverage container of the kind, size and brand sold in the state ~~by a dealer served by the center~~ as long as the label for the container is registered under section 3105, subsection 5 or refuse to pay in cash the refund value of the returned beverage container as established by section 3103. A redemption center or reverse vending machine is not obligated to count containers or to pay a cash refund at the time the beverage container is returned as long as the amount of the refund value due is placed into an account to be held for the benefit of the consumer and funded in a manner that allows the consumer to obtain deposits due within 2 business days of the time of the return.

~~**5. Posted lists.** A list of the dealers served and the kinds, sizes and brand names of empty beverage containers accepted must be prominently displayed at each local redemption center.~~

5-A. Beverage container handling. A redemption center shall tender only beverage containers sold in the state to pick-up agents in shells, shipping cartons, bags and other containers prepared to ensure accurate eligible beverage container unit counts.

6. **Withdrawal of approval.** The ~~District Court~~ department may, in a manner consistent with the Maine Administrative Procedure Act, ~~withdraw approval~~ revoke the license of a local redemption center if there has not been compliance with the approval order or if the local redemption center no longer provides a convenient service to the public.

Sec. 7. 38 MRSA §3113 sub-1, sub-2, sub-3 and sub-4 are amended, and **sub-5 and sub-6** are enacted to read:

….

1. **Procedures; licensing fees.** The department shall adopt rules establishing the requirements and procedures for issuance of licenses and annual renewals under this section, including a fee structure. Initial rules adopted pursuant to this subsection are routine technical rules as defined in Title 5, chapter 375, subchapter 2-A. ~~Rules adopted effective after calendar year 2003 are major substantive rules as defined in Title 5, chapter 375, subchapter 2-A and are subject to review by the joint standing committee of the Legislature having jurisdiction over environmental and natural resources matters.~~

2. ~~**Criteria for licensing rules**~~ **Licensing criteria.** In ~~developing rules under subsection 1 for~~ licensing redemption centers, the department shall consider at least the following:

A. The health and safety of the public, including sanitation protection when food is also sold on the premises;

B. The convenience for the public, including standards governing the distribution of centers by population or by distance, or both;

C. The proximity of the proposed redemption center to existing redemption centers and the potential impact that the location of the proposed redemption center may have on an existing redemption center;

D. The proposed owner's record of compliance with this chapter and rules adopted by the department pursuant to this chapter; and

E. The hours of operation of the proposed redemption center and existing redemption centers in the proximity of the proposed redemption center.

3. **Location of redemption centers; population requirements.** The department may grant a license to a redemption center if the following requirements are met:

A. The department may license up to 5 redemption centers in a municipality with a population over 30,000;

B. The department may license up to 3 redemption centers in a municipality with a population over 20,000 but no more than 30,000; and

C. The department may license up to 2 redemption centers in a municipality with a population over 5,000 but no more than 20,000.

For a municipality with a population of no more than 5,000, the department may license redemption centers in accordance with rules adopted by the department. ~~Rules adopted pursuant to this subsection are routine technical rules as defined in Title 5, chapter 375, subchapter 2-A.~~

4. **Exceptions.** Notwithstanding subsection 3:

A. An owner of a redemption center who is renewing the license of a redemption center licensed by the department as of April 1, 2009 need not comply with subsection 3;

B. An entity that is a ~~food establishment or~~ distributor licensed by or registered with the department need not comply with subsection 3;

C. A reverse vending machine is not considered a redemption center for purposes of subsection 3 when it is located in a licensed redemption center; and

D. The department may grant a license that is inconsistent with the requirements set out in subsection 3 only if the applicant has demonstrated a compelling public need for an additional redemption center in the municipality.

5. Initiator of deposit annual report. Each initiator of deposit shall report annually by March 1 to the department concerning its deposit transactions in the preceding calendar year. The report must be in a form prescribed by the department and must include the number of nonrefillable beverage containers sold in Maine by container size, beverage type, delineated at a minimum into wine, spirits, and all other beverages, and the number of nonrefillable beverage containers returned by redemption value. The report required by this subsection is proprietary information and must be handled by the department in the same manner as confidential information is handled under section 1310-B.

6. Pick-up agent annual report. Each third-party pick-up agent shall report annually by March 1 to the department on redemptions for each initiator of deposit it served in the preceding calendar year. The report must be in a form prescribed by the department and must include the number of nonrefillable containers returned by redemption value except that a third-party pick-up agent may report by the average weight and total weight of containers returned by material type for containers managed within a commingling agreement established in accordance with section 3107 sub-5.

Sec. 8. 38 MRSA §3115 is amended to read:

The department shall administer this chapter and has the authority, following public hearing, to adopt necessary rules to carry it into effect. The department may adopt rules governing local redemption centers that receive beverage containers from dealers supplied by distributors other than the distributors servicing the area in which the local redemption center is located in order to prevent the distributors servicing the area within which the redemption center is located from being unfairly penalized. Rules adopted pursuant to this chapter are routine technical rules pursuant to Title 5, chapter 375, subchapter 2-A except rules that establish or modify fees are major substantive rules as defined in Title 5, chapter 375, subchapter 2-A and subject to review by the joint standing committee of the Legislature having jurisdiction over environmental and natural resources matters.

Sec. 9. 38 MRSA §3116 sub-2 is amended to read:

2. **Aggrieved applicants.** An applicant aggrieved by a decision made by the department may appeal the decision to the board pursuant to section 344(2-A) or by filing an appeal with the Superior Court and serving a copy of the appeal upon the department in accordance with the Maine Rules of Civil Procedure, Rule 80C. The appeal must be filed and served within 30 days of the mailing of the department's decision.

Appendix E – Proposed changes to Maine's cellular telephone law

§ Be it enacted by the People of the State of Maine as follows:

Sec. 1. 38 M.R.S. §2143 is amended to read:

1. **Definitions.** As used in this section, unless the context otherwise indicates, the following terms have the following meanings.

A. "Cellular telephone" means a mobile wireless telephone device that is designed to send or receive transmissions through a cellular radiotelephone service as defined in 47 Code of Federal Regulations, Section 22.99 (2005). "Cellular telephone" does not include a wireless telephone device that is integrated into the electrical architecture of a motor vehicle.

B. "Cellular telephone service provider" means a provider of wireless voice or data retail service.

C. "Retailer" means a person, firm or corporation that sells or offers to sell a cellular telephone to a consumer at retail.

2. **Collection system.** Effective January 1, 2008, a retailer shall accept, at no charge, used cellular telephones from any person. A retailer required to accept used cellular telephones under this subsection shall post, in a prominent location open to public view, a notice printed in boldface type and containing the following language: "We accept used cellular telephones at no charge."

3. **Disposal ban.** Effective January 1, 2008, a person may not dispose of a cellular telephone in solid waste for disposal in a solid waste disposal facility.

~~**4. Reports.** By January 1, 2009, and every year thereafter, a cellular telephone service provider shall report to the department the number of cellular telephones collected pursuant to this section and how the collected cellular telephones were disposed of, reused or recycled. Annually, the department shall report on the collection system to the joint standing committee of the Legislature having jurisdiction over natural resources matters. The report may be included in the report required pursuant to section 1772, subsection 1.~~

Appendix F – Comments received on posted report

February 13, 2019

Mr. Mike Karagiannes
Director, Bureau of Land Resources
Maine DEP
17 State House Station
Augusta, ME 04333-0017

Mr. Karagiannes,

On behalf of the members of the Product Management Alliance (PMA), we appreciate the opportunity to express the Product Management Alliances' position on the Department of Environmental Protection's Annual Report to the Joint Standing Committee on Environment and Natural Resources, Concerning the Implement of Product Stewardship in Maine.

My name is Kevin Canan, and I serve as the Executive Director of the PMA. By way of introduction, the PMA is a coalition comprised of trade associations and corporations that represent a broad array of consumer products. Our mission is to support market-based extended producer responsibility (EPR) efforts, as well as voluntary incentives for increased recovery and sustainable products and package design. We were founded precisely as a response to the signing of LD 1631 into law in 2010, the law which compels this report.

PMA's members have long strived to voluntarily recover the products that they manufacture. The PMA understands and appreciates Maine's desire to seek ways to improve the recovery rates of goods. However, we believe that expanding current EPR programs and adding additional EPR programs for additional products, specifically the carpet and mattress industries enumerated in the report, would simply add costly and unnecessary mandates for both the state government to implement and run this program; as well as for retailers and manufacturers in Maine. These costs will ultimately be borne by taxpayers and consumers.

Additional EPR programs would set up a confusing and bureaucratic system of recovery for the residents of the state with similar types of products having very different end-of-life recovery schemes. In addition, these types of restrictive programs would likely to have a chilling effect on manufacturers and retailers doing business in Maine, and as a result business very well could be lost to neighboring states.

PMA members and businesses utilize sophisticated programs in place that continue to increase the amounts of products recovered and recycled through voluntary initiatives. Today recovery rates are at record levels, and they are continually striving to increase these numbers. The existence of these efforts illustrate that new mandates on producers are not necessary to reduce waste and increase recycling and the use of recycled content. Thus, we urge the DEP and the legislature to **strongly examine voluntary, market-based recovery efforts** for increased recovery of products and oppose any new or further expansion of EPR in the state that are enumerated in the report.

The members of the PMA, and the industries they represent, recognize the desire of the public and policymakers for environmentally responsible business practices. That is why our member companies are voluntarily involved in waste recovery programs, and support recycling where it is economically and logistically feasible.

We hope to have a positive and constructive working relationship with you.

Sincerely,

Kevin C. Canan
Executive Director

Product Management Alliance
1000 Potomac Street, NW
Suite 200
Washington, DC 20015
(888) 588-6878
info@productmanagementalliance.org
www.productmanagementalliance.org

American Forest & Paper Association

AF&PA Comments on the Annual Product Stewardship Report
Maine Department of Environmental Protection
February 2019

The American Forest & Paper Association (AF&PA) appreciates the opportunity to comment on the 2019 Maine Annual Product Stewardship Report. AF&PA supports voluntary paper and paper-based packaging recovery efforts that seek to improve upon the existing recovery and recycling programs in Maine and the United States. AF&PA strongly believes that the voluntary recovery of paper and paper-based packaging is a recycling success story.

The AF&PA serves to advance a sustainable U.S. pulp, paper, packaging, tissue and wood products manufacturing industry through fact-based public policy and marketplace advocacy. AF&PA member companies make products essential for everyday life from renewable and recyclable resources and are committed to continuous improvement through the industry's sustainability initiative — *Better Practices, Better Planet 2020*. The forest products industry accounts for approximately four percent of the total U.S. manufacturing GDP, manufactures nearly $300 billion in products annually and employs approximately 950,000 men and women. The industry meets a payroll of approximately $55 billion annually and is among the top 10 manufacturing sector employers in 45 states.

In Maine, the industry employs more than 15,000 individuals, with an annual payroll of over $814 million. The estimated state and local taxes paid by the forest products industry totals $91 million annually.

Comments on the Product Stewardship for Packaging Proposal

AF&PA has concerns with the findings of the report which will be examined in more detail below. We believe that the paper industry's consistently high recovery rates, and the industry's ongoing efforts to increase voluntary recovery, make mandates like an extended producer responsibility (EPR) program for paper and paper-based packaging unnecessary and potentially counterproductive. Along similar lines, consumer packaging is too broad to be considered a single product for a product stewardship program.

Product Stewardship for Paper-based Packaging is Not a Solution

Recent changes in markets for recyclable commodities due to China's import ban have fueled discussion of EPR as an attractive funding mechanism for municipal recycling programs. While on the surface, additional funding may be used to improve some aspects of recycling programs, there are multiple fallacies and negative consequences that make EPR for packaging, in particular paper packaging, a poor policy choice compared to the market driven system in effect today.

The Maine DEP report asserts that a product stewardship program for packaging will increase the recovery of materials for reuse and recycling, but this is not necessarily true. While funding could be raised to fund steps necessary to increase collection, EPR programs do not create end markets for recyclable materials. There are successful recycling programs in the state that would be disrupted, rather than improved by the implementation of EPR. Product stewardship for packaging programs exist in other countries but whether they are more successful than our current system is widely debated. Global demand drives paper recovery, not government mandates. Global demand for recovered fiber has been growing at a rapid rate. Global recovered paper demand increased at an average rate of 1.3 percent a year from 2012 to 2017 and is expected by RISI to increase an average of 1.8 percent a year from 2017 through 2022.

Market-based paper recovery can be a model for other industries. The paper and paper-based packaging industry has set and met voluntary goals, and publicly reported on performance. The industry works with others in the private and public sectors to maximize paper recovery, the rate of which has doubled since 1990. EPR, though well-intentioned, falls short of the mark. Government can help support paper recycling's success by avoiding mandates and arbitrary rules that disrupt the current market-based system.

As history has demonstrated, the market operates efficiently when it comes to paper recovery and recycling. To impose an EPR scheme in hopes of marginal gains could be cost prohibitive and at the detriment of the success the industry has achieved. For paper and paper-based packaging, EPR could prove to be harmful and even counterproductive. The life path of paper-based packaging is not contained in one state. For instance, a box is made in one state and breakfast cereal is put into that box in a second state. The cereal is sold in a third state to a consumer living in a fourth state. It is hard to imagine logistically how a manufacturer or brand owner could be required to pay fees on the products it introduces into a global commerce stream.

Consumer Packaging is Too Broad to be Productive
Consumer packaging is a broad category of multiple packaging materials including paper, plastic, glass, aluminum and steel. Each of these materials has distinct challenges, advantages, and economics when it comes to recovery for recycling. Solutions that may work for one material do not necessarily translate to other materials. Some materials may require different strategies and financial investments. Fee proceeds from one material should not be used to subsidize recovery initiatives for other materials. Lumping all of these issues into one stewardship program makes it extremely unlikely that there could be a fair program for all participants.

The report acknowledges the difficulties in the choice between a program that shares responsibilities between manufacturers and municipalities but misses in the mark in that it does not also explore the potential difficulties of competing materials sharing the responsibility of managing recycling for the state. An EPR program holds major financial stakes for all industries impacted and measures to facilitate equitable representation of the products impacted by the program would be a necessity at minimum.

Paper Recycling is Successful
Paper recovery is an environmental success story, saving an average of 3.3 cubic yards of landfill space for each ton of paper recycled. Paper recovery has fostered a well-developed and dynamic marketplace that allows recovered fiber to find its highest value end use in manufacturing new products. That, in turn, helps encourage more recycling which part of why paper is the most-recycled material in the U.S. today. According to the U.S. Environmental Protection Agency, more

paper (by weight) is recovered for recycling from municipal solid waste streams than glass, plastic, steel and aluminum combined. 96 percent of the U.S. population had access to community curbside and/or drop-off paper recycling services, according to the most recent (2014) survey of communities.

Based on results from the 2014 Community Access Survey, 80% of Maine residents have access to community curbside recycling programs for paper & paperboard and 90% have access to community drop-off systems. While the overall paper recovery rate is at 63% or higher for each of the last nine years, for OCC in particular, the recovery rate was 88.89% for 2017 and has exceeded 80% for the last nine years.

The paper and paper-based packaging industry's commitment to maximizing recovery of its products for recycling is real and longstanding. AF&PA and its member companies have a truly outstanding record on paper recovery. In 1990, when AF&PA began setting voluntary recovery goals, the recovery rate was a little more than one-third (33.5 percent) of the paper consumed in the United States. By 2017, thanks to voluntary industry initiatives and the millions of Americans who recycle at home, work and school every day, the recovery rate has almost doubled (65.8 percent). The recovery rate has met or exceeded 63 percent for the past nine years.

Impact and Market Adjustments After China National Sword
The current disruption in mixed paper markets is partially due to an unacceptable level of quality being generated and China's abrupt ban on mixed paper imports. The disruption caused by China's import policy has created a misperception that there is a systemic problem with the recycling system. In fact, the problem is with poor-quality recyclable materials being put into the marketplace by some processing facilities, in particular by mixed-waste processing facilities.

Fortunately, recovered fiber markets are dynamic and adapting rapidly. The paper and paper-packaging industry continues to innovate and adapt to market demands to drive future success. Communities that improve the quality of the recyclable materials in their recycling steams and improve the quality of the recovered paper bales produced by their MRFs will have greater success in recovered paper markets. Investing in improving consumers' recycling behavior and improving collection are needed steps that were made clearer in the wake of the implementation of China National Sword.

Product stewardship is not the answer to China's import policy and will not drive increased domestic consumption of recovered fiber. Instead of bringing in more capacity to handle the increase volume available, it will add another cost to already burdened paper mills in Maine.

Recovered paper consumption at domestic paper and paperboard mills increased in 2017 and during four of the past five years, rising more than four percent from 2012 to 2017. These increases were achieved even while U.S. paper and paperboard production declined three percent during that period. The fact is that quality matters and recovered fiber that meets the grade and quality requirements of mills is purchased while fiber that doesn't meet the requirements is not.

Opportunities to Improve Recovery
As an alternative to a product stewardship for packaging program, Maine should focus on hard-to-

recycle materials where there may not yet be a well-developed collection infrastructure or good recovery results. With a well-developed infrastructure for collecting paper and paper-based packaging, to increase recovery Maine should increase consumer education to drive increased participation across the entire supply chain.

The industry works with others in the private and public sectors to maximize paper recovery, with the obvious result that we have doubled our recovery rate since 1990. For example, AF&PA is an inaugural founder of The Recycling Partnership which creates public-private partnerships that promote voluntary recovery and increases communities' capability to improve the quality and quantity of recyclable materials produced by community materials recovery facilities. While the report finds the contributions (recycling carts for Portland) of the Partnership insufficient, there are potentially additional resources that are being underutilized by municipalities, such as the free Contamination kits that include tools and resources to improve the quality of what MRFs are collecting- facilitating behavior change through consumer education.

AF&PA also produces our own resources on recycling better- with recycling guides specific to the workplace, schools and the community and a guide on shredding and recycling important documents. The Responsible Package is a recycling curriculum that includes classroom activities, family take-home materials and a family recycling pledge to raise awareness about paper and paper-based packaging recycling and reuse. By targeting students in fifth grade (ages 10-11), along with their families and teachers, our program encourages students to be agents of change in their homes and schools to increase recovery through smart recycling. Jointly funded by paper-based packaging associations including AF&PA, the Carton Council, Fibre Box Association, PSSMA, TAPPI and AICC; The Responsible Package aims to reach 525,000 students around the country in 2019, an increase from 313,000 in 2018.

Conclusion

AF&PA believes responsibility for materials recovery must be shared across the entire supply chain and include consumers. The paper industry is doing its part by meeting or exceeding voluntary recovery goals for our products. We urge you to consider promoting increased participation in community recycling programs as an alternative to a product stewardship program for paper-based packaging. We hope that by sharing this information, any plan or legislation drafted to regulate the production and use of paper-based packaging will be based on sound policy to the benefit of the environment and best practices for doing business in the state.

We look forward to continuing our work with the state of Maine. Please feel free to contact Abigail Turner Sztein, Director, State Government Affairs, AF&PA at (202) 463-2596 or abigail_sztein@afandpa.org for further information.

American Chemistry Council

February 14, 2019
Director Paula Clark
Division of Materials Management
August, Maine 04333

Re: American Chemistry Council comments to the Annual Product Stewardship Report

Dear Director Clark,

The American Chemistry Council (ACC) provides the following comments to the Annual Produce Stewardship Report to the Joint Standing Committee on the Environment and Natural Resources. ACC represents leading manufacturers of plastic resins[1] and we strive to be an expert resource on innovative plastics recycling and recovery programs and educational and outreach programs to improve plastics recycling and recovery nationwide.[2] ACC has a strong interest in sustainable materials management (SMM), plastics sustainability and recovery.[3]

We commend the Committee for seeking to improve the performance of its packaging recycling and to fully utilize the value of materials that are currently being wasted in landfills. At the same time, we do not believe that the mandatory extended producer responsibility is the best way to achieve these shared goals. Reliance on EPR can lead to an overemphasis on recycling to the exclusion of source reduction and the implementation of a true "sustainable materials management" system that uses life cycle analysis to better understand environmental impacts such as waste prevention and the use of energy, water and greenhouse gas emissions. We welcome the opportunity to work with Maine to grow plastics recycling and recovery and we encourage the state to:

1) Consider adopting a holistic sustainable materials management approach that incorporates life cycle analysis and accounts for source reduction and conversion to fuels and energy along with recycling;
2) Fully enforce Maine's existing recycling provisions and pursue collaborative policy approaches;

[1] ACC's Plastics Division represents leading manufacturers of plastic resins. From life-saving medical devices to packaging that extends shelf life, versatile plastics inspire countless innovations that help make life better, healthier and safer every day.

[2] See, for example, Keep America Beautiful' s I Want to be Recycled campaign, The Recycling Partnership, WRAP Program.

[3] Plastics Recovery on ACC.com

3) Embrace voluntary plastics recycling programs and tools;
4) Leverage national partnerships for grants, loans and assistance; and
5) Treat all post-use plastics as valuable materials for conversion to chemical and plastic feedstocks and fuels.

Please consider using the recommendations outlined in our detailed comments below. ACC would be pleased to be an ongoing partner to help reduce waste and then recycle and recover more of Maine's post-use plastics. I can be reached by phone at (518) 432-7835 or by email at margaret_gorman@americanchemistry.com for any questions or additional information.

Sincerely,

Margaret Gorman

Senior Director, Northeast Region, State Affairs
American Chemistry Council
11 North Pearl Street, Suite 1400
Albany, NY 12207

<u>ACC comments to the Joint Standing Committee on the Environment and Natural Resources</u>

Plastics Contributions to Sustainable Materials Management

Plastics help us to do more with less in many ways. Because plastics are durable, lightweight and versatile, the use of plastics can help reduce waste and the consumption of energy. Lighter packaging can mean that lighter loads or fewer trucks and railcars are needed to ship the same amount of product, helping to reduce transportation energy, decrease emissions and lower shipping costs.[4]

Plastics Recycling Today

Plastics' recycling creates economic and environmental value. The *2017 United States National Postconsumer Plastics Bottle Recycling Report* found that the total pounds of plastic bottles collected for recycling in 2015 was nearly 3 billion pounds.[5] The two main types of bottles that are recycled are polyethylene terephthalate (PET) and high density polyethylene (HDPE). PET is often found in water and soda bottles and HDPE is often found in milk jugs and detergent bottles.

ACC tracks the recycling of plastic wraps, film, and bags. This category of plastics includes commercial shrink wrap, plastic wrapping around consumer products such as paper towels and bathroom tissue, protective packaging such as bubble wrap, and ordinary plastic shopping bags. The *2016 National Postconsumer Plastic Bag & Film Recycling Report* found that 1.3 billion pounds of postconsumer plastic film was recovered for recycling in 2016.[6] This represents a doubling of material collected since 2005.[7] Film, bags, and wraps can become contaminated when mixed with other materials, so are best not collected curbside. These materials can be collected at 18,000+ locations including most major grocery stores and retailers. Several years ago, ACC formed the Flexible Film Recycling Group (FFRG) to work to increase the recycling of polyethylene film. Its goal is to double polyethylene film recycling by 2020.

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[4] Impact of Plastics Packaging on Life Cycle Energy Consumption & Greenhouse Gas Emissions in The United States and Canada. 2014 http://plastics.americanchemistry.com/Education-Reso urces/Publications/Impact-of- Plastics-Packaging.pdf

[5] The 2017 United States National Postconsumer Plastic Bottle Recycling Report. https://plastics.americanchemistry.com/Reports-and-Publications/National-Post-Consumer-Plastics-Bottle-Recycling-Report.pdf

[6] The 2016 National Postconsumer Plastic Bag & Film Recycling Report https://plastics.americanchemistry.com/2016-National-Post-Consumer-Plastic-Bag-and-Film-Recycling-Report.pdf

[7] Ibid

ACC also tracks the collection of non-bottle rigid plastics collected for recycling. Non-bottle rigid plastics can be found in many forms such as tubs, containers, lids, cups and clamshells as well as larger "bulky" items such as buckets, crates, toys, and laundry baskets. The *2016 National Postconsumer Non-Bottle Rigid Plastic Recycling Report* found that over 1.46 billion pounds of postconsumer non-bottle rigid plastic was recovered for recycling.[8] Non-bottle rigid plastic recovered has increased by nearly 4.5 times since 2007.[9] The emergence of many domestic markets for non-bottle rigid plastics has led to an increasing number of cities and counties collecting these plastics for recycling. The *Plastics Recycling Collection National Reach Study: 2012 Update* found that over 60% of the United States population has some form of access to recycle non-bottle rigid containers.[10] Further, the increased amount of recycled material has driven increased reclamation opportunities in the United States.[11]

Programs to Increase Plastics Recycling

ACC commends Maine for focusing on recycling more valuable post-use packaging instead of sending it to landfill. We believe Maine could benefit from leveraging ACC and our partners' education, outreach and technical assistance programs. Below are some recommendations on programs that can deliver results for increasing plastics recycling.

1) **Pursue sustainable materials management as the long term goal.**

Plastics are an important component to preventing wastes, such as food waste, from materializing. We recommend that the state consider an approach known as "sustainable materials management" that is consistent with the approach the U.S. Environmental Protection Agency (EPA) recently adopted.[12] Sustainable materials management utilizes a holistic approach, such as life cycle analysis, as a tool to evaluate the full range of potential environmental impacts (e.g., greenhouse gas (GHG) emissions, energy, water, etc.) attributed to material use. ACC's life cycle

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[8] 2015 National Postconsumer Non-Bottle Rigid Plastic Recycling Report. https://plastics.americanchemistry.com/2016-National-Post-Consumer-Non-Bottle-Rigid-Plastic-Recycling-Report.pdf
[9] Ibid.
[10] Plastic Recycling Collection National Reach Study: 2012 Update, http://plastics.americanchemistry.com/Education-Resources/Publications/Plastic-Recycling-Collection-National-Reach-Study-2012-Update.pdf
[11] 2014 National Postconsumer Non-Bottle Rigid Plastic Recycling Report. https://plastics.americanchemistry.com/Education-Resources/Publications/20 14- National-Report-on-Post-Consumer-Non-Bottle-Rigid-Plastic-Recycling.pdf
[12] U.S. Environmental Protection Agency Sustainable Materials Management. http://www.epa.gov/smm

inventories on plastics packaging[13] including flexible coffee packaging[14] tuna packaging[15], and high density polyethylene (HOPE) milk jugs[16] provide examples of how source reductions from plastics packaging can lead to important environmental benefits even if these packages are not mechanically recycled.

Moreover, focusing on just the recycling rate can be counterproductive. For example, composting or anaerobic digestion of organic waste is often counted as recycling. And, because a large portion of organic waste is landfilled, increased diversion of organic material is often viewed as a prime opportunity to increase diversion rates. However, ACC encourages Maine to explore the fact that a truly sustainable materials management approach recognizes the critical role that sophisticated packaging plays in preventing food from being wasted in the first place. It also recognizes the greater environmental benefits from preventing food waste compared to the environmental benefits of treating organics after foods have already spoiled.[17] EPR policies ignore other sustainability considerations including greenhouse gas emissions and incentivize recycling at the expense of other environmental considerations.

2) **Enforce existing laws and regulations and pursue collaborative policy approaches.**

Quite simply, closing enforcement gaps and demonstrating an ability to enforce existing recycling laws and regulations should be pursued before new radical recycling schemes are enacted. Maine's existing bottle deposit law presents an opportunity to support recycling broadly. Unlike most other states, unclaimed bottle deposit receipts are not specifically earmarked to support local recycling programs or other statewide environmental programs. Because of a 2003 law, unclaimed bottle escheats have been directed to Maine's general fund. ACC recommends that Maine look to earmark its unclaimed bottle deposits to recycling activities and review how it spends its existing tipping fee surcharges before seeking out new sources of funding.

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[13] Impact of Plastics Packaging on Life Cycle Energy Consumption & Greenhouse Gas Emissions in the United States and Canada. http://plastics.americanchemistry.com/Educa tion-Resources/Publications/Impact-of-Plastics-Packaging.pdf

[14] LCI for Eight Coffee Packaging Systems. http://plastics.americanchemistry.com/LCI-Summa ry-for-8-Coffee-Packaging-Systems

[15] LCI Summary for Six Tuna Packaging Systems. http://plastics.americanchemistry.com/LCI-Summary-for-6-Tuna-Packaging-Systems

[16] LCI Summary for Four Half-Gallon Milk Containers. http://plastics.ame ricanchemistry.com/LCI-Summary-for-4-Half-Gallon%20Milk%20Containers

[17] U.S. Environmental Protection Agency. Sustainable Management of Food. https://www.epa.gov/sustainable- management-food/food-recovery-hierarchy

3) **Embrace Voluntary Plastics Recycling Programs and Tools**

Maine should become a WRAP partner and adopt the Plastics Recycling Terms and Tools. Increasing the recycling of plastic film, wraps and bags represents a major opportunity to help Maine meet its objectives. Clean polyethylene film is a valuable feedstock for manufacturers and most major retailers in the United States collect post-consumer plastic wraps, bags and film at front-of-store locations. The WRAP program promotes brand owner adoption of the Sustainable Packaging Coalition's (SPC) "How to Recycle Label." Additionally standardizing plastics terms and images is a best practice for community education programs. Maine can encourage its communities to fully utilize the Plastics Recycling Terms and Tools to increase collection of post-use plastics and align with its goal of generating more reliable tracking and measurement data.

4) **Leverage National Partnerships for Grants, Loans and Technical Assistance**

Communities in Maine could benefit from two significant multi-million dollar initiatives led by the private sector. These initiatives are directly investing in communities and recycling systems across the country. The Recycling Partnership (TRP), of which ACC is a funder and board member, recently partnered with the Massachusetts Department of Environmental Protection (DEP) to reduce contamination and drive the collection of more and better material for recycling.[18] Another important organization is the Closed Loop Fund (CLF), which was founded by Walmart and nine major global brands to provide no-interest loans to communities and private entities. Maine should explore a direct partnership with TRP and encourage its communities to apply for grants or loans from TRP or CLF. Lastly, Maine should support the Grocery Rigid Plastic Recycling Program.[19] Research has shown that grocery store delis, bakeries, fish markets, and pharmacies use significant quantities of high-value rigid plastics every day. These plastics are often larger, bulkier items that contain things like cake batter, frosting, and fish fillets. Growing the total supply of non-bottle rigid plastics available for reclamation in Maine could potentially help establish markets for smaller communities as well.

5) **Treat All Post-Use Plastics as Valuable Materials for Conversion Chemical and Plastic Feedstocks and Fuels**

Encouraging new recovery technologies should aid Maine as it works to increase its total diversion rate from landfill. Unfortunately, many states have yet to recognize the

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[18] MassDEP to Collaborate with The Recycling Partnership. https://www.recyclingtoday .com/article/massdep-the-recycling-partners hip-collabo rate/
[19] Recycle Grocery Rigid Plastics website. http://www.recyclegroceryplastics.org/

growing range of technologies available to convert post-use resources, including plastics, into useful products and materials. As a result, entrepreneurial manufacturers who seek to convert post-use materials into valuable products such as new chemicals and lower carbon transportation fuels are forced into regulatory schemes for recycling or disposal, when neither is an appropriate fit. Consider pyrolysis, an oxygen free process that can convert post-use plastics into chemical feedstocks for new plastics or fuels. Many state waste and recycling regulations were promulgated before these pyrolysis technologies were commercially viable, and as a result these facilities often are mischaracterized as waste disposal.

However, these facilities receive a feedstock, in this case post-use plastics, and produce a marketable commodity. These are manufacturing facilities, not waste disposal facilities. ACC developed a "Regulatory Treatment of Plastics-to-Fuel Facilities" document to provide permitting guidance to state and local regulators.[20] It includes a checklist of the typical federal, state, and local permits that are required to operate these facilities. These technologies also have considerable environmental benefits compared to disposing these resources in landfill.

ACC appreciated the opportunity to provide written comments to the Joint Standing Committee on the Environment and Natural Resources.

[20] Regulatory Treatmentof Plastics-to-Fuel Facilities. http://plastics.americanchemistry.co m/Product-G roups-and-Stats/Plastics-to-Fuel/Regulatory-Treatment-of-Plastics-to-Fuel-Facilities. pdf

AMERIPEN
The power of packaging in balance.

February 14, 2019

Mike Karagiannes
Maine DEP
17 State House Station
Augusta, ME 04333-0017

Re: AMERIPEN Comments on Product Stewardship Report, 2019

Dear Mr. Karagiannes and Department of Environmental Protection Staff,

The American Institute for Packaging and the Environment (AMERIPEN) is writing regarding the 2019 Annual Product Stewardship Report (the Report), and specifically on Section IV, A. which discusses *Product Stewardship for Packaging*. AMERIPEN does not support a product stewardship mandate as suggested in the report for Maine and notes that there are several factors that have not been considered in the report that should be articulated for full consideration of *whether* a stewardship program for packaging should be required in Maine.

AMERIPEN – the American Institute for Packaging and the Environment – is a coalition of packaging producers, users and end-of-life materials managers dedicated to improving packaging and the environment. Our membership represents the entire packaging supply chain, including materials suppliers, packaging producers, consumer packaged goods companies and end-of-life materials managers.

AMERIPEN supports programs and policies that improve recycling and works collaboratively to create cleaner recycling streams, expand access to recycling and increase the types of materials that can be recycled in states. However, we do not support product stewardship or extended producer responsibility for packaging in Maine as envisioned by the report, and encourage the Department to consider the following key issues.

1. Feasibility & Hidden Costs with Extended Producer Responsibility/Product Stewardship for Packaging

Extended Producer Responsibility (EPR) or product stewardship for packaging, as recommended by the Report, requires producers to take full or partial financial and management responsibility for products at the end of their life via product stewardship organizations (PSOs). This approach has not been proven as feasible in the U.S., and EPR has primarily been used elsewhere as a funding mechanism to implement end-of-life materials management programs where no funding source has been previously available. In the European Union, for example, funding from EPR was used to implement the widespread implementation of recycling programs *for packaging that had already been proven to be recyclable*. Most innovation funding for new recycling technology is <u>not</u> coming from EPR fees but rather through government and private funding mechanisms and EPR does not address that scenario. Maine should first consider and detail infrastructure investments needed to improve recycling capacity before jumping to financing solutions.

The Report supports EPR and cites its effectiveness in achieving three main goals (1) reduce costs to states or municipalities, (2) incentivize product design and (3) increase collection. However, currently, there is no

1000 WestGate Dr • Suite 252 • St. Paul MN 55114
Phone: +1 651-288-3431• Fax: +1 651-290-2266

research demonstrating that EPR reduces costs to taxpayers[1], and none that support EPR's role in fostering packaging changes and innovation. While there are several reports that indicate EPR may help increase recycling rates, there are also a number that indicate an increase in recycling rate also incurs an increase in contamination and costs. In a 2015 publication[2] Dr. Calvin Lakhan noted that the Ontario BlueBox program had witnessed a 78% increase in fees in over a 10-year period. Dr. Lakhan notes that a 1% increase in recycling rate corresponded with a 9.4% increase in costs, which he attributed mostly to fluctuating market economics and the introduction of hard-to-recycle materials. These types of cost increases to process materials should be noted as a potential consequence of EPR for packaging in Maine. Additionally, it should be noted in the Report, that while paying more for PSO management of materials, local municipalities are not likely to return tax dollars or solid waste fees to constituents and that they will also be generally be paying more for consumer products.

Some of these same challenges face take-back programs for electronics which have a long history of experience with EPR in the U.S. These programs are witnessing significant increases in costs as states impose unattainable recycling targets not in line with material coming back through the collection system; states impose convenience standards that may not actually result in increased collection of e-waste but instead increase costs for manufacturers; or, in some cases, states set pricing without any market influence or competition among service providers resulting in the highest program compliance costs in the U.S. Additionally, EPR programs for electronics have not proven to incentivize product design. EPR does not always result in the achievements its been touted to produce or at least not in a cost-effective manner for those ultimately fronting the bill. What started as a promising solution is now becoming a cost-burden on both states and manufacturers.

2. Market Challenges for Materials Recovery Must be Noted in the Report

AMERIPEN recognizes that increased efforts toward domestic processing can be a key strategy in reducing marine debris, improving environmental outcomes and increasing our economic competitiveness. However, the Report presupposes that if manufacturers are forced to manage the collection of packaging materials, then the technology and volumes of materials within the State are sufficient with today's existing technology. This is flawed.

Many plastic resins and mixed materials have a lack of end markets that makes it difficult to offer mechanical recycling solutions. Alternative recovery strategies such as plastics-to-fuel or other forms of energy recovery may be possible but are challenged by a lack of sufficient volume to meet their needs to process and scale, especially in Maine. The Report's belief in having all materials diverted to recycling is not likely to match the reality of capture and recovery methods and does not reflect the challenges of today's scrap trade for diverted materials.

There is ample evidence of this challenge:

A. Recycle BC recently introduced a pilot program to collect and trial recovery efforts for multi-material plastic film packages, a product which is rapidly growing in the market. While a portion of this material collected has been stated to be designated towards R&D for mechanical recycling, they are clear that the majority of this material will be pelletized for waste to energy. To date there is no public reporting available on volumes directed towards R&D or pelletization or success rate in R&D.

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[1] Miller, Chaz. "From Birth to Rebirth: Will Product Stewardship Save Resources?" American Bar Association. Section of Environment, Energy and Resources. 2011.

[2] Lakhan, Calvin. (Feb 2015) "Diversion But At What Cost: the Economic Challenges of Recycling in Ontario." Resources, Conservation and Recycling.

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Phone: +1 651-288-3431• Fax: +1 651-290-2266

B. The city of Palo Alto, CA is also in a pilot with emerging company *BioCellection* to process hard-to-recycle plastics and films but their approach is to mix resins 2-4 and films in order to capture sufficient volumes for small trials. *BioCellection* is still considered an early-stage innovator and has yet to show proven success with recovery of this material.

C. The Province of Nova Scotia recently partnered with *Renewology*, a commercially viable plastic to fuel technology, to help reduce plastic waste but this required changing Provincial statutes to permit for thermal recovery.

AMERIPEN and its member companies understand there is a need to increase the technologies available to process more packaging materials, but the challenges in the market right now require a focus on ***end market development*** and capturing ***sufficient volumes*** to ensure scale, especially in Maine. Many of our corporate members are supporting these efforts through investments into initiatives including *The Recycling Partnership*, *REMADE*, and the *Alliance to End Plastics Waste.*

However, until these investments identify new technologies or the best means to capture increased volumes of resin types, the ability to successfully re-process significant volumes of plastics 3-7 and other mixed materials will remain a challenge and the additional burden to collect, sort and process materials will slow any R&D contributions towards this goal.

3. Loss of Local Control and Solid Waste Management

While the Report does discuss different versions of shared and sole manufacturer financial responsibility under an EPR program for packaging and envisions local incentives for efficient municipal programs, it does not provide specifics on how this balance can truly be achieved to sustain both statewide collection of materials and local control.

AMERIPEN recommends that the Report clearly state that regardless of the approach, local municipalities may likely lose control and management responsibility for packaging waste under a true EPR approach. If PSO organizations are mandated to be responsible for managing packaging materials statewide, those organizations are not likely to continue to contract and support the diversity of Maine's solid waste structures within all of municipalities and local governments *and* be sustainable economically. Efficiency will be critical, especially in today's material markets, and any PSO will find it difficult to meet statewide service collection and maintain both local control and solid waste management jobs and responsibilities. Out of necessity this will result in statewide contracts for collection to those providers that can provide service that accomplishes PSO program goals but minimize variation and local cost issues. If a system is set up without this flexibility, then the alternative – costly bureaucratic duplication – is equally disruptive and unlikely to be publicly accepted.

4. Maine's Bottle Bill and EPR for Packaging

While the Report does discuss Maine's Bottle Bill program and notes where EPR and bottle bill programs exist in Canada, it does not provide a vision for how such a program would relate to EPR for packaging in Maine. Maine's privatized Bottle Bill program is unique and it is difficult to see both programs continuing to be able to operate and create enough volumes for either program to be successful – especially when the Bottle Bill in Maine appears to be in a crisis. This crisis is demonstrated by the amount of legislative interest in supporting the private system of the Bottle Bill this year. With this crisis, moving to an EPR program for all packaging, which would include beverage containers, may only exacerbate the program's current problems. If the Department intends to maintain two systems, the Report must articulate how they both could achieve economically viable volumes of materials and funds.

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Once again, AMERIPEN appreciates the opportunity to comment on the Annual Product Stewardship Report**.** While we do not support product stewardship as envisioned by the report, we look forward to working with the Department of Environmental Protection to work to address proactive policy solutions that improve access to recycling and find positive outcomes for recycled materials within Maine and beyond. We hope to continue a positive dialogue with the Department on these issues and with the Legislature as they are considered this year.

Sincerely,

Andrew R Hackman

Andrew Hackman
Principal Lobbyist on behalf of AMERIPEN

CC: Melanie Loyzim, Deputy Commissioner, Maine DEP
Paula Clark, Director, Division of Materials Management, Maine DEP
Carole Cifrino, Supervisor, Recycling Programs, Maine DEP

CHPA

founded 1881

February 14, 2019

Mr. Mike Karagiannes
Director, Bureau of Land Resources
Maine Department of Environmental Protection
17 State House Station
Augusta, ME 04333-0017

RE: Comments – Annual Product Stewardship Report (January 2019)

Dear Mr. Karagiannes,

On behalf of the Consumer Healthcare Products Association (CHPA), the 137-year-old trade association representing the leading manufacturers of over-the-counter (OTC) medications, please accept our comments related to the Maine Department of Environmental Protection's (DEP) annual report, *Implementing Product Stewardship in Maine*.

Our specific interest in the document falls on page 20 where pharmaceuticals are mentioned as a candidate for a new extended producer responsibility (EPR) law in Maine. While EPR may make sense for some consumer products, it does not work for pharmaceuticals. In fact, the report admits that one of the more critical components of product stewardship – increasing recovery of material for reuse and recycling – cannot be met with a pharmaceutical EPR law. That being the case, we strongly recommend the State of Maine take alternative approaches to address concerns with pharmaceutical diversion and environmental impact. Rather than creating an expensive, inefficient, under utilized framework for broad pharmaceutical product stewardship (drug take-back), CHPA encourages the state to educate consumers about existing disposal and safe medicine storage options.

Disposal Options Already Exist

Walgreens, in a partnership with AmerisourceBergen, Prime Therapeutics, and Pfizer (a member of CHPA) already collects unused or unwanted medications at 1,500 of its drugstores across the country. Since the program began, more than 400 tons of medications have been collected and disposed of. Late last year, Walgreens also announced it would offer drug disposal options at every single one of its stores. Available at no cost to consumers, Walgreens will distribute a "safe medication disposal kit" upon request by any customer. Both programs make the disposal of medications easier and more convenient while helping reduce potential drug diversion from their intended use.

Similarly, CVS Health accepts unused pharmaceuticals in more than 750 of their locations, and they have donated more than 900 disposal kiosks to community locations such as police departments. Together, these units have collected more than 217 tons of unwanted and unused medication.

Walmart gives pharmacy customers "Dispose Rx" powder that can turn medications mixed into a pill bottle with warm water that is then disposed of in household trash. Rite Aid offers mail back envelopes people can use to return their extra medications. These retail efforts combined with existing Drug Enforcement Agency (DEA) pharmaceutical drug take-back days, provide consumers with a plethora of options for medicine disposal. Rather than re-creating a take-back system, we suggest educating the public about existing options; concentrating efforts on driving traffic to existing disposal sites.

Safe Storage vs. Safe Disposal

According to national surveys, at least half of individuals who misuse medications obtain them from a friend or relative. More than 60,000 young children end up in emergency rooms every year after getting into medicine while their parents or caregivers were not looking. Medications left unattended or not safely stored, no matter if they're expired or not, are prone to being diverted from their intended use. As such, educating Mainers about the importance of safe medication storage has a far greater impact on drug diversion control than does a disposal program.

To remind parents and caregivers about the importance of safe medicine storage, the Centers for Disease Control and Prevention (CDC) and the CHPA Educational Foundation, in partnership with the PROTECT Initiative, launched the Up and Away and Out of Sight educational program. The program is aimed to educate parents and caregivers about how they can prevent accidental overdoses. It reminds them to store medicines safely; providing them with the information and tools to keep their child/children safe; and encouraging them to take action.

Conclusion

OTC medicines play an important role in our nation's overall healthcare. Our members' products provide millions of Americans – including thousands of Maine residents – with safe, effective, and affordable therapies to treat and prevent many common ailments and diseases. These medicines are affordably accessible to patients, and help empower families to treat conditions with trusted, Food and Drug Administration (FDA) approved treatments. According to a study by Booz and Company, for every dollar spent on an OTC medicine, we save the U.S. Healthcare system $6-$7.[1] Without access to OTC medicine, over 60 million Americans would not seek treatment for their ailments at all.[2]

For these reasons, we take very seriously any potential disruption - regulation or otherwise- to the affordability of OTC healthcare. As the first and only line of defense for many Maine families, it is critical that state officials evaluate the opportunity cost (cost of medications vs. benefits of drug take-back) associated with the implementation of a mandatory, manufacturer funded drug take back program.

CHPA recognizes the importance of safe storage, and drug disposal, but we strongly disagree that an EPR program for pharmaceuticals is necessary in the State of Maine. Thank you for considering our concerns and please feel free to contact me directly with any questions on our position.

Respectfully submitted,

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[1] The Value Of OTC Medicine To The United States, Booz & Co., January 2012.
[2] Ibid

Carlos I. Gutierrez
Vice President, State & Local Government Affairs
Consumer Healthcare Products Association
cgutierrez@chpa.org | 202-429-3521

clf
conservation law foundation

For a thriving New England

CLF Maine
53 Exchange Street, Suite 200
Portland, ME 04101
P: 207.210.6439
F: 207.221.1240
www.clf.org

February 14, 2019

Mike Karagiannes
Maine Department of Environment Protection
17 State House Station
Augusta, Maine 04333

Re: Comments on the Maine Department of Environmental Protection ("DEP")'s 2019 Annual Product Stewardship Report to the Legislature ("Report").

Dear Mr. Karagiannes,

Conservation Law Foundation ("CLF") is a nonprofit, member-supported, regional environmental organization working to conserve natural resources, protect public health, and promote thriving communities in the New England region with an office in Portland. Our Zero Waste Project aims to protect the regions' communities from the dangers posed by landfills and incinerators, support the development of a circular economy, and lift the burden of waste costs from municipalities. Thank you for the opportunity to submit comments on Maine DEP in the 2019 Annual Product Stewardship Report.

CLF supports policies which strive to include producers in the end-of-life management of the products they place on the market, including the recommendations made by Maine DEP in the 2019 Annual Product Stewardship Report. Maine is a national leader in the implementation of extended producer responsibility programs, and we hope it continues to lead by expanding and adopting the policies in the Report.

For much of the history of waste management, producers have been disconnected from end-of-life care for the products they sell to consumers. Companies do not have an incentive to design products to be recycled or use recycled content in their manufacturing, and increasingly materials are used which cannot be easily recycled or recovered. Producers of hazardous waste like plastics and electronics flood the market and our landfills and incinerators with dangerous pollution. Solid waste facilities, which are overwhelmingly located in environmental justice communities, then expose the most vulnerable populations to health hazards. Waste costs extend beyond environmental and health concerns – municipalities are responsible for cleaning up litter and paying for trash and recycling regardless of whether they purchased the products, costing taxpayers tens to hundreds of thousands of dollars each year. Extended producer responsibility ("EPR") policies require producer engagement in bearing these burdens, lifting costs from communities and incentivizing environmental stewardship from producers.

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For a thriving New England

CLF Maine
53 Exchange Street, Suite 200
Portland, ME 04101
P: 207.210.6439
F: 207.221.1240
www.clf.org

Maine is one of two states with an extended producer responsibility framework law, which has led to the adoption of product stewardship programs for a long list of products, including electronic waste, architectural paint, and beverage containers recovered through the Bottle Bill. CLF supports these programs and Maine DEP's recommendations for improvements. However, CLF cautions the DEP and Legislature with respect to any proposed statutory changes to the Bottle Bill. Maine's beverage container redemption law is highly efficient in its current form, recovering between 75 and 87% of all distributed beverage containers. The program provides jobs and a clean source of recyclable materials, while lifting the cost of recycling from the backs of municipalities. CLF agrees with the Natural Resource Council of Maine's comments on the Report that the Legislature should improve the program with:
1) Better data and reporting so that we may be more certain about the collection rate—this should be coupled with an automatic increase in deposit amount should collection targets not be reached;
2) Consideration of adding more containers into the redemption model;
3) Better ways to respond to issues of non-compliance; and,
4) Review of methods to streamline the commingling process based on input from the redemption center operators.

The Report also includes recommendations for five additional programs that the Legislature may consider: product stewardship for packaging, pharmaceuticals, carpets, mattresses and solar panels. EPR laws for each of these products exist in other U.S. states, including very successful programs in Rhode Island, Connecticut and California for mattresses, and statewide product stewardship for pharmaceuticals in California.

CLF is especially heartened by Maine DEP's focus on and insight into the implementation of an EPR program for packaging. The Report highlights the drastic increase of recycling costs for municipalities in 2018, caused by China's refusal to accept contaminated bales of mixed plastic and fiber. EPR programs for packaging in the European Union and Canada have lifted all or part of these costs from municipalities and taxpayers while pressuring producers to make the barrage of products flooding communities as recyclable as possible. In identifying program examples, Maine DEP describes the differences between recycling systems completely under producer control versus those in which municipalities maintain partial control. CLF believes that the Legislature should move quickly to adopt a shared model wherein producers are responsible for helping cover the costs of municipal recycling. Such a program will ensure that environmental goals for material recovery are met and that recycling remains under control of municipal government, not producers concerned with their bottom line.

While Maine may be a leader of EPR policies and programs, the rest of New England is also moving forward, especially Massachusetts, Connecticut, and Rhode Island. The Zero Waste Project promotes EPR programs regionally, including shared responsibility for packaging and expanded or strengthened deposit/return programs for beverage containers. EPR systems work,

CLF Maine
53 Exchange Street, Suite 200
Portland, ME 04101
P: 207.210.6439
F: 207.221.1240
www.clf.org

conservation law foundation

and regional adoption of product stewardship will only increase the efficacy of these programs, so we will be certain to share news of your hard work with other states.

CLF thanks Maine DEP for this thorough and motivating report, and for allowing us the opportunity to submit comments in support. We will urge the Legislature to vote favorably on EPR legislation under consideration this session, and to advocate for the future adoption of recommended programs. CLF stands ready to answer any questions or supply additional information if needed.

Very truly yours,

Kirstie L. Pecci

Kirstie L. Pecci
Director, Zero Waste Project, CLF

Cc: Sarah Lakeman, Sustainable Maine Project Director, Natural Resources Council of Maine
Sean Mahoney, Executive Vice President and Director, CLF Maine, Conservation Law Foundation

RETAIL ASSOCIATION OF MAINE
Voice of Maine Retail
45 Melville Street, Suite 1
Augusta, ME 04330
Phone: 207.623.1149
www.retailmaine.org

February 14, 2019

Mr. Mike Karagiannes
Maine Department of Environmental Protection
17 State House Station
Augusta, ME 04333-0017

Re: Comments on 2019 Maine Product Stewardship Report

Dear Mr. Karagiannes:

On behalf of the membership of the Retail Association of Maine, please accept the following comments regarding the 2019 Maine Product Stewardship Report. As noted in the report, the department is recommending changes to the framework law as well as four of the nine programs that currently exist. We will break our comments down in a similar fashion.

Framework Law Changes:
The report proposes a number of changes to Maine's product stewardship law most notably in Appendix A. We have some concerns:

- Each product and program is different and to mandate a permanent collection site within 15 miles of 90% of Maine's population within 1 year seems arbitrary. Given the majority of Maine's population follows the coastline, the bill would likely exclude collection in much of Maine beyond the coastal areas.
- Requiring that a program has a minimum of a ½ time employee is not clear. Must this person be located in Maine or would a program operating regionally suffice?
- The department is proposing an annual fee of up to $100,000 per year to help cover annual report review, oversight, administration and enforcement. With the existing nine programs this seems excessive. How may DEP staff are needed to adequately monitor the programs? As the report demonstrates, some of the programs are operating efficiently and need very little ongoing oversight. Additionally, when the product stewardship law was first passed, it promised two things in addition to taking certain products out of the waste stream: drive down to cost of landfilling certain materials and to prevent individual legislative proposals for new product categories. While DEP demonstrates that Maine has increased recycling costs, no evidence is provided that EPR will actually lower costs. We believe neither of those promises have been kept.

- The department is proposing an annual survey by each of the nine programs to measure consumer knowledge and collection methods. It would seem to be more efficient to have one survey that covers all of the programs. Does it need to be done annually or would bi-annually suffice?
- In summary, the department is proposing a number of dramatic changes in Appendix A. We would recommend that a stakeholder group be formed to collaboratively work with the department on any necessary changes to existing programs. The stakeholders should include representatives from the existing product programs, retailers, and collection sites.

Mercury Lamps:
The marketplace for lightbulbs has changed dramatically in the last decade. For consumers, we have moved from incandescent bulbs to CFLs to LEDs. In fact, starting January 1, 2020, there will be new requirements on producers and retailers regarding high efficiency lamps thanks to the 2007 Energy Act. It is clear the department has concerns with the existing program and we cannot comment on the effectiveness of NEMA's program. However, we do think there is an opportunity for a wider discussion of this issue with Efficiency Maine and whether or not there can be additional incentives to replace CFLs.

Recently, Efficiency Maine ran a program that lowered the cost of LEDs lightbulbs to approximately $.50 / bulb. The price was so good that it inspired me to replace all of the CFLs in my house with LEDs. However, now I am left with a good number of still-usable CFLs and it would seem silly to recycle them when they still have usable life. Could Efficiency Maine or Maine DEP provide a bounty on CFLs similar to the mercury thermostat program? Perhaps that would help drive up redemption rates.

Beverage Containers:
The report noted that Maine's beverage container redemption program is very successful with redemption rates of 75-87% compared to the national average of 34%.

We have a number of concerns with some of the proposals in the report:

- First, Mainers are well aware where they can take their bottles for redemption. Maine's program has been operating for so long that there should be no confusion as to who takes or does not take bottles.
- That being said, while we support the elimination of the redemption responsibility for retailers of 5,000 square feet or less, we cannot support the new requirement that retailers greater than 5,000 square feet must have a written agreement with a redemption center within 1 mile. As Mainers, we know we can take our bottles to a Clynk facility at Hannafords, or Shaws' redemption facility, or a stand-alone redemption center. We don't expect Reny's to redeem bottles. We don't expect Home Depot or Dick's Sporting Goods to redeem bottles. We have never understood the need for retailers to maintain written agreements with redemption centers as we are not aware of redemption deserts in Maine. In fact, our 75-87% redemption rate speaks to the success of the existing program.

- There are a large number of bills submitted this session looking to make changes to Maine's bottle redemption program so we know these issues will all get scrutinized and we welcome the discussion.

Batteries:
As the report noted, there was significant discussion in 2016 regarding the expansion of the battery stewardship program. We agree that batteries (generally rechargeable batteries) that are a fire hazard should not be in the waste stream and that additional efforts are needed to limit that risk.

However, when the discussion includes primary batteries, we are not sure those should be included in the program. Primary batteries are non-toxic and can be disposed of through the normal waste stream with no adverse effects and do not take up significant landfill space. Yet, consumers do not differentiate easily between rechargeable / recyclable batteries and primary batteries and often deposit both types in collection containers. In addition to the recommended language in the report, there is another bill title addressing batteries for legislative consideration. We look forward to participating in those discussions when those bills arise.

Cellular Phones:
We agree with the proposed changes to the cellular phone program.

Additionally, the report discusses other products for future consideration, namely *packaging, pharmaceuticals, mattresses, carpet and solar panels*. We are aware of a couple bill titles that will propose legislation regarding mattresses and pharmaceuticals as those issues have been discussed previously. There are existing programs in other states that will provide relevant information as to whether or not these products are ready for a product stewardship program in Maine.

For packaging, the report highlights many of the challenges that currently exist but we wanted to mention a few other points.

- DEP claims that other provinces have had success with EPR without providing clear before and after evidence of success. Furthermore, they confess to not being able to measure changes in sustainable packaging as a result of EPR. We support increasing the use of sustainable packaging and believe that the state can work with businesses to achieve that end within the existing recycling scheme and create incentives to encourage sustainable packaging.
- DEP is conflating product EPR programs with EPR for packaging. The complications with creating an EPR scheme for packaging in Maine are significant and cannot be taken lightly. No state in the U.S. has approved an EPR law for packaging. In fact, the CT legislature directed a task force to study methods for reducing consumer packaging. In February 2018, that task force approved final recommendations that did not include EPR for packaging.
- DEP raises a number of important questions about EPR for packaging in their report but does not provide answers. If DEP wants to explore this issue, we recommend they convene a

stakeholder discussion, of which RAM would participate, to understand the opportunities, complications and factors the legislature would need to consider before approving an EPR program for packaging.

Thank you for the opportunity to submit our comments.

Sincerely,

Curtis Picard CAE, President and CEO

Comments on Product Stewardship Report of Peter Welch Gaia, LLC

Hello Mike,

It was good to meet you up in the legislature at the time of the plastics bill hearing at ENRC. Please note that I have copied Carole Cifrino as well. I certainly wish to share openly my views with her, too, in the spirit of dialogue that she has so generously offered to me. Please know that I view this report with an understanding that the DEP is wanting to make improvements to the bottle bill & that this department bill is with the best of intention. However, the dialogue and concepts that are included in the Stewardship proposals fails to address the # 1 issue, handling fees.

Please allow this email to be my "comments" for purposes of public comment on the "Stewardship Proposal".

Handling fees have not adjusted in nearly a decade. Proposals such as LD 360 do address this issue and the need is urgent. Hence, the "emergency" status is warranted. I would hope that the department and Governor Mills would see the need and support its passage. I speak as a bottle bill veteran since 1981. I speak as a major retailer in Maine for nearly 25 years. I speak as a wine importer who sells to wine distributors in Maine. I speak as a long-time former Maine Liquor Agent. I speak as an employer who voted for the minimum wage increase. I speak as a past appointed member by the Maine Legislature on multiple "bottle bill" study groups. I speak as a longtime supporter of the bottle bill & Maine's environment.

Let me try to address the Stewardship proposal in the following prose.

The "catch all" is not a panacea- even if it were able to be implemented???? It is not well thought out, at all. The spirit of the idea is good. It would be somewhat helpful, in theory. It would only represent about 20% of the containers in the system, by my estimate**.**

Do you know of any entity that envisions themselves as the "Catch All"???? The state should be wary and cautious about getting stuck holding the bag here!!

However, this section improperly assumes that the only action and" labor" involved at a redemption center is: putting a can in a bag. It doesn't save any storage space, whatsoever. And, the storage on site for 1000 containers is the same no matter how many sorts are involved. It may save some floor space for sorting, surely.

A customer brings a container to a redemption clerk- The clerk- inspects for the "deposit"(**often difficult to find and see due to poor or out of compliance labeling by IOD's**)- requires counting the customers empties by those that are .05 separate from .15 & separating out containers not covered under the bottle bill- etc., etc. It does not include the labor needed to maintain & clean the redemption center and take care of ancillary recyclables (i.e.- cardboard & bags of which there is a lot- again envision yourself and how folks return empties) -- or trash- including the bazillion plastic bags consumers return empties in.

At some point and currently & usually once a week or every 2 weeks- the distributor picks up the containers and verifies with the redemption center the number of containers. The proposed "catch all" process is much more involved than that. Also, the idea of weights is flawed- even if you were to get

100% compliance from all these IOD's. Right now- we have containers that have ice in the bottom of them from fluid from sitting in people's garages. If anyone can picture your own empties- or what we see---- empties comeback with a variety of materials in them. First, they often have some amount of fluid or ice in them which would mess up the weight concept, completely.- Sometimes they have lemons and fruit, sometimes cig butts- sometimes straws, in the summer sand, etc- the list goes on. Also, IOD's are constantly changing and evolving their containers for marketing purposes, etc. Size, shape, and weight are regularly changing. Just recall the testimony at the Plastic Caps hearing about producers lowering the weight of their containers.

Sometimes very unsavory stuff is also in these containers. Deposits and weights don't match up & cannot be reconciled by bookkeeping.

Also, if the measurement to the consumer is a "5 cent deposit" the only way to match this up is with the same. I can picture a scenario whereby each and every bag that departs a redemption center needs to be "weighed"- OMG- that will take time and labor! From a bookkeeping point of view, I picture an army of clerks and tally's even using scanners and technology.

Practically speaking- all these IOD's which, in theory, will be part of the "catch all"- all currently have the opportunity to sell directly and "solely" to a Maine distributor and thereby be part of those distributors that have a co-mingling group- (In theory). But they have voluntarily decided to NOT pursue this avenue. Or, they have not been permitted to join for some reason. This is by choice, assumable.

Also, there has been no oversight or review of the current co-mingling groups to verify annually that they continue to be in compliance with law and regulation. This should be done.

More importantly, the existing co-mingling groups were envisioned & required to allow other producers into their groups under the original enabling legislation. If that were happening, this issue is solved. But, still not a panacea!

There are also some other issues in this Stewardship report, too. I am for fees to be increased to assist the bottle bill and enforcement- but that MUST include IOD's and distributors- not just Redemption Centers. Yes, go ahead and double everyone's fees. I find it a little burdensome that that the side of the industry with fixed revenue is being asked to carry all the weight.

I do concur with getting a "solid reporting" regime of & for "ALL" containers BOTH SOLD & REDEMMED IN MAINE. This is really slack at the moment. This should be done for containers subject to "escheat" and containers that are not subject to "escheat". "Trust & Verify", to quote Ronald Reagan.

As for the issue of Maine Liquor not meeting the "test" of a qualified commingle- well then- a "fiscal note" should be attached to this legislation as the state would owe ½ penny going back for several years on all the containers run thru its system. Because the State of Maine was envisioned as 100% of the product group in the original legislation; it was deemed compliant.

Unfortunately, I see this as well-intentioned but way off the mark of the focus needed. That is a handling fee increase such as envisioned in LD 360 and with a CPI adjustment whenever the CPI moves above the "BASE" rate by more than ¼ of a penny.

The section on “fraud” and “under bagging” at redemption, I see as somewhat of a red herring. Most and many redemption folks are hardworking, honest folks and this intonation is not fair. First, the distributor or pick up agent has the right to refuse a bag if they see or believe it to be short. Second, it makes no provision for being overfull. The system was designed on volume counts. At that has worked, well. THERE ARE NO IOD’S MORE THAN 100%!!! There is “NO” mention of unintentional or intentional fraud in the system by IOD’s. I submit this is more significant- due to “perhaps” unintentional acts- but still more significant. The fact that RSI had more contract IOD’s than Maine Revenue Services had filings for IOD’S & “escheat” is a bell weather. That should be a 1:1 and 100% correlation. THE CURRENT LAW REQUIRES IT, BUT IT IS NOT ENFORCED.

The bottom line is that the bottle bill is a “User Fee”- the single most effective piece of legislation with a 40-year history of success, delivering 80-95% return rate without a “Penny” of taxpayer money. I would think the Legislature and Governor would support this concept, universally. It does deliver 5%-10% of Maine’s MSW depending on who you talk too. If we had 5 more laws as effective as this- Maine would be at 50% recycling and meet our outdated goal. It saves property taxpayers and municipalities “statewide- rural & urban”. And BTW- the roads are clear of those containers and Maine DOT and towns do not need to employ staff to do this Vital Task in a tourist state. We are a tourist state whereby our hospitality industry is of great importance.

The Maine public has endorsed and supported the “bottle bill” with great zest and compliance. Twice rebuffing by great vote margins (85%-15%) industry efforts to dismantle and weaken the bottle bill. Wouldn’t it be grand if all of Maine’s Solid Waste legislation had this “SUCCESS”!

IT works!!-

The crux of the issue at the moment is that all manner of costs(property tax, insurances, utilities, supplies, on and on)-- have increased at the Redemption Center level since 2009 at the time of the last increase.

Significantly, the Maine minimum wage has rightly risen from 7.50/hour to 11.00/ hour starting 1.1.19. A 46% increase. Starting on 1.1.20, the minimum wage rises to 12.00/hour- a whopping 60% increase from 2009.
Maine state government has implemented this minimum wage. Maine state government implements the “handling fee”. Raising the “handling fee by .01 to .02 with a CPI adjuster” is: a matter of, FAIRNESS.

Over the past near decade, this amounts to less than 1/10 of 1 percent per year increase when related to the retail price of products such as liquor, wine, beer, soda and water.

I see the Dept. bill as perhaps well-intentioned but “noise” and distracting. I believe the Dept. had as a prerequisite, trying to do something positive- just so long as there was no fee increase. Hence, all version of mental exercises except the single most needed advocacy. I am certainly wishing to make myself available to and for the department in any manner that may be of assistance.

Thanks for letting me portray a point of view & providing me the opportunity to do so. If you would be so kind as to confirm receipt so that I know that I have properly delivered these comments; I would be thankful.

Sincerely yours,

Peter E. Welch
Gaia, LLC
d/b/a Forest Avenue Redemption Center
897 Forest Avenue
Portland, Maine 04103
207.329.3248 (cell)
pwelchoptimusimports@myfairpoint.net

Peter E. Welch
Optimus Imports, LLC.
897 Forest Avenue
Portland, ME 04103
207.329.3248 cell
207.775.4422 fax

INTERNATIONAL SLEEP PRODUCTS ASSOCIATION
ISPA

February 14, 2019

Mike Karagiannes
Maine DEP
17 State House Station
Augusta, ME 04333-0017
mike.karagiannes@maine.gov

Re: Comments on January 2019 Report, Implementing Product Stewardship in Maine

Dear Mr. Karagiannes,

The International Sleep Products Association (ISPA) is the trade association for mattress manufacturers and component suppliers to the industry. ISPA has served as the voice of the mattress industry for over 100 years. We appreciate the opportunity to comment on the Department of Environmental Protection's (DEP) January 2019 report, *Implementation of Product Stewardship in Maine* (2019 Product Stewardship Report or Report). ISPA has concerns with mattresses identified as a candidate product for new Extended Producer Responsibility (EPR) programs as well as the proposed changes to the Product Stewardship framework law.

I. Mattresses as a Candidate Product for New EPR Programs

As noted in the Report, California, Connecticut, and Rhode Island each have mattress recycling laws. Each law requires a small visible fee to be charged on each mattress and box spring sold in the state to fund the respective recycling programs. In order to implement the mattress recycling programs required by these laws, ISPA created the non-profit organization, the Mattress Recycling Council (MRC) to oversee each of the programs. The Connecticut program launched in May 2015, California in December 2015, and Rhode Island launched in May 2016.

The current fee in each state is as follows:

California - $10.50
Connecticut - $9.00
Rhode Island - $16.00

These fees are per unit. For example, an individual buying a mattress and box spring in California would pay $21.00. Geography, population size and obligations imposed by the state all play a role in influencing the level of the fee. In each of the existing program states, multiple recyclers operated in the state prior to passage of the law. Currently, we are aware of no mattress recyclers operating in Maine, meaning that any such program would have to rely on out-of-state or foreign operators to recycle mattresses. In addition to likely higher processing costs, transportation costs will be significantly higher.

In the 2019 Product Stewardship Report, the DEP concluded that, "given Maine's geographic size, low population, and lack of businesses to deconstruct mattresses, enacting a law with the same financing mechanism likely would result in a per unit fee at sale even higher than the $16 fee in Rhode Island." Instead the DEP proposed, "an EPR system for mattresses funded at least partially through cost internalization may be most appropriate for Maine."

ISPA does not agree with either statement. We have no basis upon which to estimate the cost of recycling mattresses in Maine. It could require a fee higher or lower than the $16 fee currently collected in Rhode Island. ISPA is prepared to work with DEP or others to explore options and estimate the actual cost of recycling mattresses in the state.

Likewise, funding mattress recycling through a combination of consumer fees and "internalized" costs has many disadvantages. The disadvantages include:

- The suggested mixture of consumer fees and internalized costs will not save the consumer any money. The internalized cost will be passed along to the consumer. Therefore, the consumer will pay for the full recycling costs regardless of whether it is funded exclusively by a consumer fee or not.
- In fact, the consumer may be required to pay more under the internalized cost approach. Collecting a fee at retail is relatively easy to implement and has proven highly successful in funding recycling programs in other states. If a state resident buys a mattress, the fee applies. This approach places all manufacturers and competitors on a level playing field. Under an internalized cost approach, however, an additional process will need to be established to verify whether each manufacturer is paying its proper share of the cost. This approach may be difficult to implement as well because a manufacturer that sells mattresses to retailers operating in multiple state will not necessarily know where the product will actually be used. As a result, the state recycling program will need to incur additional administrative costs to implement an internalized cost approach, and there will be a greater risk of "free riders" not paying their share of the costs. For these reasons, it is in fact likely that consumer will pay more to implement both a consumer fee and an internalized cost approach. Not pursuing an internalized cost approach will be more efficient.
- A consumer recycling fee that is collected at retail and that is clearly visible on the sales invoice or receipt provides the most transparent way for consumers to understand the cost of recycling. An internalized approach will serve to hide some of the costs that the consumer is incurring as a result of the recycling program. In order to be transparent with Maine residents, DEP should promote a process that clearly informs its residents about the actual costs of recycling, and not adopt a funding method that only obscures this fact.

The industry supports working with states to determine whether a practical mattress recycling programs is feasible. We remain concerned about the lack of available infrastructure in Maine to support a program at this time but are open to exploring alternatives for addressing these issues and options for lowering related costs. ISPA remains committed to working with the DEP and the Legislature to explore all options that can promote the recycling of mattresses.

II. Proposed Changes to the Product Stewardship Framework Law

ISPA objects to the following changes that DEP has proposed to Maine's Product Stewardship framework law.

1. **Imposing minimum standards for producers' or stewardship organization staffing.**

DEP proposal:
"Minimum standards for producers' or stewardship organization staffing, e.g., a minimum ½-fulltime equivalent (FTE) to recruit, train and monitor collection sites. For example, the PaintCare program has employed 1-FTE to perform these functions for its program in Maine and Vermont since the inception of their program. This level of staffing has ensured that collection sites receive the support they need to safely and adequately implement the program as confirmed by Department staff field visits."

ISPA response:
There is no basis for this recommendation. Just because the PaintCare program has employed a ½ FTE in Maine does not mean that it is necessary or that it will be relevant to a new mattress recycling program. Not all recycling programs operate the same way. As a result, a "one size fits all" approach, even for a minimum, is not warranted here. For example, some recycling programs involve hazardous waste, others (like mattress recycling programs) do not. Although a heightened level of monitoring may be needed for more dangerous products, it is not warranted for others. Likewise, the level of monitoring will change over time. When a program first launches, staffing needs may be greater than are needed for a mature program.

DEP's recommendation may unnecessarily drive up mattress recycling costs in Maine. For these reasons, ISPA opposes DEP's recommendation to impose a standard minimum cost on programs that do not yet exist, regardless of whether there is a demonstrated need for such additional costs.

2. **Financing for implementation and operations, including funding for regulatory oversight**.

DEP proposal:
"Adequate financing for implementation and operations, including funding for regulatory oversight. Payment into the system to finance end-of-life management must be sufficient to cover materials management costs, consumer and collection site education, a minimum ½- FTE per stewardship program assigned to implement the program in Maine, on-going program evaluation and reporting, government oversight, and any incentives for collection."

ISPA response:
ISPA disagrees with this recommendation for similar reasons. EPR programs are intended to make producers responsible for the post-consumer management of products, shifting the

burden for dealing with discarded consumer products previously borne by state and local governments to the recycling program.

Although government oversight is important, stewardship organizations and/or producers are responsible for implementing the programs. Therefore, reimbursing the department for its costs incurred in "implementing the program functions of future recycling programs" may unnecessarily drive up the program's costs. ISPA has further concerns with the draft legislative language in Appendix A that program budgets cannot cover legal fees or advocacy efforts. As separate legal entities, stewardship organizations are entitled to defend themselves and advocate on their own behalf. For these reasons, ISPA opposes reimbursing DEP for "implementing" the program and strongly opposes the language barring program budgets from accounting for legal and advocacy costs.

3. **Minimum program standards for education and outreach, and on-going evaluation of the effectiveness of education and outreach efforts.**

DEP proposal:

"No program can be successful without collection site staff and consumers knowing about the program and how it works. Staff turnover at collection sites (often retailers and/or solid waste facilities) is ongoing, as are changes in residents in Maine. Evaluation of education and outreach efforts identifies which initiatives are most effective, and where additional focus is needed. Manufacturers can use the information gained to achieve cost-effective continuous improvement in their programs."

ISPA response:

ISPA agrees that on-going education and outreach is important to achieving a recycling program's objectives. Nevertheless, we caution that not all recycling programs are identical. Different programs may require outreach to different stakeholders and each program should have the latitude to plan and develop an education an outreach program that is tailored to its objectives. For example, the mattress industry has found that for our products, targeted outreach to established collectors (retailers and solid waste facilities) and users (purchasers of new mattresses, families that are moving, hotels and institutions like universities, etc.) as opposed providing the same level of outreach to all state residents, is most effective and efficient. A minimum level of education and outreach for all Maine consumers may not achieve desirable benefits but could greatly increase program costs. For these reasons, ISPA opposes DEP's proposed changes to existing Product Stewardship framework law.

4. **Measurable, enforceable goals and defined consequences for non-compliance.**

DEP proposal:

"Measurable, enforceable goals (e.g., recycling rate, consumer awareness, convenient collection), and defined consequences for non-compliance. When manufacturers are responsible for paying for the recycling of collected products, they have a disincentive to collect or to promote the existence or ease of use of a collection system. Minimum standards for locations of collection sites along with a ban on fees at collection are critical to counteracting the financial incentive manufacturers have to discourage consumer participation. Repercussions for insufficient performance or non-participation on the part of manufacturers must be practical to implement. The Department must have the authority to direct program changes if the program fails to make sufficient progress toward achieving program goals."

ISPA response:
ISPA disagrees with DEP's recommendation. Where no recycling program currently exists, and neither the state nor the industry has any factual basis for understanding the challenges and unforeseen problems that lie ahead, a degree of flexibility and good faith give and take between the state and the recycling program is necessary to develop and implement a practical, efficient, and effective recycling program. For example, many recycling program face fluctuations in end markets for recycled materials. Likewise, the volume of products discarded may change as the economy changes. The recycling program has no control over these external factors, yet they can have a substantial impact on the volume of materials recycled, the program's total costs, and the overall efficiency of the program. A program needs the ability to absorb these fluctuations as they occur. While it is important that parties be held responsible for seeking to achieve goals that they have set (with input from the state), we think it would be impractical, unrealistic, arbitrary, and unfair to threaten a recycling program with a significant financial consequence if it cannot achieve established goals due to factors outside of its control. We disagree with DEP's recommendation to the extent that it appears to assume that such external factors either will not occur or are irrelevant to whether "consequences" are appropriate. For these reasons, ISPA opposes the inclusion of enforceable goals in the Product Stewardship framework law.

5. **Financial incentives for collection site participation and for consumers to return products to collection sites.**

DEP proposal:
"Financial incentives for collection site participation and for consumers to return products to collection sites. Successful programs provide an incentive for collection to either consumers or third-party collection agents or both. Collections in Maine's mercury thermostat recycling program increased significantly when the $5 incentive was implemented, and again when a $10 incentive was offered for a limited period of time. A similar jump in collections was achieved in Maine's mercury auto switch recycling program when the $4 incentive to collection sites was implemented. Maine's Bottle Bill program consistently achieves the highest return rate, with consumers motivated by the deposit/return payment system."

ISPA response:
ISPA agrees that financial incentives to collection sites and consumers may increase the number of units that a recycling program collects. Nevertheless, incentive programs also entail additional costs and challenges. Given DEP's justified concern about whether mattress recycling in Maine can be achieved at a reasonable cost, ISPA would oppose changes to existing law that would require all recycling programs to provide these types of incentives. Once again, whether to provide incentives under a particular recycling program involves a number of factors that can vary significantly from one program to the next. It would be inappropriate to amend existing

law to adopt a “one size fits all” approach on this issue. For these reasons, ISPA opposes a change to existing law that would make financial incentives “necessary” for all recycling programs in Maine to “achieve program collection goals”. Instead, we propose that a decision on whether to include incentives in a program should be based on a full evaluation of the incentive as part of an entire recycling program.

* * *

We look forward to working with the DEP, the Legislature and other stakeholders to identify options for promoting mattress recycling in Maine.

Please contact the undersigned should you have any questions regarding these comments.

Sincerely,

Marie Clarke
VP, Policy and Government Relations
International Sleep Products Association
571-482-5428
mclarke@sleepproducts.org

PhRMA
RESEARCH • PROGRESS • HOPE

54 STATE STREET, SUITE 304, ALBANY, NY 12207 | 518.449.5370 | **PhRMA.ORG**

Mike Karagiannes
Maine DEP
17 State House Station
Augusta, ME 04333-0017

Dear Mr. Karagiannes,

The Pharmaceutical Research and Manufacturers of America (PhRMA) represents the country's leading innovative biopharmaceutical research and biotechnology companies, which are devoted to discovering and developing medicines that enable patients to live longer, healthier, and more productive lives. PhRMA respectfully submits these comments in response to the Department's Annual Product Stewardship report, submitted to the Legislature in January 2019. Specifically, we wish to offer comment regarding the Department's identification of pharmaceuticals as a candidate program for a new Extended Producer Responsibility ("EPR") program.

The biopharmaceutical industry in the United States remains committed to working with multiple stakeholders to help address issues associated with prescription medication adherence and prescription drug abuse, safe disposal of prescription medicines.

PhRMA believes that any stakeholder approach should focus on educating patients on how to securely dispose of unused pharmaceutical products. PhRMA launched MyOldMeds in 2015 to educated patients on how to quickly, safely, and securely dispose of unused medicine. Instead of implementing a flawed and potentially unsuccessful program, we urge Maine to consider meaningful, measurable and comprehensive mechanisms to educate consumers on how to safeguard medicines in the home, how to ensure patients are taking their medicines as prescribed – thereby significantly mitigating unused medicines in the first place – and how to safely and securely dispose of their truly unused medicines in the household trash.

In-home medicine disposal offers many benefits. It removes the medicines from the home immediately so that the medicine is not available for misuse or abuse, and it does not create any additional environmental impact or cost. It also gives community members the ability to handle medicine disposal discretely and independently, and protects medical privacy when done properly.

The "MyOldMeds" Program (http://myoldmeds.com) is a consumer education program that instructs patients on how to safely dispose of medicine in the home or where to find current take back programs in their community. To safely dispose of medicines in the home, PhRMA recommends these easy steps:

- Step 1: Pour medication into a sealable plastic bag. If the medication is in solid form (pill, liquid capsule, etc.), add water to dissolve it.
- Step 2: Add kitty litter, sawdust, coffee grounds or another mixing material to the plastic bag to make the solution less appealing for pets and children.
- Step 3: Seal the plastic bag and put it in the trash.
- Step 4: Remove and destroy all identifying personal information (for example, the prescription label) from the medication containers before recycling them or throwing them away. This helps to ensure medical privacy.

Research demonstrates that household trash disposal is effective for disposing of unused medicines. For many, in-home medicine disposal offers a simple, convenient way to dispose of unwanted, unneeded or expired medication. Because all households already participate in the collection of household trash, in-home drug disposal is a safe and preferred way of disposing of unused, unwanted or unneeded medicine.

Further, in-home disposal effectively manages any potential environmental issues given that household waste in the U.S. is either incinerated or disposed of in capped, double-lined landfills equipped with leachate collection and treatment systems. Both technologies effectively isolate waste from the physical environment. In-home disposal also avoids the environmental carbon footprint and costs of trips to a collection site and of separately shipping the collected pharmaceuticals for destruction[1].

Other approaches to disposal of unused medicines bring additional complexities. The DEA requires any collector of unused medicines to have a DEA registration to collect at the site of the registration. This means sites are limited to healthcare facilities, pharmacies, a manufacturer's DEA registration address, and law enforcement locations. Many takeback programs have had challenges in securing community-wide kiosk locations. And for good reason: kiosks are necessarily a collection point – a very visible one – for prescription medications. Unfortunately, this also makes them a target for diversion, so we understand why pharmacies do not want to take on this liability.

However, educating patients on how to dispose medicines at home, as described above, avoids the complexities of Federal law and regulation and ensures that medicines are not aggregated in the community, which creates a risk of medicines being diverted or abused. Further, simply shifting funding and coordination activities of a stewardship to manufacturers does not mitigate the compliance obligations of local pharmacies and law enforcement agencies under federal law.

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[1] Sherri M. Cook, Bryan J. VanDuinen, Nancy G. Love, and Steven J. Skerlos. Department of Civil and Environmental Engineering, and Department of Mechanical Engineering. *Life Cycle Comparison of Environmental Emissions from Three Disposal Options for Unused Pharmaceuticals.* http://pubs.acs.org/doi/abs/10.1021/es203987b.

We appreciate the opportunity to comment on the Annual Product Stewardship report.

Sincerely,

Kelly Ryan
Senior Director, State Policy

NEMA
Setting Standards for Excellence

National Electrical Manufacturers Association
1300 North 17th Street, Suite 900
Rosslyn, VA 22209
703-841-3249
Fax: 703-841-3349
mar_kohorst@nema.org

DATE: **February 14, 2019**

TO: **Mike Karagiannes**
Bureau of Remediation and Waste Management
Maine Department of Environmental Protection

FROM: **The National Electrical Manufacturers Association (NEMA)**

RE: **NEMA Comments on Maine DEP "Annual Product Stewardship Report," dated January 2019**

The National Electrical Manufacturers Association (NEMA) is the primary trade association representing the interests of the US electrical products industry. Our nearly 325 member companies manufacture products used in the generation, transmission, distribution, control, and end-use of electricity, constituting the very foundation of the worldwide infrastructure for supplying power.

Most electro-industry products are long lived and used in commercial and industrial settings. Some, however - such as household lamps, batteries, and thermostats - are consumer oriented and sold primarily for residential applications. Several of these are the focus of product stewardship laws in Maine and our members have a long history of working with Maine legislators and regulatory authorities to implement these laws and the programs they authorize.

Once again, NEMA appreciates the opportunity to comment on the Maine Department of Environmental Protection's (DEP) report on Product Stewardship in Maine. We look forward to continuing discussions with DEP staff on how best to maintain the success of our stewardship programs going forward.

Our comments on the 2018 report – which focus mainly on the department's recommendations - are presented below in the order in which the topics appear in the report.

<u>Framework law – 38 M.R.S. chapter 18</u>

GENERAL COMMENT
In its report, the DEP contends that Maine's existing "Framework Law" contains *"significant deficiencies . . . . that would allow for approval of a manufacturer program plan which would not result in an effective program (sic)."* The department presents a number of recommended changes to address these perceived shortcomings but cites no evidence that they would achieve their intended effect. The report simply contends that a "*program plan designed only to meet the basic requirements in the Product Stewardship framework law will not be guaranteed to be successful."*

In truth, no government mandated program – whether funded and operated by regulated stewards or the government itself – can ever be ***guaranteed*** to be successful. For "Extended Producer Responsibility" (EPR) programs such as those addressed by the report, the most obvious and pertinent reason for this is that behavior needed to ensure success is out of the control - and the authority - of the program operators; *i.e.,* product manufacturers.

For most products, manufacturers are at least two steps removed from the parties that control the product at end of life and determine where and how to discard it. Manufacturers sold the unit into the market years or even decades in the past, to a customer that later removes it from service. The manufacturer has no involvement with or authority over that person's decision to recycle or dispose, yet is held responsible by the law for the outcome nonetheless.

It is therefore unproductive to focus so pointedly on the behavior of manufacturers as the key determinant in whether an EPR program is achieving to its "highest" potential. Yet virtually all of the proposed changes to the "Framework Law" seem guided by this presumption.

That being the case, the department is recommending changes that, if enacted, would create the most burdensome and intrusive oversight framework of any state in the U.S. It would strip manufacturers and their collective stewardship organizations of independence and flexibility and allow virtually no limit on DEP's requests for greater expenditure. In addition to supplying funds for repetitive analyses of metrics (discussed below), the department seeks to impose highly specific financial directives - *e.g.,* an annual remittance to DEP of as much as $100,000 for oversight; funding a *"minimum ½-time emplouee of esch producer or stewardship organization dedicated to implementing the program in Maine (sic)."*[1]

Integrating these requirements into new and existing EPR programs in Maine would impose dramatically higher costs on the industry stewards who not only fund the programs but (in most cases) continue to sell the targeted products to Maine consumers. These higher costs of managing old products within the state in turn would force manufacturers to raise prices of new products to absorb the expense, which likely would encourage cross-border purchases of lower priced products and loss of tax revenue.

PERFORMANCE STANDARDS

DEP is requesting authority to require programs to undertake potentially limitless expenditures towards amorphous goals such as "*<u>effective</u> education and outreach*" and "*consumer awareness,*" as determined through third-party surveys. Mandatory "Performance Goals" that would become part of every program could include awareness thresholds of 50% within three years or recycling rates that must reach 80% within 6 years.

No recycling program for any product, in any jurisdiction in the world, has achieved a collection rate of this level – with the exception of lead acid automobile batteries that have high intrinsic value and are recovered through a unique, reverse distribution framework that is not possible for other products.

Moreover, collection rate is a questionable basis for judging a program because the amount of product available to be recovered in a particular jurisdiction in a given year – the denominator of

[1] Requiring industry stewards to hire in-state employees to implement mandatory programs suggests that regulated parties (manufacturers) are being tasked with the responsibility of <u>enforcing</u> compliance with state laws. Enforcement is a state function and represents the state's contribution to the "shared responsibility" framework supposedly embodied in Product Stewardship policies.

the rate calculation – most often cannot be determined with precision. Among other complications, manufacturers of widely used products sell into vast distribution systems and can provide only rough estimates of the number of units sold in a specific state. Once purchased, products can then be stored for long periods, after which they have widely variable "lifespans" due to their conditions of use.

For these and other reasons, collection rate figures are as much guesswork as science and do not constitute a sound basis for evaluating recycling programs. They are simply one, inexact factor out of many that should be used to evaluate an recycling program. The Maine DEP is recommending, however, that it be used to judge the success of the state's EPR programs and justify seemingly unfettered demands by the department to "*implement specific changes,*" such as financial incentives.

With regard to education and outreach, NEMA does not question the need for EPR programs to contain an outreach component, carefully designed to focus on parties that use or dispose of the product. Outreach and "education" efforts should emphasize the importance of recycling the product, ***especially*** if the law is accompanied by a disposal ban that renders other management options illegal.

The program must also strive to make the "generator" of the waste product aware of the collection sites and events that are available across the state, and to ensure they are sufficiently distributed to ensure all residents have reasonable access. The collection network obviously must reflect the population distribution of the state, as it makes no sense to establish numerous sites in rural, sparsely populated areas, which adds significant cost but does little to raise collection totals.

A reasonable accessibility standard is therefore a useful feature of a program plan, mainly because providing access is within the control of the program operators. NEMA supports an accessibility metric as a way of assessing an EPR program's value and performance. Education and outreach, as described above, is a necessary and complementary activity to providing access.

Regrettably, the DEC proposes to employ "*consumer awareness*" – a vague and hard to measure concept that does not lend itself to objective assessment - as the key determinant of whether a program is performing adequately. How does one assess this concept in an individual or community within an acceptable margin of error? More importantly, to what extent does "awareness" translate into behavior, and at what point does the onus transfer from a program's efforts to notify consumers to a generator's responsibility to recycle?

The programs established for NEMA Member products (mercury-added thermostats, mercury-added lamps) devote substantial resources to growing awareness among relevant target populations. Moreover, because mercury has been widely proclaimed for more than two decades as a potential threat to human health and the environment, a high percentage of consumers are predisposed to keeping products with mercury out of the waste stream. And there is no suggestion that education and outreach activities be discontinued, as long as the program is mandated to operate under the law.

At some point, however, rising investment in "education and outreach" generates little, if any, return. People who are inclined to recycle will do so while endless messaging to those who are not so inclined becomes a waste of time and money. This is particularly true of long-standing programs that recover ubiquitous, broadly discussed products such as mercury-added lamps and consumer electronics, as well as other common household recyclables.

NEMA welcomes discussion of how to drive higher recycling rates in the context of each specific program and product, where characteristics such as the age and history of the program, target audiences, market dynamics, sales and distribution channels, number of producers, and other factors will help determine the most promising approaches. We urge the legislature to avoid the 'one-size-fits-all' prescription that DEP seeks to integrate into Maine's EPR programs.

INCENTIVES TO RECYCLE

Another of the DEP's prescriptions for the state Framework Law is the authority to require the "*implementation of financial incentives or a deposit/refund system if appropriate for the product*" if the department determines the program has failed to "*make adequate progress*" towards its goals.

Over the years, Maine has continually touted the impact of financial incentives in motivating recycling behavior in the state's mercury thermostat program. The department now offers this as rationale for potentially require all mandated programs to "*finance . . . . any incentives necessary to achieve program collection goals . . .*"

As NEMA and the industry-funded Thermostat Recycling Corporation (TRC) have consistently demonstrated, however, financial incentives – or "bounties" – have not shown to be effective at driving higher recycling rates in Maine or Vermont, the other state that requires manufacturers to pay $5 for each mercury thermostat returned to a collection site. In reality, thermostat recycling in Maine and Vermont has followed the trend typically observed in all states/regions over the years. Enactment of a disposal ban stimulates use of voluntary programs and when recycling becomes mandatory, compliance rises dramatically and large volumes of units that previously had been in storage fill collection bins. Collection rates ultimately moderate and decline when no new units are sold or installed and that has been the case over time in VT and ME.

Close inspection of year-by-year collections generally reveals that incentives reward contractors for behavior they were exhibiting already, and in other cases motivate them simply to switch collection sites. Also, a significant portion of incentive payments in ME and VT have gone unclaimed each year – if the payments truly motivated behavior, this would not happen.

Finally, bounty systems are costly, complicated, and vulnerable to fraud and abuse. Artificially placing a value on a waste product creates the potential for illicit trade practices (*i.e., shipping products in from nearby states)* and transactions that result in incentives going to parties for whom they were not intended. We urge the legislature to examine this issue carefully before imposing such a requirement onto any new or existing EPR programs.

Mercury Lamps – 38 M.R.S. § 1672

The Maine DEP report recommends a significant modification to the statute governing the state's EPR program for mercury-added lamps. NEMA opposes these changes in part for the reason discussed in the previous section. Similar to the Framework Law, DEP is seeking changes to the mercury-lamp statute that would greatly expand the department's administrative control over the program, force manufacturers to undertake virtually limitless "investments" in activities that likely will produce very little return, and rely on amorphous performance standards that likely will be a recipe for failure.

There are two additional, more substantive reasons why the DEP's proposed changes to this law are objectionable. First, the department seeks to extend the scope of "covered products" beyond waste lamps generated by households; thereby incorporating lamps disposed by commercial, industrial and institutional (CII) users. This amendment is entirely unnecessary and would seriously impact the independent providers of lamp recycling services who currently serve those generators.

The reality of the lighting market is that the ***vast*** majority of mercury-added lamps are purchased for and used within the CII sector. In almost all situations, generators within that sector are required under Federal Universal Waste (UW) Law to recycle those lamps at end of life.[2] An entire independent lamp recycling industry has been in place for nearly 20 years providing these services through private, individual contracts with retailers, commercial buildings, local governments, schools, stadiums, shopping centers, and other parties subject to the UW requirements (see www.ALMR.org). There simply is no need for the State of Maine to intervene in and disrupt these private service arrangements.

Yet the most compelling reason against expanding Maine's lamp recycling program is that the products it was most intended to capture – compact fluorescent lamps (CFLs) - are disappearing from the US market. CFLs have been displaced by light emitted diode (LED) products that, since the law was enacted, have become widely available at comparable price points. Moreover, CFL lamps no longer meet U.S. EPA ENERGY STAR specifications and thus no longer qualify for utility rebates. In 2018, NEMA estimates CFLS comprised approximately 7% of the consumer light bulb market, and the industry expects them to be virtually eliminated within the next few years. (See Appendix I for NEMA's latest shipment data for LED, Halogen, and CFL products)

In summary, when establishing priorities among environmental initiatives during the 2019-2020 session, revisiting the lamp recycling program in Maine rightfully should be at the bottom of the list. The overwhelming portion of mercury-added lamps entering the waste stream stem from CII facilities that are required to recycle them under Federal Law, while the far smaller numbers that emanate from households will soon be gone from the market.

Note also that homeowners seeking to recycle the remaining CFLs as they come out of use have ample access to collection sites both within and outside of the industry-funded program. An internet search using www.earth911.org of Piscataquis County - Maine's least populated region - produced a number of alternatives within a 20 mile radius including TruValue and other hardware stores as well as municipal transfer stations.

The problem that Title 38 § 1672 was enacted to address has been ***resolving itself*** in the intervening years. There is nothing to be gained by "ramping up" the program at this late date aside from forcing manufacturers to redirect large amounts of money and resources away from more productive uses.

Consumer Batteries (38 M.R.S. § 2165)

The NEMA Dry Battery Section encompasses the most prominent, US-based manufacturers of primary (*i.e.,* single-use) batteries including Energizer, Duracell, Panasonic, and Rayovac. As noted in the DEP report, these manufacturers promoted introduction of an "all battery" recycling

[2] Maine's Universal Waste regulations impose similar requirements – see https://www1.maine.gov/dep/waste/hazardouswaste/lamp_disposal.html

bill in the Maine legislature in 2016 and supported its passage, which did not occur. A number of factors over the intervening period have led the industry to change its position on the issue and we therefore urge the legislature not to accept DEP's recommendation to enact all battery recycling legislation in the current session.

The legislative framework that NEMA stood behind in 2016 would have established a fair and economically stable system for recycling batteries in Maine in that it required ***all*** parties that introduce primary batteries to the market to contribute to the cost of collection and processing, proportionate to their sales. Regrettably, this "shared responsibility" approach was rejected by many influential stakeholders who sought to avoid this obligation through 'carve-outs' in the legislative language, thereby acting as "free-riders" and increasing the burden of cost and program management on the manufacturers who sponsored the law. It became an increasingly untenable situation for NEMA members, who eventually withdrew their support.

NEMA has no reason to believe the same scenario will not repeat itself in the current legislature. There are simply too many political factors at play for a fair and equitable program structure to emerge from the legislative process. The same dynamics have occurred in other states that considered this issue as well.

In addition, NEMA has affirmed in the ensuing years that recycling primary batteries is in almost all cases a ***net negative*** for the environment, more harmful in many ways than disposing them in landfills. Primary, single use alkaline batteries (*e.g.,* AA, AAA, C, D, and 9-volt) are classified as non-hazardous solid waste per applicable US EPA test protocols.[3] Manufacturers eliminated toxic metals such as mercury and cadmium from these products in the early 1990s. At least two states – Connecticut and Massachusetts - advise their citizens to put spent alkaline batteries in regular trash to be landfilled.

A variety of studies have shown that recycling systems require conditions that virtually never exist for recycling primary batteries to be environmentally preferable to landfill disposal (*e.g.,* high percentage of material recovery to beneficial uses, limited transport distances). In a recent evaluation by scientists affiliated with the Massachusetts Institute of Technology, recycling scored lower than landfill disposal in ***seven out of ten environmental indices***, including Global Warming Potential.[4]

Before primary batteries reach a recovery or recycling facility, significant amounts of vehicle fuel and electricity are consumed during collection, sorting, storage and transportation. Each of these steps generates waste products and other environmental impacts – factors that must be considered when assessing the life cycle of battery products in the context of alternative, end-of-life management options.

For these reasons, NEMA respectfully recommends that the legislature not enact a mandate to recycle primary batteries in Maine before conducting its own evaluation of whether doing so would constitute a net benefit for environment and public health. NEMA members would appreciate the opportunity to lend their expertise to and participate in such an effort.

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[3] See https://archive.epa.gov/epawaste/hazard/web/html/batteries.html. Primary batteries do not exhibit any of the characteristics identified in 40 CFR part 261, subpart C.
[4] Olivetti, Elsa and Gregory, Jeremy, Camanoe Associates, March 2018, "Life Cycle Assessment of Alkaline Battery Recycling, A report for the Corporation for Battery Responsibility,"

Contact

Mark Kohorst
Senior Manager, Environment, Health & Safety
NEMA
1300 N. 17th Street
Suite 900
Rosslyn, VA 22209
703-841-3249
202-412-3326 (Cell)
Mar_kohorst@nema.org

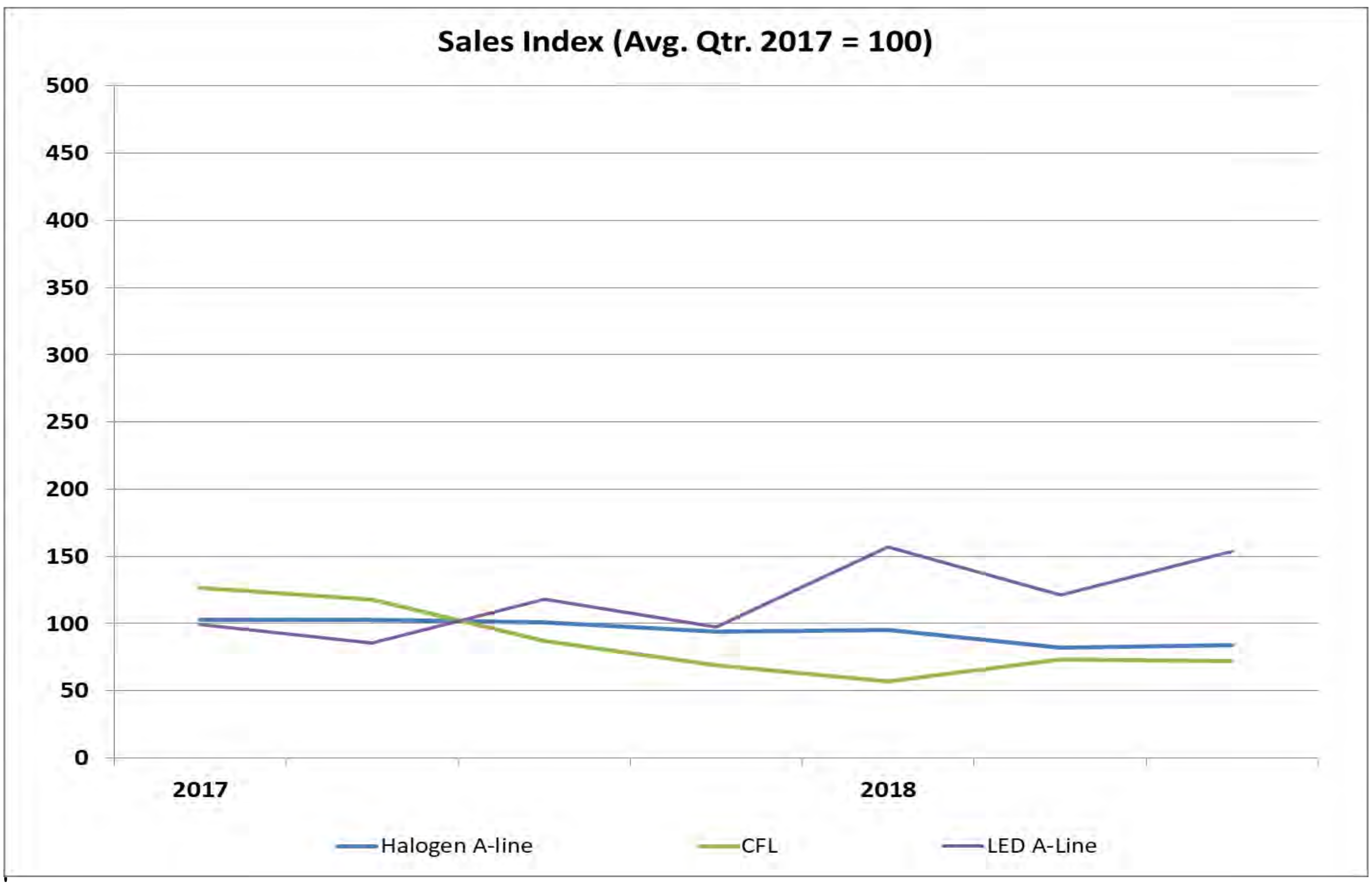
APPENDIX 1

LED A-line and Halogen Lamp Shipments Increase in Third Quarter 2018
December 2018

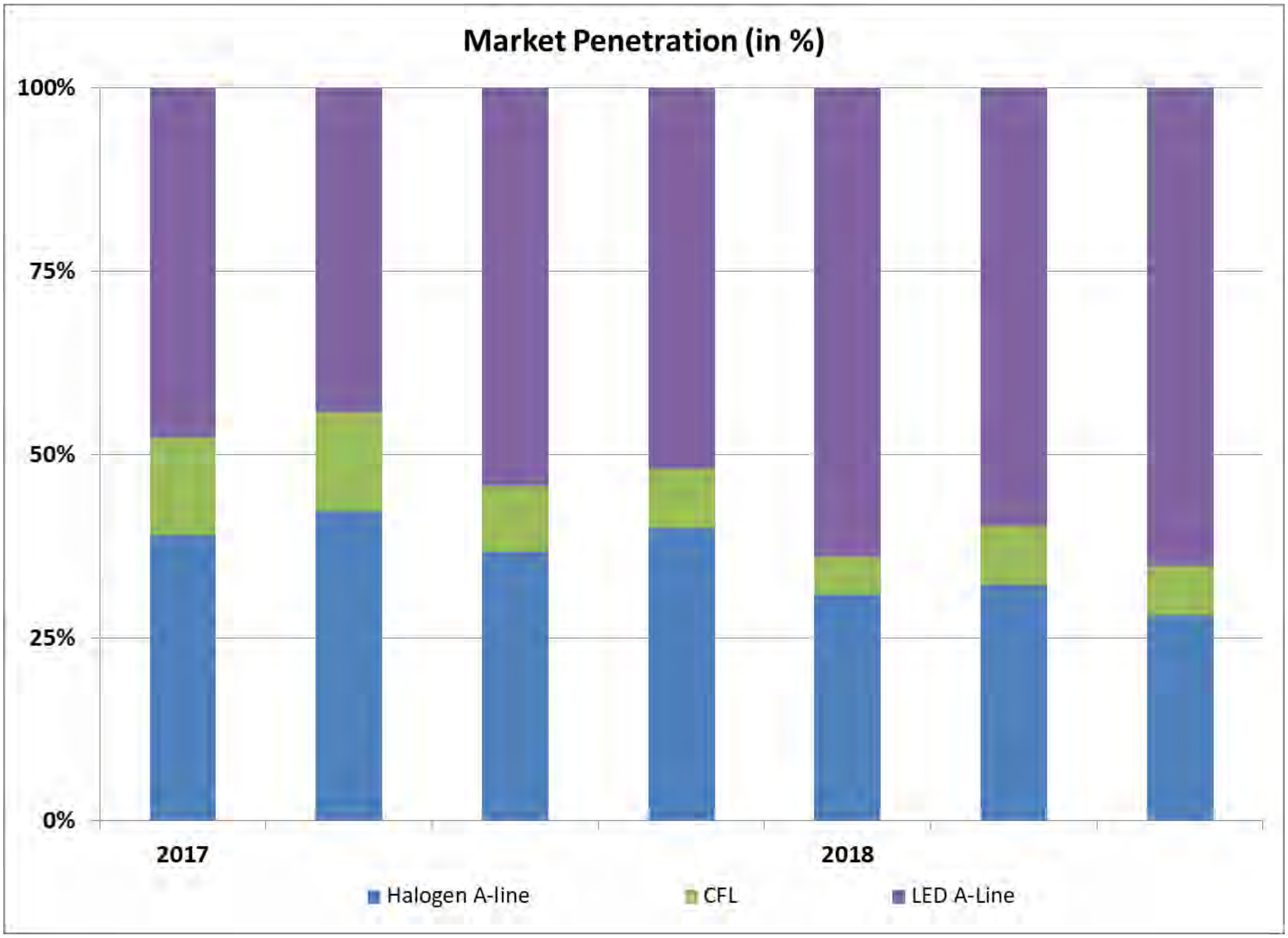
NEMA's A-line Lamp Index has been updated. To appreciate the changes we have made please read our announcement here

LED A-line shipments increased 27 percent compared to 2Q 2018 and 30.6 percent compared to 3Q 2017. Halogen A-line lamps posted an increase in shipments in 3Q 2018 compared to the previous quarter (1.7 percent), and a decrease compared to the same quarter a year ago (16.8 percent.) CFL A-line lamp shipments decreased compared to 2Q 2018 and 3Q 2017 (2.3 percent and 17.3 percent, respectively.)

LED A-line lamps account for 65.1 percent of the consumer lamp market, followed by halogen A-line lamps which account for 28.1 percent. CFLs comprised the remaining 6.7 percent of the A-line consumer market.



The NEMA Lamp Shipments Indices are composite measures of NEMA-member companies' U.S. shipments of compact fluorescent, halogen, incandescent and LED replacement lamps. Product shipments data are drawn from NEMA statistical surveys and are adjusted for seasonal fluctuations.



Contact
Laurie Miller
Director, Statistical Operations
Laurie.miller@nema.org
703-841-3269

PLASTICS
INDUSTRY ASSOCIATION

February 14, 2019

Mike Karagiannes
Maine DEP
17 State House Station
Augusta, ME 04333-0017

Via email: mike.karagiannes@maine.gov

SUBJECT: Comments on Implementing Product Stewardship in Maine, 2019

Dear Mr. Karagiannes:

The Plastics Industry Association (PLASTICS) is the national trade association that represents the entire plastics supply chain, the third largest US manufacturing sector employing almost one million people, 3,170 of whom live and work in Maine. Plastics play an important role in the Maine economy, and over 192,200 Mainers work in sectors dependent on plastics. We are grateful for the opportunity to comment on the Annual Product Stewardship Report and express our concerns about additions to the framework law and listing packaging as a candidate product.

We support the idea that manufacturers play an important role in being good stewards of the environment. This is why our industry implements sustainable materials management strategies – concepts that consider the entire lifecycle of a product. This approach requires looking beyond just the end-of-life aspects of a product and giving credit to manufacturing practices and the advantages of different materials which garner positive environmental benefits. We are opposed to extended producer responsibility (EPR) programs namely because they are an inefficient use of resources, are not flexible to changing waste streams, can hurt small businesses, do not fairly represent all manufacturers, and further hide the cost of recycling and recovery from consumers. Nevertheless, we would appreciate the opportunity to work with the Maine DEP on more impactful efforts to increase plastics recovery in the state.

Changes to Framework Law

While we understand the intent of the changes to the framework law, we believe this would further complicate the law without making it operate more efficiently or effectively. For example, the law already requires convenient and adequate collection systems, but the recommendation attempts to further specify what that collection should look like. Other administrative burdens from the recommendations we believe would detract from program success. We're also concerned with how the department would determine adequate progress and what specific changes it may direct on manufacturers.

Packaging as a Candidate Product

We understand the importance of making sure plastic packaging is recycled or reused. We also recognized the important role that plastic packaging serves in lowering the environmental impact of packaging production and protecting the products they contain from going to waste. We also want to note that important environmental, social and business decisions are made when choosing the design elements of packaging – often leading to plastic being a prime candidate.

In addition, the industry is already taking many important and valuable voluntary steps to make sure that plastic packaging is recovered after the end of its useful life. Some of these efforts are:

- educating the public on how to properly recycle or dispose of the packaging,
- supporting the expansion of collection opportunities,
- developing new end markets that increase demand for recycled plastics,

- promoting the design of plastic products in a way that facilitates recovery,
- promoting clean-ups, and
- ensuring plastics are managed properly at manufacturing sites through programs like Operation Clean Sweep and Zero Net Waste.

Despite these efforts and the role of packaging, states continue to look for methods of implementing EPR programs for packaging, even though packaging come in many shapes, sizes and materials. For multiple reasons, they have found that EPR programs for packaging would not be sustainable. In 2017, the state of Connecticut's Task Force to Study Methods for Reducing Consumer Packaging that Generates Solid Waste did not recommend implementation of extended producer responsibility. PLASTICS recommends the Maine DEP review the recommendations of that task force before pursuing packaging EPR.

Additionally, we do not think that packaging meets the candidate criteria for a stewardship program, nor the four that are specifically mentioned in this report. Those criteria and our response are below.

Criteria B: Increase the recovery of materials. Mandating added administrative costs on manufacturers will not alone change consumer behavior.

Criteria C: Reduce the cost of waste management to local governments and taxpayers. The additional cost to manufacturers will be passed down to consumers.

Criteria D: There has been success in other states or countries. As mentioned earlier, Connecticut did not determine that EPR was a viable solution; and the examples in the report are not representative of US consumers.

Criteria E: Voluntary efforts are insufficient. The report states that voluntary efforts have not taken place in Maine, but this ignores the fact that the industry is in the process of making successful projects scalable and replicating them in other states.

PLASTICS advocates for the responsible recycling, reuse, and recovery of all plastic products. We do not wish to see any of our products used irresponsibly or disposed of incorrectly. While we respectfully oppose the listing of packaging as a candidate program, we reiterate our request to work with the Maine DEP to develop meaningful and practical solutions ensuring the responsible recovery of all plastics.

Respectfully,

Shannon V. Crawford
Director, State Government Affairs

157 CAPITOL STREET, SUITE 3 | AUGUSTA, MAINE 04330
P: 207-446-3430

To: Mike Karagianees, Maine DEP
17 State House Station, Augusta, ME 04333

From: Newell A. Augur, Executive Director

Re: Comments to Implementing Product Stewardship in Maine, January 2019

Date: February 14, 2019

On behalf of the Maine Beverage Association, the trade group representing Coca Cola Northern New England, Pepsi Beverage Company, Poland Spring and Polar Beverages - the local distributors of regular and diet beverages, water, juices and sports drinks, among other refreshing non-alcoholic products - thank you for the opportunity to provide comment on the report, Implementing Product Stewardship in Maine. Our remarks are specific to that portion of the report addressing Maine's beverage container redemption law, also known as the bottle bill.

Overview

When the beverage industry first started to develop in this country, local distributors - on their own initiative - put a deposit on containers in order to reuse them, long before there was ever any legislation forcing them to do so. In the mid 1960s, distributors realized that collecting, washing and reselling these containers was unsanitary and extraordinarily expensive. They also discovered that their customers didn't like refillable containers. When local distributors transitioned away from that model, they did so at a time when our country was beginning to appreciate the importance of safeguarding clean air, clean water and a pristine environment. As beverage containers – which previously had a deposit and were being returned to the distributor - suddenly began appearing on the side of the road, the local distributors became a natural target.

The bottle bill was passed as a means to address litter. In the ten remaining states that still have one, the bottle bill has morphed, unnaturally, into a recycling program. The program has been very successful cleaning up litter caused by beverage containers and recycling beverage containers. But its success is limited to beverage containers and they make up only 4% of the total waste stream.

The bottle bill should not be classified a product stewardship program. It is a mandate that forces the use of a particular delivery and pickup model for certain beverage packages. The model is designed to replicate the operation of a refillable-based system for bottles – a delivery system broadly rejected by consumers nearly 40 years ago. An authentic product stewardship program would include <u>all</u> producers selling <u>any</u> beverages in <u>any</u> packages; Maine's bottle bill excludes all milk and milk derivatives, certain cider and blueberry juices, a number of other specialty products, and several additional categories of beverage packaging.

Moreover, product stewardship is epitomized by the flexibility it gives producers to address the lifecycle impacts of their products. Producers design and manage their own collection and processing programs to fulfill that responsibility. Government sets goals and performance standards, and producers determine the most cost-effective means of achieving those targets. Beyond that, product stewardship programs operate with minimal government involvement.

In marked contrast, the bottle bill is proscriptive, not cost-effective, limits producer flexibility, and has significant government involvement.

Costs

Bottle bill handling taxes exceed $35 million dollars every year. This tax is paid directly to the redemption centers by the local distributors. Distributors incur additional costs transporting containers from redemption centers, crushing and bailing those containers, and selling them in the materials market. When the materials market is robust, the amount of money a distributor receives from the sale of those materials can cover all other processing costs. It has never been robust enough, however, to offset handling taxes.

We are not entirely convinced that a label registration system is the most efficient means to combat non-compliance given the proliferation of alternative routes to market and given the significant investment of time maintaining that registry requires. Having said that, we appreciate the Department's efforts to streamline the process by which distributors register labels for every beverage product sold in Maine. Previously, distributors were required to provide photocopies of labels for every product sold. The Department has simplified this to allow distributors to certify that their product labels are in compliance. The Department also has developed an electronic filing system that has facilitated the online registration of products.

Fraud

The MBA Commingling Group (Coca Cola Northern New England and Pepsi Beverages Company) estimates that of the 219 million containers it redeemed in 2017, 24.2 million of those are fraudulent. Factoring the 5 cent redemption, the 3.5 cent handling fee and a 2 cent pick up and processing cost on every container, fraud costs the members of our commingling group – and ultimately our customers - $2.54 million each year.

We made a similar calculation 10 years ago as directed by the Legislature and submitted those findings to the Department of Agriculture. Neither the bottle bill nor our total sales numbers have changed much, if at all, during the past decade so those calculations remain relatively accurate. There is a slight increase - from $2.48 to $2.54 million - that reflects the increase in the handling fee - from 3 cents to 3.5 cents - in 2011.

There are two primary sources of fraud: 1) containers purchased out of state (usually New Hampshire) that are brought into Maine and redeemed here; and 2) the shorting of bags by redemption centers to distributors (i.e. when a redemption center gives us a bag that ought to have 324 twelve ounce cans in it, but has given us something considerably less than that.

A conservative estimate for the total amount of fraud in Maine's bottle bill would be $7.5 million per year. The total number of containers in the bottle bill is in the neighborhood of 900 million - 1 billion a year, so $7.5 million discounts the experience of non alcoholic distributors.

We appreciate the Department's efforts to address bottle bill fraud. We believe that giving the Department the unqualified ability to revoke the license of a redemption center deliberately shorting bags or knowingly accepting containers from outside of Maine should lose their license will help address the problem.

The root of the problem, however, is identifying who those bad actors are. Current law does not allow an initiator of deposit to adjust what is paid to a redemption center even if the amount of containers collected is substantially less than what the redemption center claims has presented for pick up. Further, the Department does not have staff or resources to visit redemption centers and conduct audits on a monthly or even yearly basis to determine which redemption centers are providing accurate counts, and which are not.

Given the logistical challenges of picking up containers from more than 400 redemption centers across the State, catching one bad actor one time has little if any practical impact on reducing fraud. Because there are no immediate fiscal consequences for shorting bags or accepting foreign containers, initiators of deposit are literally powerless to stop it from happening.

We will be presenting proposed legislation to introduce an auditing procedure for beverage containers pick-ups that we believe, along with the licensing changes proposed by the Department, will have a more meaningful impact in addressing fraud.

Commingling

The legislation that created commingling groups was passed in 2003. At the time, redemption centers were advocating for an increase in the handling fee. They also were advocating separately for legislation that would require local distributors to allow redemption centers to commingle beverage containers– as is done in Oregon and Michigan – so as to reduce the number of sorts that redemption centers have to perform and save them space in their facility.

The Legislature essentially combined the two bills. They created a framework to allow distributors to establish commingling agreements and then created incentives to "encourage" distributors to enter into those agreements. These incentives included putting a ½ handling fee increase on all beverage containers that were not commingled and requiring distributors who could not commingle to remit their unclaimed deposits to the state. As a practical matter, the only distributors who were capable of commingling were the ones who had a significant employment presence in Maine. The Legislature then gave the distributors nine months to form qualified commingling groups and register those entities with the Department of Agriculture.

The investment that local distributors made – and continue to make today – in time and money is significant. The two major existing commingling groups have been in existence for fourteen years (a third one was formed earlier in this decade) and this has prevented a considerable amount of additional sorting for redemption centers. Our product lines continue to change, but for the most part the number of sorts the members of the Maine Beverage Association are responsible is incredible small given their total volume. For example, the MBA Commingling Group sold approximately 250 million containers in 2017; all those containers can be sorted into eleven boxes.

The MBA Commingling Group has brought in several smaller distributors over the past fifteen years of its existence. The group would readily admit additional members – regardless of their size - who can identify the number of cases that they sell in Maine. We also stand ready to provide technical and legal assistance to the Department's in its effort, as set out in the report, to create a new commingling group for out of state distributors.

As the report notes, distributors are not required to provide reports regarding marketed and recycled materials. However, the MBA Commingling Group and the Polar/Poland Spring Commingling Group have provided this information on several occasions at the request of the Department of Agriculture and at the request of the Office of Program Evaluation and Government Accountability as part of June 2018 evaluation of the bottle bill.

Conclusion

Thank you for the opportunity to provide these comments. We would be pleased to provide any additional information in this regard.

Consumer Technology Association™

1919 S. Eads St.
Arlington, VA 22202
703-907-7600
CTA.tech

February 14, 2019

Mike Karagiannes
Maine Department of Environmental Protection
17 State House Station
Augusta, ME 04333-0017
Via email: mike.karagiannes@maine.gov

Re: Comments on *Implementing Product Stewardship in Maine* (January 2019) Report

Dear Mr. Karagiannes,

The Consumer Technology Association™ (CTA) respectfully submits these written comments on the "Implementing Product Stewardship in Maine" (January 2019) report from the Maine Department of Environmental Protection (DEP). CTA appreciates Maine DEP's annual review of the implementation of product stewardship laws in Maine and opportunities to improve existing programs.

CTA is the trade association representing the U.S. consumer technology industry, which supports more than 15 million U.S. jobs. For over 10 years, CTA members have participated in Maine's product stewardship program for electronic waste (e-waste). CTA appreciates this opportunity to provide comments and share insights on our industry's product stewardship experience with the Maine DEP.

CTA supports competitive markets that drive operational efficiencies which in turn lower costs for the entire recycling system. CTA does not support any policy approach that stifles competition in the recycling market or brings the currently competitive system under government control/operation. CTA supports approaches that advance the collection and recycling infrastructure in the U.S. while being responsive to product innovation.

With that in mind, CTA would like to provide the following comments to the "Implementing Product Stewardship Maine" (January 2019) report.

- **Framework Law** [Section II(B), Section III(A) and Appendix X of the Report]
  There are several items of concern CTA has with the proposed changes to the framework law primarily centered around the inclusion of prescriptive requirements that may not be appropriate for all types of EPR programs.
  - Minimum Staffing Levels: The minimum staffing standards proposed are not necessary for all types of EPR programs. Inclusion of this language to require a ½ time full time equivalent (FTE) position may be overly prescriptive given the variation in EPR program structures among product categories and should be excluded from the recommendations. An option to determine and handle on a case-by-case basis based on specific program structure would be more appropriate.
  - Convenience Requirements: The prescriptive nature of requiring "permanent collection

sites within 15 miles of 90% of Maine residents" is not necessary for all product types and may not actually increase collection and recycling rates among residents. As consumer technology companies have experienced in various state electronics EPR programs, these convenience requirements lead to increased compliance costs with no specific correlation to increased recycling rates. Additionally, permanent collection sites are not always the most appropriate solution for certain geographical areas that might be appropriately and cost effectively served by collection events. CTA recommends removing this requirement from the proposed legislation.

- Recycling Targets: Has the Maine DEP defined what diversion methods would qualify under a "recycling rate"? Does that include waste to energy? Even in EPR programs with high recycling targets, there is flexibility on how "recycling" is defined. Additionally, very few mature EPR programs are achieving 80% recycling rates. Setting unattainable, perspective goals does not benefit stakeholders and may create unintended consequences of increasing costs for producers as programs struggle to meet recycling goals. CTA recommends removing this requirement from the proposed legislation.
- Financial Incentives: Financial incentives for consumers to return products should not be part of an EPR program. EPR programs are designed to provide end of life management opportunities for hard to recycle items or items where there is a negative recycling value. Financial incentives send the wrong message to consumers that there is value in the recycling stream which is not always the case. While the proposed changes found in Appendix A make financial incentives optional, CTA encourages removal of this language.
- General:
  - CTA disagrees with the statement "when manufacturers are responsible for paying for the recycling of collected products, they have a disincentive to collect or promote the existence or ease of use of a collection system". We have found with many of our member companies that they readily promote collection infrastructure that they financially support including in states where there is no legal obligation for them to do so. A blanket statement such as this is disheartening to read when there are industries and/or companies that have demonstrated otherwise.
  - CTA is pleased to see that language was included to allow for a point of sale fee to be assessed to consumers as an additional funding option for further consideration under an EPR structure.

- **Consumer Batteries** [Section III(C) and Appendix C]:
  CTA is concerned with the proposed sample language for the consumer battery EPR program found in Appendix C. CTA's concern primarily lies in the potential for duplicative and overlapping mandates on a product and one of its components through two separate EPR programs. Batteries found in consumer electronics are captured for recycling through Maine's manufacturer-funded e-waste program as devices come back through the recycling stream, thus making this proposal unnecessary and redundant for batteries contained in our industry's products.
- **Product Stewardship for Packaging** [Section IV(A)]
  CTA does not support EPR as an effective solution for managing packaging material. CTA strongly cautions against a state-by-state approach for packaging material which is a large, complex waste stream with a significant number of responsible producers.

  Maine is not the first state to explore a packaging stewardship program. The state of Connecticut established a Task Force to Study Methods for Reducing Consumer Packaging that Generates Solid Waste in 2016. The Task Force released its recommendations in February 2018 after a year of stakeholder meetings, expert testimony, and public comments.[1] The final recommendations did not recommend product stewardship as a means of reducing consumer packaging that generates solid waste. The justifications outlined by the Task Force included concerns over the creation of a recycling monopoly through a product stewardship organization, pushing Connecticut recycling firms out of business and forcing higher costs on the collection and recycling system as a whole. There was also acknowledgement among the Task Force members that a state-by-state approach would not achieve the results touted under EPR programs in other countries.

It is unclear what the potential economic impact and costs of a packaging stewardship program would be to businesses operating in Maine. A full economic impact analysis is needed that quantifies impacts to all stakeholders (Maine DEP, producers, collectors, recyclers) and strongly encouraged prior to moving forward with any mandatory policy approach. Additionally, there are a few aspects of the Maine eport that CTA would like to address:

- Can Maine DEP provide reference/supporting documentation to or quantify the statement "a large portion of the current municipal waste stream is compromised of various types of consumer packaging. Much of it is not recyclable.". How much (in terms of a % or tons) is a "large portion"? How does that break down among packaging material types? How is Maine DEP defining "recyclable"? For example, some plastics may be recyclable but just don't have readily available recycling opportunities in Maine.
- The waste characterization study referenced in the Report is from 2011. Does Maine DEP intend to have an updated waste characterization study completed? Many significant changes have occurred in the municipal waste stream throughout the U.S. over the last several years (commonly referenced as the "evolving ton"). Updated waste characterization study data would be key to any economic impact analysis as material type significantly impacts end of life management costs.
- Regarding voluntary efforts by industry, the Report notes that DEP is "unaware of any other direct contributions by these organizations to recycling programs in Maine." It is worth noting that organizations like The Recycling Partnership and Closed Loop Fund do not provide blanket funding; rather, there is an application and evaluation process before funds are dispersed. A handful of states have started to work in conjunction with these organizations to encourage local governments or industry to apply for grants or funding. CTA encourages Maine to explore if promotion of these programs is appropriate for DEP.

CTA supports programs and policies focused on increasing recycling of packaging material by the consumer such as Pay-As-You-Throw programs and lists of mandated recyclables; increasing access to recycling; and supporting public education campaigns to reduce contamination, provided that the policy also has support from the jurisdiction and the infrastructure to execute the policy. CTA opposes mandates that would stifle packaging innovation; impact the safe delivery of products in a cost-effective manner; and/or raise costs for consumers.

- **Electronic Waste** [Section V(A)]: CTA requests that the Maine DEP think about restructuring the following sentence in a way that captures more fully the various factors impacting the collection rates for electronics under the EPR program.

[1] The Final Report of the Connecticut Task Force to Study Methods for Reducing Consumer Packaging that Generates Solid Waste can be found under the "Final Report" section of the "Meetings" portion of the Connecticut General Assembly website at https://www.cga.ct.gov/env/taskforce.asp?TF=20170216_Task%20Force%20to%20Study%20Methods%20for%20Reducing%20Consumer%20Packaging%20that%20Generates%20Solid%20Waste. Additional meeting documents including presentations, written comments and meeting notes can also be found under the "Meetings" portion.

- Original: "Overall, e-waste collection continues to level off, likely due to light-weighting in the electronics industry".
- Revised Language Proposal: "Overall, e-waste collection continues to level off, likely due to the success of the program in removing older, heavier electronics from the recycling stream and increased material efficiencies historically resulting in lighter weight electronic devices".

Conclusion
CTA appreciates this opportunity to provide the above comments to the Maine DEP. CTA and its members strongly support responsible management of electronics and associated packaging in Maine in ways that are both effective and efficient. If you have any questions regarding these comments, please do not hesitate to contact me.

Sincerely,

Katie Reilly
Senior Manager, Environmental and Sustainability Policy
(703) 625-0054
kreilly@cta.tech

cc: Paula Clark, Director, Division of Materials Management
Carole Cifrino, Supervisor, Recycling Programs

Natural Resources Council of Maine
3 Wade Street • Augusta, Maine 04330 • (207) 622-3101 • Fax: (207) 622-4343 • www.nrcm.org

February 14, 2019

Paula Clark
Director, Materials Management Division
Maine Department of Environmental Protection
17 State House Station
Augusta, ME 04333-0017

Carole Cifrino
Supervisor, Recycling Programs
Maine Department of Environmental Protection
17 State House Station
Augusta, ME 04333-0017

Comments on the Maine Department of Environmental Protection's Annual Product Stewardship to the Legislature

Dear Ms. Clark and Ms.Cifrino,

Thank you for the opportunity to submit comments on the Department of Environmental Protection's January 2019 Annual Product Stewardship Report to the Maine Legislature. The Natural Resources Council of Maine (NRCM) is a strong advocate for policies that help to create a more circular materials economy through product stewardship and extended-producer responsibility laws. We believe that businesses, governments, and consumers should work together to innovate and design waste out of the system so that we can sustain our resources and reduce our cumulative impact on our environment. It is with nearly 20 years of knowledge and experience relevant to the product stewardship laws and programs referred to in this report that we submit these comments.

<u>Highlighting the Importance of Product Stewardship:</u>

NRCM believes that the success and expansion of our extended-producer responsibility laws depend upon the extent to which the Legislature and the public embrace the concept of product stewardship. Waste and litter management has historically been a public sector problem and taxpayer expense, although the public has had essentially no choice over what materials are thrust upon them to deal with at the end of a product's useful life. Producers of waste are often reluctant to take responsibility for the design and collection systems for their products, and instead lay blame on the consumer by saying they are "meeting consumer demand." Then they leave the public sector to clean up the mess created by those products. The theory behind product stewardship is that, ideally, there would be more shared responsibility between everyone involved in a products lifecycle. This includes a higher level of forethought and planning between design, use, and collection of materials so that we can prevent more valuable materials from being wasted or polluting our environment, which benefits everyone.

To do this, we need to take a more preventative approach to our waste issues by looking up the chain at product and packaging design, and then proactively engaging producers to institute sustainably funded collection systems that can internalize all costs associated with the recovery of waste materials. Without this, we will always have piece-meal, inefficient waste management programs, funded by taxpayers, and our environment and future generations will continue taking the brunt of the damage. Maine has been a leader in the U.S. in adopting product stewardship programs; our policies have served as blueprints for other states. NRCM is very supportive of adding many more product categories to our suite of laws. We are encouraged by the 2019 Annual Product Stewardship Report because of the thoughtful, forward-thinking approach and recommendations for the expansion of our policies. We have a few specific thoughts to consider below.

Recommendations for Changes to Existing EPR Laws

For the most part, we support the each of the proposed statutory changes for the laws regarding the framework of new product stewardship programs, mercury lamps, consumer batteries, beverage containers, and cell phones. We encourage the committee to move forward with reporting out a bill for each of these proposals in Appendices A through E, though we have a few points to consider:

A. Framework law: The changes proposed are based on experience with implementing existing programs and if adopted would make new programs more effective. NRCM believes that each of our existing programs should also be updated to adhere to the framework law, as proposed.
B. Mercury lamps: Referenced above, this is an example of a policy that should be changed to reflect the proposed changes to the framework law. This has been an underperforming program for years, primarily because there is a disincentive for the producers of mercury lamps to expand their outreach and encourage people to recycle. There is also a lack of a mechanism for DEP to request and require changes that would improve effectiveness.
C. Consumer batteries: Consumer batteries are a big problem in our waste stream because they pose a risk to human health and the environment if they are not managed properly. Further, the Call2Recycle rechargeable battery program is experiencing problems because non-rechargeable batteries are ending up in the bins, but the producers who made them aren't part of the program. If the Legislature only takes one proposal forward from this report, then expanding the rechargeable battery law to include all consumer batteries should be it. Maine consumers and municipalities *need* a solution for recycling all consumer batteries, and this expansion would also solve the problem of "free riders" in the existing program. Since this policy language has already been vetted in the Legislature before, it is a strong proposal that is ready for action. We strongly encourage the Legislature to report out a bill with the language from Appendix C.
D. Container Redemption: The 2018 OPEGA review of the "bottle bill" brought attention to some of the real *or* perceived inefficiencies in the program. We urge the Legislature to proceed with any changes with caution. Overall, the existing program is very effective and is working to recover the vast majority of beverage containers for recycling. This provides jobs and a source of clean recycled commodities. It also reduces litter, provides charities with a source of funds, and takes the burden of managing the containers away from municipalities and taxpayers. NRCM believes that there should be 1) better data and reporting so that we may be more certain about the collection rate—coupled with an automatic increase in deposit amount should collection targets not be reached, 2) consideration given to adding more containers into the redemption model, 3) better ways

to respond to issues of non-compliance, and 4) review of ways to streamline the commingling process based on input from the redemption center operators.

E. Cell Phones: NRCM supports DEP's recommendation to repeal the reporting requirement by cell phone companies, since it does not provide useful data.

Candidate Products for New EPR Programs

We commend DEP for their thoughtful and forward-looking approach with the consideration of future product stewardship programs for packaging, pharmaceuticals, mattresses, carpets, and solar panels. Here are some specific thoughts on those proposals:

A. Packaging: DEP did a remarkable job making the case for the consideration of packaging materials as a potential candidate for an extended-producer responsibility program. This is an extremely timely product category since it makes up 30-40% of the total MSW stream, and many of the municipal programs that manage these materials are currently facing steep increases in costs of recycling and are either abandoning or scaling back their programs. We appreciate that the DEP took the effort to estimate the costs to municipalities and taxpayers for managing packaging waste at an astounding $16-$17.5 million each year. This type of policy is critical to moving forward with more sustainable and resilient recycling programs, as is shown in more than 40 jurisdictions throughout the world. We urge the DEP and the Legislature to move forward with urgency when developing policy language that would establish a new EPR program for packaging in Maine, and a good place to start will be to support a resolve to do just that this session.

B. Pharmaceuticals: Since 2012, five states have established producer-funded drug take-back programs: MA, VT, WA, NY, and CA. Twenty-three U.S. cities and counties have done so, too. Managing these programs costs manufacturers only pennies on a prescription, and does not increase medication cost to consumers. Benefits of this program would include decreased risk of accidental poisoning and drug overdoses by preventing unused medications, like opioids, from accumulating in homes and getting into the wrong hands; establishing an environmentally safe alternative to landfilling or flushing of unwanted drugs; relief for Maine communities, police stations, and others from the burden of organizing and staffing sporadic collection events for unused drugs, saving time and taxpayer money; and creation of a standard way that Maine people can dispose of unwanted drugs, so they know what disposal options are available throughout the year. We are pleased that DEP has signaled support for this policy, and we hope that the Legislature will pass a bill to establish this program in Maine this session.

C. Mattresses: We agree with DEP's assessment on why mattresses are an ideal product category, and also with the assessment of why establishing a program in Maine could be tricky. Unlike CT, RI, and CA, where mattress take-back programs are in place and successful, our state has more pronounced geographic constraints, low population density, and no facilities to process the deconstruction of mattresses. We concur with DEP that if we were to pursue a program in Maine, that at least some cost-internalization is necessary so that the per-unit fee does not overburden the consumer. However, we do urge DEP to consider establishing a smaller unit-fee paid at the point of sale that is used to help municipalities manage mattresses, similar to a bill that was considered by the previous Legislature.

D. Carpet: Like mattresses, this is an ideal product category but Maine has unique limiting factors dealing with this bulky material. NRCM agrees with DEP that funding a program only through a user-fee would be overly burdensome on the consumer, and doing so would not incentivize a redesign of carpet to be more readily recyclable. We hope that over the next couple of years there will be more discussions and consideration given to how we can establish a carpet take-back program that makes sense for Maine.

E. Solar panels: As the use of solar panels to create renewable, clean energy continues to rise, the disposal of older panels will begin to become more of an issue for municipalities to deal with. We like that DEP is forward thinking in its approach so that cost of collection can be anticipated and internalized now, rather than later. However, we are concerned that with lack of similar take-back programs for other forms of energy production such as oil tanks, this would create a disadvantage for companies providing our communities with a cleaner, more sustainable form of energy. We look forward to working with the DEP in the future to establish a fair product stewardship program for solar panels.

Implementation Status for Maine's Other EPR Programs

Maine's other programs for electronic waste, mercury-containing auto switches and thermostats, and architectural paint are performing satisfactorily and any potential changes we may like to see to these programs fall low on the priority list proposals in this report. DEP does mention the plastic bag recycling law that requires retailers that use plastic bags to have a receptacle for recycling, but they do not have a recommended change. NRCM believes that a statutory change to this law is indeed needed since, as a result of initiatives led by concerned citizens in communities throughout Maine, many retailers are no longer distributing plastic bags at check-out, but they are still selling products wrapped in plastic film. Consumers rely on these collection bins for recycling all film plastic, not just check-out bags. We urge the Legislature to amend the plastic bag law (Title 38§1605) so that it would require retailers that sell or provide any film plastic to continue to provide the recycling receptacles.

Overall, this report was very well done and encouraging. We urge the Legislature to place a high priority on moving forward with an expansion of the consumer battery recycling program and moving forward with an extended-producer responsibility program for packaging. Thank you for the opportunity to provide these comments. We request that these comments be submitted to the Legislature with the 2019 report.

Sincerely,

Sarah Lakeman

Sarah Lakeman
Sustainable Maine Project Director
Natural Resources Council of Maine

February 14, 2019

Mr. Mike Karagiannes
Maine Department of Environmental Protection
17 State House Station
Augusta, Maine 04333

Re: Maine Department of Environmental Protection Annual Product Stewardship Report 2019

Dear Mr. Karagiannes:

As a follow up to our meeting with DEP staff on February 6th, PRBA – The Rechargeable Battery Association submits these supplemental comments on the DEP's Annual Product Stewardship Report (2019). Our comments below focus primarily on the DEP's recommendation that the existing battery collection and recycling law for nickel cadmium (NiCd) and small sealed lead acid (SSLA) batteries be repealed and replaced with an EPR law covering all consumer batteries. For the reasons we noted during our February 6th meeting with DEP staff and as explained in more detail below, we do not believe this is the correct approach for a consumer battery EPR program in Maine.

INTRODUCTION

PRBA was formed in 1991 to respond to the growing need for workable NiCd and SSLA battery collection and recycling programs in the United States. To that end, PRBA members established pilot battery recycling programs in several states. Based on the success of these pilot programs, PRBA supported establishment of a not-for-profit public education and battery recycling program to be implemented nationally. That program is now known as the Call2Recycle® program. Attached on page 5 is a Call2Recycle summary of the batteries collected in Maine in 2018. In fact, Maine was ranked by Call2Recycle as the 12th best state in terms of battery collection based on weight of batteries collected as a function of state population. See data on right.

2018 Battery Collections **Ranked by State**

Based on weight of batteries collected as a function of state population

TOP 10					
1. VT	11. CO	21. AR	31. NY	41. MI	51. AK
2. DE	12. ME	22. OH	32. DC	42. SC	
3. GA	13. MA	23. VA	33. UT	43. MT	
4. MN	14. NJ	24. IA	34. RI	44. ND	
5. CA	15. IN	25. NC	35. OK	45. LA	
6. IL	16. FL	26. CT	36. MO	46. NE	
7. TN	17. MS	27. WY	37. KY	47. NM	
8. NH	18. OR	28. AZ	38. ID	48. WV	
9. PA	19. TX	29. WI	39. KS	49. AL	
10. WA	20. MD	30. NV	40. SD	50. HI	

In the years since PRBA was formed, lithium ion batteries have replaced NiCd and SSLA batteries in most consumer applications. Notably, these lithium ion batteries do not contain the potentially-hazardous heavy metals used in predecessor products. The existing Maine consumer battery law was, of course, designed to address environmental concerns with those metals. (Similarly, although PRBA does not focus on non-rechargeable (single use) consumer battery issues, it merits note that the mercury that historically resulted in environmental concerns with those products has now been removed from them.)

PRBA members currently manufacture approximately 65% of the rechargeable lithium ion battery cells produced in the world today. Our members also include leading manufacturers of consumer, medical, and defense products that are powered by those battery cells, battery recyclers, retailers, and large distributors of lithium batteries and equipment powered by them. Virtually all of our members are "stewards" with the Call2Recycle® program and support battery product stewardship programs in the U.S. and Canada.

CONSUMER BATTERIES IN THE WASTE STREAM TODAY

Rechargeable consumer batteries constitute a miniscule contribution to the content of Maine's waste stream: the 2011 Maine Residential Waste Characterization Study (the most recent study available), found that all types of consumer batteries – both rechargeable and non-rechargeable, taken together – made up only 0.23% of the state's overall waste stream.

As to rechargeable batteries, this low volume reflects the fact that most rechargeable batteries reach consumers as components of products, and typically last as long or longer than the products' useful life. This is a very different situation than existed when Maine enacted its existing NiCd and SSLA battery statute, when easily removable batteries were common. It also is notable that many of those products (including their batteries) are collected for recycling under Maine's electronic waste and used cell phone statutes.

Moreover, those used rechargeable batteries that are available for disposal already are collected, without the need for further legislative mandate, under the Call2Recycle® program and similar programs operating in Maine, municipal collection sites, facility-sponsored programs (*e.g.*, hospitals), and by e-waste recyclers.

For these reasons, if the DEP's concern is with reducing large volumes of waste entering landfills and preserving landfill space, products that account for significant volumes of waste (*e.g.*, carpet and mattresses) would be a logical first step for new product stewardship initiatives to help achieve Maine's waste reduction and recycling goals. Similarly, if the concern is to reduce the volume of hazardous constituents that reach landfills or incinerators, the focus need not be on consumer batteries.

LITHIUM ION BATTTERIES AND PRODUCT STEWARDSHIP LEGISLATION

Paragraph C on page 8 of the DEP report addresses a number of issues related to lithium ion batteries that warrant further comment to put them into proper context.

First, the safety issues associated with the proper handling, transport, collection, and storage of lithium ion batteries have been well documented by various federal agencies and national organizations. There are regulations and guidelines published by the U.S. Department of Transportation, Consumer Product Safety Commission, Occupational Safety & Health

Administration, and National Fire Protection Association, just to name a few, that adequately address these safety issues. These regulations and guidelines are frequently updated to account for new developments involving lithium ion batteries. We therefore do not believe a consumer battery EPR bill is the right vehicle to address these safety issues.

Second, it is generally recognized that 85 -90% of lithium ion consumer batteries enter the marketplace installed in products like cellular phones, notebooks, tablets, e-readers, and other portable electronic products. According to the DEP, from January 2006 through December 2017, Maine residents recycled more than 97 million pounds of electronics.[1] Many of these products contain lithium ion batteries that are removed by e-waste processors and recycled or refurbished for reuse in similar products. Moreover, the refurbishing of used lithium ion batteries for reuse (often referred to as "secondary use") is a relatively new phenomenon that is not accounted for when considering the collection and recycling of these batteries. Furthermore, even though Maine's current rechargeable battery recycling law does not cover the now-predominant power source in consumer products, lithium ion batteries, these batteries are already collected in large volumes through the Call2Recycle® program, e-waste processors, and other battery collection programs in the state.

Third, the DEP report contains in Appendix C a draft of potential consumer battery product stewardship legislation. PRBA did support such legislation in 2016, but we no longer do. In significant part, that is the result of the debate over Senator Saviello's 2016 proposed legislation and similar bills in other states, which demonstrated the strength of political influences that would preclude the adoption of any bill that treated all suppliers equitably. We thus must strongly urge DEP to reconsider this approach embodied in the draft bill included in its report.

To further explain our concern: the legislation in Appendix C, if introduced as a legislative proposal, will garner a significant amount of industry opposition as it did in 2016. That opposition always results in "carve outs" during the legislative process that are equivalent to the "free rider" problem Call2Recycle currently struggles with under their existing program. When these types of carve outs are granted (as was the case in Vermont in 2016 when their primary battery (single use) recycling law passed), battery suppliers and a subset of product suppliers ultimately incur all the costs of collecting and recycling even batteries they did not place on the market – which constitute the vast majority of the used rechargeable batteries collected. This is not fair or equitable.

In short, at least as to batteries, the concerns reflected in the DEP report are far more complex and merit much greater consideration before any specific legislative action is considered for introduction. Instead of moving immediately to legislation, we strongly recommend convening a panel of experts from the DEP, battery industry and other interested parties to brief the ENR committee on the history and experience of Maine and other states with battery recycling and e-waste laws, and the status of battery collection and recycling in the U.S. This might be accompanied by the preparation of a more complete study of consumer rechargeable battery recycling, and subjecting it to public comment before finalization, in order to provide all

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[1] See https://www.maine.gov/dep/waste/ewaste/#la

interested parties an opportunity to weigh in on the issues over the course of the year. The ENR Committee could then review the study and decide on the appropriate actions, legislative or otherwise, to pursue.

* * * *

We appreciate DEP's consideration of our comments and look forward to working with the agency and the legislature on these important issues to our members. Please contact me at 202.719.4109 or gkerchner@wileyrein.com with any questions regarding these issues.

Sincerely,

George A. Kerchner
Executive Director

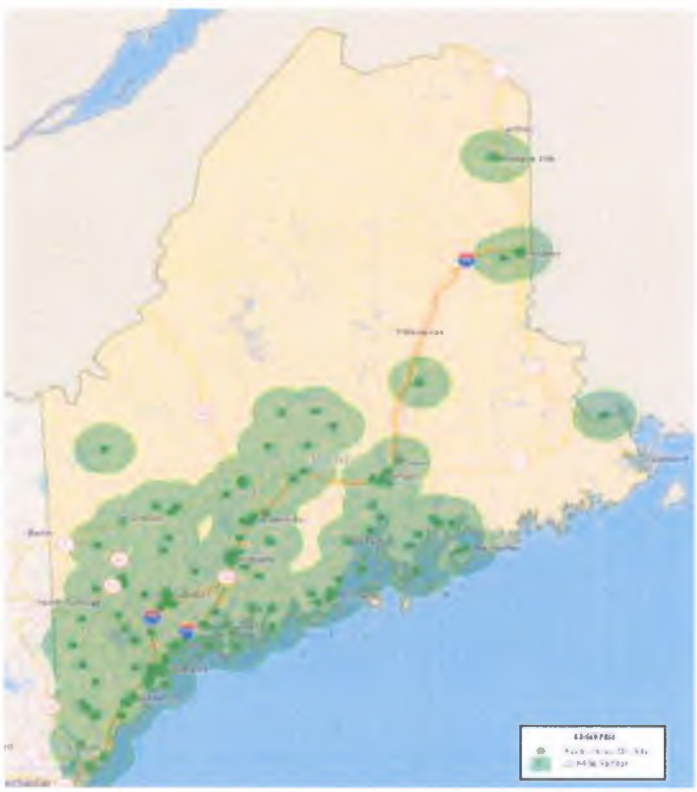
call2recycle®
Leading the charge for recycling.℠

Consumer Battery Collections
Maine - 2018

In 2018, the Call2Recycle® program collected over 31,000 pounds of consumer batteries, single use and rechargeable, in Maine from 182 collection sites. Nearly 50% of the batteries collected were from public agency sites (i.e., municipal transfer stations). Below please find the summary of Call2Recycle's battery collections in the state.

2018 Battery Collections in Maine by Collection Site Type		
Collection Site Type	Pounds of Batteries Recycled	# of Participating Sites
Retailers / Wholesalers	14,174	83
Municipal / Public Agency	14,752	85
Other	2,264	14
Totals	**31,190**	**182**

All sixteen Maine counties have at least two collections sites generating batteries through the Call2Recycle® program. Currently, 85% of the state's population lives within 10 miles of a Call2Recycle collection site. Below please find a map representing Call2Recycle's collections sites throughout the state.



Maine Grocers &
Food Producers
Association
PO Box 5234
Augusta, ME 04332
207.622.4461
info@mgfpa.org

February 14, 2019

Mr. Mike Karagiannes
Maine Department of Environmental Protection
17 State House Station
Augusta, ME 04333-0017

Re: Comments on 2019 Maine Product Stewardship Report

Dear Mr. Karagiannes:

I am submitting comments on the 2019 Maine Product Stewardship Report on behalf of the Maine Grocers & Food Producers Association, a business trade association representing 250 members of Maine's food community; main street businesses including independently owned and operated grocery stores and supermarkets, and food and beverage industry partners.

The report addresses policy changes to minimize the negative impacts of products and packaging throughout their life-cycle. We will address the Framework law as enacted in 2009 and also a selection of the laws related to consumer products and the grocer and food producer industry.

Framework Law (38 M.R.S. Chapter 18)

- Due to the large geographical size of the state, requiring collection sites within 15 miles of 90% of Maine's residents would be troublesome for rural areas leaving some without an adequate place to recycle. The varying size and types of materials require individual recycling site implementation.
- We would like to see further clarity on the staffed employee responsibilities required to oversee each of the stewardship programs. If one-full time employee is currently in place for the PaintCare program (ME&VT), we have concerns that a more complex program may require additional time for full circle implementation and vice versa for established programs.
- To generalize annual fees across the wide, breadth of the program is concerning. We would like to see a formalized breakout of costs to ensure fair budgeting expectations for the producers absorbing the program implementation.
- The program performance goals are very specific in awareness and recycling rates. Is there history from other programs or studies to ensure these objectives can be met? Can they be applied across all products?

We recognize the Department's interest in making these changes to the Framework Law so that high collection rates may be achieved along with data to support the initiatives becomes available. Prior to implementation, we would ask that you conduct additional research for feedback from all parties specifically speaking to changes in the Framework Law to ensure all the proposed changes are attainable. Others involved in the day to day can help provide additional insight on what is working and how to address areas for needed improvements.

Beverage Containers (38 M.R.S. Chapter 33)

Our industry recognizes and supports efforts to help refine the Bottle Bill to make the process easier and more viable for our beverage manufacturers/bottlers as well as retailers selling and our partners in the redemption process.

We are pleased that there is a 75-87% recycling rate for bottles which in comparison to the national avg. (34%) is quite high. We are hesitant to make drastic changes to the program that would negatively affect any of the participating players causing additional costs, present challenges, or have unintended consequences to the success of the program.

- Data reporting requirements: we express hesitation for the additional administrative costs of reporting the number of non-refillable beverage containers sold and the number of non-refillable beverage containers returned by redemption value. It may also be a challenge for larger corporations to implement these changes to comply with state regulations/reporting requirements in the global market of obligations.
- Supportive of the removal of the provisions of the law which indicate redemption centers must have written agreements to provide redemptions services for dealers and only accept containers of the kind, size brand sold by those dealers. This eliminates administration burden from redemption centers.
- Supportive of the elimination of redemption responsibility for retailers with less than 5,000 sq ft of retail space.
- Oppose redemption-centers or dealers with 5,000 sq ft or retail space of more without an agreement (with a stand alone redemption center within 1 mile) be required to redeem all beverage containers within the program. A one-mile radius, especially in rural Maine, is too restrictive. We would propose a wider acceptable radius for a partnering redemption center. It may also be out of certain store's business plans to administer a redemption program within the storefront.
- Title 22 defines a Locally owned grocery store as "Locally owned grocery store" means a grocery store at least 51% of which is owned by one or more residents of the State and that has a gross floor area of 25,000 square feet or less. Possibly the Department wants to evaluate the sq. ft threshold to exclude slightly larger store fronts from the redemption responsibilities.
- We recognize the efficiencies that may come with a "catch all" commingling group for redemption centers, we can support the effort of sorting by like materials to minimize the sorting labor. However, the "catch all" commingling group would be based on manufacturers being truthful about their portion/share of sales within the container weights. We would like to see a checks and balance system to ensure equality amongst participants.
- We are not supportive of any changes in legislation that would require additional remittance of unclaimed deposits to the State as these dollars are used within the IoDs budget to remain viable.
- We are supportive of compliance and enforcement procedures that ensure fairness amongst redemption centers and pick-up agents/IoDs. If manufacturers will be held responsible for the program than redemption centers must be accountable for their part of the process and honesty in full bag redemptions.
- While not a substantial increase, a $50 increase for a redemption center license will add a bit more of an investment into the interest in operating the redemption center.

We look forward to working with the ENR Committee this session addressing the multitude of bills submitted this session addressing the bottle bill.

Batteries (38 M.R.S. § 2165)

Grocers commonly sell batteries as a part of their common, household item product line.

- A January 1, 2020 implementation date for a battery manufacturer to change their labeling may be too short. Most batteries are manufactured by large corporations with big distribution networks. Less than a year may be difficult to comply. What would also happen to those batteries still on the shelves? Would they need to be credited back, returned, recycled without even being used? What leeway would there be for remaining inventory?

- There should be some concern given to manufacturers whom may opt not to comply and decide to stop offering their product in Maine.
- Submission Plan, "the plan must allow retailers, wholesalers, municipalities," etc to "voluntarily serve as a collection location." We are supportive of a voluntarily option but not supportive of stricter collection site requirements at the point of retail.

Plastic Bags (38 M.R.S. § 1605)

No specific amendments were proposed to address plastic bags within the Stewardship Report. We look forward to working with the ENR Committee this session on the three proposed bill titles addressing plastic bags.

Candidate products:
Packaging

As noted within the report the market for packaging is vulnerability and unpredictable. We are supportive of the industry's efforts to ensure their packaging is developed in a thoughtful and environmentally friendly manner. The report states there is a lack of data on packaging generation and municipal recycling and disposal costs. The report references somewhat outdated information from 2011 and references statistics from Europe and Canada which may not be a fair comparison to the state's actual numbers. We recognize the interest to learn more and would be supportive of further studies to ensure suggestions for manufacturers would be feasible. We would look to learn more about a proposed division of responsibilities between packaging producers and municipalities.

Overall:

As with any program in which the producers and manufacturers are responsible for recycling programs, the likelihood of increased product costs will occur and our Maine residents, the customers, will inevitably incur the costs of the recycling programs. We express an overall concern for any programs that may cause an imbalance for the manufacture to comply while still offering quality, reasonably priced products.

Thank you for the opportunity to provide testimony.

Christine Cummings

Christine Cummings
Executive Director
christine@mgfpa.org
207-622-4461

Thermostat Recycling CORPORATION

500 Office Center Drive – Suite 400 | Fort Washington, PA 19034 | thermostat-recycle.org

Via Email

February 14th, 2019

Mike Karagiannes
Maine Department of Environmental Protection
17 State House Station
Augusta, Maine 04333-0017

Re: Thermostat Recycling Corporation's (TRC) Response to MEDEP 2019 Annual Product Stewardship Report to the Joint Standing Committee on the Environment and Natural Resources

Dear Mr. Karagiannes:

Three prominent manufacturers of thermostats – Honeywell, White-Rodgers, and General Electric – voluntarily established the nonprofit, Thermostat Recycling Corporation (TRC) in 1998 to facilitate the proper management of mercury thermostats at end-of-life. TRC now has 30 corporate members and is the only U.S. based national program dedicated to recycling mercury thermostats. We have recycled more than 2.4 million mercury thermostats nationwide, thereby diverting more than 11 tons of mercury from the solid waste stream. In Maine, the program has recycled tens of thousands of these units.

TRC welcomes the opportunity to comment on the Maine Department of Environmental Protection's January 2019 Annual Product Stewardship Report (Product Stewardship Report). Our comments circle around the Department's proposed changes to 38 M.R.S § 1776, *An Act to Improve Maine's Product Stewardship Law*, and are presented below.

THE ROLE OF MANUFACTURERS AS PART OF A THREE-LEGGED STOOL

Mercury thermostats are regulated under 38 M.R.S. § 1665-B, Maine's *Mercury-added Thermostats* law. The law requires that manufacturers who have sold mercury-added thermostats into the state pay for their collection and disposal and provide a financial incentive with a minimum value of $5 for the return of each mercury-added thermostat to an established recycling collection point. This legislation has been in place since 2006. We have concerns on how the Department characterized manufacturers (a.k.a. producers) as having "*the greatest ability to affect the life-cycle impacts of products*". The Department concedes that others, including distributors, retailers and consumers, also have a role. In our twenty years of operating, we have continually stressed that **other stakeholders (distributors, retailers, or generators of waste) also have an equal, if not more important, role in recovering this material and the manufacturer does not bare sole responsibility**. Yet, there is no mention of these entities (other than the passing reference) and their requirements to promote safe disposal or safely dispose of this material.

In the Department's proposed changes to 38 M.R.S § 1776, the Department suggests placing increased requirements on producers. Such requirements include mandates to achieve a recycling rate of 50% in the third year of a program and an 80% recycling rate within the sixth year. These targets would inequitably place the responsibility for consumer and generator behavior directly on manufacturers. TRC does not support setting recycling rates based on the behavior of others, and TRC does not support a framework where there is no clear mechanism for the Department to regulate and enforce the actions of these actors. The three-legged stool of responsibility crumbles when only manufacturers are responsible for the actions of the other two involved parties (collection networks and generators of waste).

The Department also incorrectly states that "*when manufacturers are responsible for paying for the recycling of collected products, they have a disincentive to collect or to promote the existence or ease of use of a collection system*". This is not the case in TRC's experience. We promote TRC's collection and disposal program to the best of our ability. The Department should acknowledge a diminishing law of returns for increased efforts, and should base any conclusions on a cost-benefit analysis related to program performance. TRC believes the Department should remove this statement.

SPECIFIC CHANGES TO FRAMEWORK PRODUCT STEWARDSHIP LAW

As the Product Stewardship Report has provided, Maine currently has nine laws related to the end-of-life management of specific consumer products that may be considered to be product stewardship laws. The Department stated that, "*Maine's experience in implementing its great variety of EPR laws, it is now apparent the framework law does not include adequate provisions to ensure implementation of effective programs*". Further, the Department states that, "*there are certain elements that contribute to an EPR program achieving high rates of diversion from disposal*" **but the Department does not cite any sources of where this has been the case or studies that support the recommendations listed in the Product Stewardship Report**. We disagree with these characterizations and do not believe they are well supported, as evidenced by the lack of citations in the Product Stewardship Report.

TRC has concerns with the Department's specific recommended changes to the legislation, which include:

1. **A requirement that each program maintain a minimum standard for the producers' or stewardship organization staffing: "a minimum ½-fulltime equivalent (FTE)" with the work product of working to "recruit, train and monitor collection sites".** It has been TRC's experience that more hours of effort and resources do not necessarily equate to more collections. Also, this recommendation leaves no flexibility for other ways to cover extended producer responsibility (EPR) related site collection work, such as outsourcing activities or working with the Department staff. Department staff visit retailers in the state and drive economies of scale when they can ask about other EPR programs such as thermostat, batteries, lamps, or paint while there. The Department is essentially going to burden each collection site with up to 4 times as many visits with representatives of stewardship groups. It is also our experience that Department staff have better and more impactful conversations with collection locations than EPR groups because of the perception of being from the government. Lastly, there is no other precedent for this in other states with EPR programs for good reason, since it is an inefficient use of resources.

2. **Measurable, enforceable goals (e.g., recycling rate, consumer awareness, convenient collection), and defined consequences for non-compliance. The rates will use a description of the methodology and the relevant historic sales data used to develop the rate.** The Department acknowledges anti-trust concerns in the report. Sharing such information such as historic sales data may not be available to provide to the Department or the Department may not be the appropriate clearinghouse. TRC has consistently contended that collection targets do not make good public policy. Goals by themselves do little to encourage other actors to participate and place all of the ownership of the target strictly on the manufacturer.

3. **Using a permanent collection site within 15 miles of 90% of Maine residents within one year of the start of product collections.** TRC has concerns with mandates to place a collection site in a location to simply satisfy an arbitrary geographic requirement. Placing collection locations in a state is more nuanced than choosing something arbitrary such as geography to population or even a location in each county. Population centers should inform where to place collection locations and not geographic distance. By this same logic, Maine should put in place hospitals or schools within 15 miles of 90% of the population. Many current EPR laws define collection locations based on the prior sales channel

they were sold through. It is possible the sales channel is not nearby and cannot possibly satisfy such a prescriptive requirement, particularly in light of sales through online outlets. As we mentioned above, this requirement would put the ownership completely on the EPR program and not on the collection site themselves. Whenever an EPR law defines a collection location with a mandate to collect, there cannot be an accurate way to blanket the entire state if those outlets do not exist in the required regions. Mandating this also stifles innovation by legislating out the possibility of other potential collection mechanisms such as smaller/shippable containers or developing pick-up schemes. Further research and a thorough review of accessibility for Maine's population should be completed before imposing a blanket approach on EPR programs related to geographic distance and percentage within population calculation.

CONCLUSION

TRC would caution the Department from applying a "one-size-fits-all" approach to end-of-life product management. TRC spends significant time with other EPR groups reviewing programmatic elements and the constant theme is that each EPR program is different. These programs do not all share common characteristics and should not be managed in the same fashion.

TRC, as one of the first EPR programs in the nation, remains available to answer questions or clarify components of its collection program with Department staff and specifically these comments. As mentioned above, we applaud the Department's willingness to have EPR groups weigh in on these proposed changes. Please don't hesitate to contact me at your convenience at ryan.kiscaden@thermostat-recycle.org or 267-513-1727.

Sincerely,

Ryan L Kiscaden
Executive Director

CC:

Paula Clark
Carole Cifrino

Mark Ward comments on Annual Product Stewardship Report

I am writing to express my thoughts on the draft of the Annual Product Stewardship Report (compiled by the DEP in January 2019). I have reviewed this report and commend the authors for having compiled an extremely thorough and thoughtful presentation of their findings and recommendations.

I strongly encourage the legislature to consider the recommendations made to modify existing Maine laws to strengthen the state's current Extended Product Responsibility efforts. As the state entity responsible for implementing and overseeing these efforts, the DEP is uniquely positioned to understand what is and is not working in the laws as they are currently written. Because the recommendations are compiled as separate appendices, the legislature can choose to adopt all of the proposed changes or to select those that it deems most pressing (making sure, of course, that if it were to adopt a piecemeal approach that it consider the implications on the whole of Title 38, Chapter 18 Product Stewardship). Among the recommendations that I see as being especially important are the proposals to: 1) strengthen the Framework Law, 2) make the mercury lamp law more consistent with the framework, and 3) make changes to the consumer batteries section to include lithium and lithium-ion batteries to minimize the risk of fires at Materials Recovery Facilities. I also support the recommended changes to the bottle bill (38 M.R.S., Chapter 33) most notably the establishment of the "catch-all" commingling provision for containers of the same material type.

In addition, I appreciate the DEP efforts to identify candidate products for new EPR programs. I am especially enthusiastic about the potential to enact a new EPR program for packaging. The analysis provided suggests that a packaging program in Maine would best be designed through a shared responsibility model with a carefully crafted set of municipal incentives.

Mark Ward, 28 Poor Farm Road, Bristol, ME 04539

THE CARPET AND RUG INSTITUTE

February 12, 2019 VIA: E-Mail

Mr. Mike Karagiannes
Maine DEP
17 State House Station
Augusta, ME 04333-0017

Comments Re: Implementing Product Stewardship in Maine, 2019

The Carpet and Rug Institute, representing carpet manufacturers who produce over 90% of the carpet made in the United States, appreciates the opportunity to comment on Maine's 2019 Product Stewardship Annual Report and the state's consideration of EPR legislation.

The carpet manufacturing industry is working independently, and together with others, to reduce the amount of carpet going to the landfill each year. More than 15 years ago, the carpet industry entered into a voluntary agreement with many states, including Maine, the EPA and NGOs to find solutions that would facilitate the diversion of carpet from landfills.

More recently, over the past two years, CRI has collaborated with Maine's Department of Environmental Protection (DEP), the Maine Retail Association and the Carpet Americas Recovery Effort (CARE) to develop voluntary pilot programs aimed at finding solutions for carpet disposal in the state. Based on our June 2018 meeting with DEP, we look forward to continuing to pursue a number of ideas that would increase diversion to energy in Maine without a new mandate for EPR. We are particularly interested in the potential to connect installers with organizations that utlilize carpets in energy recovery. Since 2002, our industry has invested in excess of $300M on this effort and we have had continued to see growth in our diversion numbers.

The carpet and rug industry is committed, above all else, to serving our customers, our communities and the millions of people who benefit from our products every day. Our industry has long been committed to creating sustainable and beautiful products for people in their homes, schools and commercial spaces, and we continue to innovate to minimize the environmental impact of carpet products and manufacturing in Maine and throughout the U.S.

The carpet industry takes a holistic approach to sustainability that is responsible, proactive, and seeks to balance to various stakeholder needs and interests. Carpet manufacturers focus on reducing water and energy use, strive to create zero waste, integrate renewable chemistry into the manufacturing process, incorporate recycled content in new carpet products, and recycle

carpet-rug.org 3033 Wilson Blvd., Ste. 700, Arlington, VA 22201 703-875-0634

carpet to reduce the amount of discarded carpet that goes into landfills. In fact, over the past 17 years, carpet manufacturers have invested in creating a carpet recycling industry that has diverted more than 5 billion pounds of carpet from landfills (2017 CARE Annual Report).
In recent years, the carpet industry's investments in innovation and design have focused on ensuring that the products we are manufacturing today are constructed to facilitate recycling and recovery. Like many other industries, that transition is still under way. Carpet that is reaching its end of life today remains highly complex and challenging. We are continuing to invest both in technology and to further develop a market that will make even broader adoption of carpet recycling possible.

The public is best served by our continuing to invest in solutions, rather than unnecessary, distracting and expensive additional regulation that stands to do more harm than good – including putting tens of thousands of jobs at risk. It should be noted that alternative, non-legislative options in South Carolina, for example, have led to steady job growth while diverting carpet from landfill.

California, which has a higher population density and established infrastructure, enacted EPR legislation in 2010 that in many ways remains a work in progress. In addition to the very difficult chemistry and market realities faced in every state, Maine faces more challenging infrastructure and density challenge.

Carpet is an important US-based manufacturing industry, with more than 98 percent of carpet used in the United States manufactured in our country. Carpet manufacturing is one of the last major industries primarily based in the United States. More than half a million American jobs depend on the U.S. carpet manufacturing industry, in manufacturing, transportation, installation, retail sales, recycling and more. (Pending results of member economic impact survey.)

We encourage the state of Maine to work with us on existing voluntary efforts and incentivize market-based solutions. The carpet industry is committed to continue seeking solutions and has a plan to go to the next step. Legislation will only hinder our progress, cost jobs in the US, and, will not lead to the best environmental solutions to the challenges we face.

Sincerely,

Jennifer L. Stowe

Jennifer L. Stowe
Vice President, Government Relations

Chemicals of Concern

Published by Maine DEP
July 2015

		TYPE OF TOXICITY									ORIGINATING LIST																					
CAS	Chemical of Concern Name	(Persistent Bioaccumulative and Toxic) PBT	(Very Persistent and Very Bioaccumulative) vPvB	(Persistent, Bioaccumulative and inherently Toxic) PBiT	(Carcinogenic, Mutagenic and Reproductive (Toxicants)) CMR	Carcinogen	Endocrine Disruptor	Developmental Toxicant	Reproductive Toxicant	Equivalent Level of Concern	EPA Final PBT Rule for TRI	TRI PBT Chemical List	EPA Priority PBT	NWM Priority Chemicals (PBTs)	WA PBT List	EU PBT List	OSPAR Chemicals of Concern	OSPAR Chemicals for Priority Action	Canada PBiT List	CA Prop 65	EU Endocrine Disruptor	IARC	EU Carcinogen	EU Reproductive Toxicant	IRIS	REACH Substances of Very High Concern	NTP 11th/13th ROC	NTP CERHR	Pesticide Notation	Source list last reviewed	Date Listed	Source
50-00-0	Formaldehyde (gas)					CA Prop 65; IARC; IRIS; NTP 11th														cancer		Group 1			B1		Known		not a pesticide	July_2015	July 2009	NSPIRS 2011
50-07-7	Mitomycin C					CA Prop 65														cancer										Dec_2011	July 2009	
50-18-0	Cyclophosphamide (anhydrous)					CA Prop 65; IARC; NTP 11th ROC	EU Endocrine Disruptor	CA Prop 65	CA Prop 65											cancer, developmental, reproductive	Category 1 Endocrine Disruptor	Group 1					Known			Dec_2011	July 2009	
50-32-8	Benzo(a)pyrene	EPA Final PBT Rule for TRI; EPA Priority PBT;				CA Prop 65; IARC; IRIS; NTP 11th	OSPAR Chemicals of Concern; EU				PBT		PBT				PBT, Endocrine disruptor			cancer	Category 1 Endocrine Disruptor	Group 1			B2		Reasonably anticipated			Dec_2011	July 2009	
50-63-5	1,4-pentanediamine, N(4)-(7-chloro-4-quinolinyl)-N(1),N(1)-diethyl-, phosphate (1:2)	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
51-79-6	Urethane (Ethyl carbamate)					CA Prop 65; IARC; NTP 11th ROC		CA Prop 65												cancer, developmental		Group 2A					Reasonably anticipated			Dec_2011	July 2009	
52-76-6	Lynestrenol					CA Prop 65														cancer										Dec_2011	July 2009	
53-19-0	benzene, 1-chloro-2-[2,2-dichloro-1-(4-chlorophenyl)ethyl]-	OSPAR Chemicals of Concern		Canada PBiT List			EU Endocrine Disruptor										PBT		PBiT		Category 1 Endocrine Disruptor									Dec_2011	July 2009	
53-70-3	Dibenzo(a,h)anthracene	EPA Final PBT Rule for TRI; WA PBT List; OSPAR				CA Prop 65; IARC; IRIS; NTP 11th					PBT				PBT		PBT			cancer		Group 2A			B2		Reasonably anticipated			Dec_2011	July 2009	
53-96-3	2-Acetylaminofluorene					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec_2011	July 2009	
54-05-7	1,4-pentanediamine, N4-(7-chloro-4-quinolinyl)-N1,N1-diethyl-	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
54-11-5	Nicotine							CA Prop 65												developmental									P(A)(O)	Dec_2011	July 2009	NSPIRS 2011, TOXNET
55-18-5	N-Nitrosodiethylamine					CA Prop 65; IARC; IRIS; NTP 11th														cancer		Group 2A			B2		Reasonably anticipated			Dec_2011	July 2009	
56-23-5	Carbon tetrachloride					CA Prop 65; IRIS; NTP 11th ROC														cancer					B2		Reasonably anticipated		P(NR)(O)	Dec_2011	July 2009	NSPIRS 2011, TOXNET
56-49-5	3-Methylcholanthrene	EPA Final PBT Rule for TRI; WA PBT List; OSPAR				CA Prop 65	EU Endocrine Disruptor				PBT				PBT		PBT			cancer	Category 1 Endocrine Disruptor									Dec_2011	July 2009	
56-55-3	Benzo(a)anthracene	EPA Final PBT Rule for TRI; OSPAR Chemicals				CA Prop 65; IRIS; NTP 11th ROC					PBT						PBT			cancer					B2		Reasonably anticipated			Dec_2011	July 2009	
56-95-1	2,4,11,13-Tetraazatetradecanediimidamide, N,N''-bis(4-chlorophenyl)-3,12-diimino-, diacetate			Canada PBiT List															PBiT										P(O)	Dec_2011	July 2009	TOXNET 2011
57-14-7	1,1-Dimethylhydrazine (UDMH)					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated		P(M)(O)	Dec_2011	July 2009	NSPIRS 2011, TOXNET
57-41-0	Diphenylhydantoin (Phenytoin)					CA Prop 65; NTP 11th ROC		CA Prop 65												cancer, developmental							Reasonably anticipated			Dec_2011	July 2009	
57-97-6	7,12-Dimethylbenz(a)anthracene	EPA Final PBT Rule for TRI; OSPAR Chemicals				CA Prop 65	EU Endocrine Disruptor				PBT						PBT			cancer	Category 1 Endocrine Disruptor									Dec_2011	July 2009	
58-14-0	Pyrimethamine							CA Prop 65												developmental										Dec_2011	July 2009	
58-38-8	10H-Phenothiazine, 2-chloro-10-[3-(4-methyl-1-piperazinyl)propyl]-	OSPAR Chemicals of Concern		Canada PBiT List													PBT		PBiT											Dec_2011	July 2009	
58-89-9	Hexachlorocyclohexane, gamma-	NWM Priority Chemicals; OSPAR Chemicals of		Canada PBiT List		CA Prop 65; NTP 11th ROC	OSPAR Chemicals of Concern; EU							PBT			PBT, Endocrine disruptor		PBiT		Category 1 Endocrine Disruptor						Reasonably anticipated		P(NR)(O)	Dec_2011	July 2009	NSPIRS 2011
59-87-0	Nitrofurazone					CA Prop 65														cancer										Dec_2011	July 2009	
59-89-2	N-Nitrosomorpholine					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec_2011	July 2009	
60-09-3	p-Aminoazobenzene					CA Prop 65														cancer										Dec_2011	July 2009	
60-11-7	4-Dimethylaminoazobenzene					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec_2011	July 2009	
60-35-5	Acetamide					CA Prop 65														cancer										Dec_2011	July 2009	
62-50-0	Ethyl methanesulfonate					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec_2011	July 2009	
62-53-3	Aniline					CA Prop 65; IRIS														cancer					B2					Dec_2011	July 2009	
62-55-5	Thioacetamide					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec_2011	July 2009	
62-56-6	Thiourea					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec_2011	July 2009	
62-75-9	N-Nitrosodimethylamine					CA Prop 65; IARC; IRIS; NTP 11th														cancer		Group 2A			B2		Reasonably anticipated			Dec_2011	July 2009	
63-92-3	Phenoxybenzamine hydrochloride					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec_2011	July 2009	
63-98-9	Phenacemide							CA Prop 65												developmental										Dec_2011	July 2009	
64-17-5	Ethanol in alcoholic beverages					IARC		CA Prop 65												developmental		Group 1								Dec_2011	July 2009	
64-67-5	Diethyl sulfate					CA Prop 65; IARC; NTP 11th ROC														cancer		Group 2A					Reasonably anticipated			Dec_2011	July 2009	
66-27-3	Methyl methanesulfonate					CA Prop 65; IARC; NTP 11th ROC														cancer		Group 2A					Reasonably anticipated			Dec_2011	July 2009	
67-56-1	methanol							NTP CERHR																				concern [developm ental	P(NR)(O)	Dec_2011	July 2009	NSPIRS 2011, TOXNET
67-66-3	Chloroform					CA Prop 65; IRIS; NTP 11th ROC														cancer					B2 (1986 Guidel		Reasonably anticipated		P(A)(O)	Dec_2011	July 2009	NSPIRS 2011
67-72-1	Hexachloroethane	NWM Priority Chemicals; OSPAR Chemicals of				CA Prop 65; NTP 11th ROC								PBT			PBT			cancer							Reasonably anticipated			Dec_2011	July 2009	
69-05-6	1,4-pentanediamine, N4-(6-chloro-2-methoxy-9-aziridinyl)-N1,N1-diethyl-, dihydrochloride	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
69-23-8	1-Piperazineethanol, 4-[3-[2-(trifluoromethyl)-10H-phenothiazin-10-yl]propyl]-	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
70-25-7	N-Methyl-N'-nitro-N-nitrosoguanidine					CA Prop 65; IARC; NTP 11th ROC														cancer		Group 2A					Reasonably anticipated			Dec_2011	July 2009	
70-30-4	phenol, 2,2'-methylenebis[3,4,6-trichloro-	OSPAR Chemicals of Concern															PBT												P(NR)(O)	Dec_2011	July 2009	NSPIRS 2011, TOXNET
71-43-2	Benzene					CA Prop 65; IARC; EU Carcinogen;		CA Prop 65	CA Prop 65											cancer, developmental, reproductive		Group 1	Category 1 carcinogen		A (1986 Guidel		Known		not a pesticide	Dec_2011	July 2009	NSPIRS 2011

Chemicals of Concern

Published by Maine DEP
July 2015

		TYPE OF TOXICITY									ORIGINATING LIST																					
CAS	Chemical of Concern Name	(Persistent Bioaccumulative and Toxic) PBT	(Very Persistent and Very Bioaccumulative) vPvB	(Persistent, Bioaccumulative and inherently Toxic) PBiT	(Carcinogenic, Mutagenic and Reproductive (Toxicants)) CMR	Carcinogen	Endocrine Disruptor	Developmental Toxicant	Reproductive Toxicant	Equivalent Level of Concern	EPA Final PBT Rule for TRI	TRI PBT Chemical List	EPA Priority PBT	NWM Priority Chemicals (PBTs)	WA PBT List	EU PBT List	OSPAR Chemicals of Concern	OSPAR Chemicals for Priority Action	Canada PBiT List	CA Prop 65	EU Endocrine Disruptor	IARC	EU Carcinogen	EU Reproductive Toxicant	IRIS	REACH Substances of Very High Concern	NTP 11th/13th ROC	NTP CERHR	Pesticide Notation	Source list last reviewed	Date Listed	Source
71-58-9	Medroxyprogesterone acetate					CA Prop 65		CA Prop 65												cancer, developmental										Dec 2011	July 2009	
72-54-8	benzene, 1,1'-(2,2-dichloroethylidene)bis[4-chloro-	OSPAR Chemicals of Concern				CA Prop 65; IRIS	EU Endocrine Disruptor										PBT			cancer	Category 1 Endocrine Disruptor				B2					Dec_2011	July 2009	
72-55-9	benzene, 1,1'-(dichloroethenylidene)bis[4-chloro-	OSPAR Chemicals of Concern				CA Prop 65; IRIS	EU Endocrine Disruptor										PBT			cancer	Category 1 Endocrine Disruptor				B2					Dec 2011	July 2009	
72-57-1	Trypan blue (commercial grade)					CA Prop 65														cancer										Dec_2011	July 2009	
74-87-3	Methyl chloride							CA Prop 65												developmental										Dec 2011	July 2009	
74-88-4	Methyl iodide					CA Prop 65														cancer										Dec_2011	July 2009	
74-96-4	Bromoethane					CA Prop 65														cancer										Dec 2011	July 2009	
75-00-3	Chloroethane (Ethyl chloride)					CA Prop 65														cancer										Dec_2011	July 2009	
75-01-4	Vinyl chloride					CA Prop 65; IARC; EU Carcinogen;														cancer		Group 1	Category 1 carcinogen		A (1986 Guidel		Known			Dec 2011	July 2009	
75-02-5	Vinyl fluoride					CA Prop 65; IARC; NTP 11th ROC														cancer		Group 2A					Reasonably anticipated			Dec_2011	July 2009	
75-07-0	Acetaldehyde					CA Prop 65; IRIS; NTP 11th ROC														cancer					B2		Reasonably anticipated			Dec 2011	July 2009	
75-09-2	Dichloromethane (Methylene chloride)					CA Prop 65; IRIS; NTP 11th ROC														cancer					B2		Reasonably anticipated			Dec_2011	July 2009	
75-15-0	Carbon disulfide							CA Prop 65	CA Prop 65											developmental, reproductive female, male									P(NR)(O)	Dec 2011	July 2009	NSPIRS 2011, TOXNET
75-21-8	Ethylene oxide					CA Prop 65; IARC; NTP 11th ROC			CA Prop 65											cancer, reproductive female		Group 1					Known		P(NR)(O)	Dec_2011	July 2009	NSPIRS 2011, TOXNET
75-25-2	Bromoform					CA Prop 65; IRIS														cancer					B2					Dec 2011	July 2009	
75-26-3	2-Bromopropane								CA Prop 65; EU Reproductive Toxicant; NTP											reproductive female, male				Category 1 Reproductive Toxicant				some concern [reproduct		Dec_2011	July 2009	
75-27-4	Bromodichloromethane					CA Prop 65; IRIS; NTP 11th ROC														cancer					B2		Reasonably anticipated			Dec 2011	July 2009	
75-28-5	isobutane (containing 0.1 % butadiene (203-450-8))					EU Carcinogen																	Category 1 carcinogen							Dec 2011	July 2009	
75-34-3	1,1-Dichloroethane					CA Prop 65														cancer										Dec_2011	July 2009	
75-52-5	methane, nitro-	OSPAR Chemicals of Concern				CA Prop 65; NTP 11th ROC											PBT			cancer							Reasonably anticipated			Dec 2011	July 2009	
75-55-8	2-Methylaziridine (Propyleneimine)					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec_2011	July 2009	
75-56-9	Propylene oxide					CA Prop 65; IRIS; NTP 11th ROC														cancer					B2		Reasonably anticipated		P(NR)(O)	Dec 2011	July 2009	NSPIRS 2011, TOXNET
75-74-1	Tetramethyllead	EU PBT List; OSPAR Chemicals of Concern														Fulfilling PBT crit eria	PBT													Dec_2011	July 2009	
76-60-8	Phenol, 4,4'-(3H-2,1-benzoxathiol- 3-ylidene)bis[2,6-dibromo-3-methyl-, S,S-dioxide			Canada PBiT List															PBiT											Dec 2011	July 2009	
77-09-8	Phenolphthalein					CA Prop 65; NTP 11th ROC	EU Endocrine Disruptor													cancer	Category 1 Endocrine Disruptor						Reasonably anticipated			Dec_2011	July 2009	
77-40-7	2,2-Bis(4-hydroxyphenyl)-n-butan = Bisphenol B						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec 2011	July 2009	
77-52-1	Urs-12-en-28-oic acid, 3-hydroxy-, (3ß)-			Canada PBiT List															PBiT											Dec_2011	July 2009	
77-78-1	Dimethyl sulfate					CA Prop 65; IARC; IRIS; NTP 11th														cancer		Group 2A			B2		Reasonably anticipated			Dec 2011	July 2009	
78-00-2	lead, tetraethyl-	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
78-63-7	Peroxide, (1,1,4,4-tetramethyl-1,4-butanediyl)bis[(1,1-dimethylethyl)			Canada PBiT List															PBiT											Dec 2011	July 2009	
78-79-5	Isoprene					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec_2011	July 2009	
78-87-5	1,2-Dichloropropane					CA Prop 65														cancer									P(NR)(O)	Dec 2011	July 2009	NSPIRS 2011
79-00-5	Vinyl trichloride (1,1,2-Trichloroethane)					CA Prop 65														cancer										Dec_2011	July 2009	
79-01-6	Trichloroethylene					CA Prop 65; IARC; NTP 11th ROC														cancer		Group 2A					Reasonably anticipated		P(NR)(O)	Dec 2011	July 2009	NSPIRS 2011, TOXNET
79-06-1	Acrylamide					CA Prop 65; IARC; IRIS; NTP 11th		NTP CERHR	NTP CERHR											cancer		Group 2A			B2		Reasonably anticipated	some concern [developm		Dec_2011	July 2009	
79-34-5	1,1,2,2-Tetrachloroethane					CA Prop 65														cancer									P(NR)(O)	Dec 2011	July 2009	NSPIRS 2011, TOXNET
79-43-6	Dichloroacetic acid					CA Prop 65; IRIS														cancer					Likely to be carcin					Dec_2011	July 2009	
79-44-7	Dimethylcarbamoyl chloride					CA Prop 65; IARC; NTP 11th ROC														cancer		Group 2A					Reasonably anticipated			Dec 2011	July 2009	
79-46-9	2-Nitropropane					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec_2011	July 2009	
79-57-2	Oxytetracycline (internal use)							CA Prop 65												developmental										Dec 2011	July 2009	
79-92-5	bicyclo[2.2.1]heptane, 2,2-dimethyl-3-methylene-	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
79-94-7	Tetrabromobisphenol A	EPA Final PBT Rule for TRI; TRI PBT Chemical List;									PBT	PBT	PBT		PBT		PBT	PBT												Dec 2011	July 2009	
79-95-8	phenol, 4,4'-(1-methylethylidene)bis[2,6-dichloro-	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
80-06-8	benzenemethanol, 4-chloro-.alpha.-(4-chlorophenyl)-.alpha.-methyl-	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
81-15-2	benzene, 1-(1,1-dimethylethyl)-3,5-dimethyl-2,4,6-trinitro-	OSPAR Chemicals of Concern	REACH Substances of Very High Concern														PBT									vPvB				Dec 2011	July 2009	

Chemicals of Concern

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July 2015

		TYPE OF TOXICITY									ORIGINATING LIST																					
CAS	Chemical of Concern Name	(Persistent Bioaccumulative and Toxic) PBT	(Very Persistent and Very Bioaccumulative) vPvB	(Persistent, Bioaccumulative and inherently Toxic) PBiT	(Carcinogenic, Mutagenic and Reproductive (Toxicants)) CMR	Carcinogen	Endocrine Disruptor	Developmental Toxicant	Reproductive Toxicant	Equivalent Level of Concern	EPA Final PBT Rule for TRI	TRI PBT Chemical List	EPA Priority PBT	NWM Priority Chemicals (PBTs)	WA PBT List	EU PBT List	OSPAR Chemicals of Concern	OSPAR Chemicals for Priority Action	Canada PBiT List	CA Prop 65	EU Endocrine Disruptor	IARC	EU Carcinogen	EU Reproductive Toxicant	IRIS	REACH Substances of Very High Concern	NTP 11th/13th ROC	NTP CERHR	Pesticide Notation	Source list last reviewed	Date Listed	Source
81-49-2	1-Amino-2,4-dibromoanthraquinone					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec 2011	July 2009	
81-68-5	Benzenesulfonamide, N-(4-amino-9,10-dihydro-3-methoxy-9,10-dioxo-1-anthracenyl)-4-methyl-			Canada PBiT List															PBiT											Dec_2011	July 2009	
81-81-2	Warfarin							CA Prop 65	EU Reproductive Toxicant											developmental				Category 1 Reproductive Toxicant					P(A)(O)	Dec 2011	July 2009	NSPIRS 2011
81-88-9	D&C Red No. 19					CA Prop 65														cancer										Dec_2011	July 2009	
81-98-1	7H-benz[de]anthracen-7-one, 3,9-dibromo-	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
82-05-3	7H-benz[de]anthracen-7-one	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
82-28-0	1-Amino-2-methylanthraquinone					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec 2011	July 2009	
83-32-9	Acenaphthene	NWM Priority Chemicals; OSPAR Chemicals of												PBT			PBT													Dec_2011	July 2009	
83-66-9	benzene, 1-(1,1-dimethylethyl)-2-methoxy-4-methyl-3,5-dinitro-	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
84-61-7	Dicyclohexyl phthalate (DCHP)						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec_2011	July 2009	
84-65-1	Anthraquinone					CA Prop 65														cancer										Dec 2011	July 2009	
84-66-2	Diethyl phthalate (DEP)						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec_2011	July 2009	
84-69-5	1,2-benzenedicarboxylic acid, bis(2-methylpropyl) ester									OSPAR Chemicals of Concern							Equivalent level of concern													Dec 2011	July 2009	
84-74-2	1,2-benzenedicarboxylic acid, dibutyl ester (DBP) (phthalate)				REACH Substances of Very High Concern		OSPAR Chemicals of Concern; EU	CA Prop 65; NTP CERHR	CA Prop 65								Endocrine disruptor			developmental, reproductive female, male	Category 1 Endocrine Disruptor					CMR (reproductive toxicant)		some concern [developm	P(NR)(O)	Dec_2011	July 2009	NSPIRS 2011, TOXNET
84-75-3	Di-n-hexyl phthalate (DnHP)								CA Prop 65											reproductive female, male										Dec 2011	July 2009	
85-01-8	Phenanthrene	NWM Priority Chemicals												PBT																Dec_2011	July 2009	
85-22-3	pentabromoethylbenzene	OSPAR Chemicals of Concern; OSPAR Chemicals															PBT	PBT												Dec 2011	July 2009	
85-68-7	1,2-benzenedicarboxylic acid, butyl phenylmethyl ester (BBP) (phthalate)				REACH Substances of Very High Concern		OSPAR Chemicals of Concern; EU	CA Prop 65									Endocrine disruptor			developmental	Category 1 Endocrine Disruptor					CMR (reproductive toxicant)				Dec 2011	July 2009	
85-86-9	2-Naphthalenol, 1-[[4-(phenylazo)phenyl]azo]-			Canada PBiT List															PBiT											Dec_2011	July 2009	
86-30-6	N-Nitrosodiphenylamine					CA Prop 65; IRIS														cancer					B2					Dec 2011	July 2009	
86-73-7	Fluorene	NWM Priority Chemicals												PBT																Dec 2011	July 2009	
86-74-8	Carbazole					CA Prop 65														cancer										Dec 2011	July 2009	
87-10-5	Benzamide, 3,5-dibromo-N-(4-bromophenyl)-2-hydroxy-			Canada PBiT List															PBiT										P(NR)(O)	Dec_2011	July 2009	NSPIRS 2011, Merck
87-29-6	Cinnamyl anthranilate					CA Prop 65														cancer										Dec 2011	July 2009	
87-61-6	1,2,3trichlorobenzene	EU PBT List; OSPAR Chemicals of Concern;														Fulfilling PBT crit eria	PBT	PBT												Dec_2011	July 2009	
87-62-7	2,6-Xylidine (2,6-Dimethylaniline)					CA Prop 65														cancer										Dec 2011	July 2009	
87-68-3	Hexachlorobutadiene	NWM Priority Chemicals; WA PBT List; EU PBT	EU PBT List	Canada PBiT List										PBT	PBT	Fulfilling PBT & v PvB criter	PBT		PBiT											Dec_2011	July 2009	
87-82-1	benzene, hexabromo-	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
87-83-2	benzene, pentabromomethyl-	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
88-72-2	o-Nitrotoluene					CA Prop 65														cancer										Dec 2011	July 2009	
90-04-0	o-Anisidine					CA Prop 65														cancer										Dec_2011	July 2009	
90-43-7	o-Phenylphenol					CA Prop 65														cancer									P(A)(O)	Dec 2011	July 2009	NSPIRS 2011, TOXNET
90-94-8	Michler's ketone					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec 2011	July 2009	
91-20-3	Naphthalene	NWM Priority Chemicals				CA Prop 65; NTP 11th ROC								PBT						cancer							Reasonably anticipated		P(A)(O)	Dec 2011	July 2009	NSPIRS 2011
91-22-5	Quinoline					IRIS																			B2 (1986 Guidel					Dec_2011	July 2009	
91-23-6	o-Nitroanisole					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec 2011	July 2009	
91-59-8	2-Naphthylamine					CA Prop 65; IARC; EU Carcinogen;														cancer		Group 1	Category 1 carcinogen				Known			Dec_2011	July 2009	
91-94-1	[1,1'-biphenyl]-4,4'-diamine, 3,3'-dichloro-	OSPAR Chemicals of Concern				CA Prop 65; IRIS; NTP 11th ROC											PBT			cancer					B2		Reasonably anticipated			Dec 2011	July 2009	
92-24-0	naphthacene	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
92-67-1	4-Aminobiphenyl (4-amino-diphenyl)					CA Prop 65; IARC; EU Carcinogen;														cancer		Group 1	Category 1 carcinogen				Known			Dec 2011	July 2009	
92-69-3	4-Hydroxybiphenyl = 4-Phenylphenol						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec_2011	July 2009	
92-72-8	2-Naphthalenecarboxamide, N-(5-chloro-2,4-dimethoxyphenyl)-3-hydroxy-			Canada PBiT List															PBiT											Dec 2011	July 2009	
92-76-2	2-Naphthalenecarboxamide, N-(4-chloro-2-methylphenyl)-3-hydroxy-			Canada PBiT List															PBiT											Dec_2011	July 2009	
92-87-5*	Benzidine [and its salts]					CA Prop 65; IARC; EU Carcinogen;														cancer		Group 1	Category 1 carcinogen		A		Known			Dec_2011	July 2009	
92-88-6	4,4'-Dihydroxybiphenyl = 4,4'-Biphenol						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec 2011	July 2009	

Chemicals of Concern

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CAS	Chemical of Concern Name	(Persistent Bioaccumulative and Toxic) PBT	(Very Persistent and Very Bioaccumulative) vPvB	(Persistent, Bioaccumulative and inherently Toxic) PBiT	(Carcinogenic, Mutagenic and Reproductive (Toxicants)) CMR	Carcinogen	Endocrine Disruptor	Developmental Toxicant	Reproductive Toxicant	Equivalent Level of Concern	EPA Final PBT Rule for TRI	TRI PBT Chemical List	EPA Priority PBT	NWM Priority Chemicals (PBTs)	WA PBT List	EU PBT List	OSPAR Chemicals of Concern	OSPAR Chemicals for Priority Action	Canada PBiT List	CA Prop 65	EU Endocrine Disruptor	IARC	EU Carcinogen	EU Reproductive Toxicant	IRIS	REACH Substances of Very High Concern	NTP 11th/13th ROC	NTP CERHR	Pesticide Notation	Source list last reviewed	Date Listed	Source
92-93-3	4-Nitrobiphenyl					CA Prop 65														cancer										Dec_2011	July 2009	
93-15-2	Methyleugenol					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated		P(A)(O)	Dec_2011	July 2009	NSPIRS 2011, TOXNET
93-46-9	1,4-benzenediamine, N,N'-di-2-naphthalenyl-	OSPAR Chemicals of Concern		Canada PBiT List													PBT		PBiT											Dec_2011	July 2009	
94-13-3	n-propyl p-hydroxybenzoate						EU Endocrine Disruptor														Category 1 Endocrine Disruptor								P(NR)(O)	Dec_2011	July 2009	NSPIRS 2011, TOXNET
94-13-3	n-propyl p-hydroxybenzoate						EU Endocrine Disruptor														Category 1 Endocrine Disruptor								P(NR)(O)	Dec_2011	July 2009	NSPIRS 2011, TOXNET
94-26-8	n-Butyl p-Hydroxybenzoate						EU Endocrine Disruptor														Category 1 Endocrine Disruptor								P(NR)(O)	Dec_2011	July 2009	NSPIRS 2011, TOXNET
94-26-8	n-Butyl p-Hydroxybenzoate						EU Endocrine Disruptor														Category 1 Endocrine Disruptor								P(NR)(O)	Dec_2011	July 2009	NSPIRS 2011, TOXNET
94-58-6	Dihydrosafrole					CA Prop 65														cancer										Dec_2011	July 2009	
94-59-7	Safrole					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec_2011	July 2009	
94-78-0	Phenazopyridine					CA Prop 65														cancer										Dec_2011	July 2009	
95-53-4	o-Toluidine					CA Prop 65; IARC; NTP 11th ROC														cancer		Group 1					Reasonably anticipated			Dec_2011	July 2009	
95-54-5	o-Phenylenediamine and its salts, o-Phenylenediamine, o-Phenylenediamine dichydrochloride					CA Prop 65														cancer										Dec_2011	July 2009	
95-69-2	p-Chloro-o-toluidine					CA Prop 65; IARC; NTP 11th ROC														cancer		Group 2A					Reasonably anticipated			Dec_2011	July 2009	
95-76-1	3,4-dichloroaniline						OSPAR Chemicals of Concern; EU										Endocrine disruptor				Category 1 Endocrine Disruptor									Dec_2011	July 2009	
95-80-7	2,4-Diaminotoluene					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec_2011	July 2009	
95-83-0	4-Chloro-o-phenylenediamine					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec_2011	July 2009	
95-94-3	1,2,4,5-Tetrachlorobenzene	NWM Priority Chemicals; WA PBT List; OSPAR		Canada PBiT List										PBT	PBT		PBT		PBiT											Dec_2011	July 2009	
95-95-4	2,4,5-Trichlorophenol	NWM Priority Chemicals; OSPAR Chemicals of												PBT			PBT												P(NR)(O)	Dec_2011	July 2009	NSPIRS 2011, TOXNET
96-09-3	Styrene oxide					CA Prop 65; IARC; NTP 11th ROC														cancer		Group 2A					Reasonably anticipated			Dec_2011	July 2009	
96-12-8	1,2-Dibromo-3-chloropropane (DBCP)					CA Prop 65; NTP 11th ROC	EU Endocrine Disruptor		CA Prop 65; EU Reproductive Toxicant											cancer, reproductive male	Category 1 Endocrine Disruptor			Category 1 Reproductive Toxicant			Reasonably anticipated		P(NR)(O)	Dec_2011	July 2009	NSPIRS 2011
96-13-9	2,3-Dibromo-1-propanol					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec_2011	July 2009	
96-18-4	1,2,3-Trichloropropane					CA Prop 65; IARC; NTP 11th ROC														cancer		Group 2A					Reasonably anticipated			Dec_2011	July 2009	
96-45-7	Ethylene thiourea					CA Prop 65; NTP 11th ROC	EU Endocrine Disruptor	CA Prop 65												cancer, developmental	Category 1 Endocrine Disruptor						Reasonably anticipated		P(M)(O)	Dec_2011	July 2009	NSPIRS 2011, TOXNET
96-66-2	Phenol, 4,4'-thiobis[2-(1,1-dimethylethyl)-6-methyl-			Canada PBiT List															PBiT											Dec_2011	July 2009	
97-18-7	phenol, 2,2'-thiobis[4,6-dichloro-	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
97-23-4	Dichlorophene							CA Prop 65												developmental										Dec_2011	July 2009	
97-56-3	o-Aminoazotoluene					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec_2011	July 2009	
98-07-7	Benzotrichloride					CA Prop 65; IARC; IRIS; NTP 11th														cancer		Group 2A			B2		Reasonably anticipated			Dec_2011	July 2009	
98-54-4	butylphenol						OSPAR Chemicals of Concern										Endocrine disruptor												P(NR)(O)	Dec_2011	July 2009	NSPIRS 2011, Merck
98-87-3	α-Chlorinated toluenes (benzal chloride, benzo-trichloride, benzyl chloride) and benzoyl chloride (combined exposures)					IARC																Group 2A								Dec_2011	July 2009	
98-88-4	α-Chlorinated toluenes (benzal chloride, benzo-trichloride, benzyl chloride) and benzoyl chloride (combined exposures)					IARC																Group 2A								Dec_2011	July 2009	
98-95-3	Nitrobenzene					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated		P(NR)(O)	Dec_2011	July 2009	NSPIRS 2011
99-65-0	m-Dinitrobenzene								CA Prop 65											reproductive male										Dec_2011	July 2009	
99-76-3	Methyl p-Hydroxybenzoate						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec_2011	July 2009	
99-96-7	p-Hydroxybenzoic acid						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec_2011	July 2009	
99-99-0	4-Nitrotoluene						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec_2011	July 2009	
100-00-5	1-Chloro-4-nitrobenzene					CA Prop 65														cancer										Dec_2011	July 2009	
100-25-4	p-Dinitrobenzene								CA Prop 65											reproductive male										Dec_2011	July 2009	
100-40-3	4-Vinylcyclohexene					CA Prop 65														cancer										Dec_2011	July 2009	
100-41-4	Ethylbenzene					CA Prop 65														cancer										Dec_2011	July 2009	
100-42-5	Styrene						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec_2011	July 2009	
100-44-7	Benzyl chloride					CA Prop 65; IARC; IRIS														cancer		Group 2A			B2					Dec_2011	July 2009	
100-75-4	N-Nitrosopiperidine					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec_2011	July 2009	
101-14-4	4,4'-Methylene bis(2-chloroaniline)					CA Prop 65; IARC; NTP 11th ROC														cancer		Group 1					Reasonably anticipated			Dec_2011	July 2009	
101-20-2	urea, N-(4-chlorophenyl)-N'-(3,4-dichlorophenyl)-	OSPAR Chemicals of Concern															PBT												P(NR)(O)	Dec_2011	July 2009	NSPIRS 2011, TOXNET

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101-53-1	Phenyl-4-hydroxyphenylmethane = 4-Benzylphenol = p-Benzylphenol						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec 2011	July 2009	
101-55-3	4-Bromophenyl phenyl ether	NWM Priority Chemicals												PBT																Dec 2011	July 2009	
101-61-1	4,4'-Methylene bis(N,N-dimethyl)benzenamine					CA Prop 65; IRIS; NTP 11th ROC														cancer					B2		Reasonably anticipated			Dec 2011	July 2009	
101-76-8	benzene, 1,1'-methylenebis[4-chloro-	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
101-77-9	4,4'-Methylenedianiline				REACH Substances of Very High Concern	CA Prop 65; NTP 11th ROC														cancer						CMR (carcinogen)	Reasonably anticipated			Dec 2011	July 2009	
101-80-4	4,4'-Diaminodiphenyl ether (4,4'-Oxydianiline)					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec 2011	July 2009	
101-81-5	benzene, 1,1'-methylenebis-	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
101-90-6	Diglycidyl resorcinol ether (DGRE)					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec 2011	July 2009	
103-33-3	Azobenzene					CA Prop 65; IRIS														cancer					B2					Dec 2011	July 2009	
104-40-5	phenol, 4-nonyl-	OSPAR Chemicals of Concern					EU Endocrine Disruptor										PBT				Category 1 Endocrine Disruptor									Dec 2011	July 2009	
106-46-7	p-Dichlorobenzene					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated		P(A)(O)	Dec 2011	July 2009	NSPIRS 2011, TOXNET
106-47-8	p-Chloroaniline					CA Prop 65														cancer										Dec 2011	July 2009	
106-87-6	4-Vinyl-1-cyclohexene diepoxide (Vinyl cyclohexenedioxide)					CA Prop 65; NTP 11th ROC			CA Prop 65											cancer, reproductive female, male							Reasonably anticipated			Dec 2011	July 2009	
106-89-8	Epichlorohydrin					CA Prop 65; IARC; IRIS; NTP 11th	EU Endocrine Disruptor		CA Prop 65											cancer, reproductive male	Category 1 Endocrine Disruptor	Group 2A			B2		Reasonably anticipated		not a pesticide	Dec 2011	July 2009	NSPIRS 2011
106-93-4	1,2-Dibromoethane					CA Prop 65; IARC; IRIS; NTP 11th	EU Endocrine Disruptor	CA Prop 65	CA Prop 65											cancer, developmental, reproductive	Category 1 Endocrine Disruptor	Group 2A			Likely to be carcin		Reasonably anticipated		P(NR)(O)	Dec 2011	July 2009	NSPIRS 2011
106-94-5	1-Bromopropane							CA Prop 65; NTP CERHR	CA Prop 65; NTP CERHR											developmental, reproductive female, male								serious concern [developm		Dec 2011	July 2009	
106-97-8	butane (containing 0.1 % butadiene (203-450-8))					EU Carcinogen																	Category 1 carcinogen							Dec 2011	July 2009	
106-99-0	1,3-Butadiene					CA Prop 65; IARC; EU Carcinogen;		CA Prop 65	CA Prop 65											cancer, developmental, reproductive		Group 1	Category 1 carcinogen		Carcinogenic to		Known			Dec 2011	July 2009	
107-06-2	Ethylene dichloride (1,2-Dichloroethane)					CA Prop 65; IRIS; NTP 11th ROC														cancer					B2		Reasonably anticipated		P(NR)(O)	Dec 2011	July 2009	NSPIRS 2011, TOXNET
107-13-1	Acrylonitrile					CA Prop 65; IRIS; NTP 11th ROC														cancer					B1		Reasonably anticipated		P(NR)(O)	Dec 2011	July 2009	NSPIRS 2011
107-30-2	Chloromethyl methyl ether (technical grade)					CA Prop 65; IARC; EU Carcinogen;														cancer		Group 1	Category 1 carcinogen		A		Known			Dec 2011	July 2009	
107-51-7	Trisiloxane, octamethyl-			Canada PBiT List															PBiT											Dec 2011	July 2009	
108-46-3	Resorcinol						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec 2011	July 2009	
108-70-3	1,3,5-trichlorobenzene	OSPAR Chemicals of Concern; OSPAR Chemicals															PBT	PBT												Dec 2011	July 2009	
108-88-3	Toluene							CA Prop 65												developmental									P(NR)(O)	Dec 2011	July 2009	NSPIRS 2011, TOXNET
109-86-4	Ethylene glycol monomethyl ether							CA Prop 65	CA Prop 65											developmental, reproductive male									P(NR)(O)	Dec 2011	July 2009	NSPIRS 2011, TOXNET
110-00-9	Furan					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec 2011	July 2009	
110-49-6	Ethylene glycol monomethyl ether acetate							CA Prop 65	CA Prop 65											developmental, reproductive male										Dec 2011	July 2009	
110-80-5	Ethylene glycol monoethyl ether							CA Prop 65	CA Prop 65											developmental, reproductive male										Dec 2011	July 2009	
110-86-1	Pyridine					CA Prop 65														cancer									P(NR)(O)	Dec 2011	July 2009	NSPIRS 2011, TOXNET
111-15-9	Ethylene glycol monoethyl ether acetate							CA Prop 65	CA Prop 65											developmental, reproductive male										Dec 2011	July 2009	
111-44-4	Bis(2-chloroethyl)ether					CA Prop 65; IRIS														cancer					B2					Dec 2011	July 2009	
115-02-6	Azaserine					CA Prop 65														cancer										Dec 2011	July 2009	
115-27-5	4,7-methanoisobenzofuran-1,3-dione, 4,5,6,7,8,8-hexachloro-3a,4,7,7a-tetrahydro-	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
115-28-6	Chlorendic acid					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec 2011	July 2009	
115-39-9	Phenol, 4,4'-(3H-2,1-benzoxathiol- 3-ylidene)bis[2,6-dibromo-, S,S-dioxide			Canada PBiT List															PBiT											Dec 2011	July 2009	
115-40-2	Phenol, 4,4'-(3H-2,1-benzoxathiol- 3-ylidene)bis[2-bromo-6-methyl-, S,S-dioxide			Canada PBiT List															PBiT											Dec 2011	July 2009	
115-67-3	Paramethadione							CA Prop 65												developmental										Dec 2011	July 2009	
115-96-8	Tris(2-chloroethyl) phosphate					CA Prop 65														cancer										Dec 2011	July 2009	
116-14-3	Tetrafluoroethylene					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec 2011	July 2009	
116-66-5	1H-indene, 2,3-dihydro-1,1,3,3,5-pentamethyl-4,6-dinitro-	OSPAR Chemicals of Concern		Canada PBiT List													PBT		PBiT											Dec 2011	July 2009	
117-10-2	Dantron (Chrysazin; 1,8-Dihydroxyanthraquinone)					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec 2011	July 2009	
117-37-3	Anisindione							CA Prop 65												developmental										Dec 2011	July 2009	
117-79-3	2-Aminoanthraquinone					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec 2011	July 2009	
117-81-7	1,2-benzenedicarboxylic acid, bis(2-ethylhexyl) ester (DEHP) (DOP) (phthalate)	OSPAR Chemicals of Concern			REACH Substances of Very High Concern	CA Prop 65; IRIS; NTP 11th ROC	OSPAR Chemicals of Concern; EU	CA Prop 65	CA Prop 65; NTP CERHR								PBT, Endocrine disruptor			cancer, developmental, reproductive	Category 1 Endocrine Disruptor				B2	CMR (reproductive toxicant)	Reasonably anticipated	serious concern [critically		Dec 2011	July 2009	

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		TYPE OF TOXICITY									ORIGINATING LIST																					
CAS	Chemical of Concern Name	(Persistent Bioaccumulative and Toxic) PBT	(Very Persistent and Very Bioaccumulative) vPvB	(Persistent, Bioaccumulative and inherently Toxic) PBiT	(Carcinogenic, Mutagenic and Reproductive (Toxicants)) CMR	Carcinogen	Endocrine Disruptor	Developmental Toxicant	Reproductive Toxicant	Equivalent Level of Concern	EPA Final PBT Rule for TRI	TRI PBT Chemical List	EPA Priority PBT	NWM Priority Chemicals (PBTs)	WA PBT List	EU PBT List	OSPAR Chemicals of Concern	OSPAR Chemicals for Priority Action	Canada PBiT List	CA Prop 65	EU Endocrine Disruptor	IARC	EU Carcinogen	EU Reproductive Toxicant	IRIS	REACH Substances of Very High Concern	NTP 11th/13th ROC	NTP CERHR	Pesticide Notation	Source list last reviewed	Date Listed	Source
117-84-0	1,2-benzenedicarboxylic acid, dioctyl ester (DnOP) (phthalate)									OSPAR Chemicals of Concern							Equivalent level of concern													Dec 2011	July 2009	
118-74-1	Hexachlorobenzene	EPA Final PBT Rule for TRI; TRI PBT Chemical List;		Canada PBiT List		CA Prop 65; IRIS; NTP 11th ROC	OSPAR Chemicals of Concern; EU	CA Prop 65			PBT	PBT	PBT	PBT	PBT		PBT, Endocrine disruptor		PBiT	cancer, developmental	Category 1 Endocrine Disruptor				B2		Reasonably anticipated		P(NR)(O)	Dec 2011	July 2009	NSPIRS 2011, Toxnet
119-34-6	4-Amino-2-nitrophenol					CA Prop 65														cancer										Dec 2011	July 2009	
119-90-4	3,3'-Dimethoxybenzidine (o-Dianisidine)					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec 2011	July 2009	
119-93-7	3,3'-Dimethylbenzidine (ortho-Tolidine)					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec 2011	July 2009	
120-12-7	Anthracene	NWM Priority Chemicals; EU PBT List; OSPAR												PBT		Fulfilling PBT criteria	PBT									PBT				Dec 2011	July 2009	
120-47-8	ethyl 4-hydroxybenzoate						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec 2011	July 2009	
120-71-8	p-Cresidine					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec 2011	July 2009	
120-80-9	Catechol					CA Prop 65														cancer										Dec 2011	July 2009	
120-82-1	1,2,4-Trichlorobenzene	NWM Priority Chemicals; EU PBT List; OSPAR												PBT		Fulfilling PBT criteria	PBT	PBT											P(NR)(O)	Dec 2011	July 2009	NSPIRS 2011, TOXNET
120-95-6	phenol, 2,4-bis(1,1-dimethylpropyl)-	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
120-97-8	Dichlorphenamide							CA Prop 65												developmental										Dec 2011	July 2009	
121-14-2	benzene, 1-methyl-2,4-dinitro-	OSPAR Chemicals of Concern				CA Prop 65			CA Prop 65								PBT			cancer, reproductive male										Dec 2011	July 2009	
122-60-1	Phenyl glycidyl ether					CA Prop 65														cancer										Dec 2011	July 2009	
122-66-7	Hydrazobenzene (1,2-Diphenylhydrazine)					CA Prop 65; IRIS; NTP 11th ROC														cancer					B2		Reasonably anticipated			Dec 2011	July 2009	
123-91-1	1,4-Dioxane					CA Prop 65; IRIS; NTP 11th ROC														cancer					B2		Reasonably anticipated			Dec 2011	July 2009	
125-02-0	Prednisolone sodium phosphate							CA Prop 65												developmental										Dec 2011	July 2009	
125-31-5	Phenol, 4,4'-(3H-2,1-benzoxathiol- 3-ylidene)bis[2,5-dimethyl-, S,S-dioxide			Canada PBiT List															PBiT											Dec 2011	July 2009	
125-33-7	Primidone					CA Prop 65														cancer										Dec 2011	July 2009	
125-84-8	Aminoglutethimide							CA Prop 65												developmental										Dec 2011	July 2009	
126-07-8	Griseofulvin					CA Prop 65														cancer										Dec 2011	July 2009	
126-72-7	Tris(2,3-dibromopropyl)phosphate					CA Prop 65; IARC; NTP 11th ROC														cancer		Group 2A					Reasonably anticipated			Dec 2011	July 2009	
126-99-8	Chloroprene					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec 2011	July 2009	
127-18-4	Tetrachloroethylene (Perchloroethylene)					CA Prop 65; IARC; NTP 11th ROC														cancer		Group 2A					Reasonably anticipated		P(NR)(O)	Dec 2011	July 2009	NSPIRS 2011, TOXNET
128-03-0	Potassium dimethyldithiocarbamate							CA Prop 65												developmental										Dec 2011	July 2009	
128-04-1	Sodium dimethyldithiocarbamate							CA Prop 65												developmental									P(A)(O)	Dec 2011	July 2009	NSPIRS 2011, TOXNET
128-63-2	pyrene, 1,3,6,8-tetrabromo-	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
128-69-8	perylo[3,4-cd:9,10-c'd']dipyran-1,3,8,10-tetrone	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
128-83-6	9,10-anthracenedione, 1-amino-2-bromo-4-[(4-methylphenyl)amino]-	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
129-00-0	Pyrene	NWM Priority Chemicals; OSPAR Chemicals of												PBT			PBT													Dec 2011	July 2009	
129-15-7	2-Methyl-1-nitroanthraquinone (of uncertain purity)					CA Prop 65														cancer										Dec 2011	July 2009	
129-43-1	1-Hydroxyanthraquinone					CA Prop 65														cancer										Dec 2011	July 2009	
129-73-7	benzenamine, 4,4'-(phenylmethylene)bis[N,N-dimethyl-	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
131-18-0	Di-n-pentylphthalate (DPP) = Dipentylphthalate						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec 2011	July 2009	
131-55-5	Benzophenone-2 (Bp-2), 2,2',4,4'-tetrahydroxybenzophenone						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec 2011	July 2009	
131-56-6	2,4-Dihydroxybenzophenon = Resbenzophenone						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec 2011	July 2009	
131-70-4	Mono-n-butylphthalate (MPB) (MBuP)						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec 2011	July 2009	
132-27-4	*o* -Phenylphenate, sodium					CA Prop 65														cancer									P(A)(O)	Dec 2011	July 2009	NSPIRS 2011, TOXNET
132-61-6	9H-Carbazole-3-carboxamide, N-(4-chlorophenyl)-2-hydroxy-			Canada PBiT List															PBiT											Dec 2011	July 2009	
132-64-9	Dibenzofuran	NWM Priority Chemicals												PBT																Dec 2011	July 2009	
132-65-0	dibenzothiophene	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
133-49-3	Pentachlorobenzenethiol	EU PBT List; OSPAR Chemicals of Concern	EU PBT List	Canada PBiT List												Fulfilling PBT & vPvB criter	PBT		PBiT											Dec 2011	July 2009	
134-29-2	o-Anisidine hydrochloride					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec 2011	July 2009	
134-32-7	1-Naphthylamine					CA Prop 65														cancer										Dec 2011	July 2009	
135-20-6	Cupferron					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec 2011	July 2009	

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135-63-7	2-Naphthalenecarboxamide, N-(5-chloro-2-methylphenyl)-3-hydroxy-			Canada PBiT List															PBiT											Dec_2011	July 2009	
135-91-1	benzenamine, 4,4'-methylenebis[N,N-diethyl-	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
136-35-6	Diazoaminobenzene					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec_2011	July 2009	
136-40-3	Phenazopyridine hydrochloride					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec_2011	July 2009	
139-13-9	Nitrilotriacetic acid					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec_2011	July 2009	
139-60-6	1,4-benzenediamine, N,N'-bis(1-ethyl-3-methylpentyl)-	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
139-65-1	4,4'-Thiodianiline					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec_2011	July 2009	
139-91-3	5-(Morpholinomethyl)-3-[(5-nitrofurfurylidene)-amino]-2-oxazolidinone					CA Prop 65														cancer										Dec_2011	July 2009	
140-66-9	octylphenol	OSPAR Chemicals of Concern; OSPAR Chemicals					EU Endocrine Disruptor										PBT	PBT			Category 1 Endocrine Disruptor									Dec_2011	July 2009	
140-67-0	Estragole					CA Prop 65														cancer									P(NR)(O)	Dec_2011	July 2009	NSPIRS 2011, TOXNET
140-88-5	Ethyl acrylate					CA Prop 65														cancer										Dec_2011	July 2009	
142-04-1	Aniline hydrochloride					CA Prop 65														cancer										Dec_2011	July 2009	
145-39-1	Benzene, 1-(1,1-dimethylethyl)-3,4,5-trimethyl-2,6-dinitro-			Canada PBiT List															PBiT											Dec_2011	July 2009	
146-56-5	1-Piperazineethanol, 4-[3-[2-(trifluoromethyl)-10H-phenothiazin-10-yl]propyl]-, dihydrochloride	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
151-56-4	Ethyleneimine					CA Prop 65														cancer										Dec_2011	July 2009	
153-78-6	2-Aminofluorene					CA Prop 65														cancer										Dec_2011	July 2009	
156-10-5	p-Nitrosodiphenylamine					CA Prop 65														cancer										Dec_2011	July 2009	
189-55-9	Benzo(r,s,t)pentaphene	EPA Final PBT Rule for TRI; WA PBT List; OSPAR				CA Prop 65; NTP 11th ROC					PBT				PBT		PBT			cancer							Reasonably anticipated			Dec_2011	July 2009	
189-64-0	Dibenzo(a,h)pyrene	EPA Final PBT Rule for TRI; OSPAR Chemicals				CA Prop 65; NTP 11th ROC					PBT						PBT			cancer							Reasonably anticipated			Dec_2011	July 2009	
189-64-4	Dibenzo(a,h)pyrene [Polycyclic aromatic hydrocarbons (PAHs)]	WA PBT List													PBT															Dec_2011	July 2009	
191-07-1	coronene	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
191-24-2	Benzo(g,h,i)perylene	EPA Final PBT Rule for TRI; TRI PBT Chemical List;									PBT	PBT		PBT	PBT		PBT													Dec_2011	July 2009	
191-26-4	dibenzo[def,mno]chrysene	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
191-30-0	Dibenzo(a,i)pyrene	EPA Final PBT Rule for TRI; OSPAR Chemicals				CA Prop 65; IARC; NTP 11th ROC					PBT						PBT			cancer		Group 2A					Reasonably anticipated			Dec_2011	July 2009	
192-65-4	Dibenzo(a,e)pyrene	EPA Final PBT Rule for TRI; WA PBT List; OSPAR				CA Prop 65; NTP 11th ROC					PBT				PBT		PBT			cancer							Reasonably anticipated			Dec_2011	July 2009	
192-97-2	benzo[e]pyrene	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
193-39-5	Indeno(1,2,3-cd)pyrene	EPA Final PBT Rule for TRI; WA PBT List				CA Prop 65; IRIS; NTP 11th ROC					PBT				PBT					cancer					B2		Reasonably anticipated			Dec_2011	July 2009	
194-59-2	7H-Dibenzo(c,g)carbazole	EPA Final PBT Rule for TRI; WA PBT List				CA Prop 65; NTP 11th ROC					PBT				PBT					cancer							Reasonably anticipated			Dec_2011	July 2009	
195-19-7	benzo[c]phenanthrene	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
198-55-0	Perylene [Polycyclic aromatic hydrocarbons (PAHs)]	WA PBT List; OSPAR Chemicals of Concern													PBT		PBT													Dec_2011	July 2009	
205-82-3	Benzo(j)fluoranthene	EPA Final PBT Rule for TRI; WA PBT List				CA Prop 65; NTP 11th ROC					PBT				PBT					cancer							Reasonably anticipated			Dec_2011	July 2009	
205-99-2	Benzo(b)fluoranthene	EPA Final PBT Rule for TRI; WA PBT List				CA Prop 65; IRIS; NTP 11th ROC					PBT				PBT					cancer					B2		Reasonably anticipated			Dec_2011	July 2009	
206-44-0	Benzo(j,k)fluorene (fluoranthene)	EPA Final PBT Rule for TRI; WA PBT List; OSPAR									PBT				PBT		PBT													Dec_2011	July 2009	
207-08-9	Benzo(k)fluoranthene	EPA Final PBT Rule for TRI; WA PBT List; OSPAR				CA Prop 65; IRIS; NTP 11th ROC					PBT				PBT		PBT			cancer					B2		Reasonably anticipated			Dec_2011	July 2009	
208-96-8	Acenaphthylene	NWM Priority Chemicals												PBT																Dec_2011	July 2009	
215-58-7	benzo[b]triphenylene	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
217-59-4	triphenylene	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
218-01-9	Benzo(a)phenanthrene	EPA Final PBT Rule for TRI; WA PBT List; OSPAR				CA Prop 65; IRIS					PBT				PBT		PBT			cancer					B2					Dec_2011	July 2009	
224-41-9	dibenz[a,j]anthracene	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
224-42-0	Dibenz(a,j)acridine	EPA Final PBT Rule for TRI; WA PBT List				CA Prop 65; NTP 11th ROC					PBT				PBT					cancer							Reasonably anticipated			Dec_2011	July 2009	
226-36-8	Dibenz(a,h)acridine	EPA Final PBT Rule for TRI; WA PBT List				CA Prop 65; NTP 11th ROC					PBT				PBT					cancer							Reasonably anticipated			Dec_2011	July 2009	
271-89-6	Benzofuran					CA Prop 65														cancer										Dec_2011	July 2009	
294-62-2	Cyclododecane	EU PBT List; OSPAR Chemicals of Concern;														Fulfilling PBT crit eria	PBT	PBT								PBT				Dec_2011	July 2009	
297-78-9	4,7-methanoisobenzofuran, 1,3,4,5,6,7,8,8-octachloro-1,3,3a,4,7,7a-hexahydro-	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
298-81-7	8-Methoxypsoralen with ultraviolet A therapy					CA Prop 65; IARC; NTP 11th ROC														cancer		Group 1					Known			Dec_2011	July 2009	

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299-75-2	Treosulfan					CA Prop 65; IARC														cancer		Group 1								Dec_2011	July 2009	
301-04-2	Lead acetate					CA Prop 65			EU Reproductive Toxicant											cancer				Category 1 Reproductive Toxicant						Dec_2011	July 2009	
302-01-2	Hydrazine					CA Prop 65; IRIS; NTP 11th ROC														cancer					B2		Reasonably anticipated			Dec_2011	July 2009	
303-34-4	Lasiocarpine					CA Prop 65														cancer										Dec_2011	July 2009	
303-47-9	Ochratoxin A					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec_2011	July 2009	
315-22-0	Monocrotaline					CA Prop 65														cancer										Dec_2011	July 2009	
319-84-6	alpha-Hexachlorocyclohexane (alpha-HCH)					IRIS																			B2					Dec_2011	July 2009	
319-85-7	beta-HCH						OSPAR Chemicals of Concern; EU										Endocrine disruptor				Category 1 Endocrine Disruptor									Dec_2011	July 2009	
327-98-0	phosphonothioic acid, ethyl-, O-ethyl O-(2,4,5-trichlorophenyl) ester	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
331-39-5	Caffeic acid					CA Prop 65														cancer										Dec_2011	July 2009	
335-57-9	heptane, hexadecafluoro-	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
355-42-0	hexane, tetradecafluoro-	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
355-43-1	hexane, 1,1,1,2,2,3,3,4,4,5,5,6,6-tridecafluoro-6-iodo-	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
373-02-4	Nickel acetate					CA Prop 65														cancer										Dec_2011	July 2009	
375-72-4	1-butanesulfonyl fluoride, 1,1,2,2,3,3,4,4,4-nonafluoro-	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
423-50-7	1-hexanesulfonyl fluoride, 1,1,2,2,3,3,4,4,5,5,6,6,6-tridecafluoro-	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
427-45-2	stannane, fluorotris-p-chlorophenyl-	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
440-17-5	10H-phenothiazine, 10-[3-(4-methyl-1-piperazinyl)propyl]-2-(trifluoromethyl)-, dihydrochloride	OSPAR Chemicals of Concern		Canada PBiT List													PBT		PBiT											Dec_2011	July 2009	
443-48-1	Metronidazole					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated		P(NR)(O)	Dec_2011	July 2009	NSPIRS 2011
465-73-6	Isodrin	EPA Final PBT Rule for TRI; TRI PBT Chemical List;									PBT	PBT					PBT	PBT												Dec_2011	July 2009	
475-26-3	benzene, 1,1'-(2,2,2-trichloroethylidene)bis[4-fluoro-	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
475-71-8	Benzo[h]benz[5,6]acridino[2,1,9,8-klmna]acridine-8,16-dione			Canada PBiT List															PBiT											Dec_2011	July 2009	
492-80-8	Auramine					CA Prop 65														cancer									P(NR)(O)	Dec_2011	July 2009	NSPIRS 2011
494-03-1	2-naphthalenamine, N,N-bis(2-chloroethyl)-	OSPAR Chemicals of Concern				CA Prop 65; IARC											PBT			cancer		Group 1								Dec_2011	July 2009	
497-39-2	phenol, 2,4-bis(1,1-dimethylethyl)-5-methyl-	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
509-14-8	Tetranitromethane					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec_2011	July 2009	
509-34-2	Spiro[isobenzofuran-1(3H),9'-[9H]xanthen]-3-one, 3',6'-bis(diethylamino)-			Canada PBiT List															PBiT											Dec_2011	July 2009	
512-04-9	diosgenin	OSPAR Chemicals of Concern; OSPAR Chemicals															PBT	PBT												Dec_2011	July 2009	
512-56-1	Trimethyl phosphate					CA Prop 65														cancer										Dec_2011	July 2009	
513-37-1	Dimethylvinylchloride					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec_2011	July 2009	
515-03-7	1-Naphthalenepropanol, α-ethenyldecahydro- 2-hydroxy-α,2,5,5,8a-pentamethyl-, [1R-[1α(R),2ß,4aß,8aα]]-			Canada PBiT List															PBiT											Dec_2011	July 2009	
527-20-8	benzenamine, 2,3,4,5,6-pentachloro-	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
528-29-0	o-Dinitrobenzene								CA Prop 65											reproductive male										Dec_2011	July 2009	
531-82-8	N-[4-(5-Nitro-2-furyl)-2-thiazolyl]acetamide					CA Prop 65														cancer										Dec_2011	July 2009	
531-85-1	benzidine dihydrochloride					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
540-73-8	1,2-Dimethylhydrazine					CA Prop 65; IARC														cancer		Group 2A								Dec_2011	July 2009	
540-97-6	Cyclohexasiloxane, dodecamethyl-			Canada PBiT List															PBiT											Dec_2011	July 2009	
541-02-6	Cyclopentasiloxane, decamethyl-			Canada PBiT List															PBiT											Dec_2011	July 2009	
542-56-3	Isobutyl nitrite					CA Prop 65														cancer										Dec_2011	July 2009	
542-88-1	Bis(chloromethyl)ether					CA Prop 65; IARC; EU Carcinogen;														cancer		Group 1	Category 1 carcinogen		A		Known			Dec_2011	July 2009	
546-88-3	Acetohydroxamic acid							CA Prop 65												developmental										Dec_2011	July 2009	
554-13-2	Lithium carbonate							CA Prop 65												developmental										Dec_2011	July 2009	
555-84-0	1-[(5-Nitrofurfurylidene)-amino]-2-imidazolidinone					CA Prop 65														cancer										Dec_2011	July 2009	
556-52-5	Glycidol					CA Prop 65; IARC; NTP 11th ROC														cancer		Group 2A					Reasonably anticipated			Dec_2011	July 2009	
556-67-2	Cyclotetrasiloxane, octamethyl-			Canada PBiT List			EU Endocrine Disruptor												PBiT		Category 1 Endocrine Disruptor									Dec_2011	July 2009	

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559-11-5	2-propenoic acid, 2,2,3,3,4,4,5,5,6,6,7,	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
563-47-3	3-Chloro-2-methylpropene					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec 2011	July 2009	
569-57-3	Chlorotrianisene					CA Prop 65														cancer										Dec 2011	July 2009	
569-61-9	C.I. Basic Red 9 monohydrochloride					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec 2011	July 2009	
576-53-8	1,2,3,6,7,8 Hexachlorodibenzop-dioxin [Polychlorinated dibenzo-pdioxins]	WA PBT List													PBT															Dec 2011	July 2009	
592-62-1	Methylazoxymethanol acetate					CA Prop 65														cancer										Dec 2011	July 2009	
593-60-2	Vinyl bromide					CA Prop 65; IARC; NTP 11th ROC														cancer		Group 2A					Reasonably anticipated			Dec 2011	July 2009	
598-55-0	Methyl carbamate					CA Prop 65														cancer									not a pesticide	Dec 2011	July 2009	NSPIRS 2011
599-79-1	Sulfasalazine (salicylazosulfapyridine)					CA Prop 65			CA Prop 65											cancer, reproductive male										Dec 2011	July 2009	
602-87-9	5-Nitroacenaphthene					CA Prop 65														cancer										Dec 2011	July 2009	
603-33-8	Bismuthine, triphenyl-			Canada PBiT List															PBiT											Dec 2011	July 2009	
603-48-5	Benzenamine, 4,4',4"-methylidynetris[N,N-dimethyl-			Canada PBiT List															PBiT											Dec 2011	July 2009	
606-20-2	2,6-Dinitrotoluene					CA Prop 65			CA Prop 65											cancer, reproductive male										Dec 2011	July 2009	
607-57-8	2-Nitrofluorene					CA Prop 65														cancer										Dec 2011	July 2009	
608-71-9	phenol, pentabromo-	OSPAR Chemicals of Concern		Canada PBiT List													PBT		PBiT											Dec 2011	July 2009	
608-73-1	cyclohexane, 1,2,3,4,5,6-hexachloro-	OSPAR Chemicals of Concern				IRIS	EU Endocrine Disruptor										PBT				Category 1 Endocrine Disruptor				B2					Dec 2011	July 2009	
608-93-5	Pentachlorobenzene	EPA Final PBT Rule for TRI; TRI PBT Chemical List;		Canada PBiT List			EU Endocrine Disruptor				PBT	PBT		PBT	PBT		PBT		PBiT		Category 1 Endocrine Disruptor									Dec 2011	July 2009	
611-99-4	4,4'-Dihydroxybenzophenon						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec 2011	July 2009	
612-82-8	3,3'-Dimethylbenzidine dihydrochloride					CA Prop 65														cancer										Dec 2011	July 2009	
612-83-9	3,3'-Dichlorobenzidine dihydrochloride					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec 2011	July 2009	
613-35-4	N,N'-Diacetylbenzidine					CA Prop 65														cancer										Dec 2011	July 2009	
615-05-4	2,4-Diaminoanisole					CA Prop 65														cancer										Dec 2011	July 2009	
615-53-2	N-Nitroso-N-methylurethane					CA Prop 65														cancer										Dec 2011	July 2009	
621-64-7	N-Nitrosodi-n-propylamine					CA Prop 65; IRIS; NTP 11th ROC														cancer					B2		Reasonably anticipated			Dec 2011	July 2009	
626-39-1	Benzene, 1,3,5-tribromo-			Canada PBiT List															PBiT											Dec 2011	July 2009	
630-08-0	Carbon monoxide							CA Prop 65	EU Reproductive Toxicant											developmental				Category 1 Reproductive Toxicant						Dec 2011	July 2009	
630-56-8	pregn-4-ene-3,20-dione, 17-[(1-oxohexyl)oxy]-	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
631-64-1	Dibromoacetic acid					CA Prop 65														cancer										Dec 2011	July 2009	
632-79-1	1,3-isobenzofurandione, 4,5,6,7-tetrabromo-	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
634-66-2	benzene, 1,2,3,4-tetrachloro-	OSPAR Chemicals of Concern		Canada PBiT List													PBT		PBiT											Dec 2011	July 2009	
634-90-2	benzene, 1,2,3,5-tetrachloro-	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
636-21-5	o-Toluidine hydrochloride					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec 2011	July 2009	
647-42-7	1-Octanol, 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluoro-			Canada PBiT List															PBiT											Dec 2011	July 2009	
668-34-8	stannylium, triphenyl-	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
678-39-7	1-Decanol, 3,3,4,4,5,5,6,6,7,7,8,8,9, 9,10,10,10-heptadecafluoro-			Canada PBiT List															PBiT											Dec 2011	July 2009	
680-31-9	Hexamethylphosphoramide					CA Prop 65; NTP 11th ROC			CA Prop 65											cancer, reproductive male							Reasonably anticipated			Dec 2011	July 2009	
684-16-2	Hexafluoroacetone								CA Prop 65											reproductive male										Dec 2011	July 2009	
684-93-5	N-Nitroso-N-methylurea					CA Prop 65; IARC; NTP 11th ROC														cancer		Group 2A					Reasonably anticipated			Dec 2011	July 2009	
688-73-3	Stannane, tributyl-			Canada PBiT List			EU Endocrine Disruptor												PBiT		Category 1 Endocrine Disruptor									Dec 2011	July 2009	
712-68-5	2-Amino-5-(5-nitro-2-furyl)-1,3,4-thiadiazole					CA Prop 65														cancer										Dec 2011	July 2009	
732-26-3	2,4,6-tri-tert-butylphenol	OSPAR Chemicals of Concern; OSPAR Chemicals		Canada PBiT List													PBT	PBT	PBiT											Dec 2011	July 2009	
759-73-9	N-Nitroso-N-ethylurea					CA Prop 65; IARC; NTP 11th ROC														cancer		Group 2A					Reasonably anticipated			Dec 2011	July 2009	
764-41-0	1,4-Dichloro-2-butene					CA Prop 65														cancer										Dec 2011	July 2009	
765-34-4	Glycidaldehyde					CA Prop 65; IRIS														cancer					B2					Dec 2011	July 2009	
789-02-6	benzene, 1-chloro-2-[2,2,2-trichloro-1-(4-chlorophenyl)ethyl]-	OSPAR Chemicals of Concern					EU Endocrine Disruptor	CA Prop 65	CA Prop 65								PBT			developmental, reproductive female, male	Category 1 Endocrine Disruptor									Dec 2011	July 2009	

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CAS	Chemical of Concern Name	TYPE OF TOXICITY									ORIGINATING LIST																		Pesticide Notation	Source list last reviewed	Date Listed	Source
		PBT (Persistent Bioaccumulative and Toxic)	vPvB (Very Persistent and Very Bioaccumulative)	PBiT (Persistent, Bioaccumulative and inherently Toxic)	CMR (Carcinogenic, Mutagenic and Reproductive (Toxicants))	Carcinogen	Endocrine Disruptor	Developmental Toxicant	Reproductive Toxicant	Equivalent Level of Concern	EPA Final PBT Rule for TRI	TRI PBT Chemical List	EPA Priority PBT	NWM Priority Chemicals (PBTs)	WA PBT List	EU PBT List	OSPAR Chemicals of Concern	OSPAR Chemicals for Priority Action	Canada PBiT List	CA Prop 65	EU Endocrine Disruptor	IARC	EU Carcinogen	EU Reproductive Toxicant	IRIS	REACH Substances of Very High Concern	NTP 11th/13th ROC	NTP CERHR				
793-24-8	4-(dimethylbutylamino)diphenylamin	OSPAR Chemicals of Concern; OSPAR Chemicals															PBT	PBT												Dec_2011	July 2009	
794-93-4	Panfuran S					CA Prop 65														cancer										Dec_2011	July 2009	
817-09-4	Trichlormethine (Trimustine hydrochloride)					CA Prop 65														cancer										Dec_2011	July 2009	
838-88-0	4,4'-Methylene bis(2-methylaniline)					CA Prop 65														cancer										Dec_2011	July 2009	
842-07-9	C.I. Solvent Yellow 14					CA Prop 65														cancer										Dec_2011	July 2009	
872-50-4	N-Methylpyrrolidone							CA Prop 65												developmental										Dec_2011	July 2009	
924-16-3	N-Nitrosodi-n-butylamine					CA Prop 65; IRIS; NTP 11th ROC														cancer					B2		Reasonably anticipated			Dec_2011	July 2009	
924-42-5	N-Methylolacrylamide					CA Prop 65														cancer										Dec_2011	July 2009	
930-55-2	N-Nitrosopyrrolidine					CA Prop 65; IRIS; NTP 11th ROC														cancer					B2		Reasonably anticipated			Dec_2011	July 2009	
944-61-6	Benzene, 1,2,3,4-tetrachloro-5,6-dimethoxy-			Canada PBiT List															PBiT											Dec_2011	July 2009	
1000-05-1	Tetrasiloxane, 1,1,3,3,5,5,7,7-octamethyl-			Canada PBiT List															PBiT											Dec_2011	July 2009	
1022-22-6	p,p'-DDMU						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec_2011	July 2009	
1068-27-5	Peroxide, (1,1,4,4-tetramethyl-2-butyne- 1,4-diyl)bis[(1,1-dimethylethyl)			Canada PBiT List															PBiT											Dec_2011	July 2009	
1116-54-7	N-Nitrosodiethanolamine					CA Prop 65; IRIS; NTP 11th ROC														cancer					B2		Reasonably anticipated			Dec_2011	July 2009	
1120-71-4	1,3-Propane sultone					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec_2011	July 2009	
1131-60-8	4-Cyclohexylphenol						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec_2011	July 2009	
1138-52-9	phenol, 3,5-bis(1,1-dimethylethyl)-	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
1154-59-2	Benzamide, 3,5-dichloro-N-(3,4-dichlorophenyl)-2-hydroxy-			Canada PBiT List															PBiT											Dec_2011	July 2009	
1163-19-5	Decabromodiphenyl ether [Polybrominated diphenyl ethers]	WA PBT List; OSPAR Chemicals of Concern													PBT		PBT													Dec_2011	July 2009	
1176-74-5	Benzoic acid, 2-[(3,5-dibromo-4-hydroxyphenyl)(3,5-dibromo-4-oxo-2,5-cyclohexadien-1-ylidene)methyl]-, ethyl ester			Canada PBiT List															PBiT											Dec_2011	July 2009	
1229-55-6	2-Naphthalenol, 1-[(2-methoxyphenyl)azo]-			Canada PBiT List															PBiT											Dec_2011	July 2009	
1241-94-7	phosphoric acid, 2-ethylhexyl diphenyl ester	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
1257-78-9	1,2-Ethanedisulfonic acid, compd. with 2-chloro-10-[3-(4-methyl-1-piperazinyl)propyl]-10H-phenothiazine (1:1)	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
1271-28-9	Nickelocene					CA Prop 65														cancer										Dec_2011	July 2009	
1303-00-0	Gallium arsenide					CA Prop 65; IARC														cancer		Group 1								Dec_2011	July 2009	
1303-28-2	arsenic oxide, arsenic pentoxide, diarsenic pentaoxide				REACH Substances of Very High Concern	EU Carcinogen																	Category 1 carcinogen			CMR (carcinogen)			P(A)(O)	Dec_2011	July 2009	TOXNET 2011
1307-96-6	Cobalt [II] oxide					CA Prop 65														cancer										Dec_2011	July 2009	
1309-64-4	Antimony oxide (Antimony trioxide)					CA Prop 65														cancer										Dec_2011	July 2009	
1313-99-1	Nickel oxide					CA Prop 65; EU Carcinogen														cancer			Category 1 carcinogen							Dec_2011	July 2009	
1314-06-3	dinickel trioxide					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
1314-20-1	Thorium dioxide					CA Prop 65; NTP 11th ROC														cancer							Known			Dec_2011	July 2009	
1314-62-1	Vanadium pentoxide (orthorhombic crystalline form)					CA Prop 65														cancer										Dec_2011	July 2009	
1321-64-8	Pentachloronaphthalene [Polychlorinated naphthalenes]	WA PBT List; OSPAR Chemicals of Concern													PBT		PBT													Dec_2011	July 2009	
1321-65-9	Trichloronaphthalene [Polychlorinated naphthalenes]	WA PBT List; OSPAR Chemicals of Concern													PBT		PBT													Dec_2011	July 2009	
1325-85-5	1-Naphthalenemethanol, α,α-bis[4-(dimethylamino) phenyl]-4-(methylphenylamino)-			Canada PBiT List															PBiT											Dec_2011	July 2009	
1325-86-6	1-Naphthalenemethanol, α,α-bis[4-(diethylamino) phenyl]-4-(ethylamino)-			Canada PBiT List															PBiT											Dec_2011	July 2009	
1326-05-2	Spiro[isobenzofuran-1(3H),9'-[9H]xanthen]-3-one, 2',4',5',7'-tetrabromo-3',6'-dihydroxy-, lead salt			Canada PBiT List															PBiT											Dec_2011	July 2009	
1326-49-4	C.I. Sulphur Orange 1			Canada PBiT List															PBiT											Dec_2011	July 2009	
1327-53-3	arsenic trioxide, diarsenic trioxide				REACH Substances of Very High Concern	EU Carcinogen																	Category 1 carcinogen			CMR (carcinogen)			P(NR)(O)	Dec_2011	July 2009	NSPIRS 2011, TOXNET
1332-21-4	Asbestos (amphibole forms)					CA Prop 65; IARC; IRIS; NTP 11th														cancer		Group 1			A		Known		not a pesticide	Dec_2011	July 2009	NSPIRS 2011; Merck
1333-82-0	chromium (VI) trioxide					EU Carcinogen																	Category 1 carcinogen						P(A)(O)	Dec_2011	July 2009	NSPIRS 2011, TOXNET
1333-86-4	Carbon black (airborne, unbound particles of respirable size)					CA Prop 65														cancer										Dec_2011	July 2009	
1335-32-6	Lead subacetate					CA Prop 65			EU Reproductive Toxicant											cancer				Category 1 Reproductive Toxicant						Dec_2011	July 2009	
1335-87-1	Hexachloronaphthalene [Polychlorinated naphthalenes]	WA PBT List; OSPAR Chemicals of Concern													PBT		PBT													Dec_2011	July 2009	
1335-88-2	Tetrachloronaphthalene [Polychlorinated naphthalenes]	WA PBT List; OSPAR Chemicals of Concern													PBT		PBT													Dec_2011	July 2009	

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CAS	Chemical of Concern Name	TYPE OF TOXICITY (Persistent Bioaccumulative and Toxic) PBT	(Very Persistent and Very Bioaccumulative) vPvB	(Persistent, Bioaccumulative and inherently Toxic) PBiT	(Carcinogenic, Mutagenic and Reproductive (Toxicants)) CMR	Carcinogen	Endocrine Disruptor	Developmental Toxicant	Reproductive Toxicant	Equivalent Level of Concern	ORIGINATING LIST EPA Final PBT Rule for TRI	TRI PBT Chemical List	EPA Priority PBT	NWM Priority Chemicals (PBTs)	WA PBT List	EU PBT List	OSPAR Chemicals of Concern	OSPAR Chemicals for Priority Action	Canada PBiT List	CA Prop 65	EU Endocrine Disruptor	IARC	EU Carcinogen	EU Reproductive Toxicant	IRIS	REACH Substances of Very High Concern	NTP 11th/13th ROC	NTP CERHR	Pesticide Notation	Source list last reviewed	Date Listed	Source
1336-36-3	Polychlorinated Biphenyls (PCBs)	EPA Final PBT Rule for TRI; TRI PBT Chemical List;		Canada PBiT List		IARC; IRIS; NTP 11th ROC	EU Endocrine Disruptor				PBT	PBT	PBT	PBT			PBT		PBiT		Category 1 Endocrine Disruptor	Group 2A			B2		Reasonably anticipated			Dec_2011	July 2009	
1344-37-2	C.I. Pigment Yellow 34 [This substance is identified in the Colour Index by Colour Index Constitution Number, C.I. 77603.], Lead								EU Reproductive Toxicant															Category 1 Reproductive Toxicant						Dec_2011	July 2009	
1402-68-2	Aflatoxins (naturally occurring mixtures of)					CA Prop 65; IARC; NTP 11th ROC														cancer		Group 1					Known			Dec_2011	July 2009	
1460-02-2	benzene, 1,3,5-tris(1,1-dimethylethyl)-	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
1461-25-2	Tetrabutyltin (TTBT)						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec_2011	July 2009	
1464-53-5	Diepoxybutane					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec_2011	July 2009	
1594-08-7	9,10-Anthracenedione, 1-hydroxy-4-[[4-[(methylsulfonyl) oxy]phenyl]amino]-			Canada PBiT List															PBiT											Dec_2011	July 2009	
1606-67-3	1-pyrenamine	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
1615-80-1	1,2-Diethylhydrazine					CA Prop 65														cancer										Dec_2011	July 2009	
1634-04-4	methyl tertiary butyl ether (MTBE)						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec_2011	July 2009	
1652-63-7	1-Propanaminium, 3-[[(heptadecafluorooctyl) sulfonyl]amino]-N,N,N-trimethyl-, iodide			Canada PBiT List															PBiT											Dec_2011	July 2009	
1689-83-4	Ioxynil						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec_2011	July 2009	
1691-99-2	1-octanesulfonamide, N-ethyl-1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro-N-(2-hydroxyethyl)-	OSPAR Chemicals of Concern		Canada PBiT List													PBT		PBiT											Dec_2011	July 2009	
1694-09-3	Benzyl violet 4B					CA Prop 65														cancer										Dec_2011	July 2009	
1705-85-7	chrysene, 6-methyl-	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
1715-40-8	bromocylene	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
1746-01-6	2,3,7,8-Tetrachlorodibenzo-p-dioxin	EPA Final PBT Rule for TRI; NWM Priority Chemicals;				CA Prop 65; IARC; NTP 11th ROC	EU Endocrine Disruptor	CA Prop 65			PBT			PBT	PBT		PBT			cancer, developmental	Category 1 Endocrine Disruptor	Group 1					Known			Dec_2011	July 2009	
1763-23-1*	Perfluorooctane sulfonic acid (PFOS) and its salts	WA PBT List													PBT															Dec_2011	July 2009	
1806-26-4	Phenol, 4-octyl-						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec_2011	July 2009	
1825-21-4	pentachloroanisole	OSPAR Chemicals of Concern; OSPAR Chemicals															PBT	PBT												Dec_2011	July 2009	
1836-77-7	benzene, 1,3,5-trichloro-2-(4-nitrophenoxy)-	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
1871-22-3	2H-Tetrazolium, 3,3'-(3,3'-dimethoxy[1,1'-biphenyl]-4,4'-diyl)bis[2,5-diphenyl-, dichloride			Canada PBiT List															PBiT											Dec_2011	July 2009	
1897-45-6	Chlorothalonil					CA Prop 65														cancer									P(A)(O)	Dec_2011	July 2009	NSPIRS 2011
1937-37-7	2,7-Naphthalenedisulfonic acid, 4-amino-3-[[4-[(2,4-diaminophenyl) azo][1,1'-biphenyl]-4-yl]azo]-5-hydroxy -6-(phenylazo)-, disodium salt			Canada PBiT List		CA Prop 65													PBiT	cancer										Dec_2011	July 2009	
1940-43-8	phenol, 2,2'-methylenebis[4,6-dichloro-	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
1949-07-1	dicroden	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
2051-24-3	1,1'-biphenyl, 2,2',3,3',4,4',5,5',6,6'-decachloro-	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
2058-46-0	Oxytetracycline hydrochloride (internal use)							CA Prop 65												developmental										Dec_2011	July 2009	
2092-56-0	D&C Red No. 8					CA Prop 65														cancer										Dec_2011	July 2009	
2104-96-3	phosphorothioic acid, O-(4-bromo-2,5-dichlorophenyl) O,O-dimethyl ester	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
2134-15-8	Benzoic acid, 2,3,4,5-tetrachloro-6-(2, 4,5,7-tetrabromo-6-hydroxy-3-oxo-3H-xanthen-9-yl) -			Canada PBiT List															PBiT											Dec_2011	July 2009	
2155-70-6	Stannane, tributyl[(2-methyl-1-oxo-2-propenyl)oxy]-			Canada PBiT List			EU Endocrine Disruptor	CA Prop 65											PBiT	developmental	Category 1 Endocrine Disruptor								P(NR)(O)	Dec_2011	July 2009	NSPIRS 2011, TOXNET
2215-35-2	Zinc, bis[O,O-bis(1,3-dimethylbutyl) phosphorodithioato-S,S']-, (T-4)-			Canada PBiT List															PBiT											Dec_2011	July 2009	
2234-13-1	octachloronaphthalene	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
2277-92-1	benzamide, 2,3,5-trichloro-N-(3,5-dichlo	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
2279-76-7	Tri-n-propyltin (TPrT)						EU Endocrine Disruptor														Category 1 Endocrine Disruptor								not a pesticide	Dec_2011	July 2009	NSPIRS 2011, TOXNET
2379-74-0	Benzo[b]thiophen-3(2H)-one, 6-chloro-2-(6-chloro-4-methyl- 3-oxobenzo[b]thien-2(3H)-ylidene)-4-methyl-			Canada PBiT List															PBiT											Dec_2011	July 2009	
2379-75-1	Benzo[b]thiophen-3(2H)-one, 5-chloro-2-(5-chloro-4,7- dimethyl-3-oxobenzo[b]thien-2(3H)-ylidene)-4,7-dimethyl -			Canada PBiT List															PBiT											Dec_2011	July 2009	
2425-85-6	2-Naphthalenol, 1-[(4-methyl-2-nitrophenyl)azo]-			Canada PBiT List															PBiT											Dec_2011	July 2009	
2429-74-5	C.I. Direct Blue 15					CA Prop 65														cancer										Dec_2011	July 2009	
2437-79-8	1,1'-biphenyl, 2,2',4,4'-tetrachloro-	OSPAR Chemicals of Concern					EU Endocrine Disruptor										PBT				Category 1 Endocrine Disruptor									Dec_2011	July 2009	
2475-45-8	Disperse Blue 1					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec_2011	July 2009	
2537-62-4	Acetamide, N-[2-[(2-bromo-6-cyano-4-nitrophenyl)azo]-5-(diethylamino)phenyl]-			Canada PBiT List															PBiT											Dec_2011	July 2009	
2538-84-3	Anthra[9,1,2-cde]benzo[rst]pentaphene-5,10-diol, 16,17-dimethoxy-, bis(hydrogen sulfate), disodium salt			Canada PBiT List															PBiT											Dec_2011	July 2009	
2602-46-2	Direct Blue 6 (technical grade)					CA Prop 65														cancer										Dec_2011	July 2009	

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		TYPE OF TOXICITY									ORIGINATING LIST																					
CAS	Chemical of Concern Name	(Persistent Bioaccumulative and Toxic) PBT	(Very Persistent and Very Bioaccumulative) vPvB	(Persistent, Bioaccumulative and inherently Toxic) PBiT	(Carcinogenic, Mutagenic and Reproductive (Toxicants)) CMR	Carcinogen	Endocrine Disruptor	Developmental Toxicant	Reproductive Toxicant	Equivalent Level of Concern	EPA Final PBT Rule for TRI	TRI PBT Chemical List	EPA Priority PBT	NWM Priority Chemicals (PBTs)	WA PBT List	EU PBT List	OSPAR Chemicals of Concern	OSPAR Chemicals for Priority Action	Canada PBiT List	CA Prop 65	EU Endocrine Disruptor	IARC	EU Carcinogen	EU Reproductive Toxicant	IRIS	REACH Substances of Very High Concern	NTP 11th/13th ROC	NTP CERHR	Pesticide Notation	Source list last reviewed	Date Listed	Source
2646-17-5	Oil Orange SS					CA Prop 65														cancer										Dec_2011	July 2009	
2653-64-7	2-Naphthalenol, 1-(1-naphthalenylazo)-			Canada PBiT List															PBiT											Dec_2011	July 2009	
2668-47-5	[1,1'-biphenyl]-4-ol, 3,5-bis(1,1-dimethylethyl)-	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
2746-81-8	Heptanoic acid, 2-[4-[3-[2-(trifluoromethyl)-10H-phenothiazin-10-yl]propyl]-1-piperazinyl]ethyl ester			Canada PBiT List															PBiT											Dec_2011	July 2009	
2778-42-9	Benzene, 1,3-bis(1-isocyanato-1-methylethyl)-			Canada PBiT List															PBiT											Dec_2011	July 2009	
2784-94-3	HC Blue 1					CA Prop 65														cancer										Dec_2011	July 2009	
2795-39-3	Potassium salt [Perfluorooctane sulfonates (PFOS)]	WA PBT List		Canada PBiT List											PBT				PBiT											Dec_2011	July 2009	
2814-77-9	2-Naphthalenol, 1-[(2-chloro-4-nitrophenyl)azo]-			Canada PBiT List															PBiT											Dec_2011	July 2009	
2971-22-4	1,1,1-Trichloro-2,2-bis(4-chlorophenyl)ethane						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec_2011	July 2009	
2971-36-0	Bis-OH-Methoxychlor = 1,1,1-trichloro-2,2-bis(4-hydroxyphenyl)ethane (HTPE)						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec_2011	July 2009	
2973-10-6	Diisopropyl sulfate					CA Prop 65														cancer										Dec_2011	July 2009	
3068-88-0	beta-Butyrolactone					CA Prop 65														cancer										Dec_2011	July 2009	
3081-01-4	1,4-benzenediamine, N-(1,4-dimethylpentyl)-N'-phenyl-	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
3090-35-5	Stannane, tributyl[(1-oxo-9-octadecenyl)						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec_2011	July 2009	
3118-97-6	2-Naphthalenol, 1-[(2,4-dimethylphenyl)azo]-			Canada PBiT List															PBiT											Dec_2011	July 2009	
3147-75-9	phenol, 2-(2H-benzotriazol-2-yl)-4-(1,1,3,3-tetramethylbutyl)-	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
3165-93-3	p-chloro-o-toluidine hydrochloride					NTP 11th ROC																					Reasonably anticipated			Dec_2011	July 2009	
3194-55-6	Cyclododecane, 1,2,5,6,9,10-hexabromo-			Canada PBiT List															PBiT											Dec_2011	July 2009	
3268-87-9	1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin	EPA Final PBT Rule for TRI; WA PBT List									PBT				PBT															Dec_2011	July 2009	
3271-22-5	1,3,5-Triazine, 2,4-dimethoxy-6-(1-pyrenyl)-			Canada PBiT List															PBiT											Dec_2011	July 2009	
3278-89-5	benzene, 1,3,5-tribromo-2-(2-propenyloxy)-	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
3296-90-0	2,2-Bis(bromomethyl)-1,3-propanediol					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec_2011	July 2009	
3333-67-3	Nickel carbonate					CA Prop 65														cancer										Dec_2011	July 2009	
3351-28-8	chrysene, 1-methyl-	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
3385-03-3	Flunisolide							CA Prop 65	CA Prop 65											developmental, reproductive female										Dec_2011	July 2009	
3389-71-7	bicyclo[2.2.1]hepta-2,5-diene, 1,2,3,4,7,7-hexachloro-	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
3424-82-6	benzene, 1-chloro-2-[2,2-dichloro-1-(4-chlorophenyl)ethenyl]-	OSPAR Chemicals of Concern					EU Endocrine Disruptor										PBT				Category 1 Endocrine Disruptor									Dec_2011	July 2009	
3468-63-1	2-Naphthalenol, 1-[(2,4-dinitrophenyl)azo]-			Canada PBiT List		CA Prop 65													PBiT	cancer										Dec_2011	July 2009	
3555-47-3	Trisiloxane, 1,1,1,5,5,5-hexamethyl-3, 3-bis[(trimethylsilyl)oxy]-			Canada PBiT List															PBiT											Dec_2011	July 2009	
3563-45-9	1,1,1,2-Tetrachloro-2,2-bis(4-chlorophenyl)ethane (tetrachloro DDT)						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec_2011	July 2009	
3564-09-8	Ponceau 3R					CA Prop 65														cancer										Dec_2011	July 2009	
3570-75-0	2-(2-Formylhydrazino)-4-(5-nitro-2-furyl)thiazole					CA Prop 65														cancer										Dec_2011	July 2009	
3687-67-0	3H-indol-3-one, 5-bromo-2-(9-chloro-3-oxonaphtho[1,2-b]thien-2(3H)-ylidene)-1,2-dihydro-			Canada PBiT List															PBiT											Dec_2011	July 2009	
3688-53-7	AF-2;[2-(2-furyl)-3-(5-nitro-2-furyl)]acrylamide					CA Prop 65														cancer										Dec_2011	July 2009	
3697-24-3	5-Methylchrysene	EPA Final PBT Rule for TRI				CA Prop 65; NTP 11th ROC					PBT									cancer							Reasonably anticipated			Dec_2011	July 2009	
3701-40-4	2,7-Naphthalenedisulfonic acid, 4-hydroxy-3-[[4'-[(2-hydroxy- 1-naphthalenyl)azo]-2,2'-dimethyl[1,1'-biphenyl]-4-yl]azo]-, disodium salt			Canada PBiT List															PBiT											Dec_2011	July 2009	
3734-48-3	4,7-methano-1H-indene, 4,5,6,7,8,8-hexachloro-3a,4,7,7a-tetrahydro-	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
3759-07-7	10(9H)-acridinepropanamine, N,N,9,9-tetramethyl-, [R-(R*,R*)]-2,3-dihydroxybutanedioate (1:1)	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
3761-53-3	Ponceau MX					CA Prop 65														cancer										Dec_2011	July 2009	
3767-68-8	9,10-Anthracenedione, 1-amino-4-(2-benzothiazolylthio)-			Canada PBiT List															PBiT											Dec_2011	July 2009	
3778-73-2	Ifosfamide							CA Prop 65												developmental										Dec_2011	July 2009	
3810-74-0	Streptomycin sulfate							CA Prop 65												developmental									P(A)(O)	Dec_2011	July 2009	NSPIRS 2011, TOXNET
3846-71-7	phenol, 2-(2H-benzotriazol-2-yl)-4,6-bis(1,1-dimethylethyl)-	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
3972-13-2	DIDT	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
4027-18-3	4-Oxo-4-[(tributylstannyl)oxy]-2-butenoic acid			Canada PBiT List															PBiT										P(O)	Dec_2011	July 2009	TOXNET 2011

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		TYPE OF TOXICITY									ORIGINATING LIST																					
CAS	Chemical of Concern Name	(Persistent Bioaccumulative and Toxic) PBT	(Very Persistent and Very Bioaccumulative) vPvB	(Persistent, Bioaccumulative and inherently Toxic) PBiT	(Carcinogenic, Mutagenic and Reproductive (Toxicants)) CMR	Carcinogen	Endocrine Disruptor	Developmental Toxicant	Reproductive Toxicant	Equivalent Level of Concern	EPA Final PBT Rule for TRI	TRI PBT Chemical List	EPA Priority PBT	NWM Priority Chemicals (PBTs)	WA PBT List	EU PBT List	OSPAR Chemicals of Concern	OSPAR Chemicals for Priority Action	Canada PBiT List	CA Prop 65	EU Endocrine Disruptor	IARC	EU Carcinogen	EU Reproductive Toxicant	IRIS	REACH Substances of Very High Concern	NTP 11th/13th ROC	NTP CERHR	Pesticide Notation	Source list last reviewed	Date Listed	Source
4051-63-2	[1,1'-bianthracene]-9,9',10,10'-tetrone, 4,4'-diamino-	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
4342-30-7	Phenol, 2-[[(tributylstannyl)oxy]carbonyl]-			Canada PBiT List			EU Endocrine Disruptor												PBiT		Category 1 Endocrine Disruptor									Dec_2011	July 2009	
4376-20-9	Mono 2 ethyl hexylphthalate (MEHP)						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec 2011	July 2009	
4378-61-4	dibenzo[def,mno]chrysene-6,12-dione, 4,10-dibromo-	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
4395-65-7	9,10-Anthracenedione, 1-amino-4-(phenylamino)-			Canada PBiT List															PBiT											Dec 2011	July 2009	
4400-06-0	4-Hydroxy-3,4',5-trichlorobiphenyl						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec_2011	July 2009	
4474-24-2	Benzenesulfonic acid, 3,3'-[(9,10-dihydro-9,10-dioxo-1,4-anthracenediyl)diimino]bis[2,4,6-trimethyl -, disodium salt			Canada PBiT List															PBiT											Dec 2011	July 2009	
4549-40-0	N-Nitrosomethylvinylamine					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec_2011	July 2009	
4757-55-5	10(9h)-acridinepropanamine, n,n,9,9-tetramethyl-	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
4782-29-0	Stannane, [1,2-phenylenebis(carbonyloxy)						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec_2011	July 2009	
4824-78-6	phosphorothioic acid, O-(4-bromo-2,5-dichlorophenyl) O,O-diethyl ester	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
4904-61-4	1,5,9-cyclododecatriene	OSPAR Chemicals of Concern; OSPAR Chemicals															PBT	PBT												Dec_2011	July 2009	
5103-73-1	Cis-Nonachlor						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec 2011	July 2009	
5160-02-1	D&C Red No. 9					CA Prop 65														cancer										Dec_2011	July 2009	
5216-25-1	p-a,a,a-Tetrachlorotoluene					CA Prop 65														cancer										Dec 2011	July 2009	
5261-31-4	Propanenitrile, 3-[[2-(acetyloxy)ethyl][4- [(2,6-dichloro-4-nitrophenyl)azo]phenyl]amino]-			Canada PBiT List															PBiT											Dec_2011	July 2009	
5285-60-9	benzenamine, 4,4'-methylenebis[N-(1-methylpropyl)-	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
5385-75-1	Dibenzo(a,e)fluoranthene	EPA Final PBT Rule for TRI									PBT																			Dec_2011	July 2009	
5411-22-3	Benzphetamine hydrochloride							CA Prop 65												developmental										Dec 2011	July 2009	
5466-77-3	2-ethyl-hexyl-4-methoxycinnamate						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec_2011	July 2009	
5510-99-6	phenol, 2,6-bis(1-methylpropyl)-	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
5522-43-0	1-Nitropyrene	EPA Final PBT Rule for TRI; OSPAR Chemicals				CA Prop 65; NTP 11th ROC					PBT						PBT			cancer							Reasonably anticipated			Dec_2011	July 2009	
5543-57-7	(S)-4-hydroxy-3-(3-oxo-1-phenylbutyl)-2-benzopyrone								EU Reproductive Toxicant															Category 1 Reproductive Toxicant						Dec 2011	July 2009	
5543-58-8	(R)-4-hydroxy-3-(3-oxo-1-phenylbutyl)-2-benzopyrone								EU Reproductive Toxicant															Category 1 Reproductive Toxicant						Dec_2011	July 2009	
5989-27-5	cyclohexene, 1-methyl-4-(1-methylethenyl)-, (R)-	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
6109-97-3	3-Amino-9-ethylcarbazole hydrochloride					CA Prop 65														cancer										Dec_2011	July 2009	
6130-43-4	Heptanoic acid, tridecafluoro-, ammonium salt			Canada PBiT List															PBiT											Dec 2011	July 2009	
6232-56-0	Ethanol, 2-[[4-[(2,6-dichloro-4-nitrophenyl) azo]phenyl]methylamino]-			Canada PBiT List															PBiT											Dec_2011	July 2009	
6250-23-3	Phenol, 4-[[4-(phenylazo)phenyl]azo]-			Canada PBiT List															PBiT											Dec 2011	July 2009	
6253-10-7	Phenol, 4-[[4-(phenylazo)-1-naphthalenyl]azo]-			Canada PBiT List															PBiT											Dec_2011	July 2009	
6257-39-2	[1,1'-Biphenyl]-4-ol, 3,4',5-tris(1,1-dimethylethyl)-			Canada PBiT List															PBiT											Dec 2011	July 2009	
6300-37-4	Phenol, 2-methyl-4-[[4-(phenylazo)phenyl]azo]-			Canada PBiT List															PBiT											Dec_2011	July 2009	
6358-53-8	Citrus Red No. 2					CA Prop 65														cancer										Dec 2011	July 2009	
6358-57-2	2,7-Naphthalenedisulfonic acid, 3-[[2,2'-dimethyl-4'-[[4- [[(4-methylphenyl)sulfonyl]oxy]phenyl]azo][1,1'-			Canada PBiT List															PBiT											Dec_2011	July 2009	
6368-72-5	2-Naphthalenamine, N-ethyl-1-[[4-(phenylazo)phenyl]azo]-			Canada PBiT List															PBiT											Dec 2011	July 2009	
6371-23-9	Benzo[b]thiophen-3(2H)-one, 5,7-dichloro-2-(6-chloro- 4-methyl-3-oxobenzo[b]thien-2(3H)-ylidene)-4-methyl -			Canada PBiT List															PBiT											Dec_2011	July 2009	
6373-31-5	Naphth[2,3-c]acridine-5,8,14(13H)-trione, 6,10,12-trichloro-			Canada PBiT List															PBiT											Dec 2011	July 2009	
6407-74-5	3H-Pyrazol-3-one, 4-[(2-chlorophenyl)azo]-2, 4-dihydro-5-methyl-2-phenyl-			Canada PBiT List															PBiT											Dec_2011	July 2009	
6407-78-9	3H-Pyrazol-3-one, 4-[(2,4-dimethylphenyl)azo] -2,4-dihydro-5-methyl-2-phenyl-			Canada PBiT List															PBiT											Dec 2011	July 2009	
6408-50-0	9,10-Anthracenedione, 1-(methylamino)-4-[(3-methylphenyl)amino]-			Canada PBiT List															PBiT											Dec_2011	July 2009	
6409-68-3	2-Anthracenecarboxaldehyde, 1-amino-9,10-dihydro-9,10-dioxo-, 2-[(1-amino-9,10-dihydro-9,10-dioxo-2-anthracenyl)methylene]hydrazone			Canada PBiT List															PBiT											Dec 2011	July 2009	
6410-09-9	2-Naphthalenol, 1-[(2-nitrophenyl)azo]-			Canada PBiT List															PBiT											Dec_2011	July 2009	
6410-13-5	2-Naphthalenol, 1-[(4-chloro-2-nitrophenyl)azo]-			Canada PBiT List															PBiT											Dec 2011	July 2009	
6410-41-9	2-Naphthalenecarboxamide, N-(5-chloro-2,4-dimethoxyphenyl) -4-[[5-[(diethylamino)sulfonyl]-2-methoxyphenyl]azo]-3-hydroxy-			Canada PBiT List															PBiT											Dec_2011	July 2009	
6417-38-5	Naphth[2,3-c]acridine-10-carboxamide, N-[3-(benzoylamino)-9,10- dihydro-9,10-dioxo-1-anthracenyl]-5,8,13,14-tetrahydro -5,8,14-trioxo-			Canada PBiT List															PBiT											Dec 2011	July 2009	

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CAS	Chemical of Concern Name	TYPE OF TOXICITY									ORIGINATING LIST																		Pesticide Notation	Source list last reviewed	Date Listed	Source
		(Persistent Bioaccumulative and Toxic) PBT	(Very Persistent and Very Bioaccumulative) vPvB	(Persistent, Bioaccumulative and inherently Toxic) PBiT	(Carcinogenic, Mutagenic and Reproductive (Toxicants)) CMR	Carcinogen	Endocrine Disruptor	Developmental Toxicant	Reproductive Toxicant	Equivalent Level of Concern	EPA Final PBT Rule for TRI	TRI PBT Chemical List	EPA Priority PBT	NWM Priority Chemicals (PBTs)	WA PBT List	EU PBT List	OSPAR Chemicals of Concern	OSPAR Chemicals for Priority Action	Canada PBiT List	CA Prop 65	EU Endocrine Disruptor	IARC	EU Carcinogen	EU Reproductive Toxicant	IRIS	REACH Substances of Very High Concern	NTP 11th/13th ROC	NTP CERHR				
6420-06-0	1-Naphthalenesulfonic acid, 4-hydroxy-3-[[4'-[(1-hydroxy- 5-sulfo-2-naphthalenyl)azo]-3,3'-dimethyl[1,1' -biphenyl]-4-yl]azo]-, disodium salt			Canada PBiT List															PBiT											Dec_2011	July 2009	
6459-94-5	C.I. Acid Red 114					CA Prop 65														cancer										Dec_2011	July 2009	
6465-02-7	Carbamic acid, [4-[[4-[(4-hydroxyphenyl) azo]-2-methylphenyl]azo]phenyl]-, methyl ester			Canada PBiT List															PBiT											Dec_2011	July 2009	
6471-01-8	2-Anthracenesulfonic acid, 4,4'-[(1-methylethylidene) bis(4,1-phenyleneimino)]bis[1-amino-9,10-dihydro -9,10-dioxo-, disodium salt			Canada PBiT List															PBiT											Dec_2011	July 2009	
6535-42-8	1-Naphthalenol, 4-[(4-ethoxyphenyl)azo]-			Canada PBiT List															PBiT											Dec_2011	July 2009	
6731-36-8	Peroxide, (3,3,5-trimethylcyclohexylidene) bis[(1,1-dimethylethyl)			Canada PBiT List															PBiT											Dec_2011	July 2009	
6786-83-0	1-Naphthalenemethanol, α,α-bis[4-(dimethylamino) phenyl]-4-(phenylamino)-			Canada PBiT List															PBiT											Dec_2011	July 2009	
6842-15-5	1-propene, tetramer	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
6936-40-9	benzene, 1,2,4,5-tetrachloro-3-methoxy-	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
7012-37-5	1,1'-biphenyl, 2,4,4'-trichloro-	OSPAR Chemicals of Concern					EU Endocrine Disruptor										PBT				Category 1 Endocrine Disruptor									Dec_2011	July 2009	
7099-43-6	5,6-Cyclopento-1,2-benzanthracene						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec_2011	July 2009	
7139-02-8	pyrimido[5,4-d]pyrimidine, 2,6-dichloro-4,8-di-1-piperidinyl-	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
7147-42-4	Butanamide, 2,2'-[(3,3'-dimethoxy[1,1'- biphenyl]-4,4'-diyl)bis(azo)]bis[N-(2-methylphenyl)-3-oxo-			Canada PBiT List															PBiT											Dec_2011	July 2009	
7280-37-7	Estropipate					CA Prop 65		CA Prop 65												cancer, developmental										Dec_2011	July 2009	
7328-97-4	Oxirane, 2,2',2",2'"-[1,2-ethanediylidenetetrakis(4,1-phenyleneoxymethylene)]tetrakis -			Canada PBiT List															PBiT											Dec_2011	July 2009	
7400-08-0	p-Coumaric acid (PCA)						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec_2011	July 2009	
7439-92-1	Lead	TRI PBT Chemical List; EPA Priority PBT; NWM				IRIS; NTP 11th ROC		CA Prop 65	CA Prop 65			PBT	PBT	PBT						developmental, reproductive female, male					B2		Reasonably anticipated			Dec_2011	July 2009	
7439-97-6	Mercury	TRI PBT Chemical List; EPA Priority PBT; NWM						CA Prop 65				PBT	PBT	PBT						developmental									P(NR)(O)	Dec_2011	July 2009	NSPIRS 2011, TOXNET
7440-02-0	Nickel (Metallic)					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec_2011	July 2009	
7440-38-2	Arsenic and arsenic compounds					CA Prop 65; IARC; IRIS; NTP 11th														cancer		Group 1			A		Known		P(A)(O)	Dec_2011	July 2009	NSPIRS 2011, TOXNET
7440-41-7	Beryllium and beryllium compounds					CA Prop 65; IARC; IRIS; NTP 11th														cancer		Group 1			B1 (1986 Guidel		Known			Dec_2011	July 2009	
7440-43-9	Cadmium	NWM Priority Chemicals				IARC; IRIS; NTP 11th ROC		CA Prop 65	CA Prop 65					PBT						developmental, reproductive male		Group 1			B1		Known		P(NR)(O)	Dec_2011	July 2009	NSPIRS 2011, TOXNET
7440-48-4	Cobalt metal powder					CA Prop 65														cancer										Dec_2011	July 2009	
7446-27-7	Lead phosphate					CA Prop 65			EU Reproductive Toxicant											cancer				Category 1 Reproductive Toxicant						Dec_2011	July 2009	
7446-34-6	Selenium sulfide					CA Prop 65; IRIS; NTP 11th ROC														cancer					B2		Reasonably anticipated			Dec_2011	July 2009	
7496-02-8	6-Nitrochrysene					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec_2011	July 2009	
7646-79-9	Cobalt dichloride				REACH Substances of Very High Concern																					CMR (carcinogen)				Dec_2011	July 2009	
7664-93-9	strong inorganic acid mists containing sulfuric acid					CA Prop 65; IARC; NTP 11th ROC														cancer		Group 1					Known			Dec_2011	July 2009	
7758-01-2	Potassium bromate					CA Prop 65														cancer										Dec_2011	July 2009	
7758-97-6	lead chromate								EU Reproductive Toxicant															Category 1 Reproductive Toxicant						Dec_2011	July 2009	
7789-12-0	Sodium dichromate, dihydrate				REACH Substances of Very High Concern																					CMR (carcinogen, reproductive			P(A)(O)	Dec_2011	July 2009	NSPIRS 2011, TOXNET
8001-58-9	Creosotes					IARC; IRIS																Group 2A			B1				P(A)(O)	Dec_2011	July 2009	NSPIRS 2011, TOXNET
8002-05-9	Petroleum			Canada PBiT List															PBiT											Dec_2011	July 2009	
8007-45-2	Coal-tars					IARC; EU Carcinogen; IRIS																Group 1	Category 1 carcinogen		A				P(A)(O)	Dec_2011	July 2009	NSPIRS 2011, TOXNET
8068-44-8	Clophen A50						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec_2011	July 2009	
8072-20-6	ethanol, 1,1-bis(4-chlorophenyl)-, mixed	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
9004-66-4	Iron dextran complex					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec_2011	July 2009	
10024-97-2	Nitrous oxide							CA Prop 65												developmental										Dec_2011	July 2009	
10026-24-1	Cobalt sulfate heptahydrate					CA Prop 65														cancer										Dec_2011	July 2009	
10034-93-2	Hydrazine sulfate					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec_2011	July 2009	
10043-35-3	Boric acid						EU Endocrine Disruptor														Category 1 Endocrine Disruptor								(P)(A)(O)	Dec_2011	July 2009	NSPIRS 2011, TOXNET
10043-92-2	Radon-222 and its decay products					IARC; NTP 11th ROC																Group 1					Known			Dec_2011	July 2009	
10048-13-2	Sterigmatocystin					CA Prop 65														cancer										Dec_2011	July 2009	
10108-64-2	cadmium chloride	OSPAR Chemicals of Concern															PBT												P(NR)(O)	Dec_2011	July 2009	NSPIRS 2011, TOXNET
10124-43-3	Cobalt sulfate					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec_2011	July 2009	

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		TYPE OF TOXICITY									ORIGINATING LIST																					
CAS	Chemical of Concern Name	(Persistent Bioaccumulative and Toxic) PBT	(Very Persistent and Very Bioaccumulative) vPvB	(Persistent, Bioaccumulative and inherently Toxic) PBiT	(Carcinogenic, Mutagenic and Reproductive (Toxicants)) CMR	Carcinogen	Endocrine Disruptor	Developmental Toxicant	Reproductive Toxicant	Equivalent Level of Concern	EPA Final PBT Rule for TRI	TRI PBT Chemical List	EPA Priority PBT	NWM Priority Chemicals (PBTs)	WA PBT List	EU PBT List	OSPAR Chemicals of Concern	OSPAR Chemicals for Priority Action	Canada PBiT List	CA Prop 65	EU Endocrine Disruptor	IARC	EU Carcinogen	EU Reproductive Toxicant	IRIS	REACH Substances of Very High Concern	NTP 11th/13th ROC	NTP CERHR	Pesticide Notation	Source list last reviewed	Date Listed	Source
10331-57-4	[1,1'-biphenyl]-2,2'-diol, 5,5'-dichloro	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
10448-09-6	Cyclotetrasiloxane, heptamethylphenyl-			Canada PBiT List															PBiT											Dec 2011	July 2009	
10595-95-6	N-Nitrosomethylethylamine					CA Prop 65; IRIS														cancer					B2					Dec 2011	July 2009	
11081-15-5	phenol, isooctyl-						EU Endocrine Disruptor			OSPAR Chemicals of Concern							Equivalent level of concern				Category 1 Endocrine Disruptor									Dec 2011	July 2009	
11096-82-5	PCB Aroclor 1260 (Clophen A60)						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec 2011	July 2009	
11097-69-1	PCB Aroclor 1254						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec 2011	July 2009	
12001-28-4	asbestos (crocidolite)					EU Carcinogen																	Category 1 carcinogen							Dec 2011	July 2009	
12001-29-5	asbestos (chrysotile)					EU Carcinogen																	Category 1 carcinogen							Dec 2011	July 2009	
12002-48-1	Trichlorobenzene						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec 2011	July 2009	
12035-36-8	nickel dioxide					EU Carcinogen																	Category 1 carcinogen							Dec 2011	July 2009	
12035-72-2	Nickel subsulfide					CA Prop 65; EU Carcinogen;														cancer			Category 1 carcinogen		A					Dec 2011	July 2009	
12054-48-7	Nickel (II) hydroxide					CA Prop 65														cancer										Dec 2011	July 2009	
12122-67-7	Zineb						EU Endocrine Disruptor														Category 1 Endocrine Disruptor								P(NR)(O)	Dec 2011	July 2009	NSPIRS 2011
12125-56-3	Nickel (III) hydroxide					CA Prop 65														cancer										Dec 2011	July 2009	
12172-73-5	asbestos (amosite)					EU Carcinogen																	Category 1 carcinogen							Dec 2011	July 2009	
12174-11-7	Palygorskite fibers (> 5mm in length)					CA Prop 65														cancer										Dec 2011	July 2009	
12236-64-5	2-Naphthalenecarboxamide, N-[4-(acetylamino)phenyl] -4-[[5-(aminocarbonyl)-2-chlorophenyl]azo]-3-hydroxy -			Canada PBiT List															PBiT											Dec 2011	July 2009	
12239-34-8	Acetamide, N-[5-[bis[2-(acetyloxy)ethyl] amino]-2-[(2-bromo-4,6-dinitrophenyl)azo]-4-ethoxyphenyl]-			Canada PBiT List															PBiT											Dec 2011	July 2009	
12408-10-5	Benzene, tetrachloro-			Canada PBiT List															PBiT											Dec 2011	July 2009	
12510-42-8	Erionite					CA Prop 65; EU Carcinogen														cancer			Category 1 carcinogen							Dec 2011	July 2009	
12642-23-8	PCT Aroclor 5442						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec 2011	July 2009	
12656-85-8	C.I. Pigment Red 104 [This substance is identified in the Colour Index by Colour Index Constitution Number, C.I. 77605.], Lead chromate molybdate								EU Reproductive Toxicant															Category 1 Reproductive Toxicant						Dec 2011	July 2009	
12672-29-6	PCB Aroclor 1248						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec 2011	July 2009	
13010-47-4	1-(2-Chloroethyl)-3-cyclohexyl-1-nitrosourea (CCNU) (Lomustine)					CA Prop 65; IARC; NTP 11th ROC		CA Prop 65												cancer, developmental		Group 2A					Reasonably anticipated			Dec 2011	July 2009	
13049-13-3	4,4'-Dihydroxy-3,3',5,5'-tetrachlorobiphenyl						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec 2011	July 2009	
13080-86-9	Benzenamine, 4,4'-[(1-methylethylidene) bis(4,1-phenyleneoxy)]bis-			Canada PBiT List															PBiT											Dec 2011	July 2009	
13256-22-9	N-Nitrososarcosine					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec 2011	July 2009	
13424-46-9	lead azide, lead diazide								EU Reproductive Toxicant															Category 1 Reproductive Toxicant						Dec 2011	July 2009	
13463-39-3	Nickel carbonyl					CA Prop 65; IRIS		CA Prop 65												cancer, developmental					B2					Dec 2011	July 2009	
13552-44-8	4,4'-Methylenedianiline dihydrochloride					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec 2011	July 2009	
13593-03-8	Quinalphos = Chinalphos						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec 2011	July 2009	
13654-09-6	1,1'-biphenyl, 2,2',3,3',4,4',5,5',6,6'-decabromo-	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
13680-35-8	benzenamine, 4,4'-methylenebis[2,6-diethyl-	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
13909-09-6	1-(2-Chloroethyl)-3-(4-methylcyclohexyl)-1-nitrosourea (Methyl-CCNU)					CA Prop 65; IARC; NTP 11th ROC														cancer		Group 1					Known			Dec 2011	July 2009	
14295-43-3	Benzo[b]thiophen-3(2H)-one, 4,7-dichloro-2-(4,7-dichloro- 3-oxobenzo[b]thien-2(3H)-ylidene)-			Canada PBiT List															PBiT											Dec 2011	July 2009	
14808-60-7	Silica, crystalline (in the form of quartz or cristobalite dust)					IARC																Group 1								Dec 2011	July 2009	
14816-18-3	3,5-dioxa-6-aza-4-phosphaoct-6-ene-8-nitrile, 4-ethoxy-7-phenyl-, 4-sulfide	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
14835-94-0	o,p'-DDMU						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec 2011	July 2009	
14901-08-7	Cycasin					CA Prop 65														cancer										Dec 2011	July 2009	
14962-28-8	4-Hydroxy-2',4',6'-trichlorobiphenyl						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec 2011	July 2009	
15086-94-9	Spiro[isobenzofuran-1(3H),9'-[9H]xanthen]-3-one, 2',4',5',7'-tetrabromo-3',6'-dihydroxy-			Canada PBiT List															PBiT											Dec 2011	July 2009	
15087-24-8	3-Benzylidene camphor (3-BC)						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec 2011	July 2009	
15114-15-5	9,10-anthracenedione, 4,8-diamino-2-(4-ethoxyphenyl)-1,5-dihydroxy-	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
15245-44-0	lead 2,4,6-trinitro-m-phenylene dioxide, lead 2,4,6-trinitroresorcinoxide, lead styphnate								EU Reproductive Toxicant															Category 1 Reproductive Toxicant						Dec 2011	July 2009	
15541-45-4	Bromate					CA Prop 65; IRIS														cancer					B2 (1986 Guidel				not a pesticide	Dec 2011	July 2009	NSPIRS 2011, TOXNET

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CAS	Chemical of Concern Name	TYPE OF TOXICITY (Persistent Bioaccumulative and Toxic) PBT	(Very Persistent and Very Bioaccumulative) vPvB	(Persistent, Bioaccumulative and inherently Toxic) PBiT	(Carcinogenic, Mutagenic and Reproductive (Toxicants)) CMR	Carcinogen	Endocrine Disruptor	Developmental Toxicant	Reproductive Toxicant	Equivalent Level of Concern	ORIGINATING LIST EPA Final PBT Rule for TRI	TRI PBT Chemical List	EPA Priority PBT	NWM Priority Chemicals (PBTs)	WA PBT List	EU PBT List	OSPAR Chemicals of Concern	OSPAR Chemicals for Priority Action	Canada PBiT List	CA Prop 65	EU Endocrine Disruptor	IARC	EU Carcinogen	EU Reproductive Toxicant	IRIS	REACH Substances of Very High Concern	NTP 11th/13th ROC	NTP CERHR	Pesticide Notation	Source list last reviewed	Date Listed	Source
15606-95-8	triethyl arsenate				REACH Substances of Very High Concern	EU Carcinogen																	Category 1 carcinogen			CMR (carcinogen)				Dec 2011	July 2009	
15958-27-7	Propanenitrile, 3-[[4-[(4-nitrophenyl)azo] phenyl][2- [[(phenylamino)carbonyl]oxy]ethyl]amino]-			Canada PBiT List															PBiT											Dec_2011	July 2009	
15958-61-9	9,10-Anthracenedione, 1-[[4-(phenylsulfonyl)phenyl]amino]-			Canada PBiT List															PBiT											Dec 2011	July 2009	
16071-86-6	Direct Brown 95 (technical grade)					CA Prop 65														cancer										Dec_2011	July 2009	
16421-40-2	Acetamide, N-[5-[[2-(acetyloxy)ethyl] (phenylmethyl)amino]-2-[(2-chloro-4,6-dinitrophenyl)azo]-4-methoxyphenyl]-			Canada PBiT List															PBiT											Dec 2011	July 2009	
16421-41-3	Acetamide, N-[5-[[2-(acetyloxy)ethyl] (phenylmethyl)amino]-2-[(2,4-dinitrophenyl)azo]-4 -methoxyphenyl]-			Canada PBiT List															PBiT											Dec_2011	July 2009	
16543-55-8	N-Nitrosonornicotine					CA Prop 65; IARC; NTP 11th ROC														cancer		Group 1					Reasonably anticipated			Dec 2011	July 2009	
16568-02-8	Gyromitrin (Acetaldehyde methylformylhydrazone)					CA Prop 65														cancer										Dec_2011	July 2009	
16586-42-8	Propanenitrile, 3-[ethyl[3-methyl-4-[(6-nitro- 2-benzothiazolyl)azo]phenyl]amino]-			Canada PBiT List															PBiT											Dec 2011	July 2009	
16812-54-7	nickel sulphide					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
16834-13-2	21H,23H-Porphine, 5,10,15,20-tetra-4-pyridinyl-			Canada PBiT List															PBiT											Dec 2011	July 2009	
17202-41-4	1-Nonanesulfonic acid, 1,1,2,2,3,3,4,4,5,5,6,6,7, 7,8,8,9,9,9-nonadecafluoro-, ammonium salt			Canada PBiT List															PBiT											Dec_2011	July 2009	
17321-77-6	5H-Dibenz[b,f]azepine-5-propanamine, 3-chloro-10,11-dihydro-N,N-dimethyl-, monohydrochloride			Canada PBiT List															PBiT											Dec 2011	July 2009	
17464-91-4	Ethanol, 2,2'-[[4-[(2-bromo-6-chloro- 4-nitrophenyl)azo]-3-chlorophenyl]imino]bis-			Canada PBiT List															PBiT											Dec_2011	July 2009	
17540-75-9	phenol, 2,6-bis(1,1-dimethylethyl)-4-(1-methylpropyl)-	OSPAR Chemicals of Concern		Canada PBiT List													PBT		PBiT											Dec 2011	July 2009	
17570-76-2	lead(II) methanesulphonate								EU Reproductive Toxicant															Category 1 Reproductive Toxicant						Dec_2011	July 2009	
18181-70-9	phosphorothioic acid, O-(2,5-dichloro-4-iodophenyl) O,O-dimethyl ester	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
18540-29-9	Chromium(VI)					IARC; IRIS; NTP 11th ROC																Group 1			A (1986 Guidel		Known		not a pesticide	Dec 2011	July 2009	NSPIRS 2011
18662-53-8	Nitrilotriacetic acid, trisodium salt monohydrate					CA Prop 65														cancer										Dec_2011	July 2009	
18883-66-4	Streptozocin (streptozotocin)					CA Prop 65; NTP 11th ROC		CA Prop 65	CA Prop 65											cancer, developmental, reproductive							Reasonably anticipated			Dec 2011	July 2009	
19163-98-5	Benzoxazolium, 2-[3-[5,6-dichloro-1-ethyl- 1,3-dihydro-3-(3-sulfopropyl)-2H-benzimidazol-2 -ylidene]-1-propenyl]-3-ethyl-, hydroxide, inner			Canada PBiT List															PBiT											Dec_2011	July 2009	
19408-74-3	1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	EPA Final PBT Rule for TRI; WA PBT List									PBT				PBT															Dec 2011	July 2009	
19745-44-9	Propanenitrile, 3-[4-[(5-nitro-2-thiazolyl) azo](2-phenylethyl)amino]-			Canada PBiT List															PBiT											Dec_2011	July 2009	
19774-82-4	methanone, (2-butyl-3-benzofuranyl)[4-[2-(diethylamino)ethoxy]-3,5-diiodophenyl]-, hydrochloride	OSPAR Chemicals of Concern						CA Prop 65	CA Prop 65								PBT			developmental, reproductive female, male										Dec 2011	July 2009	
19800-42-1	Phenol, 4-[[2-methoxy-4-[(4-nitrophenyl)azo]phenyl]azo]-			Canada PBiT List															PBiT											Dec_2011	July 2009	
20241-76-3	9,10-Anthracenedione, 1,8-dihydroxy-4-nitro-5-(phenylamino)-			Canada PBiT List															PBiT											Dec 2011	July 2009	
20265-96-7	p-Chloroaniline hydrochloride					CA Prop 65														cancer										Dec_2011	July 2009	
20325-40-0	3,3'-Dimethoxybenzidine dihydrochloride					CA Prop 65														cancer										Dec 2011	July 2009	
20830-81-3	Daunomycin					CA Prop 65														cancer										Dec_2011	July 2009	
21136-70-9	benzidine sulphate					EU Carcinogen																	Category 1 carcinogen							Dec 2011	July 2009	
21150-89-0	phenol, 4-(1,1-dimethylethyl)-, hydrogen phosphate	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
21609-90-5	phosphonothioic acid, phenyl-, O-(4-bromo-2,5-dichlorophenyl) O-methyl ester	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
21811-64-3	Phenol, 4,4'-[1,4-phenylenebis(azo)]bis-			Canada PBiT List															PBiT											Dec_2011	July 2009	
21850-44-2	benzene, 1,1'-(1-methylethylidene)bis[3,5-dibromo-4-(2,3-dibromopropoxy)-	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
22398-80-7	Indium phosphide					CA Prop 65; IARC														cancer		Group 2A								Dec_2011	July 2009	
22506-53-2	3,9-Dinitrofluoranthene					CA Prop 65														cancer										Dec 2011	July 2009	
22832-87-7	1H-imidazole, 1-[2-(2,4-dichlorophenyl)-2-[(2,4-dichlorophenyl)methoxy]ethyl]-, mononitrate	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
22916-47-8	1H-imidazole, 1-[2-(2,4-dichlorophenyl)-2-[(2,4-dichlorophenyl)methoxy]ethyl]-	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
22967-92-6	Methyl mercury	WA PBT List						CA Prop 65							PBT					developmental										Dec_2011	July 2009	
23077-61-4	9H-Carbazole-1-carboxamide, N-(4-chlorophenyl)-2-hydroxy-			Canada PBiT List															PBiT											Dec 2011	July 2009	
23246-96-0	Riddelliine					CA Prop 65														cancer										Dec_2011	July 2009	
23355-64-8	Ethanol, 2,2'-[[3-chloro-4-[(2,6-dichloro- 4-nitrophenyl)azo]phenyl]imino]bis-			Canada PBiT List															PBiT											Dec 2011	July 2009	
23541-50-6	Daunorubicin hydrochloride							CA Prop 65												developmental										Dec_2011	July 2009	
24169-02-6	1H-Imidazole, 1-[2-[(4-chlorophenyl)methoxy] -2-(2,4-dichlorophenyl)ethyl]-, mononitrate			Canada PBiT List															PBiT											Dec 2011	July 2009	
24448-09-7	1-Octanesulfonamide, 1,1,2,2,3,3,4,4,5,5,6,6,7, 7,8,8,8-heptadecafluoro-N-(2-hydroxyethyl)-N-methyl -			Canada PBiT List															PBiT											Dec 2011	July 2009	

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24610-00-2	Benzonitrile, 2-[[4-[(2-cyanoethyl)(2-phenylethyl) amino]phenyl]azo]-5-nitro-			Canada PBiT List															PBiT											Dec 2011	July 2009	
25013-16-5	butylhydroxyanisol					CA Prop 65; NTP 11th ROC	OSPAR Chemicals of Concern; EU										Endocrine disruptor			cancer	Category 1 Endocrine Disruptor						Reasonably anticipated			Dec 2011	July 2009	
25036-25-3	2,2'-bis(2-(2,3-epoxypropoxy)phenyl)-propane						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec 2011	July 2009	
25150-28-1	Propanenitrile, 3-[[4-[(6,7-dichloro-2-benzothiazolyl) azo]phenyl]ethylamino]-			Canada PBiT List															PBiT											Dec 2011	July 2009	
25154-52-3	phenol, nonyl-	OSPAR Chemicals of Concern					EU Endocrine Disruptor										PBT				Category 1 Endocrine Disruptor									Dec 2011	July 2009	
25155-25-3	Peroxide, [1,3(or 1,4)-phenylenebis(1-methylethylidene)]bis[(1,1-dimethylethyl)			Canada PBiT List															PBiT											Dec 2011	July 2009	
25168-15-4	acetic acid, (2,4,5-trichlorophenoxy)-, isooctyl ester	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
25176-89-0	Propanenitrile, 3-[[4-[(5,6-dichloro-2-benzothiazolyl) azo]phenyl]ethylamino]-			Canada PBiT List															PBiT											Dec 2011	July 2009	
25321-09-9	benzene, bis(1-methylethyl)-	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
25637-99-4	Hexabromocyclododecane	WA PBT List; EU PBT List; REACH Substances of Very													PBT	Fulfilling PBT crit eria										PBT				Dec 2011	July 2009	
25808-74-6	lead hexafluorosilicate								EU Reproductive Toxicant															Category 1 Reproductive Toxicant						Dec 2011	July 2009	
25857-05-0	Hexanedioic acid, bis[2-[[4-(2,2-dicyanoethenyl) -3-methylphenyl]ethylamino]ethyl] ester			Canada PBiT List															PBiT											Dec 2011	July 2009	
25973-55-1	phenol, 2-(2H-benzotriazol-2-yl)-4,6-bis(1,1-dimethylpropyl)-	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
26140-60-3	terphenyl	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
26148-68-5	A-alpha-C (2-Amino-9H-pyrido[2,3-b]indole)					CA Prop 65														cancer										Dec 2011	July 2009	
26447-49-4	hexabromododecane	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
26471-62-5	Toluene diisocyanate					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec 2011	July 2009	
26603-40-7	1,3,5-triazine-2,4,6(1H,3H,5H)-trione, 1,3,5-tris(3-isocyanatomethylphenyl)-	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
26636-32-8	Tributyltinnaphthalate						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec 2011	July 2009	
26761-40-0	Di-isodecyl phthalate (DIDP)							CA Prop 65												developmental										Dec 2011	July 2009	
26850-12-4	Propanamide, N-[5-[bis[2-(acetyloxy)ethyl] amino]-2-[(2-chloro-4-nitrophenyl)azo]phenyl] -			Canada PBiT List															PBiT											Dec 2011	July 2009	
26864-56-2	4-piperidinol, 1-[4,4-bis(4-fluorophenyl	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
26999-29-1	phosphorodithioic acid, O,O-diisooctyl ester	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
27193-28-8	Phenol, (1,1,3,3-tetramethylbutyl)- = Octylphenol						EU Endocrine Disruptor														Category 1 Endocrine Disruptor								P(NR)(O)	Dec 2011	July 2009	NSPIRS 2011
27208-37-3	Cyclopenta[cd]pyrene					IARC																Group 2A								Dec 2011	July 2009	
27341-33-9	9,10-Anthracenedione, 1-amino-4-[(methoxyphenyl)amino]-			Canada PBiT List															PBiT											Dec 2011	July 2009	
27554-26-3	1,2-benzenedicarboxylic acid, diisooctyl ester									OSPAR Chemicals of Concern							Equivalent level of concern													Dec 2011	July 2009	
27753-52-2	nonabromobiphenyl	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
27858-07-7	octabromobiphenyl	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
28118-10-7	1H-Benzimidazolium, 5,6-dichloro-2-[3-(5,6-dichloro- 1,3-diethyl-1,3-dihydro-2H-benzimidazol-2-ylidene)-1-propenyl]-1-ethyl-3-(3-			Canada PBiT List															PBiT											Dec 2011	July 2009	
28407-37-6	C.I. Direct Blue 218					CA Prop 65														cancer										Dec 2011	July 2009	
28434-86-8	3,3'-Dichloro-4,4'-diamino-diphenyl ether					CA Prop 65														cancer										Dec 2011	July 2009	
28680-45-7	heptachloronorbornene	OSPAR Chemicals of Concern; OSPAR Chemicals															PBT	PBT												Dec 2011	July 2009	
28824-41-1	Propanenitrile, 3-[[4-[(4,6-dibromo-2-benzothiazolyl) azo]phenyl]ethylamino]-			Canada PBiT List															PBiT											Dec 2011	July 2009	
28911-01-5	Triazolam							CA Prop 65												developmental										Dec 2011	July 2009	
28981-97-7	Alprazolam							CA Prop 65												developmental										Dec 2011	July 2009	
29081-56-9	Ammonium salt [Perfluorooctane sulfonates (PFOS)]	WA PBT List		Canada PBiT List											PBT				PBiT											Dec 2011	July 2009	
29082-74-4	Octachlorostyrene	EPA Final PBT Rule for TRI; TRI PBT Chemical List;									PBT	PBT	PBT																	Dec 2011	July 2009	
29098-15-5	benzoic acid, 2-[(2,6-dichloro-3-methylp	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
29312-59-2	benzenamine, 4-(2,6-diphenyl-4-pyridinyl)-N,N-dimethyl-	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
29398-96-7	[1,1'-biphenyl]-4,4'-diamine, N,N'-bis(2,4-dinitrophenyl)-3,3'-dimethoxy-	OSPAR Chemicals of Concern		Canada PBiT List													PBT		PBiT											Dec 2011	July 2009	
29457-72-5	Lithium salt [Perfluorooctane sulfonates (PFOS)]	WA PBT List													PBT															Dec 2011	July 2009	
29761-21-5	phosphoric acid, isodecyl diphenyl ester	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
29765-00-2	Benzamide, N-[5-[bis[2-(acetyloxy)ethyl] amino]-2-[(4-nitrophenyl)azo]phenyl]-			Canada PBiT List															PBiT											Dec 2011	July 2009	
30668-06-5	1,3-Dichloro-2,2-bis(4-methoxy-3-methylphenyl)propane						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec 2011	July 2009	

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CAS	Chemical of Concern Name	TYPE OF TOXICITY (Persistent Bioaccumulative and Toxic) PBT	(Very Persistent and Very Bioaccumulative) vPvB	(Persistent, Bioaccumulative and inherently Toxic) PBiT	(Carcinogenic, Mutagenic and Reproductive (Toxicants)) CMR	Carcinogen	Endocrine Disruptor	Developmental Toxicant	Reproductive Toxicant	Equivalent Level of Concern	ORIGINATING LIST EPA Final PBT Rule for TRI	TRI PBT Chemical List	EPA Priority PBT	NWM Priority Chemicals (PBTs)	WA PBT List	EU PBT List	OSPAR Chemicals of Concern	OSPAR Chemicals for Priority Action	Canada PBiT List	CA Prop 65	EU Endocrine Disruptor	IARC	EU Carcinogen	EU Reproductive Toxicant	IRIS	REACH Substances of Very High Concern	NTP 11th/13th ROC	NTP CERHR	Pesticide Notation	Source list last reviewed	Date Listed	Source
31030-27-0	Benzenamine, 4-[(2-chloro-4-nitrophenyl) azo]-N-ethyl-N-(2-phenoxyethyl)-			Canada PBiT List															PBiT											Dec 2011	July 2009	
31508-00-6	2,3',4,4',5-Pentachlorobiphenyl	EPA Final PBT Rule for TRI; WA PBT List					EU Endocrine Disruptor				PBT				PBT						Category 1 Endocrine Disruptor									Dec 2011	July 2009	
32241-08-0	Heptachloronaphthalene [Polychlorinated naphthalenes]	WA PBT List; OSPAR Chemicals of Concern													PBT		PBT													Dec 2011	July 2009	
32534-81-9	Pentabromodiphenyl ether [Polybrominated diphenyl ethers]	WA PBT List; OSPAR Chemicals of Concern		Canada PBiT List											PBT		PBT		PBiT											Dec 2011	July 2009	
32536-52-0	Octabromodiphenyl ether [Polybrominated diphenyl ethers]	WA PBT List; EU PBT List; OSPAR Chemicals of													PBT	Fulfilling PBT criteria	PBT													Dec 2011	July 2009	
32598-13-3	3,3',4,4'-Tetrachlorobiphenyl	EPA Final PBT Rule for TRI					EU Endocrine Disruptor				PBT										Category 1 Endocrine Disruptor									Dec 2011	July 2009	
32598-14-4	2,3,3',4,4'-Pentachlorobiphenyl	EPA Final PBT Rule for TRI; WA PBT List					EU Endocrine Disruptor				PBT				PBT						Category 1 Endocrine Disruptor									Dec 2011	July 2009	
32774-16-6	3,3',4,4',5,5'-Hexachlorobiphenyl	EPA Final PBT Rule for TRI; WA PBT List					EU Endocrine Disruptor				PBT				PBT						Category 1 Endocrine Disruptor									Dec 2011	July 2009	
33204-76-1	2,6-cis-Diphenylhexamethylcyclotetrasiloxane - 2,6-cis-[(PhMeSiO)2(Me2SiO)2][						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec 2011	July 2009	
33979-03-2	1,1'-biphenyl, 2,2',4,4',6,6'-hexachloro-	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
33979-43-0	Propanenitrile, 3-[[2-(acetyloxy)ethyl][4- [(5,6-dichloro-2-benzothiazolyl)azo]phenyl]amino]-			Canada PBiT List															PBiT											Dec 2011	July 2009	
34455-03-3	1-Hexanesulfonamide, N-ethyl-1,1,2,2,3,3,4,4,5, 5,6,6,6-tridecafluoro-N-(2-hydroxyethyl)-			Canada PBiT List															PBiT											Dec 2011	July 2009	
34465-46-8	Hexachlorodibenzodioxin					CA Prop 65														cancer										Dec 2011	July 2009	
35065-27-1	PCB 153 (2,2',4,4',5,5'-Hexachlorobiphenyl)						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec 2011	July 2009	
35693-99-3	PCB 52 (2,2';5,5'-Tetrachlorobiphenyl)						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec 2011	July 2009	
35822-46-9	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	EPA Final PBT Rule for TRI; WA PBT List									PBT				PBT															Dec 2011	July 2009	
36065-30-2	2,4,6-bromophenyl 1-2(2,3-dibromo-2-methylpropyl)	OSPAR Chemicals of Concern; OSPAR Chemicals															PBT	PBT												Dec 2011	July 2009	
36294-24-3	Benzenepropanoic acid, 3,5-bis(1,1-dimethylethyl)-4-hydroxy-, ethyl ester			Canada PBiT List															PBiT											Dec 2011	July 2009	
36341-27-2	benzidine acetate					EU Carcinogen																	Category 1 carcinogen							Dec 2011	July 2009	
36355-01-8	1,1'-biphenyl, hexabromo-	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
36483-60-0	Benzene, 1,1'-oxybis-, hexabromo deriv.			Canada PBiT List															PBiT											Dec 2011	July 2009	
36631-23-9	Stannane, tributyl = Tributyltin naphtalate						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec 2011	July 2009	
36861-47-9	bicyclo(2.2.1)heptan-2-one, 1,7,7-trimethyl-3-[(4-methylphenyl)methylene]-	OSPAR Chemicals of Concern					EU Endocrine Disruptor										PBT				Category 1 Endocrine Disruptor									Dec 2011	July 2009	
37680-65-2	PCB 18 (2,2',5-Trichlorobiphenyl)						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec 2011	July 2009	
37893-02-0	benzenamine, N-[3-phenyl-4,5-bis[(trifluoromethyl)imino]-2-thiazolidinylidene]-	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
38006-74-5	1-Propanaminium, 3-[[(heptadecafluorooctyl) sulfonyl]amino]-N,N,N-trimethyl-, chloride			Canada PBiT List															PBiT											Dec 2011	July 2009	
38380-07-3	PCB 128 (2,2',3,3',4,4'-Hexachlorobiphenyl)						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec 2011	July 2009	
38380-08-4	2,3,3',4,4',5-Hexachlorobiphenyl	EPA Final PBT Rule for TRI; WA PBT List									PBT				PBT															Dec 2011	July 2009	
38465-55-3	Nickel, bis[1-[4-(dimethylamino)phenyl] -2-phenyl-1,2-ethenedithiolato(2-)-S,S']-			Canada PBiT List															PBiT											Dec 2011	July 2009	
38521-51-6	benzene, pentabromo(bromomethyl)-	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
38640-62-9	naphthalene, bis(1-methylethyl)-	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
39001-02-0	1,2,3,4,6,7,8,9-Octachlorodibenzofuran	EPA Final PBT Rule for TRI; WA PBT List									PBT				PBT															Dec 2011	July 2009	
39156-41-7	2,4-Diaminoanisole sulfate					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec 2011	July 2009	
39227-28-6	1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	EPA Final PBT Rule for TRI; WA PBT List									PBT				PBT															Dec 2011	July 2009	
39365-31-9	2,3,3',4,4',5,5' Heptachlorobiphenyl [Polychlorinated biphenyls (PCBs)]	WA PBT List													PBT															Dec 2011	July 2009	
39489-75-3	phenol, 2,4-dichloro-5-nitro-, carbonate (2:1) (ester)	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
39635-31-9	2,3,3',4,4',5,5'-Heptachlorobiphenyl	EPA Final PBT Rule for TRI									PBT																			Dec 2011	July 2009	
39765-80-5	Trans-Nonachlor						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec 2011	July 2009	
40088-47-9	Benzene, 1,1'-oxybis-, tetrabromo deriv.			Canada PBiT List															PBiT											Dec 2011	July 2009	
40321-76-4	1,2,3,7,8-Pentachlorodibenzo-p-dioxin	EPA Final PBT Rule for TRI; WA PBT List					EU Endocrine Disruptor				PBT				PBT						Category 1 Endocrine Disruptor									Dec 2011	July 2009	
40615-36-9	Benzene, 1,1'-(chlorophenylmethylene)bis[4-methoxy-			Canada PBiT List															PBiT											Dec 2011	July 2009	
41362-82-7	Propanenitrile, 3-[[4-[(5,6-dichloro-2-benzothiazolyl) azo]phenyl]methylamino]-			Canada PBiT List															PBiT											Dec 2011	July 2009	
41556-26-7	Decanedioic acid, bis(1,2,2,6,6-pentamethyl-4-piperidinyl) ester			Canada PBiT List															PBiT											Dec 2011	July 2009	
41604-19-7	1,1'-biphenyl, 4-bromo-2-fluoro-	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
41999-84-2	benzene, 1,4-dichloro-2,5-bis(dichloromethyl)-	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	

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42074-68-0	benzene, 1-chloro-2-(chlorodiphenylmethyl)-	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
42397-64-8	1,6-Dinitropyrene					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec 2011	July 2009	
42397-65-9	1,8-Dinitropyrene					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec 2011	July 2009	
42479-88-9	[1,1'-Biphenyl]-4-ol, 3,4'-bis(1,1-dimethylethyl)-			Canada PBiT List															PBiT											Dec_2011	July 2009	
42576-02-3	benzoic acid, 5-(2,4-dichlorophenoxy)-2-nitro-, methyl ester	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
42739-61-7	Nickel, bis[2,3-bis(hydroxyimino) -N-(2-methoxyphenyl)butanamidato]-			Canada PBiT List															PBiT											Dec_2011	July 2009	
42852-92-6	Acetamide, N-[2-[(2-bromo-4,6-dinitrophenyl) azo]-4-methoxy-5-[(phenylmethyl)-2-propenylamino]phenyl]-			Canada PBiT List															PBiT											Dec_2011	July 2009	
43035-18-3	Benzenesulfonic acid, 4-[[3-[[2-hydroxy-3-[[(4-methoxyphenyl)amino]carbonyl]-1-naphthalenyl]azo] -4-methylbenzoyl]amino]-,			Canada PBiT List															PBiT											Dec_2011	July 2009	
50585-41-6	2,3,7,8-tetrabromodibenzo-pdioxin [Polybrominated dibenzodioxins and furans]	WA PBT List					EU Endocrine Disruptor								PBT						Category 1 Endocrine Disruptor									Dec 2011	July 2009	
50772-29-7	butanoyl chloride, 4-[2,4-bis(1,1-dimethylpropyl)phenoxy]-	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
50849-47-3	benzaldehyde, 2-hydroxy-5-nonyl-, oxime	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
51000-52-3	neodecanoic acid, ethenyl ester	OSPAR Chemicals of Concern; OSPAR Chemicals															PBT	PBT												Dec 2011	July 2009	
51207-31-9	2,3,7,8-Tetrachlorodibenzofuran	EPA Final PBT Rule for TRI; WA PBT List									PBT				PBT															Dec 2011	July 2009	
51775-36-1	2,2,5-endo,6-exo,8,9,10-heptachloronorbornane	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
52179-28-9	propanoic acid, 2-[4-(2,2-dichlorocyclopropyl)phenoxy]-2-methyl-, ethyl ester	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
52434-90-9	1,3,5-triazine-2,4,6(1H,3H,5H)-trione, 1,3,5-tris(2,3-dibromopropyl)-	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
52591-25-0	9,10-Anthracenedione, 2,2'-(1,3,4-oxadiazole-2,5-diyl)bis[1-amino-			Canada PBiT List															PBiT											Dec_2011	July 2009	
52663-72-6	2,3',4,4',5,5'-Hexachlorobiphenyl	EPA Final PBT Rule for TRI; WA PBT List									PBT				PBT															Dec 2011	July 2009	
52671-38-2	9,10-Anthracenedione, 2,2'-[1,4-phenylenebis(1,3,4-oxadiazole-5,2-diyl)]bis[1-amino-			Canada PBiT List															PBiT											Dec_2011	July 2009	
52697-38-8	Acetamide, N-[2-[(2-bromo-4,6-dinitrophenyl) azo]-5-(diethylamino)phenyl]-			Canada PBiT List															PBiT											Dec_2011	July 2009	
52740-90-6	2-anthracenecarboxamide, 1-amino-N-(3-bromo-9,10-dihydro-9,10-dioxo-2-anthracenyl)-9,10-dihydro-9,10-dioxo-	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
53184-75-1	Phosphorous acid, (1-methylethylidene)di-4,1-phenylene tetrakis[(3-ethyl-3-oxetanyl)methyl] ester			Canada PBiT List															PBiT											Dec_2011	July 2009	
53469-21-9	PCB Aroclor 1242						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec 2011	July 2009	
53742-07-7	1,1'-biphenyl, nonachloro-	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
53905-33-2	4-Hydroxy-2,2',5'-trichlorobiphenyl						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec 2011	July 2009	
53973-98-1	Polygeenan					CA Prop 65														cancer										Dec 2011	July 2009	
54079-53-7	Propanedinitrile, [[4-[[2-(4-cyclohexylphenoxy) ethyl]ethylamino]-2-methylphenyl]methylene]-			Canada PBiT List															PBiT											Dec_2011	July 2009	
54079-60-6	Propanedinitrile, [[4-[[2-(2-cyclohexylphenoxy) ethyl]ethylamino]-2-methylphenyl]methylene]-			Canada PBiT List															PBiT											Dec_2011	July 2009	
54243-60-6	9,10-Anthracenedione, 1-amino-4-hydroxy-2-(4-methoxyphenoxy)-			Canada PBiT List															PBiT											Dec_2011	July 2009	
54991-93-4	Clophen A30						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec 2011	July 2009	
55252-53-4	Acetamide, N-[2-[(2-cyano-6-iodo-4-nitrophenyl) azo]-5-(diethylamino)phenyl]-			Canada PBiT List															PBiT											Dec_2011	July 2009	
55281-26-0	Propanenitrile, 3-[[4-[(2,6-dibromo-4-nitrophenyl) azo]phenyl]ethylamino]-			Canada PBiT List															PBiT											Dec_2011	July 2009	
55525-54-7	3,3'-(ureylenedimethylene)bis(3,5,5-trimethylcyclohexyl) diisocyanate	OSPAR Chemicals of Concern; OSPAR Chemicals															PBT	PBT												Dec_2011	July 2009	
55619-18-6	Ethanol, 2,2'-[[4-[(2,6-dibromo-4-nitrophenyl)azo]phenyl]imino]bis-, diacetate (ester)			Canada PBiT List															PBiT											Dec_2011	July 2009	
55673-89-7	1,2,3,4,7,8,9-Heptachlorodibenzofuran	EPA Final PBT Rule for TRI; WA PBT List									PBT				PBT															Dec 2011	July 2009	
55702-46-0	PCB 21 (2,3,4-Trichlorobiphenyl)						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec 2011	July 2009	
55738-54-0	trans-2-[(Dimethylamino)methylimino]-5-[2-(5-nitro-2-furyl)vinyl]-1,3,4-oxadiazole					CA Prop 65														cancer										Dec 2011	July 2009	
56296-78-7	benzenepropanamine, N-methyl-.gamma.-[4-(trifluoromethyl)phenoxy]-, hydrochloride	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
56307-70-1	Benzenediazonium, 2-methoxy-4-nitro-, salt with naphthalenedisulfonic acid (2:1)			Canada PBiT List															PBiT											Dec_2011	July 2009	
56532-53-7	Acetamide, N-[2-[(2,6-dicyano-4-nitrophenyl) azo]-5-(dipropylamino)phenyl]-			Canada PBiT List															PBiT											Dec 2011	July 2009	
56614-97-2	3,9-Dihydroxybenz(a)anthracene						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec_2011	July 2009	
57018-52-7	Propylene glycol mono-t-butyl ether					CA Prop 65														cancer										Dec 2011	July 2009	
57117-31-4	2,3,4,7,8-Pentachlorodibenzofuran	EPA Final PBT Rule for TRI; WA PBT List					EU Endocrine Disruptor				PBT				PBT						Category 1 Endocrine Disruptor									Dec 2011	July 2009	
57117-41-6	1,2,3,7,8-Pentachlorodibenzofuran	EPA Final PBT Rule for TRI; WA PBT List									PBT				PBT															Dec 2011	July 2009	
57117-44-9	1,2,3,6,7,8-Hexachlorodibenzofuran	EPA Final PBT Rule for TRI; WA PBT List									PBT				PBT															Dec 2011	July 2009	

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57465-28-8	3,3',4,4',5-Pentachlorobiphenyl	EPA Final PBT Rule for TRI					EU Endocrine Disruptor				PBT										Category 1 Endocrine Disruptor									Dec 2011	July 2009	
57648-21-2	1-butanone, 4-[4-(2,3-dihydro-2-thioxo-1	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
57653-85-7	1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	EPA Final PBT Rule for TRI				IRIS					PBT														B2					Dec 2011	July 2009	
57808-65-8	benzamide, N-[5-chloro-4-[(4-chlorophenyl)cyanomethyl]-2-methylphenyl]-2-hydroxy-3,5-diiodo-	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
57835-92-4	4-Nitropyrene					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec 2011	July 2009	
58019-27-5	Anthra[9,1,2-cde]benzo[rst]pentaphene-5,10-dione, diamino-			Canada PBiT List															PBiT											Dec_2011	July 2009	
58138-08-2	oxirane, 2-(3,5-dichlorophenyl)-2-(2,2,2-trichloroethyl)-	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
58161-93-6	Benzoic acid, 4-[1-[[(2,4-dichlorophenyl) amino]carbonyl]-3,3-dimethyl-2-oxobutoxy]-			Canada PBiT List															PBiT											Dec_2011	July 2009	
59447-55-1	2-propenoic acid, (pentabromophenyl)methyl ester	OSPAR Chemicals of Concern; OSPAR Chemicals															PBT	PBT												Dec 2011	July 2009	
59467-70-8	4H-imidazo[1,5-a][1,4]benzodiazepine, 8-chloro-6-(2-fluorophenyl)-1-methyl-	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
59487-23-9	2-Naphthalenecarboxamide, 4-[[5-[[[4-(aminocarbonyl) phenyl]amino]carbonyl]-2-methoxyphenyl]azo]-N-(5 -chloro-2,4-			Canada PBiT List															PBiT											Dec 2011	July 2009	
59536-65-1	Hexabromobiphenyl	WA PBT List													PBT															Dec_2011	July 2009	
59583-77-6	Carbamic acid, (3,4-dichlorophenyl)-, 2-[butyl[4-(2,2-dicyanoethenyl) -3-methylphenyl]amino]ethyl ester			Canada PBiT List															PBiT											Dec 2011	July 2009	
59709-10-3	Pyridinium, 1-[2-[[4-[(2-chloro-4-nitrophenyl) azo]phenyl]ethylamino]ethyl]-, acetate			Canada PBiT List															PBiT											Dec_2011	July 2009	
59709-38-5	b-Alanine, N-[4-[(2-bromo-6-chloro-4-nitrophenyl)azo]phenyl]-N-(3-methoxy-3-oxopropyl)-, methyl ester			Canada PBiT List															PBiT											Dec 2011	July 2009	
60153-49-3	3-(N-Nitrosomethylamino) propionitrile					CA Prop 65														cancer										Dec_2011	July 2009	
60352-98-9	1-Propanaminium, 3-[[4-[(2,4-dimethylphenyl) amino]-9,10-dihydro-9,10-dioxo-1-anthracenyl]amino]-N,N,N-trimethyl-, methyl			Canada PBiT List															PBiT											Dec 2011	July 2009	
60391-92-6	N-Carboxymethyl-N-nitrosourea					CA Prop 65														cancer										Dec_2011	July 2009	
60851-34-5	2,3,4,6,7,8-Hexachlorodibenzofuran	EPA Final PBT Rule for TRI; WA PBT List									PBT				PBT															Dec 2011	July 2009	
61788-33-8	terphenyl, chlorinated	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
61788-76-9	Alkanes, chloro			Canada PBiT List															PBiT											Dec 2011	July 2009	
61799-13-1	3-Pyridinecarbonitrile, 5-[(2-cyano-4-nitrophenyl) azo]-2-[(2-hydroxyethyl)amino]-4-methyl-6-[[3-(2 -phenoxyethoxy)propyl]amino]-			Canada PBiT List															PBiT											Dec_2011	July 2009	
62450-06-0	Trp-P-1 (Tryptophan-P-1)					CA Prop 65														cancer										Dec 2011	July 2009	
62450-07-1	Trp-P-2 (Tryptophan-P-2)					CA Prop 65														cancer										Dec_2011	July 2009	
62625-32-5	Phenol, 4,4'-(3H-1,2-benzoxathiol- 3-ylidene)bis[2,6-dibromo-3-methyl-, S,S-dioxide, monosodium salt			Canada PBiT List															PBiT											Dec 2011	July 2009	
63133-84-6	1(2H)-Quinolineethanol, 6-[(2-chloro-4,6-dinitrophenyl) azo]-3,4-dihydro-2,2,4,7-tetramethyl-			Canada PBiT List															PBiT											Dec_2011	July 2009	
63134-15-6	Acetamide, N-[5-(dipropylamino)-2-[[5-(ethylthio)-1,3,4-thiadiazol-2-yl]azo]phenyl]-			Canada PBiT List															PBiT											Dec 2011	July 2009	
63281-10-7	3-Pyridinecarbonitrile, 5-[[2-chloro-4-(methylsulfonyl) phenyl]azo]-4-methyl-2,6-bis[[3-(2-phenoxyethoxy)propyl]amino]-			Canada PBiT List															PBiT											Dec_2011	July 2009	
63449-39-8	paraffin waxes and hydrocarbon waxes, chlorinated	OSPAR Chemicals of Concern		Canada PBiT List													PBT		PBiT											Dec 2011	July 2009	
63467-15-2	1(2H)-Quinolinepropanamide, 6-(2,2-dicyanoethenyl)-3, 4-dihydro-2,2,4,7-tetramethyl-N-phenyl-			Canada PBiT List															PBiT											Dec_2011	July 2009	
63467-19-6	Propanedinitrile, [[1,2,3,4-tetrahydro-2,2, 4-trimethyl-1-[2-[[(phenylamino)carbonyl]oxy]ethyl]-6-quinolinyl]methylene]-			Canada PBiT List															PBiT											Dec 2011	July 2009	
63833-78-3	3-Pyridinecarbonitrile, 5-[(2-cyano-4-nitrophenyl) azo]-6-[(2-hydroxyethyl)amino]-4-methyl-2-[[3-(2 -phenoxyethoxy)propyl]amino]-			Canada PBiT List															PBiT											Dec_2011	July 2009	
64086-95-9	9,10-Anthracenedione, 1-amino-2-bromo-4-[[4-[(1-methylethyl)amino]-6-phenyl-1,3,5-triazin-2-yl]amino]-			Canada PBiT List															PBiT											Dec 2011	July 2009	
64086-96-0	9,10-Anthracenedione, 2-acetyl-1-amino-4-[[4-[(1-methylethyl)amino]-6-phenyl-1,3,5-triazin-2-yl]amino]-			Canada PBiT List															PBiT											Dec_2011	July 2009	
64091-91-4	4-(N-Nitrosomethylamino)-1-(3-pyridyl)1-butanone					CA Prop 65; IARC; NTP 11th ROC														cancer		Group 1					Reasonably anticipated			Dec_2011	July 2009	
64111-81-5	Triclosan			Canada PBiT List															PBiT										P(A)(O)	Dec 2011	July 2009	NSPIRS 2011, TOXNET
64131-85-7	phosphorothioic acid, O,O,O-tris(4-nitrophenyl) ester	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
64325-78-6	Adenosine, N-benzoyl-5'-O-[bis(4-methoxyphenyl) phenylmethyl]-2'-deoxy-			Canada PBiT List															PBiT											Dec 2011	July 2009	
64338-16-5	7-Oxa-3,20-diazadispiro[5.1.11.2] heneicosan-21-one, 2,2,4,4-tetramethyl-			Canada PBiT List															PBiT											Dec 2011	July 2009	
64365-17-9	Resin acids and Rosin acids, hydrogenated, esters with pentaerythritol			Canada PBiT List															PBiT											Dec 2011	July 2009	
64381-97-1	1,4-benzenediamine, N,N,N'-tris(1-methylpropyl)-	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
64741-42-0	Naphtha (petroleum), full-range straight-run			Canada PBiT List															PBiT											Dec 2011	July 2009	
64741-47-5	Natural gas condensates (petroleum)			Canada PBiT List															PBiT											Dec 2011	July 2009	
64741-50-0	Distillates (petroleum), light paraffinic, Unrefined or mildly refined baseoil					EU Carcinogen																	Category 1 carcinogen							Dec 2011	July 2009	
64741-51-1	Distillates (petroleum), heavy paraffinic, Unrefined or mildly refined baseoil					EU Carcinogen																	Category 1 carcinogen							Dec 2011	July 2009	

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CAS	Chemical of Concern Name	TYPE OF TOXICITY: (Persistent Bioaccumulative and Toxic) PBT	(Very Persistent and Very Bioaccumulative) vPvB	(Persistent, Bioaccumulative and inherently Toxic) PBiT	(Carcinogenic, Mutagenic and Reproductive (Toxicants)) CMR	Carcinogen	Endocrine Disruptor	Developmental Toxicant	Reproductive Toxicant	Equivalent Level of Concern	ORIGINATING LIST: EPA Final PBT Rule for TRI	TRI PBT Chemical List	EPA Priority PBT	NWM Priority Chemicals (PBTs)	WA PBT List	EU PBT List	OSPAR Chemicals of Concern	OSPAR Chemicals for Priority Action	Canada PBiT List	CA Prop 65	EU Endocrine Disruptor	IARC	EU Carcinogen	EU Reproductive Toxicant	IRIS	REACH Substances of Very High Concern	NTP 11th/13th ROC	NTP CERHR	Pesticide Notation	Source list last reviewed	Date Listed	Source
64741-52-2	Distillates (petroleum), light naphthenic, Unrefined or mildly refined baseoil					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
64741-53-3	Distillates (petroleum), heavy naphthenic, Unrefined or mildly refined baseoil					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
64741-58-8	Gas oils (petroleum), light vacuum			Canada PBiT List															PBiT											Dec_2011	July 2009	
64741-61-3	Distillates (petroleum), heavy catalytic cracked			Canada PBiT List															PBiT											Dec_2011	July 2009	
64741-67-9	Residues (petroleum), catalytic reformer fractionator			Canada PBiT List															PBiT											Dec_2011	July 2009	
64741-78-2	Naphtha (petroleum), heavy hydrocracked			Canada PBiT List															PBiT											Dec_2011	July 2009	
64741-81-7	Distillates (petroleum), heavy thermal cracked			Canada PBiT List															PBiT											Dec_2011	July 2009	
64741-83-9	Naphtha (petroleum), heavy thermal cracked			Canada PBiT List															PBiT											Dec_2011	July 2009	
64741-85-1	Raffinates (petroleum), sorption process			Canada PBiT List															PBiT											Dec_2011	July 2009	
64741-87-3	Naphtha (petroleum), sweetened			Canada PBiT List															PBiT											Dec_2011	July 2009	
64742-18-3	Distillates (petroleum), acid-treated heavy naphthenic, Unrefined or mildly refined baseoil					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
64742-19-4	Distillates (petroleum), acid-treated light naphthenic, Unrefined or mildly refined baseoil					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
64742-20-7	Distillates (petroleum), acid-treated heavy paraffinic, Unrefined or mildly refined baseoil					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
64742-21-8	Distillates (petroleum), acid-treated light paraffinic, Unrefined or mildly refined baseoil					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
64742-22-9	Naphtha (petroleum), chemically neutralized heavy			Canada PBiT List															PBiT											Dec_2011	July 2009	
64742-27-4	Distillates (petroleum), chemically neutralized heavy paraffinic, Unrefined or mildly refined baseoil					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
64742-28-5	Distillates (petroleum), chemically neutralized light paraffinic, Unrefined or mildly refined baseoil					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
64742-34-3	Distillates (petroleum), chemically neutralized heavy naphthenic, Unrefined or mildly refined baseoil					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
64742-35-4	Distillates (petroleum), chemically neutralized light naphthenic, Unrefined or mildly refined baseoil					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
64742-48-9	Naphtha (petroleum), hydrotreated heavy			Canada PBiT List															PBiT											Dec_2011	July 2009	
64742-59-2	Gas oils (petroleum), hydrotreated vacuum			Canada PBiT List															PBiT											Dec_2011	July 2009	
64742-66-1	Naphtha (petroleum), catalytic dewaxed			Canada PBiT List															PBiT											Dec_2011	July 2009	
64742-82-1	Naphtha (petroleum), hydrodesulfurized heavy			Canada PBiT List															PBiT											Dec_2011	July 2009	
64742-87-6	Gas oils (petroleum), hydrodesulfurized light vacuum			Canada PBiT List															PBiT											Dec_2011	July 2009	
64742-90-1	Residues (petroleum), steam-cracked			Canada PBiT List															PBiT											Dec_2011	July 2009	
65140-91-2	Phosphonic acid, [[3,5-bis(1,1-dimethylethyl)-4-hydroxyphenyl]methyl]-, monoethyl ester, calcium salt (2:1)			Canada PBiT List															PBiT											Dec_2011	July 2009	
65148-83-6	o,p'-DDA-glycinat = N-[(2-chlorophenyl)(4-chlorophenyl)acetyl]glycin						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec_2011	July 2009	
65277-42-1	Ketoconazol						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec_2011	July 2009	
65294-17-9	methylium, tris[4-(dimethylamino)phenyl]-, salt with 3-[[4-(phenylamino)phenyl]azo]benzenesulfonic acid	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
65510-44-3	2',3,4,4',5-Pentachlorobiphenyl	EPA Final PBT Rule for TRI									PBT																			Dec_2011	July 2009	
65925-28-2	benzene, 1-[2-(2-chloroethoxy)ethoxy]-4-(1,1,3,3-tetramethylbutyl)-	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
65996-89-6	Coal tar, Tar, coal, high-temp.					EU Carcinogen; NTP 11th																	Category 1 carcinogen				Known			Dec_2011	July 2009	
65996-90-9	Coal oil, Tar, coal, low-temp.					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
65996-93-2	Pitch, coal tar, hightemp.	EU PBT List				IARC; NTP 11th ROC										Fulfilling PBT crit eria						Group 1					Known			Dec_2011	July 2009	
65997-06-0	Rosin, hydrogenated			Canada PBiT List															PBiT											Dec_2011	July 2009	
65997-13-9	Resin acids and Rosin acids, hydrogenated, esters with glycerol			Canada PBiT List															PBiT											Dec_2011	July 2009	
66733-21-9	Erionite					CA Prop 65; IARC; NTP 11th ROC														cancer		Group 1					Known			Dec_2011	July 2009	
67124-09-8	2-propanol, 1-(tert-dodecylthio)-	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
67219-55-0	Cytidine, N-benzoyl-5'-O-[bis(4-methoxyphenyl) phenylmethyl]-2'-deoxy-			Canada PBiT List															PBiT											Dec_2011	July 2009	
67562-39-4	1,2,3,4,6,7,8-Heptachlorodibenzofuran	EPA Final PBT Rule for TRI; WA PBT List									PBT				PBT															Dec_2011	July 2009	
67651-34-7	4-Hydroxy-2',3',4',5'-tetrachlorobiphenyl						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec_2011	July 2009	
67651-37-0	3-Hydroxy-2',3',4',5'-tetrachlorobiphenyl						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec_2011	July 2009	
67701-37-5	Stannane, [(2-octyl-1,4-dioxo-1,4-butanediyl) bis(oxy)]bis[tributyl-			Canada PBiT List															PBiT											Dec_2011	July 2009	
67730-10-3	Glu-P-2 (2-Aminodipyrido[1,2-a:3',2'-d]imidazole)					CA Prop 65														cancer										Dec_2011	July 2009	
67730-11-4	Glu-P-1 (2-Amino-6-methyldipyrido[1,2- a:3',2'-d]imidazole)					CA Prop 65														cancer										Dec_2011	July 2009	

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67733-57-7	2,3,7,8-tetrabromodibenzofuran [Polybrominated dibenzodioxins and furans]	WA PBT List													PBT															Dec 2011	July 2009	
67940-02-7	1-Heptanesulfonamide, N-[3-(dimethylamino)propyl] - 1,1,2,2,3,3,4,4,5,5,6,6,7,7,7-pentadecafluoro- ,			Canada PBiT List															PBiT											Dec 2011	July 2009	
67969-69-1	1-octanesulfonamide, N-ethyl-1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro-N-[2-(phosphonooxy)ethyl]-, diammonium salt	OSPAR Chemicals of Concern		Canada PBiT List													PBT		PBiT											Dec 2011	July 2009	
68006-83-7	Me-A-alpha-C (2-Amino-3-methyl-9H-pyrido[2,3-b]indole)					CA Prop 65														cancer										Dec 2011	July 2009	
68015-60-1	benzenesulfonic acid, 2-amino-, (1-methylethylidene)di-4,1-phenylene ester	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
68083-48-7	2-butanone, O-[[[[1,3,3-trimethyl-5-[[[[(1-methylpropylidene)amino]oxy]carbonyl]amino]cyclohexyl]methyl]amino]carbonyl]oxime	OSPAR Chemicals of Concern															PBT													Dec 2011	July 2009	
68131-75-9	Gases (petroleum), C.sb.3-4.sb., Petroleum gas, [A complex combination of hydrocarbons produced by distillation of products from the cracking of					EU Carcinogen																	Category 1 carcinogen							Dec 2011	July 2009	
68214-66-4	Carbamic acid, [2-[(2-chloro-4-nitrophenyl) azo]-5-(diethylamino)phenyl]-, 2-ethoxyethyl ester			Canada PBiT List															PBiT											Dec 2011	July 2009	
68227-79-2	Benzenesulfonic acid, 2-[[9,10-dihydro-4-[(4-methylphenyl) amino]-9,10-dioxo-1-anthracenyl]amino] -5-methyl-, monoammonium			Canada PBiT List															PBiT											Dec 2011	July 2009	
68259-07-4	1-Heptanesulfonic acid, 1,1,2,2,3,3,4,4,5,5,6,6,7,7,7-pentadecafluoro-, ammonium salt			Canada PBiT List															PBiT											Dec 2011	July 2009	
68259-14-3	1-Heptanesulfonamide, 1,1,2,2,3,3,4,4,5,5,6,6,7,7,7-pentadecafluoro-N-methyl-			Canada PBiT List															PBiT											Dec 2011	July 2009	
68259-15-4	1-Hexanesulfonamide, 1,1,2,2,3,3,4,4,5,5,6,6,6-tridecafluoro-N-methyl-			Canada PBiT List															PBiT											Dec 2011	July 2009	
68298-13-5	1-Pentanesulfonamide, 1,1,2,2,3,3,4,4,5,5,5-undecafluoro-N-methyl-			Canada PBiT List															PBiT											Dec 2011	July 2009	
68307-98-2	Petroleum gas, Tail gas (petroleum), catalytic cracked distillate and catalytic cracked naphtha fractionation absorber, [The complex combination					EU Carcinogen																	Category 1 carcinogen							Dec 2011	July 2009	
68307-99-3	Petroleum gas, Tail gas (petroleum), catalytic polymn. naphtha fractionation stabilizer, [A complex combination of hydrocarbons from the					EU Carcinogen																	Category 1 carcinogen							Dec 2011	July 2009	
68308-00-9	Petroleum gas, Tail gas (petroleum), catalytic reformed naphtha fractionation stabilizer, hydrogen sulfide-free, [A complex combination of					EU Carcinogen																	Category 1 carcinogen							Dec 2011	July 2009	
68308-01-0	Petroleum gas, Tail gas (petroleum), cracked distillate hydrotreater stripper, [A complex combination of hydrocarbons obtained by treating					EU Carcinogen																	Category 1 carcinogen							Dec 2011	July 2009	
68308-03-2	Petroleum gas, Tail gas (petroleum), gas oil catalytic cracking absorber, [A complex combination of hydrocarbons obtained from the					EU Carcinogen																	Category 1 carcinogen							Dec 2011	July 2009	
68308-04-3	Petroleum gas, Tail gas (petroleum), gas recovery plant, [A complex combination of hydrocarbons from the distillation of products from					EU Carcinogen																	Category 1 carcinogen							Dec 2011	July 2009	
68308-05-4	Petroleum gas, Tail gas (petroleum), gas recovery plant deethanizer, [A complex combination of hydrocarbons from the distillation of products					EU Carcinogen																	Category 1 carcinogen							Dec 2011	July 2009	
68308-06-5	Petroleum gas, Tail gas (petroleum), hydrodesulfurized distillate and hydrodesulfurized naphtha fractionator, acid-free, [A complex					EU Carcinogen																	Category 1 carcinogen							Dec 2011	July 2009	
68308-07-6	Petroleum gas, Tail gas (petroleum), hydrodesulfurized vacuum gas oil stripper, hydrogen sulfide-free, [A complex combination of					EU Carcinogen																	Category 1 carcinogen							Dec 2011	July 2009	
68308-08-7	Petroleum gas, Tail gas (petroleum), isomerized naphtha fractionation stabilizer, [A complex combination of hydrocarbons obtained from the					EU Carcinogen																	Category 1 carcinogen							Dec 2011	July 2009	
68308-09-8	Tail gas (petroleum), light straight-run naphtha stabilizer, hydrogen sulfide-free, [A complex combination of hydrocarbons obtained from					EU Carcinogen																	Category 1 carcinogen							Dec 2011	July 2009	
68308-10-1	Petroleum gas, Tail gas (petroleum), straight-run distillate hydrodesulfurizer, hydrogen sulfide-free, [A complex combination of hydrocarbons obtained					EU Carcinogen																	Category 1 carcinogen							Dec 2011	July 2009	
68308-11-2	Petroleum gas, Tail gas (petroleum), propane-propylene alkylation feed prep deethanizer, [A complex combination of hydrocarbons obtained					EU Carcinogen																	Category 1 carcinogen							Dec 2011	July 2009	
68308-12-3	Petroleum gas, Tail gas (petroleum), vacuum gas oil hydrodesulfurizer, hydrogen sulfide-free, [A complex combination of hydrocarbons obtained					EU Carcinogen																	Category 1 carcinogen							Dec 2011	July 2009	
68308-34-9	Shale-oils					CA Prop 65; IARC														cancer		Group 1								Dec 2011	July 2009	
68308-48-5	Amines, tallow alkyl, ethoxylated, phosphates			Canada PBiT List															PBiT											Dec 2011	July 2009	
68333-22-2	Residues (petroleum), atmospheric			Canada PBiT List															PBiT											Dec 2011	July 2009	
68391-08-2	Alcohols, C8-14, γ-ω-perfluoro			Canada PBiT List															PBiT											Dec 2011	July 2009	
68400-36-2	2,7-Naphthalenedisulfonic acid, 4-amino-5-hydroxy-6-[[4'- [(4-hydroxyphenyl)azo]-3,3'-dimethyl[1,1'-biphenyl]-4-yl]azo]-3-[(4-			Canada PBiT List															PBiT											Dec 2011	July 2009	
68409-99-4	Gases (petroleum), catalytic cracked overheads, Petroleum gas, [A complex combination of hydrocarbons produced by the distillation of					EU Carcinogen																	Category 1 carcinogen							Dec 2011	July 2009	
68410-00-4	Distillates (petroleum), crude oil			Canada PBiT List															PBiT											Dec 2011	July 2009	
68412-48-6	2-Propanone, reaction products with diphenylamine			Canada PBiT List															PBiT											Dec 2011	July 2009	
68412-68-0	Phosphonic acid, perfluoro-C6-12-alkyl derivs.			Canada PBiT List															PBiT											Dec 2011	July 2009	
68443-10-7	Amines, C18-22-tert-alkyl, ethoxylated			Canada PBiT List															PBiT											Dec 2011	July 2009	
68475-57-0	Alkanes, C.sb.1-2.sb., Petroleum gas					EU Carcinogen																	Category 1 carcinogen							Dec 2011	July 2009	
68475-58-1	Alkanes, C.sb.2-3.sb., Petroleum gas					EU Carcinogen																	Category 1 carcinogen							Dec 2011	July 2009	
68475-59-2	Alkanes, C.sb.3-4.sb., petroleum gas					EU Carcinogen																	Category 1 carcinogen							Dec 2011	July 2009	
68475-60-5	Alkanes, C.sb.4-5.sb., Petroleum gas					EU Carcinogen																	Category 1 carcinogen							Dec 2011	July 2009	
68476-26-6	Fuel gases, Petroleum gas, [A combination of light gases. It consists predominantly of hydrogen and/or low molecular weight hydrocarbons.]					EU Carcinogen																	Category 1 carcinogen							Dec 2011	July 2009	
68476-29-9	Fuel gases, crude oil of distillates, Petroleum gas, [A complex combination of light gases produced by distillation of crude oil and by catalytic					EU Carcinogen																	Category 1 carcinogen							Dec 2011	July 2009	
68476-31-3	Fuel oil, no. 4			Canada PBiT List															PBiT											Dec 2011	July 2009	
68476-40-4	Hydrocarbons, C.sb.3-4.sb., Petroleum gas					EU Carcinogen																	Category 1 carcinogen							Dec 2011	July 2009	

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68476-42-6	Hydrocarbons, C.sb.4-5.sb., Petroleum gas					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68476-44-8	Hydrocarbons, C$<G3			Canada PBiT List															PBiT											Dec_2011	July 2009	
68476-46-0	Hydrocarbons, C3-11, catalytic cracker distillates			Canada PBiT List															PBiT											Dec_2011	July 2009	
68476-49-3	Hydrocarbons, C.sb.2-4.sb., C.sb.3.sb.-rich, Petroleum gas					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68476-77-7	Lubricating oils, refined used			Canada PBiT List															PBiT											Dec_2011	July 2009	
68476-85-7	Petroleum gas, Petroleum gases, liquefied, [A complex combination of hydrocarbons produced by the distillation of crude oil. It consists of					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68476-86-8	Petroleum gas, Petroleum gases, liquefied, sweetened, [A complex combination of hydrocarbons obtained by subjecting liquefied					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68477-33-8	Petroleum gas, [A complex combination of hydrocarbons from the distillation of saturated and unsaturated hydrocarbons usually ranging in					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68477-35-0	Distillates (petroleum), C.sb.3-6.sb., piperylene-rich, Petroleum gas, [A complex combination of hydrocarbons from the distillation of saturated and					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68477-65-6	Gases (petroleum), amine system feed, Refinery gas, [The feed gas to the amine system for removal of hydrogen sulfide. It consists of hydrogen.					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68477-66-7	Gases (petroleum), benzene unit hydrodesulfurizer off, Refinery gas, [Off gases produced by the benzene unit. It consists primarily of hydrogen.					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68477-67-8	Gases (petroleum), benzene unit recycle, hydrogen-rich, Refinery gas, [A complex combination of hydrocarbons obtained by recycling the gases of					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68477-68-9	Gases (petroleum), blend oil, hydrogen-nitrogen-rich, Refinery gas, [A complex combination of hydrocarbons obtained by distillation of a blend					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68477-69-0	Gases (petroleum), butane splitter overheads, Petroleum gas, [A complex combination of hydrocarbons obtained from the distillation of the					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68477-70-3	Gases (petroleum), C.sb.2-.sb., Petroleum gas, [A complex combination of hydrocarbons produced by the distillation of products from a catalytic					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68477-71-4	Gases (petroleum), catalytic-cracked gas oil depropanizer bottoms, C.sb.4.sb.-rich acid-free, Petroleum gas, [A complex combination of					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68477-72-5	Gases (petroleum), catalytic-cracked naphtha debutanizer bottoms, C.sb.3-5.sb.-rich, Petroleum gas, [A complex combination of hydrocarbons					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68477-73-6	Gases (petroleum), catalytic cracked naphtha depropanizer overhead, C.sb.3.sb.-rich acid-free, Petroleum gas, [A complex combination of					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68477-74-7	Gases (petroleum), catalytic cracker, Petroleum gas, [A complex combination of hydrocarbons produced by the distillation of the products from a					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68477-75-8	Gases (petroleum), catalytic cracker, C.sb.1-5.sb.-rich, Petroleum gas, [A complex combination of hydrocarbons produced by the distillation of					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68477-76-9	Gases (petroleum), catalytic polymd. naphtha stabilizer overhead, C.sb.2-4.sb.-rich, Petroleum gas, [A complex combination of hydrocarbons					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68477-77-0	Gases (petroleum), catalytic reformed naphtha stripper overheads, Refinery gas, [A complex combination of hydrocarbons obtained from					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68477-79-2	Gases (petroleum), catalytic reformer, C.sb.1-4.sb.-rich, Petroleum gas, [A complex combination of hydrocarbons produced by distillation of products					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68477-80-5	Gases (petroleum), C.sb.6-8.sb. catalytic reformer recycle, Refinery gas, [A complex combination of hydrocarbons produced by distillation of products					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68477-81-6	Gases (petroleum), C.sb.6-8.sb. catalytic reformer, Refinery gas, [A complex combination of hydrocarbons produced by distillation of products					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68477-82-7	Gases (petroleum), C.sb.6-8.sb. catalytic reformer recycle, hydrogen-rich, Refinery gas					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68477-83-8	Gases (petroleum), C.sb.3-5.sb. olefinic-paraffinic alkylation feed, Petroleum gas, [A complex combination of olefinic and paraffinic					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68477-84-9	Gases (petroleum), C.sb.2.sb.-return stream, Refinery gas, [A complex combination of hydrocarbons obtained by the extraction of					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68477-85-0	Gases (petroleum), C.sb.4.sb.-rich, Petroleum gas, [A complex combination of hydrocarbons produced by distillation of products from a					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68477-86-1	Gases (petroleum), deethanizer overheads, Petroleum gas, [A complex combination of hydrocarbons produced from distillation of the gas					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68477-87-2	Gases (petroleum), deisobutanizer tower overheads, Petroleum gas, [A complex combination of hydrocarbons produced by the					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68477-90-7	Gases (petroleum), depropanizer dry, propene-rich, Petroleum gas, [A complex combination of hydrocarbons produced by the distillation of					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68477-91-8	Gases (petroleum), depropanizer overheads, Petroleum gas, [A complex combination of hydrocarbons produced by distillation of products					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68477-92-9	Gases (petroleum), dry sour, gas-concn.-unit-off, Refinery gas, [The complex combination of dry gases from a gas concentration unit. It consists of					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68477-93-0	Gases (petroleum), gas concn. reabsorber distn., Refinery gas, [A complex combination of hydrocarbons produced by distillation of products					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68477-94-1	Gases (petroleum), gas recovery plant depropanizer overheads, Petroleum gas, [A complex combination of hydrocarbons obtained by					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68477-95-2	Gases (petroleum), Girbatol unit feed, Petroleum gas, [A complex combination of hydrocarbons that is used as the feed into the Girbatol unit to remove					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68477-96-3	Gases (petroleum), hydrogen absorber off, Refinery gas, [A complex combination obtained by absorbing hydrogen from a hydrogen rich stream.					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68477-97-4	Gases (petroleum), hydrogen-rich, Refinery gas, [A complex combination separated as a gas from hydrocarbon gases by chilling. It consists					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68477-98-5	A complex combination obtained from recycled hydrotreated blend oil. It consists primarily of hydrogen and nitrogen with various small amounts					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68477-99-6	Gases (petroleum), isomerized naphtha fractionator, C.sb.4.sb.-rich, hydrogen sulfide-free, Petroleum gas					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68478-00-2	Gases (petroleum), recycle, hydrogen-rich, Refinery gas, [A complex combination obtained from recycled reactor gases. It consists primarily of					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68478-01-3	Gases (petroleum), reformer make-up, hydrogen-rich, Refinery gas, [A complex combination obtained from the reformers. It consists primarily					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68478-02-4	Gases (petroleum), reforming hydrotreater, Refinery gas, [A complex combination obtained from the reforming hydrotreating process. It					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68478-03-5	Gases (petroleum), reforming hydrotreater, hydrogen-methane-rich, Refinery gas, [A complex combination obtained from the reforming					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	

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		TYPE OF TOXICITY									ORIGINATING LIST																		Pesticide Notation	Source list last reviewed	Date Listed	Source
CAS	Chemical of Concern Name	(Persistent Bioaccumulative and Toxic) PBT	(Very Persistent and Very Bioaccumulative) vPvB	(Persistent, Bioaccumulative and inherently Toxic) PBiT	(Carcinogenic, Mutagenic and Reproductive (Toxicants)) CMR	Carcinogen	Endocrine Disruptor	Developmental Toxicant	Reproductive Toxicant	Equivalent Level of Concern	EPA Final PBT Rule for TRI	TRI PBT Chemical List	EPA Priority PBT	NWM Priority Chemicals (PBTs)	WA PBT List	EU PBT List	OSPAR Chemicals of Concern	OSPAR Chemicals for Priority Action	Canada PBiT List	CA Prop 65	EU Endocrine Disruptor	IARC	EU Carcinogen	EU Reproductive Toxicant	IRIS	REACH Substances of Very High Concern	NTP 11th/13th ROC	NTP CERHR				
68478-04-6	Gases (petroleum), reforming hydrotreater make-up, hydrogen-rich, Refinery gas, [A complex combination obtained from the reforming					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68478-05-7	Gases (petroleum), thermal cracking distn., Refinery gas, [A complex combination produced by distillation of products from a thermal cracking					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68478-17-1	Residues (petroleum), heavy coker gas oil and vacuum gas oil			Canada PBiT List															PBiT											Dec_2011	July 2009	
68478-21-7	Petroleum gas, Tail gas (petroleum), catalytic cracked clarified oil and thermal cracked vacuum residue fractionation reflux drum, [A complex					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68478-22-8	Petroleum gas, Tail gas (petroleum), catalytic cracked naphtha stabilization absorber, [A complex combination of hydrocarbons obtained					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68478-24-0	Petroleum gas, Tail gas (petroleum), catalytic cracker, catalytic reformer and hydrodesulfurizer combined fractionater, [A complex combination of					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68478-25-1	Refinery gas, Tail gas (petroleum), catalytic cracker refractionation absorber, [A complex combination of hydrocarbons obtained from					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68478-26-2	Petroleum gas, Tail gas (petroleum), catalytic reformed naphtha fractionation stabilizer, [A complex combination of hydrocarbons obtained					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68478-27-3	Refinery gas, Tail gas (petroleum), catalytic reformed naphtha separator, [A complex combination of hydrocarbons obtained from the					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68478-28-4	Refinery gas, Tail gas (petroleum), catalytic reformed naphtha stabilizer, [A complex combination of hydrocarbons obtained from the					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68478-29-5	Refinery gas, Tail gas (petroleum), cracked distillate hydrotreater separator, [A complex combination of hydrocarbons obtained by treating					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68478-30-8	Refinery gas, Tail gas (petroleum), hydrodesulfurized straight-run naphtha separator, [A complex combination of hydrocarbons obtained					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68478-32-0	Petroleum gas, Tail gas (petroleum), saturate gas plant mixed stream, C.sb.4.sb.-rich, [A complex combination of hydrocarbons obtained from the					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68478-33-1	Petroleum gas, Tail gas (petroleum), saturate gas recovery plant, C.sb.1-2.sb.-rich, [A complex combination of hydrocarbons obtained from					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68478-34-2	Petroleum gas, Tail gas (petroleum), vacuum residues thermal cracker, [A complex combination of hydrocarbons obtained from the thermal					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68478-45-5	1,4-Benzenediamine, N,N'-mixed tolyl and xylyl derivs.			Canada PBiT List															PBiT											Dec_2011	July 2009	
68512-30-1	Phenol, methylstyrenated			Canada PBiT List															PBiT											Dec_2011	July 2009	
68512-62-9	Residues (petroleum), light vacuum			Canada PBiT List															PBiT											Dec_2011	July 2009	
68512-91-4	Hydrocarbons, C.sb.3-4.sb.-rich, petroleum distillate, Petroleum gas, [A complex combination of hydrocarbons produced by distillation and					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68513-02-0	Naphtha (petroleum), full-range coker			Canada PBiT List															PBiT											Dec_2011	July 2009	
68513-14-4	Gases (petroleum), catalytic reformed straight-run naphtha stabilizer overheads, Refinery gas, [A complex combination of hydrocarbons obtained					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68513-15-5	Gases (petroleum), full-range straight-run naphtha dehexanizer off, [A complex combination of hydrocarbons obtained by the fractionation of the					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68513-16-6	Gases (petroleum), hydrocracking depropanizer off, hydrocarbon-rich, Petroleum gas, [A complex combination of hydrocarbon produced by the					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68513-17-7	Gases (petroleum), light straight-run naphtha stabilizer off, Petroleum gas, [A complex combination of hydrocarbons obtained by the					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68513-18-8	Gases (petroleum), reformer effluent high-pressure flash drum off, Refinery gas, [A complex combination produced by the high-pressure					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68513-19-9	Gases (petroleum), reformer effluent low-pressure flash drum off, Refinery gas, [A complex combination produced by low-pressure flashing of					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68513-66-6	Petroleum gas, Residues (petroleum), alkylation splitter, C.sb.4.sb.-rich, [A complex residuum from the distillation of streams various refinery					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68514-31-8	Hydrocarbons, C.sb.1-4.sb., Petroleum gas, [A complex combination of hydrocarbons provided by thermal cracking and absorber operations and by					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68514-36-3	Hydrocarbons, C.sb.1-4.sb., sweetened, Petroleum gas, [A complex combination of hydrocarbons obtained by subjecting hydrocarbon gases to a					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68515-49-1	Di-isodecyl phthalate (DIDP)							CA Prop 65												developmental										Dec_2011	July 2009	
68516-64-3	Propanenitrile, 3-[[2-(acetyloxy)ethyl][4- [(2-chloro-4-nitrophenyl)azo]-3-methylphenyl]amino]-			Canada PBiT List															PBiT											Dec_2011	July 2009	
68527-15-1	Gases (petroleum), oil refinery gas distn. off, Refinery gas, [A complex combination separated by distillation of a gas stream containing					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68527-16-2	Hydrocarbons, C.sb.1-3.sb., Petroleum gas, [A complex combination of hydrocarbons having carbon numbers predominantly in the range of					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68527-19-5	Hydrocarbons, C.sb.1-4.sb., debutanizer fraction, Petroleum gas					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68551-44-0	Fatty acids, C6-19-branched, zinc salts			Canada PBiT List															PBiT											Dec_2011	July 2009	
68553-00-4	Fuel oil, no. 6			Canada PBiT List															PBiT											Dec_2011	July 2009	
68555-72-6	1-Pentanesulfonamide, N-ethyl-1,1,2,2,3,3,4,4,5,5,5-undecafluoro-N-(2-hydroxyethyl)-			Canada PBiT List															PBiT											Dec_2011	July 2009	
68555-73-7	1-Heptanesulfonamide, N-ethyl-1,1,2,2,3,3,4,4,5,5,6,6,7,7,7-pentadecafluoro-N-(2-hydroxyethyl)-			Canada PBiT List															PBiT											Dec_2011	July 2009	
68555-75-9	1-Hexanesulfonamide, 1,1,2,2,3,3,4,4,5,5,6,6,6-tridecafluoro-N-(2-hydroxyethyl)-N-methyl-			Canada PBiT List															PBiT											Dec_2011	July 2009	
68555-76-0	1-Heptanesulfonamide, 1,1,2,2,3,3,4,4,5,5,6,6,7,7,7-pentadecafluoro-N-(2-hydroxyethyl)-N-methyl-			Canada PBiT List															PBiT											Dec_2011	July 2009	
68583-58-4	Ethanamine, N-ethyl-N-hydroxy-, reaction products with hexamethylcyclotrisiloxane, silica and 1,1,1-trimethyl-N-(trimethylsilyl)silanamine			Canada PBiT List															PBiT											Dec_2011	July 2009	
68602-82-4	Gases (petroleum), benzene unit hydrotreater depentanizer overheads, Refinery gas, [A complex combination produced by treating the feed from					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68602-83-5	Gases (petroleum), C.sb.1-5.sb., wet, Petroleum gas, [A complex combination of hydrocarbons produced by the distillation of crude oil and/or the					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68602-84-6	Gases (petroleum), secondary absorber off, fluidized catalytic cracker overheads fractionator, Refinery gas, [A complex combination produced					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68606-25-7	Hydrocarbons, C.sb.2-4.sb., Petroleum gas					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	

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68606-26-8	Hydrocarbons, C.sb.3.sb., Petroleum gas					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68606-27-9	Gases (petroleum), alkylation feed, Petroleum gas, [A complex combination of hydrocarbons produced by the catalytic cracking of gas oil. It					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68606-34-8	Gases (petroleum), depropanizer bottoms fractionation off, Petroleum gas, [A complex combination of hydrocarbons obtained from the					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68607-11-4	Petroleum products, refinery gases, Refinery gas, [A complex combination which consists primarily of hydrogen with various small amounts of					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68607-30-7	Residues (petroleum), topping plant, low-sulfur			Canada PBiT List															PBiT											Dec_2011	July 2009	
68648-53-3	Resin acids and Rosin acids, hydrogenated, esters with triethylene glycol			Canada PBiT List															PBiT											Dec_2011	July 2009	
68783-06-2	Gases (petroleum), hydrocracking low-pressure separator, Refinery gas, [A complex combination obtained by the liquid-vapor separation of the					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68783-07-3	Gases (petroleum), refinery blend, Petroleum gas, [A complex combination obtained from various processes. It consists of hydrogen, hydrogen					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68783-08-4	Gas oils (petroleum), heavy atmospheric			Canada PBiT List															PBiT											Dec_2011	July 2009	
68783-12-0	Naphtha (petroleum), unsweetened			Canada PBiT List															PBiT											Dec_2011	July 2009	
68783-64-2	Gases (petroleum), catalytic cracking, Petroleum gas, [A complex combination of hydrocarbons produced by the distillation of the products from a					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68783-65-3	Gases (petroleum), C.sb.2-4.sb., sweetened, Petroleum gas, [A complex combination of hydrocarbons obtained by subjecting a petroleum					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68814-67-5	Gases (petroleum), refinery, Refinery gas, [A complex combination obtained from various petroleum refining operations. It consists of					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68814-90-4	Gases (petroleum), platformer products separator off, Refinery gas, [A complex combination obtained from the chemical reforming of					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68815-10-1	Petroleum, sulfurized			Canada PBiT List															PBiT											Dec_2011	July 2009	
68877-63-4	Acetamide, N-[2-[(2-bromo-4,6-dinitrophenyl) azo]-5-[(2-cyanoethyl)-2-propenylamino]-4 -methoxyphenyl]-			Canada PBiT List															PBiT											Dec_2011	July 2009	
68910-11-2	Benzenemethanol, 3,5-bis(1,1-dimethylethyl)-4-hydroxy-, reaction products with 1,3,5-trimethylbenzene			Canada PBiT List															PBiT											Dec_2011	July 2009	
68911-58-0	Gases (petroleum), hydrotreated sour kerosine depentanizer stabilizer off, Refinery gas, [The complex combination obtained from the					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68911-59-1	Gases (petroleum), hydrotreated sour kerosine flash drum, Refinery gas, [A complex combination obtained from the flash drum of the unit treating					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68918-99-0	Gases (petroleum), crude oil fractionation off, Petroleum gas, [A complex combination of hydrocarbons produced by the fractionation of					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68919-00-6	Gases (petroleum), dehexanizer off, Petroleum gas, [A complex combination of hydrocarbons obtained by the fractionation of combined naphtha streams.					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68919-01-7	Gases (petroleum), distillate unifiner desulfurization stripper off, Refinery gas, [A complex combination stripped from the liquid					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68919-02-8	Gases (petroleum), fluidized catalytic cracker fractionation off, Refinery gas, [A complex combination produced by the fractionation of the					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68919-03-9	Gases (petroleum), fluidized catalytic cracker scrubbing secondary absorber off, Refinery gas, [A complex combination produced by scrubbing the					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68919-04-0	Gases (petroleum), heavy distillate hydrotreater desulfurization stripper off, Refinery gas, [A complex combination stripped from the liquid					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68919-05-1	Gases (petroleum), light straight run gasoline fractionation stabilizer off, Petroleum gas, [A complex combination of hydrocarbons obtained by					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68919-06-2	Gases (petroleum), naphtha unifiner desulfurization stripper off, Petroleum gas, [A complex combination of hydrocarbons produced					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68919-07-3	Gases (petroleum), platformer stabilizer off, light ends fractionation, Refinery gas, [A complex combination obtained by the fractionation of the					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68919-08-4	Gases (petroleum), preflash tower off, crude distn., Refinery gas, [A complex combination produced from the first tower used in the distillation of					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68919-09-5	Gases (petroleum), straight-run naphtha catalytic reforming off, Petroleum gas, [A complex combination of hydrocarbons obtained by the					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68919-10-8	Gases (petroleum), straight-run stabilizer off, Petroleum gas, [A complex combination of hydrocarbons obtained from the fractionation of					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68919-11-9	Gases (petroleum), tar stripper off, Refinery gas, [A complex combination obtained by the fractionation of reduced crude oil. It consists of					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68919-12-0	Gases (petroleum), unifiner stripper off, Refinery gas, [A combination of hydrogen and methane obtained by fractionation of the products from the					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68919-20-0	Gases (petroleum), fluidized catalytic cracker splitter overheads, Petroleum gas, [A complex combination of hydrocarbons produced by the					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68920-70-7	Alkanes, C6-18, chloro			Canada PBiT List															PBiT											Dec_2011	July 2009	
68921-45-9	Benzenamine, N-phenyl-, reaction products with styrene and 2,4,4-trimethylpentene			Canada PBiT List															PBiT											Dec_2011	July 2009	
68937-51-9	Silanamine, 1,1,1-trimethyl-N-(trimethylsilyl)-, reaction products with ammonia, octamethylcyclotetrasiloxane and silica			Canada PBiT List															PBiT											Dec_2011	July 2009	
68938-42-1	Paraffin waxes and Hydrocarbon waxes, chloro, reaction products with naphthalene			Canada PBiT List															PBiT											Dec_2011	July 2009	
68938-51-2	Siloxanes and Silicones, 3-cyanopropyl Me, di-Me			Canada PBiT List															PBiT											Dec_2011	July 2009	
68952-02-3	Siloxanes and Silicones, Me 3,3,3-trifluoropropyl, Me vinyl, hydroxy-terminated			Canada PBiT List															PBiT											Dec_2011	July 2009	
68952-76-1	Gases (petroleum), catalytic cracked naphtha debutanizer, Petroleum gas, [A complex combination of hydrocarbons obtained from					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68952-77-2	Petroleum gas, Tail gas (petroleum), catalytic cracked distillate and naphtha stabilizer, [A complex combination of hydrocarbons obtained by					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68952-79-4	Refinery gas, Tail gas (petroleum), catalytic hydrodesulfurized naphtha separator, [A complex combination of hydrocarbons obtained from the					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68952-80-7	Refinery gas, Tail gas (petroleum), straight-run naphtha hydrodesulfurizer, [A complex combination obtained from the					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68952-81-8	Tail gas (petroleum), thermal-cracked distillate, gas oil and naphtha absorber, [A complex combination of hydrocarbons obtained from the					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	

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68952-82-9	Petroleum gas, Tail gas (petroleum), thermal cracked hydrocarbon fractionation stabilizer, petroleum coking, [A complex combination of					EU Carcinogen																	Category 1 carcinogen							Dec 2011	July 2009	
68953-84-4	1,4-Benzenediamine, N,N'-mixed Ph and tolyl derivs.			Canada PBiT List															PBiT											Dec 2011	July 2009	
68955-27-1	Distillates (petroleum), petroleum residues vacuum			Canada PBiT List															PBiT											Dec 2011	July 2009	
68955-28-2	Gases (petroleum), light steam-cracked, butadiene conc., Petroleum gas, [A complex combination of hydrocarbons produced by the distillation of					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68955-33-9	Gases (petroleum), sponge absorber off, fluidized catalytic cracker and gas oil desulfurizer overhead fractionation, Refinery gas, [A complex					EU Carcinogen																	Category 1 carcinogen							Dec 2011	July 2009	
68955-34-0	Gases (petroleum), straight-run naphtha catalytic reformer stabilizer overhead, Petroleum gas, [A complex combination of hydrocarbons obtained by					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
68957-62-0	1-Heptanesulfonamide, N-ethyl-1,1,2,2,3,3,4,4,5, 5,6,6,7,7,7-pentadecafluoro-			Canada PBiT List															PBiT											Dec 2011	July 2009	
68989-88-8	Gases (petroleum), crude distn. and catalytic cracking, Refinery gas, [A complex combination produced by crude distillation and catalytic					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
69430-47-3	Siloxanes and Silicones, di-Me, reaction products with Me hydrogen siloxanes and 1,1,3,3-tetramethyldisiloxane			Canada PBiT List															PBiT											Dec_2011	July 2009	
69695-75-6	9,10-Anthracenedione, 1-amino-4-[[3-[(dimethylamino) methyl]phenyl]amino]-, monohydrochloride			Canada PBiT List															PBiT											Dec_2011	July 2009	
69782-90-7	2,3,3',4,4',5'-Hexachlorobiphenyl	EPA Final PBT Rule for TRI; WA PBT List									PBT				PBT															Dec_2011	July 2009	
69898-41-5	furo[3,4-b]pyridin-7(5H)-one, 5-[4-(diethylamino)-2-ethoxyphenyl]-5-(1-ethyl-2-methyl-1H-indol-3-yl)-	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
69898-66-4	5-Isobenzofurancarboxylic acid, 3-[4-(diethylamino)-2-ethoxyphenyl] -3-(1-ethyl-2-methyl-1H-indol-3-yl)-1,3 -dihydro-1-oxo-, ethyl			Canada PBiT List															PBiT											Dec_2011	July 2009	
69898-67-5	5-Isobenzofurancarboxylic acid, 1-[4-(diethylamino)-2-ethoxyphenyl] -1-(1-ethyl-2-methyl-1H-indol-3-yl)-1,3 -dihydro-3-oxo-, ethyl			Canada PBiT List															PBiT											Dec_2011	July 2009	
70161-19-2	Benzenesulfonic acid, [(9,10-dihydro-9,10-dioxo-1,4-anthracenediyl)bis(imino-4,1-phenyleneoxy)]bis -, disodium salt			Canada PBiT List															PBiT											Dec_2011	July 2009	
70210-08-1	2-Naphthalenesulfonamide, N-[2-(acetyloxy)ethyl]-6- hydroxy-N-methyl-5-[[4-(phenylazo)phenyl]azo]-			Canada PBiT List															PBiT											Dec_2011	July 2009	
70225-14-8	Diethanolamine salt [Perfluorooctane sulfonates (PFOS)]	WA PBT List		Canada PBiT List											PBT				PBiT											Dec_2011	July 2009	
70225-15-9	1-Heptanesulfonic acid, 1,1,2,2,3,3,4,4,5,5,6,6,7,7,7-pentadecafluoro-, compd. with 2,2'-iminobis[ethanol] (1:1)			Canada PBiT List															PBiT											Dec_2011	July 2009	
70331-94-1	Benzenepropanoic acid, 3,5-bis(1,1-dimethylethyl)-4-hydroxy-, (1,2-dioxo-1,2-ethanediyl) bis(imino-2,1-ethanediyl) ester			Canada PBiT List															PBiT											Dec_2011	July 2009	
70514-12-4	Lubricating oils, used			Canada PBiT List															PBiT											Dec_2011	July 2009	
70592-76-6	Distillates (petroleum), intermediate vacuum			Canada PBiT List															PBiT											Dec_2011	July 2009	
70592-77-7	Distillates (petroleum), light vacuum			Canada PBiT List															PBiT											Dec_2011	July 2009	
70592-78-8	Distillates (petroleum), vacuum			Canada PBiT List															PBiT											Dec_2011	July 2009	
70592-79-9	Residues (petroleum), atm. tower, light			Canada PBiT List															PBiT											Dec_2011	July 2009	
70648-26-9	1,2,3,4,7,8-Hexachlorodibenzofuran	EPA Final PBT Rule for TRI; WA PBT List									PBT				PBT															Dec_2011	July 2009	
70660-55-8	1-Naphthalenamine, 4-[(2-bromo-4,6-dinitrophenyl) azo]-N-(3-methoxypropyl)-			Canada PBiT List															PBiT											Dec_2011	July 2009	
70776-03-3	naphthalene, chloro derivs.	OSPAR Chemicals of Concern		Canada PBiT List													PBT		PBiT											Dec_2011	July 2009	
70776-86-2	2-Butanone, 4-[[[1,2,3,4,4a,9,10,10a- octahydro-1,4a-dimethyl-7-(1-methylethyl)-1-phenanthrenyl]methyl](3-oxo-3-phenylpropyl)amino]-, [1R-			Canada PBiT List															PBiT											Dec_2011	July 2009	
70900-21-9	Siloxanes and Silicones, di-Me, hydrogen-terminated			Canada PBiT List															PBiT											Dec_2011	July 2009	
70969-47-0	Thiols, C8-20, γ-ω-perfluoro, telomers with acrylamide			Canada PBiT List															PBiT											Dec_2011	July 2009	
71032-95-6	2-Naphthalenesulfonic acid, 7-[[4,6-bis[[3-(diethylamino) propyl]amino]-1,3,5-triazin-2-yl]amino]-4-hydroxy -3-[[4-			Canada PBiT List															PBiT											Dec_2011	July 2009	
71720-89-3	2-Naphthalenesulfonic acid, 5-[[4-(4-cyclohexylphenoxy) -2-sulfophenyl]azo]-6-[(2,6-dimethylphenyl)amino]-4-hydroxy-, disodium salt			Canada PBiT List															PBiT											Dec_2011	July 2009	
71832-83-2	2-Naphthalenecarboxylic acid, 4-[(5-chloro-4-methyl-2-sulfophenyl) azo]-3-hydroxy-, magnesium salt (1:1)			Canada PBiT List															PBiT											Dec_2011	July 2009	
72102-55-7	Methylium, [4-(dimethylamino)phenyl] bis[4-(ethylamino)-3-methylphenyl]-, acetate			Canada PBiT List															PBiT											Dec_2011	July 2009	
72102-56-8	Methylium, [4-(dimethylamino)phenyl] bis[4-(ethylamino)-3-methylphenyl]-, chloride			Canada PBiT List															PBiT											Dec_2011	July 2009	
72102-64-8	Methylium, bis[4-(dimethylamino)phenyl] [4-(ethylamino)-3-methylphenyl]-, chloride			Canada PBiT List															PBiT											Dec_2011	July 2009	
72243-90-4	Benzenesulfonic acid, 3-[[4-amino-9,10-dihydro-9,10-dioxo-3-[sulfo-4-(1,1,3,3-tetramethylbutyl)phenoxy]-1-anthracenyl]amino]-			Canada PBiT List															PBiT											Dec_2011	July 2009	
72318-87-7	Phenol, [[[3-(dimethylamino)propyl]amino]methyl]-, isobutylenated			Canada PBiT List															PBiT											Dec_2011	July 2009	
72749-91-8	Benzenesulfonic acid, [(9,10-dihydro-9,10-dioxo-1,4-anthracenediyl)diimino]bis[(1,1-dimethylethyl)-, sodium salt			Canada PBiT List															PBiT											Dec_2011	July 2009	
72812-39-6	Methylium, bis(4-amino-3,5-dimethylphenyl) (2,6-dichlorophenyl)-, phosphate (1:1)			Canada PBiT List															PBiT											Dec_2011	July 2009	
72828-63-8	Benzonitrile, 2-[[4-[[2-(acetyloxy)ethyl] butylamino]-2-methylphenyl]azo]-3-bromo-5-nitro -			Canada PBiT List															PBiT											Dec_2011	July 2009	
72828-64-9	1,3-Benzenedicarbonitrile, 2-[[4-[[2-(acetyloxy)ethyl] butylamino]-2-methylphenyl]azo]-5-nitro-			Canada PBiT List															PBiT											Dec_2011	July 2009	
72828-93-4	1-Propanaminium, 3-[[9,10-dihydro-4-[(4-methylphenyl) amino]-9,10-dioxo-1-anthracenyl]amino] -N,N,N-trimethyl-, methyl			Canada PBiT List															PBiT											Dec_2011	July 2009	
72869-85-3	Chromate(1-), bis[3,5-bis(1,1-dimethylethyl) -2-hydroxybenzoato(2-)-O1,O2]-, hydrogen			Canada PBiT List															PBiT											Dec_2011	July 2009	
72918-21-9	1,2,3,7,8,9-Hexachlorodibenzofuran	EPA Final PBT Rule for TRI; WA PBT List									PBT				PBT															Dec_2011	July 2009	

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CAS	Chemical of Concern Name	TYPE OF TOXICITY (Persistent Bioaccumulative and Toxic) PBT	(Very Persistent and Very Bioaccumulative) vPvB	(Persistent, Bioaccumulative and inherently Toxic) PBiT	(Carcinogenic, Mutagenic and Reproductive (Toxicants)) CMR	Carcinogen	Endocrine Disruptor	Developmental Toxicant	Reproductive Toxicant	Equivalent Level of Concern	ORIGINATING LIST EPA Final PBT Rule for TRI	TRI PBT Chemical List	EPA Priority PBT	NWM Priority Chemicals (PBTs)	WA PBT List	EU PBT List	OSPAR Chemicals of Concern	OSPAR Chemicals for Priority Action	Canada PBiT List	CA Prop 65	EU Endocrine Disruptor	IARC	EU Carcinogen	EU Reproductive Toxicant	IRIS	REACH Substances of Very High Concern	NTP 11th/13th ROC	NTP CERHR	Pesticide Notation	Source list last reviewed	Date Listed	Source
72927-94-7	Benzenamine, 4-[(2,6-dichloro-4-nitrophenyl) azo]-N-(4-nitrophenyl)-			Canada PBiT List															PBiT											Dec_2011	July 2009	
72968-82-2	Methanesulfonamide, N-[2-[(2,6-dicyano-4-methylphenyl) azo]-5-(dipropylamino)phenyl]-			Canada PBiT List															PBiT											Dec_2011	July 2009	
73003-64-2	2,4,10-Trioxa-7-azaundecan-11-oic acid, 7-[4-[(2,6-dichloro-4-nitrophenyl) azo]-3-methylphenyl]-3-oxo-, methyl ester			Canada PBiT List															PBiT											Dec_2011	July 2009	
73398-86-4	Pyridine, 4-(3-chloro-5-propylphenyl)-			Canada PBiT List															PBiT											Dec_2011	July 2009	
73398-87-5	Pyridine, 4-(4-chloro-3-propylphenyl)-			Canada PBiT List															PBiT											Dec_2011	July 2009	
73398-96-6	3-Pyridinecarbonitrile, 5-[(9,10-dihydro-9,10-dioxo- 1-anthracenyl)azo]-2,6-bis[(2-methoxyethyl)amino]-4-methyl-			Canada PBiT List															PBiT											Dec_2011	July 2009	
73528-78-6	3-Pyridinecarbonitrile, 5-[[4-[(2,6-dichloro-4-nitrophenyl) azo]-2,5-dimethoxyphenyl]azo]-2,6-bis[(2 -methoxyethyl)amino]-4-methyl-			Canada PBiT List															PBiT											Dec_2011	July 2009	
74336-60-0	9,10-Anthracenedione, 1-[(5,7-dichloro-1,9-dihydro- 2-methyl-9-oxopyrazolo[5,1-b]quinazolin-3-yl)azo]-			Canada PBiT List															PBiT											Dec_2011	July 2009	
74472-37-0	2,3,4,4',5-Pentachlorobiphenyl	EPA Final PBT Rule for TRI; WA PBT List									PBT				PBT															Dec_2011	July 2009	
75768-65-9	Phosphonium, triphenyl(phenylmethyl)-, salt with 4,4'-[2,2,2-trifluoro-1-(trifluoromethyl)ethylidene]bis[phenol] (1:1)			Canada PBiT List															PBiT											Dec_2011	July 2009	
75908-83-7	Benzenesulfonic acid, oxybis[(1,1,3,3-tetramethylbutyl)-, dipotassium salt			Canada PBiT List															PBiT											Dec_2011	July 2009	
76180-96-6	IQ (2-Amino-3-methylimidazo[4,5-f] quinoline)					CA Prop 65; IARC; NTP 11th ROC														cancer		Group 2A					Reasonably anticipated			Dec_2011	July 2009	
77094-11-2	MeIQ (2-Amino-3,4-dimethylimidazo[4,5-f]quinoline)					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec_2011	July 2009	
77439-76-0	MX (3-chloro-4-dichloromethyl-5-hydroxy-2(5H)-furanone)					CA Prop 65														cancer										Dec_2011	July 2009	
77500-04-0	MeIQx (2-Amino-3,8-dimethylimidazo[4,5-f]quinoxaline)					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec_2011	July 2009	
77536-67-5	asbestos (anthophyllite)					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
77536-68-6	asbestos (tremolite)					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
78952-70-2	Butanamide, 2-[[3,3'-dichloro-4'-[[1- [[(2-chlorophenyl)amino]carbonyl]-2-oxopropyl]azo][1,1'-biphenyl]-4-yl]azo]-N-(2,4-dimethylphenyl)-			Canada PBiT List															PBiT											Dec_2011	July 2009	
79357-73-6	Amines, C18-22-tert-alkyl, (chloromethyl)phosphonates (2:1)			Canada PBiT List															PBiT											Dec_2011	July 2009	
79542-46-4	Acetamide, N-[4-chloro-2-[(2-chloro- 4-nitrophenyl)azo]-5-[(2-hydroxy-3-phenoxypropyl)amino]phenyl]-			Canada PBiT List															PBiT											Dec_2011	July 2009	
79748-81-5	Fusarin C					CA Prop 65														cancer										Dec_2011	July 2009	
81412-43-3	morpholine, 2,6-dimethyl-4-(C10-13)-alkyl-	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
83006-67-1	Benzenesulfonic acid, 2,2'-[(9,10-dihydro-5,8-dihydroxy- 9,10-dioxo-1,4-anthracenediyl)diimino]bis [5-(1,1-dimethylethyl)-			Canada PBiT List															PBiT											Dec_2011	July 2009	
83027-51-4	1,7-Naphthalenedisulfonic acid, 6-[[2-(4-cyclohexylphenoxy) phenyl]azo]-4-[[(2,4-dichlorophenoxy)acetyl]amino]-5-hydroxy-,			Canada PBiT List															PBiT											Dec_2011	July 2009	
83027-52-5	1,7-Naphthalenedisulfonic acid, 6-[[2-(2-cyclohexylphenoxy) phenyl]azo]-4-[[(2,4-dichlorophenoxy)acetyl]amino]-5-hydroxy-,			Canada PBiT List															PBiT											Dec_2011	July 2009	
83249-47-2	Acetamide, N-[2-[(2-bromo-6-cyano-4-nitrophenyl)azo]-5-(dipropylamino)phenyl]-			Canada PBiT List															PBiT											Dec_2011	July 2009	
83249-49-4	Benzonitrile, 3-bromo-2-[[4-(diethylamino) -2-methylphenyl]azo]-5-methyl-			Canada PBiT List															PBiT											Dec_2011	July 2009	
83249-53-0	Methanesulfonamide, N-[2-[(2-bromo-6-cyano-4-methylphenyl)azo]-5-(diethylamino)phenyl]-			Canada PBiT List															PBiT											Dec_2011	July 2009	
83249-54-1	Methanesulfonamide, N-[2-[(2-bromo-6-cyano-4-methylphenyl)azo]-5-(dipropylamino)phenyl]-			Canada PBiT List															PBiT											Dec_2011	July 2009	
83721-47-5	Methanesulfonamide, 1-chloro-N-[2,3,4-trichloro-6-(2,4-dichlorophenoxy)phenyl]-, sodium salt			Canada PBiT List															PBiT											Dec_2011	July 2009	
83721-48-6	Methanesulfonamide, 1-chloro-N-[2,3,4,5-tetrachloro- 6-(2,4-dichlorophenoxy)phenyl]-, sodium salt			Canada PBiT List															PBiT											Dec_2011	July 2009	
83968-86-9	9,10-Anthracenedione, 1-amino-4-[[3-[(dimethylamino) methyl]phenyl]amino]-, monoacetate			Canada PBiT List															PBiT											Dec_2011	July 2009	
84082-38-2	Alkanes, C10-21, chloro			Canada PBiT List															PBiT											Dec_2011	July 2009	
84852-15-3	phenol, 4-nonyl-, branched	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
85005-63-6	2-Naphthalenecarboxamide, 4-[(2,4-dinitrophenyl)azo]-3-hydroxy-N-phenyl-			Canada PBiT List															PBiT											Dec_2011	July 2009	
85186-47-6	Xanthylium, 9-(2-carboxyphenyl)-3,6-bis(diethylamino)-, salt with mono-C10-14-alkylbenzenesulfonic acid (1:1)			Canada PBiT List															PBiT											Dec_2011	July 2009	
85392-21-8	3-Pyridinecarbonitrile, 5-[[2-chloro-4-(phenylazo) phenyl]azo]-2,6-bis[(3-methoxypropyl)amino]-4-methyl -			Canada PBiT List															PBiT											Dec_2011	July 2009	
85409-17-2	stannane, tributyl-, mono(naphthenoyloxy) derivs.	OSPAR Chemicals of Concern					EU Endocrine Disruptor										PBT				Category 1 Endocrine Disruptor									Dec_2011	July 2009	
85422-92-0	Paraffin oils, chloro			Canada PBiT List															PBiT											Dec_2011	July 2009	
85535-84-8	Short-chain chlorinated paraffins	WA PBT List; EU PBT List; OSPAR Chemicals of		Canada PBiT List			EU Endocrine Disruptor								PBT	Fulfilling PBT crit eria	PBT		PBiT		Category 1 Endocrine Disruptor					PBT				Dec_2011	July 2009	
85535-85-9	alkanes, C14-17, chloro			Canada PBiT List			EU Endocrine Disruptor			OSPAR Chemicals of Concern							Equivalent level of concern		PBiT		Category 1 Endocrine Disruptor									Dec_2011	July 2009	
85535-86-0	Alkanes, C18-28, chloro			Canada PBiT List															PBiT											Dec_2011	July 2009	
85702-64-3	3H-indol-3-one, 5,7-dibromo-2-(5-bromo-7-chloro-1,3-dihydro-3-oxo-2H-indol-2-ylidene)-1,2-dihydro -			Canada PBiT List															PBiT											Dec_2011	July 2009	
85702-90-5	2,9,11,13-Tetraazanonadecanethioic acid, 19-isocyanato-11-(6-isocyanatohexyl)-10,12-dioxo-, S-[3-(trimethoxysilyl)propyl] ester			Canada PBiT List															PBiT											Dec_2011	July 2009	
86220-42-0	Nafarelin acetate							CA Prop 65												developmental										Dec_2011	July 2009	

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		TYPE OF TOXICITY									ORIGINATING LIST																					
CAS	Chemical of Concern Name	(Persistent Bioaccumulative and Toxic) PBT	(Very Persistent and Very Bioaccumulative) vPvB	(Persistent, Bioaccumulative and inherently Toxic) PBiT	(Carcinogenic, Mutagenic and Reproductive (Toxicants)) CMR	Carcinogen	Endocrine Disruptor	Developmental Toxicant	Reproductive Toxicant	Equivalent Level of Concern	EPA Final PBT Rule for TRI	TRI PBT Chemical List	EPA Priority PBT	NWM Priority Chemicals (PBTs)	WA PBT List	EU PBT List	OSPAR Chemicals of Concern	OSPAR Chemicals for Priority Action	Canada PBiT List	CA Prop 65	EU Endocrine Disruptor	IARC	EU Carcinogen	EU Reproductive Toxicant	IRIS	REACH Substances of Very High Concern	NTP 11th/13th ROC	NTP CERHR	Pesticide Notation	Source list last reviewed	Date Listed	Source
86290-81-5	Gasoline			Canada PBiT List															PBiT											Dec_2011	July 2009	
86551-61-3	Butanamide, 2-[2,4-bis(1,1-dimethylpropyl) phenoxy]-N-[4-(2-formylhydrazino)phenyl]-			Canada PBiT List															PBiT											Dec_2011	July 2009	
87237-48-7	propanoic acid, 2-[4-[[3-chloro-5-(trifluoromethyl)-2-pyridinyl]oxy]phenoxy]-, 2-ethoxyethyl ester									OSPAR Chemicals of Concern							Equivalent level of concern													Dec_2011	July 2009	
87741-01-3	Hydrocarbons, C.sb.4.sb., Petroleum gas					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
90218-20-5	Benzenesulfonic acid, 5-amino-2,4-dimethyl-, diazotized, coupled with diazotized 2,4-, 2,5-and 2,6-xylidine and 4-[(2,4-			Canada PBiT List															PBiT											Dec_2011	July 2009	
90268-98-7	Carbonic acid disodium salt, reaction products with aniline, 4-nitrobenzenamine, p-phenylenediamine, sodium sulfide, sulfur and p-			Canada PBiT List															PBiT											Dec_2011	July 2009	
90459-02-2	2,7-Naphthalenedisulfonic acid, 5-amino-4-hydroxy-3-[[6-sulfo- 4-[(4-sulfo-1-naphthalenyl)azo]-1-naphthalenyl]azo]-,			Canada PBiT List															PBiT											Dec_2011	July 2009	
90481-05-3	phenol, nonyl-, manuf. of, by-products from, high-boiling	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
90622-55-2	Alkanes, C.sb.1-4.sb., C.sb.3.sb.-rich, Petroleum gas					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
90640-80-5	Anthracene oil	EU PBT List; OSPAR Chemicals of Concern														Fulfilling PBT criteria	PBT													Dec_2011	July 2009	
90640-81-6	Anthracene oil, anthracene paste	EU PBT List; OSPAR Chemicals of Concern														Fulfilling PBT criteria	PBT													Dec_2011	July 2009	
90640-82-7	Anthracene oil, anthracenelow	EU PBT List; OSPAR Chemicals of Concern														Fulfilling PBT criteria	PBT													Dec_2011	July 2009	
90640-86-1	Distillates (coal tar), heavy oils	EU PBT List; OSPAR Chemicals of Concern														Fulfilling PBT criteria	PBT													Dec_2011	July 2009	
90729-40-1	3-Pyridinecarbonitrile, 1-butyl-5-[[4-(4-chlorobenzoyl) -2-nitrophenyl]azo]-1,2-dihydro-6-hydroxy-4 -methyl-2-oxo-			Canada PBiT List															PBiT											Dec_2011	July 2009	
91696-90-1	[2,6'-Bibenzothiazole]-7-sulfonic acid, 2'-(4-aminophenyl)-6-methyl-, diazotized, coupled with diazotized 4-aminobenzenesulfonic acid and			Canada PBiT List															PBiT											Dec_2011	July 2009	
91995-15-2	Anthracene oil, anthracene paste, anthracene fraction	EU PBT List; OSPAR Chemicals of Concern														Fulfilling PBT criteria	PBT													Dec_2011	July 2009	
91995-17-4	Anthracene oil, anthracene paste, distn. Lights	EU PBT List; OSPAR Chemicals of Concern														Fulfilling PBT criteria	PBT													Dec_2011	July 2009	
91995-42-5	Distillates (coal tar), heavy oils, pyrene fraction	EU PBT List; OSPAR Chemicals of Concern														Fulfilling PBT criteria	PBT													Dec_2011	July 2009	
91995-52-7	Distillates (coal tar), pitch, pyrene fraction	EU PBT List; OSPAR Chemicals of Concern														Fulfilling PBT criteria	PBT													Dec_2011	July 2009	
92045-15-3	Gases (petroleum), gas oil diethanolamine scrubber off, Refinery gas, [A complex combination produced by desulfurization of gas					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
92045-16-4	Gases (petroleum), gas oil hydrodesulfurization effluent, Refinery gas, [A complex combination obtained by separation of the liquid phase from					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
92045-17-5	Gases (petroleum), gas oil hydrodesulfurization purge, Refinery gas, [A complex combination of gases obtained from the reformer and from the					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
92045-18-6	Gases (petroleum), hydrogenator effluent flash drum off, Refinery gas, [A complex combination of gases obtained from flash of the effluents after					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
92045-19-7	Gases (petroleum), naphtha steam cracking high-pressure residual, Refinery gas, [A complex combination obtained as a mixture of the non-					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
92045-20-0	Gases (petroleum), residue visbaking off, Refinery gas, [A complex combination obtained from viscosity reduction of residues in a furnace. It					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
92045-22-2	Gases (petroleum), steam-cracker C.sb.3.sb.-rich, Petroleum gas, [A complex combination of hydrocarbons produced by the distillation of					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
92045-23-3	Hydrocarbons, C.sb.4.sb., steam-cracker distillate, Petroleum gas, [A complex combination of hydrocarbons produced by the distillation of the					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
92045-41-5	Lubricating oils, used, vacuum distd.			Canada PBiT List															PBiT											Dec_2011	July 2009	
92045-52-8	Naphtha (petroleum), hydrodesulfurized full-range			Canada PBiT List															PBiT											Dec_2011	July 2009	
92045-80-2	Petroleum gas, Petroleum gases, liquefied, sweetened, C.sb.4.sb. fraction, [A complex combination of hydrocarbons obtained by					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
92061-94-4	Residues (coal tar), pitch distn.	EU PBT List; OSPAR Chemicals of Concern														Fulfilling PBT criteria	PBT													Dec_2011	July 2009	
93384-84-0	Naphthalenesulfonic acid, reaction products with formaldehyde and hydroxybenzenesulfonic acid, ammonium salts			Canada PBiT List															PBiT											Dec_2011	July 2009	
93805-00-6	Phenol, 4-[[2-methoxy-4-[(2-methoxyphenyl) azo]-5-methylphenyl]azo]-			Canada PBiT List															PBiT											Dec_2011	July 2009	
93918-79-7	Carbamic acid, cyclohexyl-, nitrilotri-2,1-ethanediyl ester			Canada PBiT List															PBiT											Dec_2011	July 2009	
94088-85-4	Doxycycline calcium (internal use)							CA Prop 65												developmental										Dec_2011	July 2009	
94199-57-2	2-Naphthalenecarboxamide, N-(2-ethoxyphenyl)-3-hydroxy- 4-[(2-nitrophenyl)azo]-			Canada PBiT List															PBiT											Dec_2011	July 2009	
94248-26-7	Methanesulfonamide, 1-chloro-N-(2-phenoxyphenyl)-, pentachloro deriv., sodium salt			Canada PBiT List															PBiT											Dec_2011	July 2009	
97722-19-5	Petroleum gas, Raffinates (petroleum), steam-cracked C.sb.4.sb. fraction cuprous ammonium acetate extn., C.sb.3-5.sb. and C.sb.3-5.sb.					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
100702-98-5	4,4'-Dihydroxy-2,3,5,6-tetrachlorobiphenyl						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec_2011	July 2009	
101200-53-7	Pyridine, 2-[3-(3-chlorophenyl)propyl]-			Canada PBiT List															PBiT											Dec_2011	July 2009	
101316-50-1	distillates (petroleum), alkene-alkyne manuf. pyrolysis oil, condensed arom. ring-contg.	OSPAR Chemicals of Concern															PBT													Dec_2011	July 2009	
101316-83-0	Tar brown-coal					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
101316-84-1	Tar, brown-coal, low-temp.					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
103331-97-1	Fatty acids, tallow, hydrogenated, [6-[bis(methoxymethyl)amino] -1,3,5-triazine-2,4-diyl]bis[[(methoxymethyl)imino]methylene] ester			Canada PBiT List															PBiT											Dec_2011	July 2009	
103331-98-2	Fatty acids, tallow, hydrogenated, hexaesters with 2-[[[4-[[[2-hydroxy-1-(hydroxymethyl) ethoxy]methyl](hydroxymethyl)amino]-6 -			Canada PBiT List															PBiT											Dec_2011	July 2009	

Chemicals of Concern

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CAS	Chemical of Concern Name	TYPE OF TOXICITY									ORIGINATING LIST																		Pesticide Notation	Source list last reviewed	Date Listed	Source
		(Persistent Bioaccumulative and Toxic) PBT	(Very Persistent and Very Bioaccumulative) vPvB	(Persistent, Bioaccumulative and inherently Toxic) PBiT	(Carcinogenic, Mutagenic and Reproductive (Toxicants)) CMR	Carcinogen	Endocrine Disruptor	Developmental Toxicant	Reproductive Toxicant	Equivalent Level of Concern	EPA Final PBT Rule for TRI	TRI PBT Chemical List	EPA Priority PBT	NWM Priority Chemicals (PBTs)	WA PBT List	EU PBT List	OSPAR Chemicals of Concern	OSPAR Chemicals for Priority Action	Canada PBiT List	CA Prop 65	EU Endocrine Disruptor	IARC	EU Carcinogen	EU Reproductive Toxicant	IRIS	REACH Substances of Very High Concern	NTP 11th/13th ROC	NTP CERHR				
104376-69-4	Formaldehyde, reaction products with branched nonylphenol and xylenol, ethoxylated			Canada PBiT List															PBiT											Dec_2011	July 2009	
104948-36-9	Alkanes, C10-22, chloro			Canada PBiT List															PBiT											Dec_2011	July 2009	
105650-23-5	PhiP(2-Amino-1-methyl-6-phenylimidazol[4,5-b]pyridine)					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec_2011	July 2009	
105735-71-5	3,7-Dinitrofluoranthene					CA Prop 65														cancer										Dec_2011	July 2009	
106232-85-3	Alkanes, C18-20, chloro			Canada PBiT List															PBiT											Dec_2011	July 2009	
106276-78-2	Benzoic acid, 2,3,4,5-tetrachloro-6-cyano-, methyl ester, reaction products with 4-[(4-aminophenyl)azo]-3-methylbenzenamine and			Canada PBiT List															PBiT											Dec_2011	July 2009	
108004-27-9	1H-Imidazole-1-ethanol, α-(2,4-dichlorophenyl) -α-[2-(2,4-dichlorophenyl)cyclopropyl]-, [1α(R),2ß]-			Canada PBiT List															PBiT											Dec_2011	July 2009	
108171-26-2	Chlorinated paraffins (Average chain length, C12;approximately 60 percent chlorine by weight)					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec_2011	July 2009	
113089-51-3	Alkenes, C12-14, hydroformylation products, distn. residues, ethoxylated propoxylated, dihydrogen phosphates, sodium salts			Canada PBiT List															PBiT											Dec_2011	July 2009	
113163-36-3	Formaldehyde, reaction products with sulfonated 1,1'-biphenyl and sulfonated terphenyl, sodium salts			Canada PBiT List															PBiT											Dec_2011	July 2009	
114910-04-2	1-Naphthalenediazonium, 4-[[4-[(4-nitro-2-sulfophenyl) amino]phenyl]azo]-6-sulfo-, chloride, reaction products with formaldehyde and salicylic			Canada PBiT List															PBiT											Dec_2011	July 2009	
116355-83-0	Fumonisin B1					CA Prop 65														cancer										Dec_2011	July 2009	
117310-64-2	Phosphine oxide, (butylphenyl)bis(2,6-dichlorobenzoyl)-			Canada PBiT List															PBiT											Dec_2011	July 2009	
118174-38-2	6-Methyl-1,3,8-trichlorodibenzofuran						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec_2011	July 2009	
119209-64-2	Alkenes, C12-14, hydroformylation products, distn. residues, ethoxylated, dihydrogen phosphates, sodium salts			Canada PBiT List															PBiT											Dec_2011	July 2009	
121181-53-1	Filgrastim							CA Prop 65												developmental										Dec_2011	July 2009	
124751-15-1	Resin acids and Rosin acids, fumarated, barium salts			Canada PBiT List															PBiT											Dec_2011	July 2009	
125328-28-1	Phenol, 4,4'-(1-methylethylidene)bis-, reaction products with hexakis(methoxymethyl)melamine			Canada PBiT List															PBiT											Dec_2011	July 2009	
125351-99-7	9,10-Anthracenedione, 1,4-bis[(4-methylphenyl)amino]-, sulfonated, potassium salts			Canada PBiT List															PBiT											Dec_2011	July 2009	
125471-97-8	Lubricating oils (petroleum), hydrotreated, used, distn. residues			Canada PBiT List															PBiT											Dec_2011	July 2009	
127126-02-7	Propanenitrile, 3-[[2-(acetyloxy)ethyl][4- [(6,7-dichloro-2-benzothiazolyl)azo]phenyl]amino]-			Canada PBiT List															PBiT											Dec_2011	July 2009	
128683-25-0	Crude oil (oil sand)			Canada PBiT List															PBiT											Dec_2011	July 2009	
128683-26-1	Distillates (petroleum), full-range atm.			Canada PBiT List															PBiT											Dec_2011	July 2009	
128683-28-3	Gas oils (petroleum), full-range			Canada PBiT List															PBiT											Dec_2011	July 2009	
128683-29-4	Gas oils (oil sand), hydrotreated			Canada PBiT List															PBiT											Dec_2011	July 2009	
128683-30-7	Gas oils (oil sand)			Canada PBiT List															PBiT											Dec_2011	July 2009	
128683-33-0	Naphtha (oil sand), hydrotreated			Canada PBiT List															PBiT											Dec_2011	July 2009	
128683-35-2	Residues (oil sand), atm. tower			Canada PBiT List															PBiT											Dec_2011	July 2009	
129566-94-5	Hydrocarbons, C12-25, dehydrated used lubricating oil distillates			Canada PBiT List															PBiT											Dec_2011	July 2009	
129893-11-4	Residues (petroleum), vacuum, hydrocracked, naphtha fraction			Canada PBiT List															PBiT											Dec_2011	July 2009	
129893-17-0	Lubricating oils, used, residues			Canada PBiT List															PBiT											Dec_2011	July 2009	
129893-18-1	Lubricating oils, used, vacuum distd., clay-treated			Canada PBiT List															PBiT											Dec_2011	July 2009	
129893-21-6	Natural gas condensates, C4-12 distillate			Canada PBiT List															PBiT											Dec_2011	July 2009	
129893-22-7	Natural gas condensates, C5-12 distillate			Canada PBiT List															PBiT											Dec_2011	July 2009	
132207-32-0	asbestos					EU Carcinogen																	Category 1 carcinogen							Dec_2011	July 2009	
132538-91-1	Lubricating oils, used, distd., C5-18 fraction			Canada PBiT List															PBiT											Dec_2011	July 2009	
132538-93-3	Lubricating oils, used, distd., light oil			Canada PBiT List															PBiT											Dec_2011	July 2009	
140923-17-7	Iprovalicarb (also CAS#140923-25-7)					CA Prop 65														cancer										Dec_2011	July 2009	
177406-68-7	Benthiavalicarb-isopropyl					CA Prop 65														cancer										Dec_2011	July 2009	
223777-68-2	Benzenesulfonic acid, hydroxydinonyl-, branched, monoammonium salt			Canada PBiT List															PBiT											Dec_2011	July 2009	
N/A	zinc chromates including zinc potassium chromate					EU Carcinogen																	Category 1 carcinogen						P(NR)(O)	Dec_2011	July 2009	NSPIRS 2011, TOXNET
N/A	Lead compounds	TRI PBT Chemical List; OSPAR Chemicals for				CA Prop 65; IARC; NTP 11th ROC			EU Reproductive Toxicant			PBT						PBT		cancer		Group 2A		Category 1 Reproductive Toxicant			Reasonably anticipated		P(NR)(O)	Dec_2011	July 2009	NSPIRS 2011, TOXNET
N/A	Nickel compounds					CA Prop 65; IARC; NTP 11th ROC														cancer		Group 1					Known		P(NR)(O)	Dec_2011	July 2009	NSPIRS 2011, TOXNET
N/A	1,1-trichloro-2,2-bis(4-hydroxyphenyl)ethane (HPTE)						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec_2011	July 2009	
N/A	2,4,5-Trimethylaniline and its strong acid salts					CA Prop 65														cancer										Dec_2011	July 2009	

Chemicals of Concern

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		TYPE OF TOXICITY									ORIGINATING LIST																					
CAS	Chemical of Concern Name	(Persistent Bioaccumulative and Toxic) PBT	(Very Persistent and Very Bioaccumulative) vPvB	(Persistent, Bioaccumulative and inherently Toxic) PBiT	(Carcinogenic, Mutagenic and Reproductive (Toxicants)) CMR	Carcinogen	Endocrine Disruptor	Developmental Toxicant	Reproductive Toxicant	Equivalent Level of Concern	EPA Final PBT Rule for TRI	TRI PBT Chemical List	EPA Priority PBT	NWM Priority Chemicals (PBTs)	WA PBT List	EU PBT List	OSPAR Chemicals of Concern	OSPAR Chemicals for Priority Action	Canada PBiT List	CA Prop 65	EU Endocrine Disruptor	IARC	EU Carcinogen	EU Reproductive Toxicant	IRIS	REACH Substances of Very High Concern	NTP 11th/13th ROC	NTP CERHR	Pesticide Notation	Source list last reviewed	Date Listed	Source
35693-92-6	2,4-6-trichlorobiphenyl						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec 2011	July 2009	
N/A	2,4-Hexadienal (89% trans, trans isomer; 11% cis, trans isomer)					CA Prop 65														cancer										Dec 2011	July 2009	
38444-88-1	3,4',5-trichlorobiphenyl						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec 2011	July 2009	
N/A	4-Hydroxy-3,3',4',5'-tetrachlorobiphenyl						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec 2011	July 2009	
N/A	4-OH-2,2',4',5,5'-pentachlorobiphenyl						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec 2011	July 2009	
N/A	5-Chloro-o-toluidine and its strong acid salts					CA Prop 65														cancer										Dec 2011	July 2009	
N/A	Aristolochic acids					CA Prop 65; IARC														cancer		Group 2A								Dec 2011	July 2009	
N/A	Arsenic in drinking-water					IARC																Group 1								Dec 2011	July 2009	
N/A	Arsenic (inorganic oxides)																												P(A)(O)	Dec 2011	July 2009	NSPIRS 2011, TOXNET
N/A	Benzidine-based dyes					CA Prop 65														cancer										Dec 2011	July 2009	
108-60-1	Bis(2-chloro-1-methylethyl)ether, technical grade					CA Prop 65														cancer										Dec 2011	July 2009	
N/A	brominated flame retardants	OSPAR Chemicals for Priority Action					OSPAR Chemicals for Priority Action											PBT, Endocrine disruptor												Dec 2011	July 2009	
N/A	Cobalt metal with tungsten carbide					IARC																Group 2A								Dec 2011	July 2009	
N/A	Diaminotoluene (mixed)					CA Prop 65														cancer										Dec 2011	July 2009	
N/A	Dinitrotoluene (technical grade)								CA Prop 65											reproductive female, male										Dec 2011	July 2009	
N/A	Dinitrotoluene mixture, 2,4-/2,6-					CA Prop 65; IRIS														cancer					B2					Dec 2011	July 2009	
N/A	Dioxin and dioxin-like compounds	TRI PBT Chemical List										PBT																		Dec 2011	July 2009	
N/A	Dioxins and furans	EPA Priority PBT											PBT																	Dec 2011	July 2009	
N/A	dyes metabolized to 3,3'-dimethoxybenzidine					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec 2011	July 2009	
N/A	Dyes metabolized to 3,3'-dimethylbenzidine					CA Prop 65; NTP 11th ROC														cancer							Reasonably anticipated			Dec 2011	July 2009	
N/A	Dyes metabolized to benzidine					IARC; NTP 11th ROC																Group 1					Known			Dec 2011	July 2009	
N/A	lead alkyls								EU Reproductive Toxicant															Category 1 Reproductive Toxicant						Dec 2011	July 2009	
N/A	Lindane and other hexachlorocyclohexane isomers					CA Prop 65														cancer										Dec 2011	July 2009	
N/A	Mercury compounds	TRI PBT Chemical List; OSPAR Chemicals for						CA Prop 65				PBT						PBT		developmental										Dec 2011	July 2009	
N/A	Methoxyetylacrylate tinbutyltin, copolymer						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec 2011	July 2009	
N/A	Methylhydrazine and its salts, methylhydrazine, methylhydrazine sulfate					CA Prop 65														cancer										Dec 2011	July 2009	
N/A	Methylmercury compounds					CA Prop 65														cancer										Dec 2011	July 2009	
N/A	Mineral oils (untreated and mildly treated)					IARC; NTP 11th ROC																Group 1					Known			Dec 2011	July 2009	
N/A	Mixture of 2,3,4,5-tetrachlorobiphenyl (PCB 61), 2,2',4,5,5'-octachlorobiphenyl (PCB 101) and 2,2',3,3',4,4',5,5'-octachlorobiphenyl (PCB 194)						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec 2011	July 2009	
81-15-2	2,4,6-Trinitro-5-tert-butyl-m-xylene	OSPAR Chemicals for Priority Action																PBT												Dec 2011	July 2009	
N/A	Nitrate or nitrite (ingested) under conditions that result in endogenous nitrosation					IARC																Group 2A								Dec 2011	July 2009	
N/A	nonylphenol/ethoxylates and related substances	OSPAR Chemicals for Priority Action					OSPAR Chemicals for Priority Action											PBT, Endocrine disruptor												Dec 2011	July 2009	
N/A	PBBs = Brominated Flame retardants = PBB (mixed group of 209 Congeners)						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec 2011	July 2009	
56558-16-8	PCB 104 (2,2',4,6,6'-Pentachlorobiphenyl)						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec 2011	July 2009	
74472-37-0	PCB 114 (2,3,4,4',5-pentachlorobiphenyl)						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec 2011	July 2009	
76842-07-4	PCB 122 (2,3,3',4,5 -Pentachlorobiphenyl)						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec 2011	July 2009	
12674-11-2	Aroclor 1016						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec 2011	July 2009	
35065-28-2	PCB138 2,2',3,4,4',5'-hexachlorobiphenyl						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec 2011	July 2009	
35065-29-3	PCB180 2,2',3,4,4',5,5'-heptachlorobiphenyl						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec 2011	July 2009	
N/A	p-Chloro-o-toluidine, strong acid salts of / p-Chloro-o-toluidine, hydrochloride					CA Prop 65														cancer										Dec 2011	July 2009	
N/A	Phenylhydrazine and its salts, phenylhydrazine, phenylhydrazine hydrochloride					CA Prop 65														cancer										Dec 2011	July 2009	
N/A	Polybrominated biphenyls					CA Prop 65; NTP 11th ROC		CA Prop 65												cancer, developmental							Reasonably anticipated			Dec 2011	July 2009	
1336-36-3	Polychlorinated biphenyls					CA Prop 65		CA Prop 65												cancer, developmental										Dec 2011	July 2009	
N/A	polychlorinated dibenzodioxins (PCDDs)	OSPAR Chemicals for Priority Action																PBT												Dec 2011	July 2009	
N/A	Polychlorinated dibenzofurans (PCDFs)	OSPAR Chemicals for Priority Action				CA Prop 65												PBT		cancer										Dec 2011	July 2009	

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CAS	Chemical of Concern Name	TYPE OF TOXICITY									ORIGINATING LIST																		Pesticide Notation	Source list last reviewed	Date Listed	Source
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N/A	Polychlorinated dibenzo-p-dioxins					CA Prop 65														cancer										Dec 2011	July 2009	
N/A	polychlorinated naphthalenes	OSPAR Chemicals for Priority Action																PBT												Dec 2011	July 2009	
N/A	Polycyclic aromatic compounds (PACs)	TRI PBT Chemical List; NWM Priority Chemicals										PBT		PBT																Dec 2011	July 2009	
N/A	Quinoline and its strong acid salts					CA Prop 65														cancer										Dec 2011	July 2009	
N/A	salts of 2-naphthylamine					EU Carcinogen																	Category 1 carcinogen							Dec 2011	July 2009	
N/A	salts of 4-aminobiphenyl, salts of biphenyl-4-ylamine, salts of xenylamine					EU Carcinogen																	Category 1 carcinogen							Dec 2011	July 2009	
114466-38-5	Sermorelin acetate							CA Prop 65												developmental										Dec 2011	July 2009	
N/A	short chained chlorinated paraffins (SCCP)	OSPAR Chemicals for Priority Action																PBT												Dec 2011	July 2009	
N/A	Tributyltincarboxylate						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec 2011	July 2009	
N/A	Tributyltinpolyethoxylate						EU Endocrine Disruptor														Category 1 Endocrine Disruptor									Dec 2011	July 2009	
N/A	cadmium compounds					CA Prop 65; NTP 11th ROC														cancer							Known		P(NR)(O)	Dec 2011	July 2009	NSPIRS 2011, TOXNET
N/A	Arsenic (inorganic oxides)							CA Prop 65												developmental									P(A)(O)	Dec 2011	July 2009	NSPIRS 2011, TOXNET
N/A	arsenic acid and its salts					EU Carcinogen																	Category 1 carcinogen						P(A)(O)	Dec 2011	July 2009	NSPIRS 2011, TOXNET
N/A	Bitumens, extracts of steam-refined and air refined					CA Prop 65														cancer										Dec 2011	July 2009	
N/A	Carbon-black extracts					CA Prop 65														cancer										Dec 2011	July 2009	
N/A	Certain combined chemotherapy for lymphomas					CA Prop 65														cancer										Dec 2011	July 2009	
N/A	Diesel engine exhaust					CA Prop 65; IARC; IRIS														cancer		Group 2A			Likely to be carcin					Dec 2011	July 2009	
N/A	diesel exhaust particulates					NTP 11th ROC																					Reasonably anticipated			Dec 2011	July 2009	
N/A	Gasoline engine exhaust (condensates/extracts)					CA Prop 65														cancer										Dec 2011	July 2009	
N/A	Histrelin acetate							CA Prop 65												developmental										Dec 2011	July 2009	
N/A	Residual (heavy) fuel oils					CA Prop 65														cancer										Dec 2011	July 2009	
N/A	silica, crystalline (respirable size)					CA Prop 65; NTP 11th ROC														cancer							Known			Dec 2011	July 2009	
N/A	Soots					IARC; NTP 11th ROC																Group 1					Known			Dec 2011	July 2009	
N/A	Soots, tars, and mineral oils (untreated and mildly treated oils and used engine oils)					CA Prop 65														cancer										Dec 2011	July 2009	
N/A	Talc containing asbestiform fibers					CA Prop 65; IARC														cancer		Group 1								Dec 2011	July 2009	
N/A	Unleaded gasoline (wholly vaporized)					CA Prop 65														cancer										Dec 2011	July 2009	
N/A	coke oven emissions					CA Prop 65; NTP 11th ROC														cancer							Known			Dec 2011	July 2009	
N/A	Environmental tobacco smoke					NTP 11th ROC		CA Prop 65												developmental							Known			Dec 2011	July 2009	
N/A	smokeless tobacco					CA Prop 65; IARC; NTP 11th ROC														cancer		Group 1					Known			Dec 2011	July 2009	
N/A	Tobacco smoke					CA Prop 65; IARC; NTP 11th ROC		CA Prop 65	CA Prop 65											cancer, developmental, reproductive		Group 1					Known			Dec 2011	July 2009	
N/A	Alcoholic beverages					CA Prop 65; IARC; NTP 11th ROC														cancer		Group 1					Known			Dec 2011	July 2009	
N/A	Chromium (hexavalent compounds)					CA Prop 65														cancer									P(A)(O)	Dec 2011	July 2009	NSPIRS 2011, TOXNET
668-34-8	Triphenylstannanylium, also known as "Stannylium, triphenyl"						EU Endocrine Disruptor														Category 1 Endocrine Disruptor								P(O)	Dec 2011	July 2009	2011, TOXNET 2011

Legend

P(A)	Pesticide active federally
P(A)(NR)	Pesticide some active; some not-active
P(A)(O)	Pesticide active federally (Other uses)
P(NR)	Pesticide not-active federally
P(NR)(O)	Pesticide not-active federally (Other uses)
P(M)	Pesticide metabolite
P(M)(O)	Pesticide metabolite (Other uses)
*	* CAS numbers are specific for the parent chemical, but the COC listing includes both the parent chemical and parent chemical-related salt compounds.

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July 2015

		TYPE OF TOXICITY									ORIGINATING LIST																					
CAS	Chemical of Concern Name	(Persistent Bioaccumulative and Toxic) PBT	(Very Persistent and Very Bioaccumulative) vPvB	(Persistent, Bioaccumulative and inherently Toxic) PBiT	(Carcinogenic, Mutagenic and Reproductive (Toxicants)) CMR	Carcinogen	Endocrine Disruptor	Developmental Toxicant	Reproductive Toxicant	Equivalent Level of Concern	EPA Final PBT Rule for TRI	TRI PBT Chemical List	EPA Priority PBT	NWM Priority Chemicals (PBTs)	WA PBT List	EU PBT List	OSPAR Chemicals of Concern	OSPAR Chemicals for Priority Action	Canada PBiT List	CA Prop 65	EU Endocrine Disruptor	IARC	EU Carcinogen	EU Reproductive Toxicant	IRIS	REACH Substances of Very High Concern	NTP 11th/13th ROC	NTP CERHR	Pesticide Notation	Source list last reviewed	Date Listed	Source

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NSPIRS 2011	National State Pesticide Information Retrieval System; http://nspirs.ceris.purdue.edu/
TOXNET 2011	National Library of Medicines Toxicology Network;http://toxnet.nlm.nih.gov/
Merck 2006	Merck Index, 14th edition Mrck & Co Whitehouse NJ

Recycling solar panels in 2018

https://news.energysage.com/recycling-solar-panels/

Solar panels have a lifetime of about 30 years. With the increasing number of solar panels being sold and installed in the United States each year, it's only a matter of time before high volumes of silicon solar panels are at the end of their useful life and have to be disposed of. Solar panel recycling is still at a very early stage, but as the market continues to grow, it will have an important part to play in the solar industry.

Solar panel recycling is important for the future of solar

Solar energy is inexpensive and environmentally friendly – until your solar panels have reached the end of their lifetime. After about 30 years, many crystalline silicon solar panels will start having significant dips in energy production and it may be time to replace them or dispose of them entirely.

Like any manufactured product, disposing of solar panels is hardly environmentally friendly. Heavy metals like cadmium and lead are found in solar cells, which can harm the natural environment if they are not recycled or disposed of properly. Additionally, solar panels that are carelessly thrown away can end up in large landfills.

Besides environmental protection, recycling solar panels will be economically impactful as well. Some of the rare elements in photovoltaic (PV) cells like gallium and indium are being depleted from the environment over time. If we were able to recover those elements, we can conserve the limited amount available on earth and continue to use them for solar panels and other products. Furthermore, a 2016 study by the International Renewable Agency (IRENA) estimated that $15 billion could be recovered from recycling solar modules by the year 2050.

When do solar panels need to be recycled?

With a lifetime of about 30 years on average, crystalline silicon solar panels don't become obsolete very quickly. However, given the rapid expansion of the solar industry, the number of solar panels needing to be recycled or disposed of in the coming years will continue to increase. More and more panels will reach the end of their life each year, and even now, old solar panels are beginning to become a problem.

What parts of solar panels can be recycled?

Recycling solar panels can only be effective if the materials used to build them are able to be used again, 30 or more years later. Solar panels are made from several components, including:

- Silicon solar cells
- Metal framing
- Glass sheets
- Wires
- Plexiglas

Right away, it's clear that many of the core components of solar panels can be recycled on their own. Metal, glass, and wiring can all be recycled and reused. Silicon cells, the component that is most essential to producing electricity, are a slightly different story. While silicon wafers are not recyclable like glass and plastic are, some specialty recycling companies are able to reuse silicon cells by melting them down and reclaiming the silicon and various metals.

The difficulty with recycling solar panels isn't that the materials they are made from are hard to recycle; rather, it's that they are constructed from many parts all used together in one product. Separating those materials and recycling them each in a unique way is a complex and potentially expensive process.

Solar panel recycling options

What are the current options for recycling your old solar panels? Solar panels have traditionally been recycled at general purpose glass recycling facilities, where the metal frames and glass parts are salvaged but the remaining parts are disposed of or burned. Nowadays, there are a few organizations working to make solar panel recycling both complete and mainstream:

Veolia

Unlike the U.S., Europe has a developed solar market. Due to government regulations, European solar panel owners must recycle their panels once they are done using them. This has created a market for panel recyclers, one of which is Veolia.

Veolia partners with the non-profit PV Cycle in Europe to collect and recycle solar panels. They opened their first recycling plant in 2018, where robots separate glass, silicon, plastics, and metals from solar panels.

Recycle PV

One company looking to bring solar recycling to the U.S. is Recycle PV. Because of the lack of governmental solar recycling requirements, the company has trouble operating on a wide scale locally. Despite this, Recycle PV is partnering with PV Cycle to help move U.S. panels to recycling facilities in Europe. While currently only a small operation compared to some European panel recycling efforts, groups like Recycle PV will almost definitely see the demand for their recycling services grow over the next several years.

Solar Energy Industries Association (SEIA)

SEIA has a PV Recycling Working Group that chooses recycling partners offering benefits to SEIA members. These partners give special pricing to the SEIA members, and in exchange, recycle their solar panels at special facilities. An example of a SEIA recycling partner is the company Cleanlites. Cleanlites operates recycling facilities that aren’t dedicated only to solar but can handle recycling panels and other solar equipment.

Manufacturer recycling

Another example of solar recycling efforts comes from manufacturers. Companies like SunPower and First Solar run global recycling programs for their customers, allowing them to return old solar panels (often through groups like PV Cycle) to the manufacturer to be recycled or repurposed.

Solar panels are good for the environment, and recycling is coming

While solar panel recycling isn’t widely available in the U.S. for all of the components in solar panels, there’s still a little time before the number of panels needing to be recycled gets too high. Groups like SEIA and Recycle PV are doing important groundwork for the industry, but there’s more to do in years to come.

Solar panel recycling may not be widespread, but solar energy is still a great financial investment that is environmentally friendly as well. By going solar now, you can cut your electric bill and start saving right away. Sign up for the EnergySage Solar Marketplace to receive free quotes from our network of qualified, pre-vetted installers so you can start the process of going solar.

Posted on AUGUST 30, 2018 by JACOB MARSH.

Categories: ENVIRONMENT AND CLEAN TECHNOLOGY

Tags: ENVIRONMENTAL IMPACT OF SOLAR ENERGY, FIRST SOLAR, SOLAR ENERGY INDUSTRIES ASSOCIATION (SEIA), SUNPOWER

About Jacob Marsh

Jacob is a Digital Marketing Analyst working primarily on EnergySage's SEO and content marketing. He recently graduated from Tufts University with a degree in Geoscience. When he's not checking up on the latest Google algorithm update, you can find him playing Ultimate Frisbee or rewatching Game of Thrones.

Solar New ZealandNovember 2, 2018 at 9:12 am

this is cool info, getting more and more green. Love it!

Jeff BrownDecember 4, 2018 at 2:26 pm

Hi Jacob

I have some Great news to share! Solar Pioneer Sam Vanderhoof has built a PV recycling plant in Tuscon AZ and it is up and running, In the last couple weeks Peter Beadle and myself, both old solar guys 3 decades each plus have joined him in his efforts.
Doing my due diligence I am blown away of the need for this to prevent in the near future billions of pounds of our "Green" technology each year ending up in landfills.

I too have been guilty simply assuming PV was a small sin to simply toss into dumpsters out of convenience just as computers and monitors. I never had anyone in our industry push recycling especially due to the fact today in California where I am they are listed as "Hazardous Waste" not Universal as computers are.

For a follow up article it would be great to have EnergySage do a follow up article on RecyclePV,Solar and how several solar veterans are tackling this issue.
It is a fact over 90% of day to day solar contractors are tossing modules in dumpsters. Some have them stacking up in their warehouse or using the very popular method of stacking them up outside near the dumpsters of their building next to the used pallets only to watch them simply go away.

This issue is larger than us and we need our solar associations and groups as you to help educate our industry and step up ensuring every pv module at end of life is recycled, Used PV Mods are re purposed and even those with say a bad diode are repaired then re-purposed,

Cheers

Jeff Brown

Brady RoseDecember 27, 2018 at 11:29 am

How much of the energy produced by panels, on a watt / dollar basis, prior to subsidization, will be consumed through the processes needed to recycle them? Melting glass, electro-winning, ball milling, and chemical separation are all VERY energy intensive processes. Given that solar panels are already only about as profitable as the subsidies paid for by tax payers, and that likely most of the energy used to produce them, let alone recycle them do not come from solar energy. I can't imagine that the true end cost of properly recycling them doesn't completely bottom out their economic feasibility. More than likely, much of them will end up in the landfill and the efforts to avert environmental disaster will become the causes of such.

Marc FontanaJanuary 24, 2019 at 8:07 am

It’s nice to know that solar PV modules can potentially be recycled. But what do I do with old pv panels today? If a homeowner living in the San Francisco Bay area has solar modules they want to dispose of, where can they take them? I searched online and came up empty. California does not allow disposing of PV modules in landfills. Frankly, I’m surprised there isn’t a recycling fee imposed on PV modules like there is for LCD displays and TV’S.

BrianMarch 6, 2019 at 6:45 pm

The easiest way I have heard of to recycle solar panels is as follows.

Put them in a pyrolysis sealed oven with no oxygen. Heat them till all the plastic and organics have evaporated or turned to char.
Vibrate the panels and they fall apart with the organics glues.
Recycle the glass which is about 90% of the mass of the panels, and the aluminum with not all panels have. Folks have also refinished the cells to updated performance. It takes half as much energy to make a solar panels from recycled parts as new. The silver is also recycled.

96% of solar panels contain ZERO Cadmium, can we stop with this meme? The toxic CdTe panels are the sole reason 96% solar panels which are not toxic are considered toxic by some govs. CdTe and any other toxic solar panels should have a mandatory label.

The question I have is, are solar panels uses lead free solder or not?

Kenneth A. Capron, 1375 Forest Ave D-11, Portland, ME 04103 207-797-7891 solar@maine.rr.com

SUMMARY

This bill provides for significant and appropriate stewardship of solar panel waste. It provides for the development of a 95-98% recycling process and facility. It conforms the definitions of solar equipment. It provides for a tracking process to provide early detection of panel cracks, damages and leaks. And it provides for funding of this plan.

With a projected solar farm installation of 30,000 panels in Oxford and more such installations elsewhere, it is urgent that we get out ahead of a potential chemical hazard as identified in the 2019 DEP stewardship report.

We urge emergency adoption of this legislation.

Title 5: ADMINISTRATIVE PROCEDURES AND SERVICES
Chapter 153: PUBLIC IMPROVEMENTS
§1764. LIFE-CYCLE COSTS

3. Determination of life-cycle costs. To determine the life-cycle costs, the Bureau of General Services shall adopt rules that include but are not limited to:

C. The effect of insulation incorporated into the facility design and the effect on solar utilization to the properties of external surfaces including the cost(s) of recycling;

F. The cost-effectiveness of integrating wind or solar electricity generating equipment into the design and construction of the facility including the cost(s) of recycling.

Title 5: ADMINISTRATIVE PROCEDURES AND SERVICES
Chapter 13: DEPARTMENT OF ADMINISTRATIVE AND FINANCIAL SERVICES
Subchapter 1: GENERAL PROVISIONS
§282. Powers and duties of commissioner

9. Energy infrastructure benefits fund. To establish an energy infrastructure benefits fund. Except as otherwise provided by Title 35-A, section 122, subsections 1-C and 6-B or any other law, including the Constitution of Maine, the fund consists of any revenues derived from the use of state-owned land and assets for energy infrastructure development pursuant to Title 35-A, section 122. Each fiscal year, the Treasurer of State shall transfer revenues collected in the fund to the Efficiency Maine Trust for deposit by the Efficiency Maine Trust Board in program funds pursuant to Title 35-A, section 10103, subsection 4 and use by the trust in accordance with Title 35-A, section 10103, subsection 4-A. For the purposes of this subsection, "energy infrastructure" and "state-owned" have the same meanings as in Title 35-A, section 122, subsection 1;

NOTE: **Title 35-A, section 122 Energy infrastructure corridors has been repealed**
Title 35-A, Chapter 95 Energy Efficiency, §10103, Training for energy auditors, has been repealed

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Title 10: COMMERCE AND TRADE
Part 3: REGULATION OF TRADE
Chapter 221: WARRANTIES FOR SALE AND INSTALLATION OF SOLAR ENERGY EQUIPMENT
§1492. Definitions

As used in this chapter, unless the context indicates otherwise, the following terms shall have the following meanings.

~~1. Solar energy equipment. "Solar energy equipment" means all controls, tanks, pumps, heat exchangers, collectors and all other equipment necessary for the collection, transfer and storage of solar energy,~~

~~as determined by the Governor's Energy Office. Passive solar energy systems or those systems using natural means to collect, store and transfer solar energy may not be included under this chapter.~~

1. <u>"Solar energy equipment" has the same meaning as the Title 35-A §3475(1) definition.</u>

Title 30-A: MUNICIPALITIES AND COUNTIES
Part 2: MUNICIPALITIES
Subpart 4: ORDINANCE AUTHORITY AND LIMITATIONS
Chapter 141: ORDINANCES

§3013. Solar energy devices; ordinances

A municipal ordinance, bylaw or regulation adopted after September 30, 2009 that directly regulates the installation or use of solar energy devices on residential property must comply with the requirements of Title 33, chapter 28-A. For the purposes of this section, ~~"solar energy device" has the same meaning as in Title 33, section 1421, subsection 5~~. <u>"Solar energy equipment" has the same meaning as the Title 35-A §3475(1) definition.</u>

<u>Title 33: PROPERTY</u>

§1423. USE AND INSTALLATION OF SOLAR ENERGY ~~DEVICES~~ <u>EQUIPMENT</u>

2. Right to install and use solar energy ~~devices~~ <u>equipment</u>. Except as provided in subsections 3 and 4, a legal instrument subject to this section may not prohibit a person from installing or using:

A. ~~A solar~~ Solar energy ~~devices~~ <u>equipment</u>. on residential property owned by that person; or

3. Exception. A legal instrument subject to this section may prohibit the installation and use of solar energy ~~devices~~ <u>equipment</u> on residential property in common ownership with 3rd parties or common elements of a condominium.

4. Reasonable restrictions. A legal instrument subject to this section may include reasonable restrictions on the installation and use of a solar energy ~~devices~~ <u>equipment</u>. For the purposes of this section, a reasonable restriction is any restriction that is necessary to protect:

Title 33: PROPERTY
Chapter 28-A: SOLAR RIGHTS
§1421. DEFINITIONS

As used in this chapter, unless the context otherwise indicates, the following terms have the following meanings.

5. Solar energy ~~device~~ <u>equipment</u>. "Solar energy ~~device~~ <u>equipment</u>" ~~means a solar collector or solar clothes-drying device.~~ <u>has the same meaning as the Title 35-A §3475(1) definition.</u>

Title 35-A: PUBLIC UTILITIES
Chapter 34-B: The Maine Solar Energy Act
§3472. Legislative findings
<u>3. Risk to Environment</u>

Kenneth A. Capron, 1375 Forest Ave D-11, Portland, ME 04103 207-797-7891 solar@maine.rr.com

A. The Legislature hereby recognizes the chemical hazard that solar panels present based on the 2019 Product Stewardship Report [Section 4-E] from the Maine DEP
B. The Legislature hereby acknowledges that solar panels contain the following Chemicals of Concern or Chemicals of High Concern (Maine CDC 6-27-2012 Report) - aluminum; **cadmium**; copper; gallium; silica; indium; **lead**; selenium; silicon; silver; **tellurium**; **tin**; zinc. Of these, CADMIUM is a Regulated Priority Chemical.
C. The Legislature finds that the production and/or recycling of solar panels uses chemical such as sodium hydroxide and hydrochloric acid
D. The average life span of a solar panel is estimated to be 25 to 30 years.
E. In addition, Legislature hereby acknowledges the likelihood that properties on which solar panels are installed are likely to change ownership at one or more points in their life cycle.
F. International Renewable Energy Agency (IRENA) estimated that global PV waste streams will grow from 250,000 tonnes at the end of 2016 - less than one percent of installed capacity - to more than five million tonnes by 2050. By then, the amount of PV waste will almost match the mass contained in new installations.
G. "[I]f recycling processes were not put in place, there would be 60 million tons of PV panel waste lying in landfills by the year 2050"
H. The Legislature acknowledges that since all PV cells contain certain amount of toxic substances that would truly become a not-so-sustainable way of sourcing energy."
I. The Legislature recognizes that this risk to our environment is critical and thus this legislature is an emergency and shall be implemented as soon as possible.

*Source: 2016 International Renewable Energy Agency_IEAPVPS_End-of-Life_Solar_PV_Panels.pdf

Title 35-A: PUBLIC UTILITIES
Chapter 34-B: The Maine Solar Energy Act
§3472. Legislative findings
4. Prevention and Tracking: In order to prevent or minimize the potential damage from solar panel deterioration, the following requirements will be implemented immediately:

A. Ban disposal of solar panels in whole or in part in landfills, dumps, waste stations, transfer stations or other place. Solar panels are classified different from electronic waste.
B. Mandate that all 'solar energy equipment' be recycled by a Maine DEP approved "solar recycling facility" using an approved solar equipment recycling process that prevents transmission into the air, water or land of Maine CDC Designated Chemicals of High Concern; allergens and other irritants harmful to organic life forms.
C. At time of purchase of any solar panel, a tracking document will be completed by the seller and/or the installer identifying the specific brand(s), size, model, serial number, location and any other information needed to assure the proper tracking and future disposal of each and every solar panel.
D. In order to assure adequate tracking of solar installations to assure proper disposal, a $25 fee per standard unit will be assessed at time of purchase.
E. The fees collected for tracking are restricted to the funding of one or more FTE's solely for the purpose of tracking purchases and dispositions of solar panels in Maine and the proper disposal of panels that are damaged, that have reached end of life cycle or are otherwise no longer functional. That FTE may be an employee of the DEP or of the recycling facility.
F. To assure funds are available for proper and timely recycling, a deposit of $100 per panel for that purpose must be made at time of purchase. It is assumed that at EOL, there is a propensity to not remove the panels if a fee is assessed at time of disposal.

Kenneth A. Capron, 1375 Forest Ave D-11, Portland, ME 04103 207-797-7891 solar@maine.rr.com

G. In an effort to detect and prevent leakage of chemicals, an authorized agent of the agency or municipality may enter upon and inspect the health of the installed solar panels and surrounding environment once in any five (5) calendar year(s).
H. An owner is required to maintain solar panels in a healthy state such that hazardous materials do not leak or otherwise impact the air, soil, water, inhabitants nor environment of the installation area.
I. An approved recycling facility must deploy regional take back locations.
J. Information gathered for tracking purposes is public and not exempt from Maine's FOAA.

Title 35-A: PUBLIC UTILITIES
Chapter 34-B: The Maine Solar Energy Act
§3472. Legislative findings
5. Insurance: All property where solar panels are installed must carry **insurance that pays the full costs of recycling solar panels damaged in any form of catastrophe**; and to that extent, insurance companies are required to pay such costs before any other distributions of proceeds of the insurance.

Title 35-A: PUBLIC UTILITIES
Chapter 34-B: The Maine Solar Energy Act
§**3475 Funding of Recycling Process Development; Equipment and Facility:** Whereas no approved solar panel recycling process currently exists in Maine, and no approved recycling facilities exist, the legislature approves the following:

A. Funding to develop a recycling process that recycles 95% of the entire panel regardless of manufacturer or engineering. An allocation of up to $2,500,000 in grants from the 35-A §10109 Regional Greenhouse Gas Initiative Trust Fund is authorized for this purpose.
B. Funding to design and construct recycling equipment and a recycling facility to assure success of the process identified above. An allocation of up to $2,500,000 in grants from the 35-A §10109. Regional Greenhouse Gas Initiative Trust Fund is authorized for this purpose.
C. Similar allocations are approved from the following and other available government resources if needed to assure an approved process, facility and collection scheme.
    1. Maine Solid Waste Management Fund
    2. Maine Solid Waste Diversion Grant Program
    3. Maine Technology Institute

Title 35-A: PUBLIC UTILITIES
Chapter 34-B: The Maine Solar Energy Act
§**3499 Penalties: Failure to Comply**

A. Failure to dispose of solar equipment in a manner other than an approved recycling process will result in a fine equal to the costs to recover, retrieve and recycle said equipment in an approved manner.
B. Failure to register identification information including serial number(s) of any solar equipment will result in a fine of up to $250 per unit. Such levy will be recorded as an addendum to the deed of the property in the Registry of Deeds on which the equipment is installed.
C. Refusal to permit inspection of any solar equipment will result in a fine of up to $250 per unit. Such levy will be recorded as an addendum to the deed of the property in the Registry of Deeds on which the equipment is installed.

Title 35-A: PUBLIC UTILITIES
Chapter 34-B: The Maine Solar Energy Act
§3475. Definitions

1. Solar energy equipment. "Solar energy equipment" means all controls, tanks, pumps, heat exchangers, collectors and all other equipment necessary for the collection, transfer and storage of solar energy, as determined by the Governor's Energy Office. **Passive solar** energy systems or those systems using natural means to collect, store and transfer solar energy may not be included under this chapter.

Title 36: TAXATION
Part 3: SALES AND USE TAX
Chapter 211: GENERAL PROVISIONS
§1752. Definitions
The following words, terms and phrases when used in chapters 211 to 225 have the meaning ascribed to them in this section, except where the context clearly indicates a different meaning:

~~**14-A. Solar energy equipment**~~. **repeal**

Title 36: TAXATION
Part 3: SALES AND USE TAX
Chapter 211: GENERAL PROVISIONS
§1760. Exemptions

Subject to the provisions of section 1760-C, no tax on sales, storage or use may be collected upon or in connection with:

~~**38. Solar energy equipment**~~. **repeal**

ICLEI Local Governments for Sustainability

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

IRENA International Renewable Energy Agency

SCALING UP RENEWABLES IN CITIES:

OPPORTUNITIES FOR MUNICIPAL GOVERNMENTS

Integrated planning enables cities to pursue ambitious renewable energy targets

Cities are responsible for 65% of global energy demand. Their contribution will therefore be crucial in accelerating the world's transition to a sustainable energy future. Given continued urban population growth – including the migration of some 80 million people from rural to urban areas each year – the importance of cities continues to rise.

Renewable energy solutions for buildings, transport and other urban systems will be especially crucial to ensure energy security, fulfil climate commitments and secure social benefits for all urban residents. Fortunately, successes are already being achieved.

Renewable buildings and transport will be crucial to ensure energy security

Cities are responsible for 65% of global energy demand

To examine ongoing challenges and highlight effective solutions in this regard, the International Renewable Energy Agency (IRENA) has collaborated with ICLEI (Local Governments for Sustainability)[1] and the German Agency for International Cooperation (GIZ) to produce a new set of case studies that review crucial aspects of the urban energy transition. The selected cases highlight local policy instruments – including public procurement, ordinances, mandates, and pilot projects – with a focus on ensuring reliable energy supply and on the building and transportation sectors.

As drivers of change, cities assume a multitude of roles, including decision-making, planning, giving key authorisations, managing assets, operating local energy suppliers and providing guidance or models for the public to follow. Municipalities can encourage, enable, measure and regulate the shift to new energy technologies and inform the debate on the necessary changes before turning them into relevant policies (IRENA, 2016).

Renewable energy procurement, for instance, helps municipalities meet rising electricity demand. To address the challenge of electricity shortages, Cape Town, South Africa, is deploying solar photovoltaic (PV) rooftop installations on municipality-operated buildings and purchasing renewable electricity both from small-scale embedded generation and independent renewable power producers. Cape Town has also initiated a campaign to raise public awareness of energy efficiency.

Ordinances and mandates are common policy tools that may be employed to encourage more sustainable building construction; for example, they can set minimum requirements for the share of renewable energy in a building's overall energy consumption or establish specific energy efficiency targets. A solar thermal ordinance adopted in Rosario, Argentina, has resulted in the installation of considerable numbers of solar water heaters on both new and upgraded municipality-owned buildings. Meanwhile, the municipality is partnering with various stakeholders from academia, civil society and the state government to provide dedicated training and loan options to expand installations. This has led to widespread use of solar water heaters throughout the community. On average, households have reduced their energy costs for hot water by 80%, compared to the cost of conventional water heaters. Following this successful implementation in Rosario, the market for solar water heaters is expanding across the different provinces of Argentina.

1 ICLEI was founded in 1990 as the International Council for Local Environmental Initiatives.

Pilot projects have shown that powering local transport systems with renewables can be cost competitive. In **New Delhi, India**, the government-owned Delhi Metro Rail Company (DMRC) has commissioned 20 MW_p of solar rooftop installations on metro stations and other buildings. Solar electricity is expected to cost less than the power supplied to DMRC by distribution utilities. The solar deployment will result not only in financial savings but also create 34 jobs per installed MW. With a 50 MW_p target, solar PV is expected to allow the Delhi Metro Rail system to become climate-neutral by 2021.

Integrated planning enables cities to pursue more ambitious renewable energy targets. **Malmö, Sweden**, for example, was sourcing all energy for municipal operations (such as city-owned buildings, city vehicle fleets and city-owned power-generation assets) from renewables by 2015. By 2016, renewables accounted for roughly one quarter of energy use within the municipality as a whole, putting the city on on track to reach 100% by 2030. **Vancouver, Canada**, meanwhile, has committed to sourcing 100% of its energy consumption from renewables by 2050. Vancouver integrates its renewable energy targets within existing sectoral strategies, including its Zero Emissions Building Plan, the Neighbourhood Energy Strategy, and the Transportation 2040 Strategy. In 2016, Vancouver achieved a 30% share of energy derived from renewable sources.

Reliable public lighting improves safety and navigation in cities but also contributes to local energy consumption and GHG emissions. **Sydney, Australia**, has substantially benefitted from measures to introduce energy efficient public lighting, which previously accounted for one third of municipal electricity consumption. Since the publication of an initial IRENA/ICLEI case study of Sydney in 2013, the replacement of conventional light bulbs with energy-efficient LED street lights has resulted in annual savings of USD 1.3 million in electricity and maintenance costs, as well as in saving 2.8 million kilowatt hours of electricity use.

IRENA also co-operated with ICLEI to produce an earlier set of case studies on renewable energy policy in cities (IRENA and ICLEI, 2013). Those cases examined renewable energy industries in Dezhou, China; strategies for the use of renewable sources in Chemnitz, Germany; emission reduction and waste-to-energy development in Belo Horizonte, Brazil; efficient street lighting in Sydney and in Nagpur, India; solar water heater mandates in Sao Paolo, Brazil; and earlier target development in Malmö.

Cities are drivers of change, taking on decision-making, planning and public guidance roles in the shift to new energy technologies

Ambitious renewable energy strategies can contribute significantly to enhancing the quality of life in cities through lowered costs, as well as reduced air pollution and carbon emissions. Turning successful pilot projects into well-defined roadmaps requires adequate policy support, strategic partnerships with public shareholders and development of the necessary technical capacity. A clear roadmap also demonstrates strong political commitment.

Furthermore, engagement with community stakeholders through consultations and awareness campaigns is essential. However, because they do not always have the requisite regulatory authority or the financial wherewithal, in many cases municipal actors also need to co-ordinate their efforts with regional and national levels of government.

These case studies offer a detailed review of the different approaches that municipal authorities can adopt to achieve progress. While each city faces particular challenges and opportunities, they share a common need for swift action. Avoiding climate disruption, reducing dangerous air pollutants and securing adequate energy supplies are immediate requirements that leave no time for delay.

The promotion of renewable energy, together with greater energy efficiency, offers practical solutions to these problems. As the experiences highlighted here confirm, however, those solutions work best when they are informed by pro-active consultations with the urban community and emphasise the socio-economic benefits for all residents.

Photograph: Shutterstock

Renewable energy, together with greater energy efficiency, offers practical solutions

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Further references are cited within each case study.

International Renewable Energy Agency

SOLAR SIMULATORS:

Application to Developing Cities

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About IRENA

The International Renewable Energy Agency (IRENA) is an intergovernmental organisation that supports countries in their transition to a sustainable energy future, and serves as the principal platform for international cooperation, a centre of excellence, and a repository of policy, technology, resource and financial knowledge on renewable energy. IRENA promotes the widespread adoption and sustainable use of all forms of renewable energy, including bioenergy, geothermal, hydropower, ocean, solar and wind energy, in the pursuit of sustainable development, energy access, energy security and low-carbon economic growth and prosperity.

www.irena.org

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The report is available for download: www.irena.org/publications

For further information or to provide feedback: publications@irena.org

CONTENTS

FIGURES

ABBREVIATIONS

3D	three-dimensional
cm	centimetre
DEM	digital elevation model
DHI	diffuse horizontal irradiation
DNI	direct normal irradiation
DTI	direct tilted irradiation
GHI	global horizontal irradiance
GIS	geographic information system
GTI	global tilted irradiance
IEA	International Energy Agency
IRENA	International Renewable Energy Agency
LAI	leaf area index
LCOE	levelised cost of electricity
LiDAR	light detection and ranging
PV	photovoltaic
S	shadowing effect
t	time

EXECUTIVE SUMMARY

Over half the world's population, or 3.5 billion people, are now living in cities. By 2050 this number is expected to reach nearly 6.5 billion. Cities, moreover, already account for 60-80% of global energy consumption, while urban energy supply systems face increasing pressure.

Typical challenges range from ageing infrastructure and high consumer prices, mainly in developed cities, to efficiency and reliability issues, typically seen in the cities of developing countries.

At the same time, the energy supply landscape globally is experiencing rapid change made possible by cutting-edge innovation. Storage technologies are improving and electrical loads are more efficient. Mini-grid applications are better understood and direct end uses such as heating, cooling and transport are being electrified. In addition, the cost of technologies that exploit alternative energy sources, notably solar photovoltaic (PV) systems, is continuing to decline.

With the right policies and sound urban planning practices at city level, administrators are particularly well positioned to effectively use these developments to manage energy demand, while simultaneously securing energy supply for their constituents that is clean, affordable and reliable both today and in the future. Urban planning and policy design, however, are complex. They require astute attention to the local conditions of the city – the structure of the local economy, income levels, existing regulations and overarching fiscal policies. They may also require attention to the priorities of central government and potential market players, including the private sector.

In advanced economies such as France, the Netherlands, the Republic of Korea and the United States, solar PV rooftop simulators have been put to effective use to aid the assessment of conditions in specific cities, with the prospect of establishing rooftop PV markets. These simulators use cutting-edge technology that combines know-how in remote sensing, high-performance data processing, three-dimensional (3D) building footprint generation and solar irradiation modelling.

This study explores the possibility of deploying similar simulation engines inexpensively, but effectively, in developing cities. If deployed correctly, they can quicken the pace of energy planning and improve the efficiency of policy structures aimed at creating sustainable markets for rooftop solar PV in these parts of the world. They can also provide important metrics for individual businesses and homeowners to assess PV systems as an electricity supply option for their properties.

The study elaborates the evolution of solar PV simulators, accounting for a wide range of applications from single rooftop assessments, typically performed by individuals, to large-scale, aggregate-level analyses undertaken by municipal authorities and other large entities. Larger-scale applications typically precede establishment of the optimal level and mix of incentives to stimulate this form of decentralised generation while, at the same time, ensuring the long-term viability of traditional power supply markets.

In the past, the need for specific expertise and the significant costs to develop these simulators have limited their use to advanced economies with well-established electricity markets and a strong research culture. This study finds that the technology landscape has evolved and that solar simulators can now be deployed to maximum benefit anywhere in the world at an affordable cost.

Major cost drivers – 3D rooftop footprint generation and solar irradiation modelling – can now be achieved at significantly lower cost with reasonable accuracy. The quality of satellite imagery required for modelling at this scale can now be produced with a resolution as high as 30 centimetres.

The typical energy supply challenges cities face range from ageing infrastructure and high consumer prices, mainly in developed cities, to efficiency and reliability issues, typically seen in the cities of developing countries.

In addition, the emergence of cloud computing solutions coupled with advancements in solar irradiation modelling – especially techniques that account for the tilt and shading typical of modern multifaceted roofing architecture – mean that the solar potential of rooftops can now be captured and modelled more accurately. This potential is subsequently provided as an input to complex economic models that examine multiple pathways to sustainable rooftop solar markets in cities.

As encouraging as this is, each individual city faces its own challenges. That is, while modelling techniques may be similar, energy services vary between cities. Thus, simulation of energy services and any subsequent shift in them must be tailored individually to the level of policy and market maturity in each city.

On this issue, the study finds that existing solar simulators, tuned to the business and regulatory setting of developed cities, may not readily be applicable to the developing world without considerable reworking. This is because they do not incorporate the issues faced by cities in these countries, where energy access and affordability are constrained, and where private-sector participation in the energy sector is limited. Furthermore, the regulatory regimes in these settings are often not sophisticated and still skewed towards traditional generators.

The solar PV potential of rooftops in developing cities can now be captured and modelled more accurately using low-cost solar simulators

Accordingly, this study provides a breakdown of potential policy design cases for low-cost solar city simulators. The opportunity for rooftop PV markets in developing countries is highlighted with a detailed explanation of the techniques required to build cost-effective simulators that can be deployed with considerable ease in these settings. Finally, the study highlights the ongoing effort of the International Renewable Energy Agency (IRENA) to use the expertise, data-sharing and hosting capabilities of its Global Atlas for Renewable Energy in demonstrating this technology in selected cities in Uganda and China.

The findings of this work should motivate further dialogue on energy planning in the urban context. More importantly, they make the case for greater use of proven data-driven techniques – such as solar simulators – in creating actionable, pragmatic policy and economic solutions for enhancing energy sustainability in cities in developing countries.

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INTRODUCTION

This report has been prepared to assist cities around the world to take advantage of new developments in solar simulation technology to meet their increasing energy needs. It focuses on aspects of these developments – technology and expertise, mostly pioneered in developed countries – that can be transferred cost-effectively to help alleviate the energy challenges of cities in the developing world.

With this focus, the report explains how city energy planning can benefit from an enhanced understanding of the potential of rooftop solar, appealing both to local municipalities at an aggregate scale and home owners on a small scale. It highlights aspects of the process that can be achieved at a cost significantly lower than previously possible, and presents particular cases where outputs are adapted to the most pressing issues being faced in these settings.

The report opens with an appraisal of the opportunity, shedding light on the common issues faced by cities in most developing countries – growing demand, access, reliability and affordability. It explains the evolving trends in innovation in this space, requiring sound data-driven policies and regulatory regimes to increase access to clean and sustainable energy services in cities in developing countries.

Next, the report explains the findings from an extensive literature review of the methods for developing citywide solar simulators and their application, detailing instances where the results can feed into key processes such as target setting, policy design and market facilitation. It explains key aspects of the modelling process (i.e. three-dimensional [3D] building footprint generation and rooftop solar resource estimation) that were hitherto only achievable at significantly higher cost. It also documents a potential alternative that can enable these tools to be applied at significantly lower cost and adapted to the needs of these cities.

Further, the report provides an extensive overview of these needs, segmenting various cases and establishing four practically applicable scenarios for the use of solar city simulators in developing countries. These include studying the economics of solar photovoltaic (PV) generation and the impacts of rooftop PV electricity production; assessing potential ways to boost access to or improve intermittent supply of electricity; investigating options to reduce consumer prices for electricity through rooftop PV programmes; and finally, assessing the opportunities for end-use sector coupling (e.g. solar heating and cooling, transport).

Finally, the report outlines the International Renewable Energy Agency (IRENA) plan to demonstrate these simulators in two cities, one in China and another in Uganda, capitalising on the technical capabilities of its *Global Atlas for Renewable Energy*. The report provides initial insights into the key functionalities and outputs that can be expected from IRENA's pilot implementation of low-cost simulators. It also features two annexes, one providing a list of examples of solar simulators deployed mostly in cities in developed economies, and a second reviewing the technical process for developing citywide solar irradiation rooftop models.

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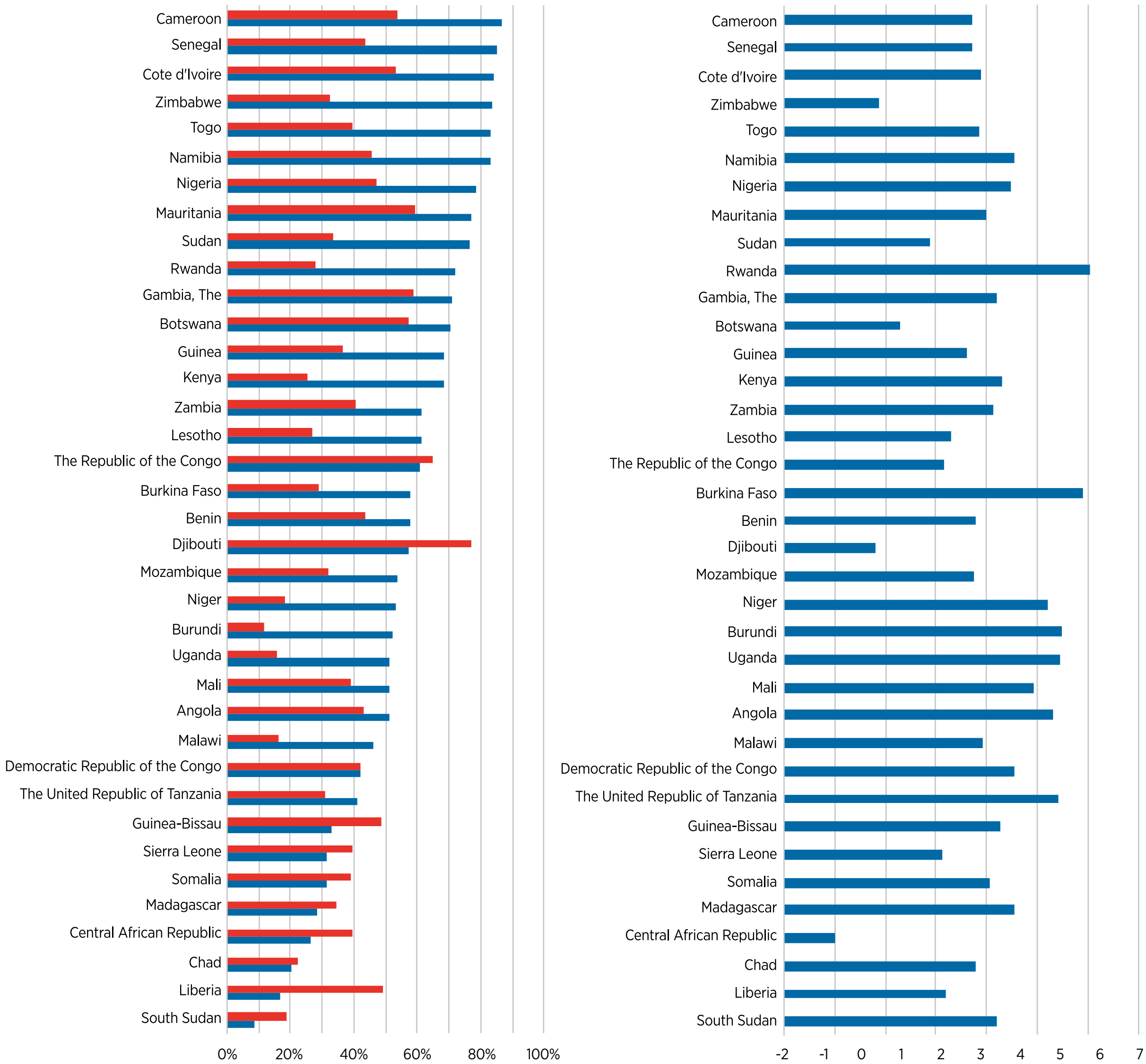
1. URBAN ENERGY CHALLENGES AND THE NEED FOR SOLAR SIMULATORS

Demand growth and access

By 2050 two-thirds of the global population is expected to live in urban areas, with most of the growth occurring in Africa and Asia. The trend is clear in large cities such as Delhi, Dhaka, Jakarta, Rio de Janeiro and Shanghai, where electricity demand grew by factors between 1.5 and 2.0 in the decade 2001 to 2011.(ibid.) This rapid pace of urbanisation is creating a massive surge in demand for energy services and the electricity they require.

Currently, however, more than 130 million people lack access to electricity in urban areas, with 95 million of these living in sub-Saharan Africa (World Bank, 2017). Figure 1, for example, illustrates the situation in a number of countries in the subcontinent as of 2014. As highlighted, while the urban growth rate tops 4% in most of the countries, a significant proportion of residents are still without access to electricity.

Figure 1: Countries in sub-Saharan Africa with below 80% electricity access in urban areas, 2014



Notes: The left-hand chart illustrates electricity access in urban areas as a percentage of the urban population (blue), and the urban population as a percentage of the total population (red). The right-hand chart represents the annual rate of growth of the urban population in percentage terms.
Based on World Bank (2017), World Bank Open Data, https://data.worldbank.org.

Reliability

In countries with greater than average urban electricity access, the reliability of supply is a challenge. For example, although 30% of the population in Africa and 60% in Southeast Asia are reportedly connected to an electricity grid, the service is often infrequent, with disruptions that compel consumers to rely on back-up generators at a high cost (ESMAP, 2017).

These disruptions result in a loss of productive capacity for business and they negatively impact the standard of living of residents. In 2016, for example, the loss of value to business due to electrical outages in sub-Saharan Africa was quoted at 8%. In the Middle East and North Africa these losses reached 5.9%, and 3% in East Asia and the Pacific. By comparison, they are less than 1% in the European Union (World Bank, 2017).

Potential solutions

With the rapidly falling price of rooftop PV systems and smart system design, this option is becoming attractive and reliable, offering competitive economics compared to the extension of grids (IRENA, 2017). Rooftop PV installations can bring value to residential and commercial buildings by supplying electricity during grid outages, as well as increasing the resilience of the electricity system (NREL, 2014). In India, for example, Sundaray et al. (2014) highlight the value of rooftop PV in compensating for the regular power outages experienced in most Indian cities due to load shedding.

This shedding and consequent loss of productivity also are mentioned as the main drivers for assessing the potential of rooftop PV in other developing-country cities: see, for example, Adeleke and Smit (2016) for South Africa; Khan (2016) for Pakistan; and Luqman et al. (2015) for Lahore. In this context, simulators capture the potential for decentralised rooftop installations. This makes them essential to modelling solar-based business and policy solutions.

1.1. Solar simulators for cities in developing countries

The energy services landscape is evolving rapidly. With the falling cost of PV systems and wide-ranging innovation – net-metering, microgrids and electric mobility on the engineering front, and the evolution of business and financing models and payment systems – there is no a better time for cities to incorporate rooftop PV solutions into their supply mix. Municipal planners in these cities, however, need to develop sound data-driven policies and regulatory regimes to incentivise this process. More pertinently, these policies need to reflect the economic realities of these cities, particularly in developing countries where – as indicated earlier – the issue is a dire need.

Developing this enabling framework for the most part can be quite complex and expensive, depending on the approach taken. It typically starts with a citywide assessment of the rooftop solar potential, where the total available rooftop surface of the entire city is established and then delimited to determine the share of the surface that is suitable for installing solar PV. Castellanos, Sunte and Kammen (2017) distinguish three categories of methods to do this:

- Sampling methodology: A calculation is made of the total available roof surface, based on a detailed analysis over a sample area that is generalised to the entire city.
- Multivariate sampling methodology: The rooftop area per capita is calculated using population density correlated with the types of building and the available area. This is then multiplied by the total city population.
- Complete census methodology: The entire rooftop area is computed by producing either statistical datasets that contain building information (i.e. proportions of commercial, residential and industrial buildings) or by carrying out an analysis by way of a geographic information system (GIS) with 3D models of the city.

Rooftop PV supplies residential and commercial power during grid outages and increases the resilience of the whole electricity system

The results obtained, using any of these methods, ultimately feed into studies that assess suitable policy options to improve the supply, efficiency and sustainability of energy in these cities. In principle, this outcome is achievable through desktop research and anecdotal experience from other cities.

It is also achievable through initial demonstrations on a sample of buildings. For example, Ethekwini – a small municipality in the city of Durban, South Africa – installed solar PV systems on five of its municipal buildings in 2017 to learn about the daily and yearly generation profiles obtainable from these systems. One of the main objectives of this pilot was to create enough local experience of PV systems to develop policies that would guide their deployment across the entire municipality.

The anecdotal approach to policy analysis and design is obviously susceptible to potential flaws, as knowledge gaps can result from limited understanding of all potential outcomes of deployment, with a fuller understanding obtainable only through multiple simulations. Pilot implementation, conversely, can be costly. Pilots require time and do not necessarily guarantee representative results. This is where solar simulators that apply complete census methods play a key role, as they provide the capacity to pre-emptively analyse several outcomes prior to roll-out.

Solar simulators employ cutting-edge technology that combines know-how in remote sensing, high-performance data processing, 3D building footprint generation and solar irradiation modelling. They are by far the most accurate methodology, can be deployed to study entire cities, and can be applied to support target setting, policy design and market facilitation.

They can also be tuned to provide a variety of outputs, including estimates of the installable capacity and generation potential of each rooftop, directly relevant to individual homeowners and property investors, but also very useful for city planning when output is aggregated. Examples of solar simulators include Google's Project Sunroof[1] and MIT's Mapdwell.[2]

Annex 1 provides a non-exhaustive list of places that have employed interactive rooftop solar simulators. As a result they have enabling frameworks with sound policies to lessen the risks associated with investing in rooftop PV. Most of these platforms have been made public and interactive to reach the targeted audience. They form the knowledge base from which to exploit solar energy (Kanters, Wall and Kjellsson, 2014).

The listed cities are, however, exclusively in developed countries with a strong research culture and funding base, where key ingredients of a simulator, such as 3D city plans based on expensive airborne light detection and ranging (LiDAR) measurements, already exist. For the most part, these simulators are also used in other areas of analysis, including estate and infrastructure development.

Therefore, bringing the value of this technology to cities in developing countries would require significant adaptation, both in the technical methodologies – to save cost – and in the development of business cases that adequately reflect these cities' characteristics. The subsequent parts of this report review in detail the current methods deployed in developing existing solar simulators. The limitations of these methods are highlighted, with an emphasis on the need for their adaptation to solve problems in developing-country cities. It provides insight into a revised cost-competitive approach that can be deployed with considerable ease in such places.

The work also provides a general breakdown of potential cases for the use of simulators, with a solution-focused approach to urban energy planning. It highlights important international influencers, such as the New Urban Agenda adopted by the United Nations General Assembly in resolution 71/256 of 23 December 2016, which could support the push for their deployment across several cities and communities in the developing world.

1. See *www.google.com/get/sunroof#p=0* for more information.
2. See *www.mapdwell.com/en/solar* for more information.

2. SOLAR CITY SIMULATORS: APPLICATIONS AND ALTERNATIVE METHODS

Kanters, Wall and Kjellsson (2014) have compared the outputs and impacts of 19 solar simulators in 8 countries. Half of the cadastres in their review were designed to illustrate the level of incoming solar irradiation on rooftops, while the other half simulate the PV output (technical potential). In terms of impact, the city of Basel in Switzerland was cited as an example where the deployment of a solar city simulator encouraged citizens to renovate their roofs so that solar PV systems could be installed on 500 of them.

Nevertheless, the level of complexity of solar simulators varies significantly, from simple static maps describing the potential suitability of a rooftop PV system (e.g. from high to low), to tools that pre-calculate technical potential under fixed assumptions (e.g. production, investment, net present value), to fully interactive technical and financial simulators. IRENA's literature review supports the classification of solar cadastres by complexity level, as proposed by Kanters, Wall and Kjellsson (2014):

- Basic: Indicates irradiation levels and their categorisation (e.g. high, medium, low irradiation values).
- Medium: Indicates irradiation levels, solar system outputs, categorisation of suitable area for solar production and system effect.
- Advanced: Indicates irradiation levels, system (PV, thermal) output, categorisation of suitable area for solar production, system effect, monthly output, financial considerations, information about installers and data regarding solar energy.

The new generation of advanced online solar simulators can provide analytical support in three major opportunity areas:

- Opportunity 1: target setting: high-level data to provide a broad analysis of solar PV rooftop potential.
- Opportunity 2: policy design: detailed information required to deliver an effective and efficient business case to achieve objectives.
- Opportunity 3: market growth: support to citizens, financers and installers in order to lower investment barriers and risks of investing, as well as increase the volume of installations.

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Opportunity 1: Target setting

Setting renewable energy targets is a policy-driven process that uses evaluations of the renewable energy potential as a knowledge base. Solar simulators can support this by providing an evidence- and data-based analysis of solar PV rooftop potential. The analysis establishes the suitability of rooftop areas, corresponding installable capacity, production potential, and levelised cost of electricity (LCOE), particularly for public buildings (AfDB, 2017).

At this level the prevailing preference is for high-level approaches, whereby an initial assessment is made through sampling and extrapolation (Amado and Poggi, 2014a; Gagnon et al., 2016; Sundaray et al., 2014; Wiginton, Nguyen and Pearce, 2010). With more time and effort, solar simulators that are developed using census methodologies result in more accurate analysis. At such an early stage (target setting), however, the use of this approach should be limited, in the event the municipality does not proceed with solar PV as an option for the city's energy supply.

Opportunity 2: Policy design

Post target setting, once the municipal authorities are convinced of the solar potential for their city as derived either from simplified estimates or advanced solar simulators, the need for an appropriate policy framework arises. This brings more complexity with regard to the granularity of data and required modelling, and is the environment in which solar simulators are most valuable, since they provide a precise vision of the solar rooftop potential.

Solar simulators are used in the design of these policy frameworks, which may include investment incentives, attractive business models (Sundaray et al., 2014) and various tariff scenarios (Martin and Rice, 2018), often in combination. A simulation of the distribution grids with a large share of rooftop solar PV may also be made available.

The target audience for solar simulators as applied to policy design are those cities that are sufficiently ambitious to pursue renewable energy alternatives, and which are in the process of developing relevant regulations. These cities may be participants in or members of the Sustainable Cities Integrated Approach Pilot programme (supported by the Global Environment Facility [GEF, 2017]); the World Bank's Global Platform for Sustainable Cities; the International Council for Local Environmental Initiatives (ICLEI) (1 500 members); or the Covenant of Mayors (7 700 signatories). The main outcomes of policy design are evidence-based recommendations and the enhanced capacity of local policy makers in urban energy planning, together with the solar simulator (cadastre) as a knowledge base.

Opportunity 3: Market facilitation

During implementation of local policy, advanced solar simulators (as presented previously) that are publicly available (web-based) can help identify projects that are potentially profitable, while taking into account the local enabling environment. These online platforms are currently of commercial value and are managed by start-up companies. They operate in countries where the policy framework has reached maturity and the rooftop PV market is sufficiently large to allow these start-ups to sell solar simulators or analysis as a service to municipalities, and/or to use them to connect consumers and installers. At this stage, the most comprehensive online solar simulators are essentially business-to-business and business-to-consumer multi-dimensional platforms that compare electricity demand with supply for each building in the city, and highlight the need for and prospective gains from rooftop installation.

2.1. Developing solar simulators based on a complete census approach

The creation of a solar simulator can be summarised by a four-step workflow, adapted from Lukač et al. (2013) and Gagnon et al. (2016), as follows:

- creation of detailed 3D building footprint and digital elevation model (DEM)
- simulation of solar rooftop resource
- identification of suitable roof areas
- simulation of rooftop systems.

These steps provide a geospatial dataset relating to city rooftops. Each polygon (building rooftop) includes information on the height, azimuth, tilt and suitable area(s) of the rooftop, installable capacity and generation potential.

The creation of the 3D building footprint and DEM represent the major cost drivers in the process, which could significantly hinder their deployment in low-income countries. Existing techniques create these by using LiDAR measurement campaigns, which are highly detailed and extremely expensive. The spatial resolution of these input datasets (in centimetres [cm]), reflecting the close accuracy of this method, represents the city while capturing detailed features such as sharp elevation changes in complex rooftop structures.

Using attributes of the 3D building rooftop structures, an estimate of the solar irradiation captured on the surface of each rooftop – and, consequently, the generation potential – can be computed. These pro-forma solar resource generation estimates rely on methods developed to calculate the irradiation on tilted surfaces, which effectively transpose the direct normal (DNI), the diffuse horizontal (DHI) and the ground-reflected irradiation components (see detailed model review in Annex 2). Critical factors, such as shading, are accounted for and used to limit the rooftops to suitable portions upon which PV cells should be installed. This area then forms the basis of rooftop system simulations to estimate generation capacity (Annex 2).

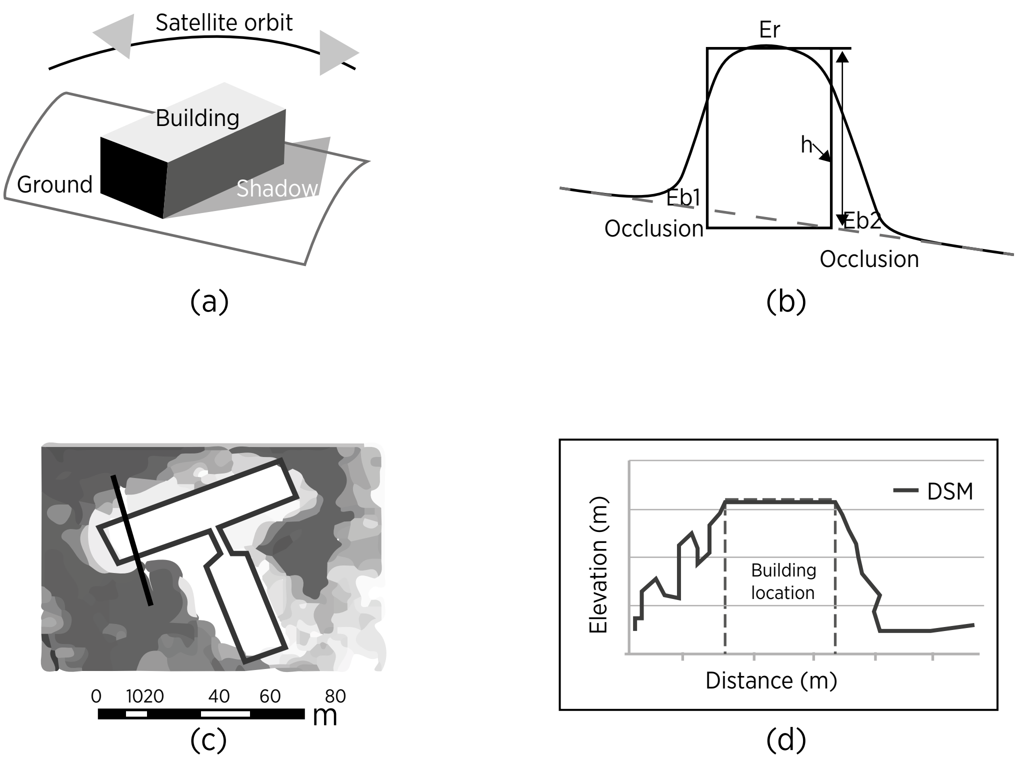
2.2. Emerging alternative to expensive 3D building footprint and DEM generation

An alternative approach to LiDAR measurement campaigns in the generation of the 3D building footprints and DEMs, which is deemed to be less expensive, relies on stereoscopy (photogrammetric techniques) that use high-resolution satellite imagery (up to 30 cm spatial resolution) as input.

For illustrative purposes, IRENA conducted an in-house exercise to develop a DEM from a pair of stereoscopic images at 50 cm resolution, representing two perspectives of the same scene (buildings in a city). The height (elevation) of each building was estimated by processing an ortho-rectified pair of images and combining them to observe the parallax between the exact features in the same position. The DEM from this could then be segmented and further processed to create representations of each rooftop's structure and, eventually, the 3D building rooftop model of the city.

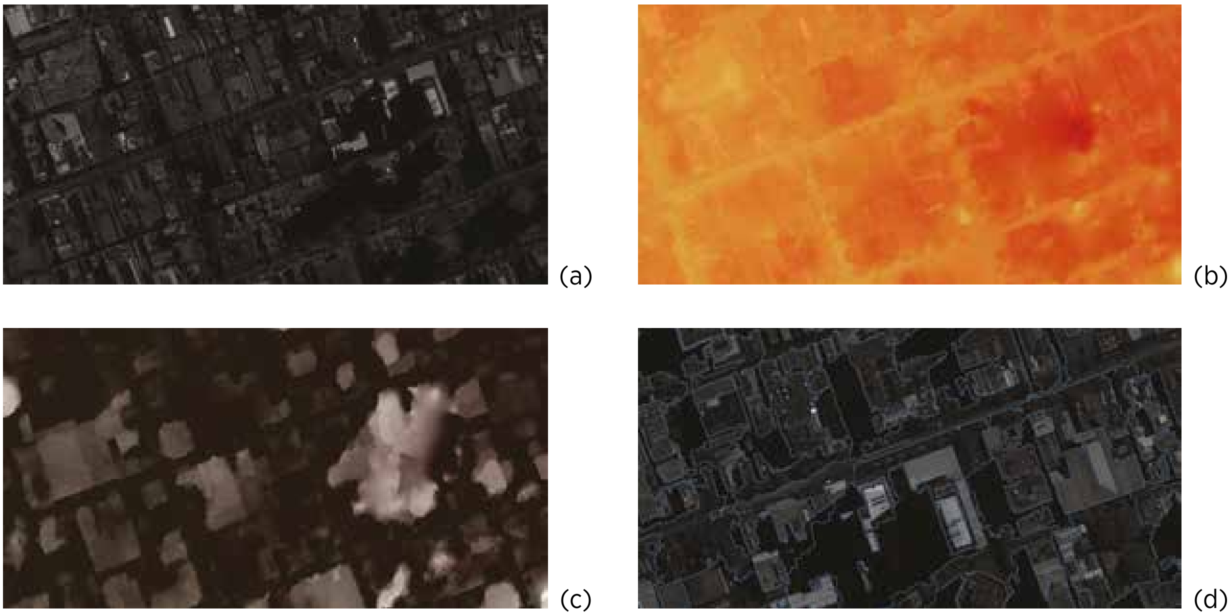
Although the DEM from this exercise identifies the rooftop locations (Figure 2), the results require additional refinement to be practically applicable. Specifically, manual edits are necessary at the edges of complex roof types to correct classification errors due to shade or other image noise phenomena, and also to account for obstructions such as trees, water tanks or mounted structures on rooftops (Figure 3).

Figure 2: Approach and uncertainties of DEM generation from stereo imaging



Notes: A building is imaged twice (a), with a difference in parallax; the curve in (b) represents the colour gradient for a cross-section of the building (the rooftop edge is not sharply identified, and the actual elevation differs from the calculated height); (c) the grey-coded elevation and the actual building edges are overlaid in black lines; and the elevation profile across the line is observed in (d); artefacts next to the building location may confuse automated recognition software.
Source: Zeng, Chuiqing (2014), "Automated building information extraction and evaluation from high-resolution remotely sensed data", *https://ir.lib.uwo.ca/etd/2076*.

Figure 3: Reconstruction of city DEM from stereo imaging



Notes: Internal simulation using sample satellite images over Melbourne for testing purposes: (a) mosaicked Tri-stero panchromatic image bundle shows; (b) the digital terrain model created from ortho-rectified stereoscopic images with resolution at 50 cm; in areas with strong elevation gradients, shading is the cause of difficulties in extracting the elevation ; (c) initial outlines of rooftops are extracted from one of the ortho-images; (d) both inputs are combined to assign an elevation and to delineate the sections of each rooftop. The artefacts on some of the buildings are not properly captured in the digital elevation and terrain model which result in notable omissions in the rooftop segmentation in this image. To correct this, manual edits are required.

Source: Internal simulation produced by IRENA using Airbus (2012), Sample Imagery: Pleiades Tri-stereo panchromatic bundle for Melbourne Australia, *www.intelligence-airbusds.com/en/8262-sample-imagery*.

Although commercial software programs, such as PCI Geomatica used in IRENA's previously mentioned exercise, allow the processing of stereo images, the generation of a high-resolution DEM for an entire city requires significant computational capabilities and skills. The study found these to be obtainable with varying levels of accuracy from a number of private companies, for a fee, for any location in the world due to the availability of high-resolution satellite imagery. The quality of the output, however, may vary depending on the resolution of data input.

Notably, LiDAR and stereoscopy alike produce clouds of elevation points, with the former being better due to the ultra-high resolution, possibly less than 10 cm. The cost of LiDAR campaigns, however, can run into the millions of US dollars for cities 20–30 square kilometres in size – hence the reason 3D building footprint data and high-resolution DEMs are not readily available in developing countries.

Although LiDAR campaigns (sometimes coupled with aerial imagery) remain the ideal option, satellite imagery based stereoscopic modelling – achievable for under USD 50 000 for a similar area – provides an inexpensive and fairly accurate option that can be deployed rapidly in developing countries to build the essential data input for the solar resource modelling process. The required overlapping satellite images are, in general, available at 50 cm resolution globally[3] and, in some instances, at 30 cm resolution from DigitalGlobe's WorldView-3 and Worldview-4 satellites. The availability of such images taken in conditions that allow for stereoscopic pairing depends on the latitude of the city, with frequencies improving at higher latitudes.

Agugiaro et al. (2012) compare the performance of 50 cm resolution images with those of 25 cm and conclude that the former would be sufficient to extract the rooftop surfaces and required attributes (tilt and azimuth) for rooftop PV simulation. At that scale, the detailed structure of the roof (e.g. presence of chimneys and other artefacts) would remain unknown.

3. The satellite coverage can be tested online. See DigitalGlobe at https://discover.digitalglobe.com and LandInfo Worldwide Mapping LLC at http://search.landinfo.com/. For some campaigns, images can be downloaded from US Geological Survey archives at https://earthexplorer.usgs.gov (accessed March 2018).

3. LOW-COST SIMULATORS FOR SOLAR POLICY DESIGN

Having established in earlier chapters the technical feasibility of developing and running solar simulators, the next question is how these simulators can practically make a difference for cities in the developing world. In other words, what impact can solar simulators have on improving the accessibility, affordability and reliability of electricity supplies?

Building the use-case scenario requires a preliminary assessment of each city's strategy, with the aim of reaching solutions that are tailored to local needs (design thinking). The sections that follow discuss some of the issues that developing-country cities may face, based on the body of literature reviewed:

- Case 1 provides a baseline scenario: the interest in growing rooftop PV is driven by the economics of the technology and the opportunity to reduce the carbon dioxide impacts of electricity production.
- Case 2 presents constrained access based on supply: the main issue is the lack of access to or intermittent supply of electricity, rather than that of pricing.
- Case 3 presents constrained access based on prices: the prospective cost of grid extension, especially to remote communities, results in electricity prices that hamper economic and social development.
- Case 4 offers a sustainable city scenario: the municipality investigates the opportunities for modern energy services and sector coupling (e.g. coupling solar with heating and cooling or with transport).

Building the use-case scenario for solar simulators requires a preliminary assessment of each city's energy strategy

Case 1. Accessible, affordable and reliable electricity supply

This is the current environment in which solar simulators have been produced so far (see list in Annex 2). In this case, specific attention is paid to taking advantage of falling PV production costs where grid parity has been reached or surpassed. Simulations are based on the expectation that the electricity produced would satisfy household demand either partially or completely. The existing simulators that address this case have options to assume gross or net metering, allowing the economics of a PV system to be assessed in an interactive fashion based on available financial incentives. The decision of a building owner to invest in a PV system is assumed to be one based on a comparison of the system's LCOE against the electricity retail price, accounting for possible local tax exemptions, premiums or tariffs.

Case 2. Unreliable electricity supply

In this case, solar PV adds value by bridging the gap created by electricity demand that is unsatisfied. When backup power capacity is used, the economics of the PV system is compared to the LCOE of alternatives (e.g. diesel generator, kerosene). In such case, the solar PV system improves access by lowering the kilowatt hour price. When there is no alternative, however, the PV system may improve access by increasing power reliability and daily energy availability.

A major variance in this scenario would be the addition of storage for a single household, or for mini-grids at the district level. This level of simulation requires a more complex supply and demand analysis, as well as a review of load profiles. IRENA's online Project Navigator offers a residential solar PV evaluation model that includes storage criteria (IRENA, 2018).

Case 3. High electricity prices due to excessive grid extension costs

In this case, rooftop PV is investigated as an alternative to extending the electricity grid to remote communities or creating standalone electricity grids – which could give rise to electricity prices that are exorbitant, that constrain demand for the service, and consequently result in adverse impacts on the local economy. The main dimensioning parameters include the load and production profiles, investment costs, and capital and maintenance costs (e.g. inverter).

Case 4. End-use sector coupling

Accelerated urbanisation rates translate into an urgent demand for improved infrastructure, services and institutions. The complexity of urban infrastructure requires collaboration at the highest levels to address multiple-sector coupling, referred to as the Urban Nexus in GIZ and ICLEI (2014). Urban issues are complex and require solar simulators to provide the necessary baseline information to conduct an analysis of energy policy. A prime example for reference is electric mobility (e-mobility).

The global market for electric vehicles is growing at a rapid pace, having exceeded 2 million units in 2016 (IEA, 2017). Electric cars outnumber public charging stations at a 6:1 ratio, and most drivers rely on private charging stations to power their vehicles.

According to the International Energy Agency (IEA, 2017) and Bauer et al. (2017), the e-mobility sector is expected to create important sector coupling opportunities and could change demand profiles. One option to mitigate the impacts of electric vehicle charging is to incentivise self-consumption through solar systems (IEA, 2017). This is a case of sector coupling that is examined by Byrd et al. (2013). A high-resolution solar simulator is used to simulate daily net-metering patterns and assess the energy absorption of electric vehicles through self-consumption.

One option to mitigate the effect of electric vehicle charging on the electricity system in cities in the future will be to encourage self consumption through solar PV.

4. AN IRENA SOLAR CITY SIMULATOR: DEMONSTRATION IN UGANDA AND CHINA

The Global Atlas for Renewable Energy is IRENA's platform to promote best practices in renewable energy resource assessment globally. It comprises a web-based geographic information platform, coupled with offline zoning and site assessment services aimed at facilitating the development of renewable energy markets worldwide. The web platform provides access to more than 2 000 renewable energy maps covering solar, wind, geothermal, biomass and tidal energy, and has played host to more than 200 000 online professionals since 2013.

Drawing on the technical expertise, datasets and network built around the platform over the years, IRENA is in the process of demonstrating a pilot solar city simulator – the SolarCityEngine – in the cities of Kasese in Uganda and Zhangjiakou in China. While the demonstration in Zhangjiakou is yet to start, that in Kasese has progressed significantly. In Kasese, a settlement with a population of slightly more than a 100 000 people, Case 1 and Case 2 will be tested.

The solar simulator for Kasese – now quite advanced in design – addresses purchase and lease financing options for rooftop solar PV installations in the city, with three business cases:

- That of an individual home owner seeking to compare rooftop PV to alternatives.
- An estate promoter investigating the prospects of a small community (group of buildings) being equipped with rooftop solar.
- A simplified case of a municipality investigating the cost of different policy options on a broad scale, across the entire city.

For individual homes and small communities, this simulator allows for the dynamic optimisation of PV systems on rooftops in the city and generates several key decision factors, such as total available surface area, installable capacity, generation potential, total investment cost, LCOE, net present value and savings, among others. The same tool also helps to investigate the long-term benefits of rooftop PV installations in load-shedding situations compared to alternatives (e.g. small gasoline generator sets).

For municipal authorities, the system optimises installations for the entire city, assuming the best areas are equipped to meet target capacity. It allows for highly simplified simulations of the impact of a limited list of policy options – on the viability and affordability of rooftop systems in the community. One example addressed in this tool is the effect of import tax reductions on the tariff (under a lease model) for a target installed capacity across the city. The outputs may include the total volume of investment created, the value per unit of government spending, and indices to estimate affordability, i.e. the per kilowatt-hour PV electricity price as a percentage of daily household income, and the quantity of electricity that can be purchased at this price with 10% of daily household income.

This demonstration is intended to highlight the opportunities for growth in rooftop installations in Kasese. In addition, and as a consequence, it should stimulate the appetite of municipal authorities in other cities in developing countries to take full advantage of the benefits of low-cost solar simulators.

A simulator for Kasese, Uganda, offers financing options for solar PV installation

5. CONCLUSION

This report was prepared in the context of ongoing activity by IRENA to demonstrate the impact of deploying low-cost rooftop solar PV simulators, primarily to support the energy transition in cities of developing countries. The report is a product of a detailed review of literature to understand the processes behind solar rooftop PV simulator tools and their effectiveness at providing accurate information on solar potential at a resolution high enough to assess rooftop spaces in cities.

The report concludes that solar PV simulators that embrace cutting-edge technology – combining know-how in remote sensing, high-performance data processing, 3D building footprint generation and solar irradiation modelling – can be deployed cost-effectively in cities in developing countries for a wide range of applications.

Primarily, at the individual level, they can be used to study the economics of a rooftop solar PV installation. For municipalities, they can be used to: assess ways to boost access to electricity or improve intermittent electricity supply; investigate options to reduce consumer prices for electricity through rooftop PV programmes; or to assess the opportunities for end-use sector coupling (e.g. coupling solar heating and cooling with transport).

The report also concludes that these tools – currently only available to cities in developed countries (see Annex 1) – can now be built cost-effectively and deployed in cities in developing countries to provide input to the process of urban planning and, specifically, that of developing solar PV rooftop programmes in these settings.

The findings of this work are intended to motivate further dialogue on energy planning in the urban context. Most importantly, they are meant to spur the increased use of proven data-driven techniques – such as solar simulators – to create actionable and pragmatic policy and economic solutions. Better-informed solutions, in turn, should enhance energy sustainability in the cities of developing countries.

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ANNEX 1. INTERACTIVE SOLAR ROOFTOP SIMULATORS AND CADASTRES: A NON-EXHAUSTIVE LIST

Aachen (Germany)	Geoportal Aachen: https://geoportal.aachen.de/extern/?lang=de&basemap=luftbild2016&blop=1&x=294405.36611213&y=5628845.6132009&zl=15&hl=0&layers=solaranalyse57e2770b86066&theme=3
Amersfoort (the Netherlands)	Amersfoort rooftop solar PV installation and generation potential simulator: http://amersfoort.burokarto.nl
Annecy, Bordeaux, Lyon, Nantes, Paris (France)	Solar cadastres for: Annecy, Bordeaux, Lyon: www.cythelia.fr/energies-renouvelables/expertise/cadastre-solaire/ Nantes https://nantes-metropole.insunwetrust.solar/simulateur Paris: http://capgeo.sig.paris.fr/Apps/CadastreSolaire/
Berlin (Germany)	Berlin Solar Atlas (by business location centre) www.businesslocationcenter.de/wab/maps/solaratlas/?startingmap=ol3&legendposition=left&layerToActivate=solarpotential_gebaeude_2013&groundPosition=13.39848,52.51573&distance=3217.64&headerTitle=Solaratlas+Berlin&lang=de&WAB-REDIRECT=1
Calgary (Canada)	Calgary Solar Potential Map: https://maps.calgary.ca/SolarPotential/
Dusseldorf (Germany)	Rooftop Solar Suitability Indicator for Dusseldorf: http://details.solare-stadt.de/duesseldorf
Geneva (Switzerland)	Solar Cadastre of the Territory of Geneva: www.etat.ge.ch/geoportail/pro/?mapresources=GEOTHERMIE%2CENERGIE_SOLAIRE%2CENERGIE&hidden=GEOTHERMIE%2CENERGIE_SOLAIRE
Graz (Austria)	Geodata Portal of Graz: https://geodaten.graz.at/WebOffice/synserver?project=solar_pv&client=core
Lisbon (Portugal)	Rooftop Solar Potential Platform of Lisbon by Lisboa e.Nova: http://80.251.174.200/lisboae-nova/potencialsolar/
Marburg (Germany)	Solar Cadastre of Marburg: www.gpm-webgis-10.de/geoapp/solarkataster/marburg/
Solingen (Germany)	Rooftop Solar Potential Platform for Solingen: https://stadtplan.solingen.de/buergerservice1/ol3/sg_layout.html?gui=solar&scale=4&x=2576000&y=5671201&wmslayer=1,0
The Netherlands	Zone Atlas of the Netherlands: www.zonatlas.nl/home/
United States	Mapdwell: www.mapdwell.com/en/solar Google sunroof: www.google.com/get/sunroof#p=0
Tyrol (Austria)	SOLAR-TIROL Solar Potential Database: http://webgis.eurac.edu/solartirol/
Vienna (Austria)	Vienna Solar Potential Cadastre: www.wien.gv.at/umweltgut/public/grafik.aspx?ThemePage=9

ANNEX 2. THE SOLAR RESOURCE MODELLING PROCESS

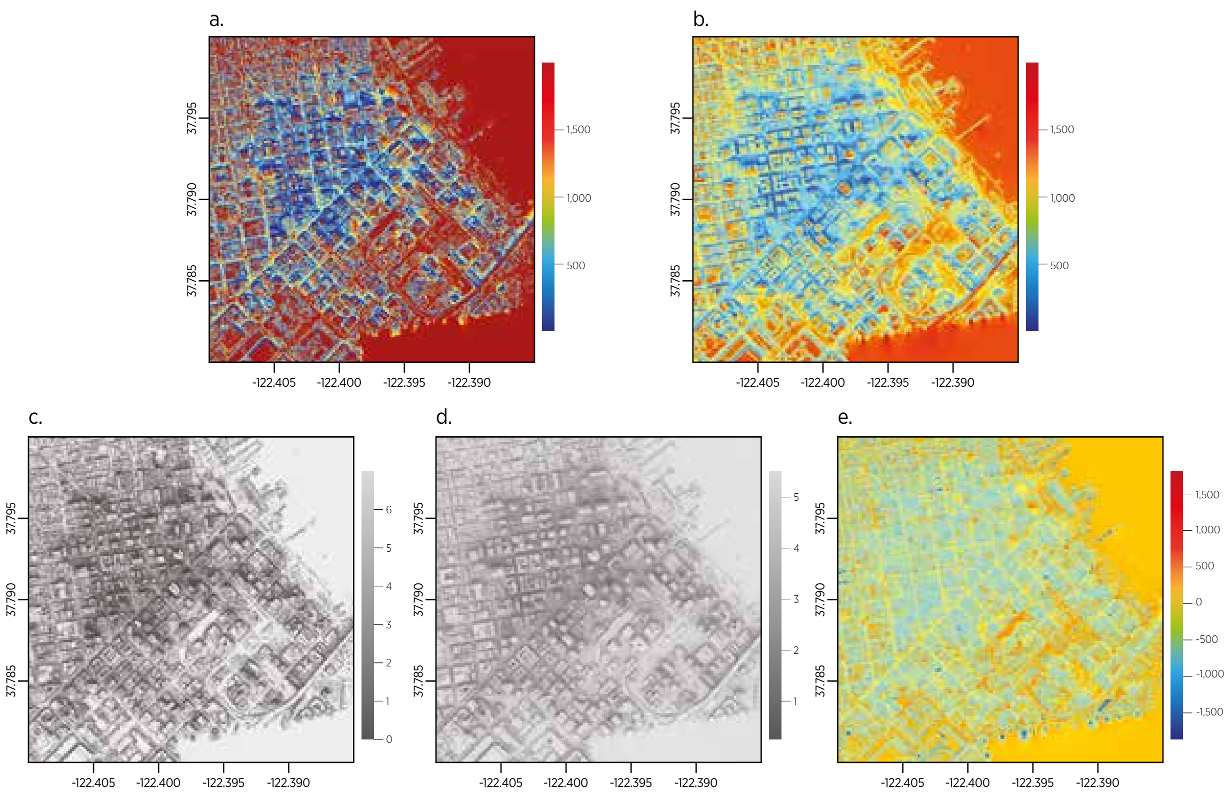
An estimate of solar irradiation on the tilted surfaces of various orientations is essential to simulate the production of PV arrays. For this, transposition models that estimate the solar irradiance incident on tilted PV panels are used. The global horizontal irradiance (GHI) consists of three components: the direct normal, the diffuse and a third component due to reflectance from earth surfaces.

Transposing the direct component is fairly straightforward, using commonly agreed trigonometric transformations that take into account the sun's azimuth and the tilt angle of the location. Where opinions differ is in the handling of the diffuse component. Mubarak et al. (2017) compared five models built for this purpose (i.e. the models of Liu and Jordan, Klucher, Hay and Davies, Reidl and Perez). In their review, anisotropic models offer a finer description of the diffuse component, presenting a higher performance compared to isotropic models, which assume that all directions contribute equally to the diffuse irradiance component (Bourges, 1986).

The influence of isotropy on solar rooftop resource estimation has been calculated by Clean Power Research, comparing the results from current isotropic methods (Figure A2.1(a) and Figure A2.1(c)) to the results obtained with anisotropic methods (Figure A2.1(b) and Figure A2.1(d)). Isotropic methods tend to underestimate the predicted hours of sunlight and irradiation (Figure A2.1(e)).

Beyond isotropy, other elements explain the differences between the two approaches. The isotropic method used in this example was used to evaluate the rooftop potential for the United States. Reflecting the magnitude of this work, attempts were made to optimise the calculation time by binning tilt and azimuth data into 15-degree sectors, discarding north-oriented surfaces and discarding heavily tilted surfaces (above 60 degrees in tilt).

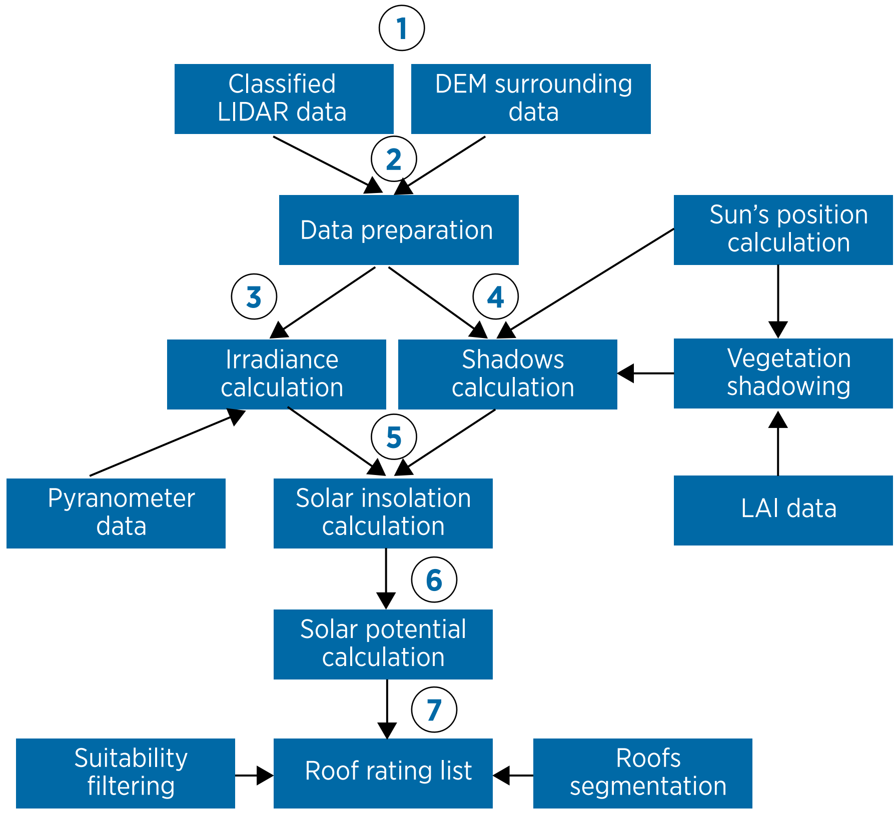
Figure A2.1: Illustration of the influence of anisotropy on solar rooftop resource estimation



Notes: Estimates of annual radiation in kilowatt hour/square metre/year from (a) isotropic method and (b) anisotropic method; predicted number of hours of sunlight with (c) isotropic method and (d) anisotropic method; the error map (isotropic–anisotropic) in kilowatt hour/square metre/year is presented in (e).
Source: Clean Power Research.

Once calculated on a tilted plane, the irradiance values should be corrected for shadowing effects from neighbouring buildings and vegetation. Lukač et al. (2013) detailed a methodology using an isotropic transposition model. While the irradiance calculation differs, their approach to shadowing calculations is similar to the open-source software r.sun[4] and the ArcGIS solar analyst (Wolfs, 2017).

Figure A2.2: Solar cadastre generation workflow



Notes: Irradiance, shadows and vegetation shadowing are considered separately, and combined to calculate the solar insolation at any given point of the rooftop area; LAI = leaf area index.
Source: Lukač, N. et al. (2013), "Rating of roofs' surfaces regarding their solar potential and suitability for PV systems, based on LiDAR data", Applied Energy, Vol. 102, pp. 803–12.

As explained in Lukač et al. (2013) (Figure A2.2), the irradiance at any point is calculated in a time-dependent manner (e.g. hourly, although r.sun indicates a 30-minute timestamp) by weighting the direct irradiation component on the tilted surface with a shading coefficient. The shadowing is assumed to affect only the direct tilted irradiation (DTI) component. The diffuse horizontal irradiation (DHI) component remaining unaffected.

These assumptions lead to a simplified instantaneous global tilted irradiance (GTI) on a tilted surface that becomes, at any moment t:

GTI (t) = DTI (t) (1 – S) + DHI (t), where:

» S is the shadowing effect, which is discussed below.

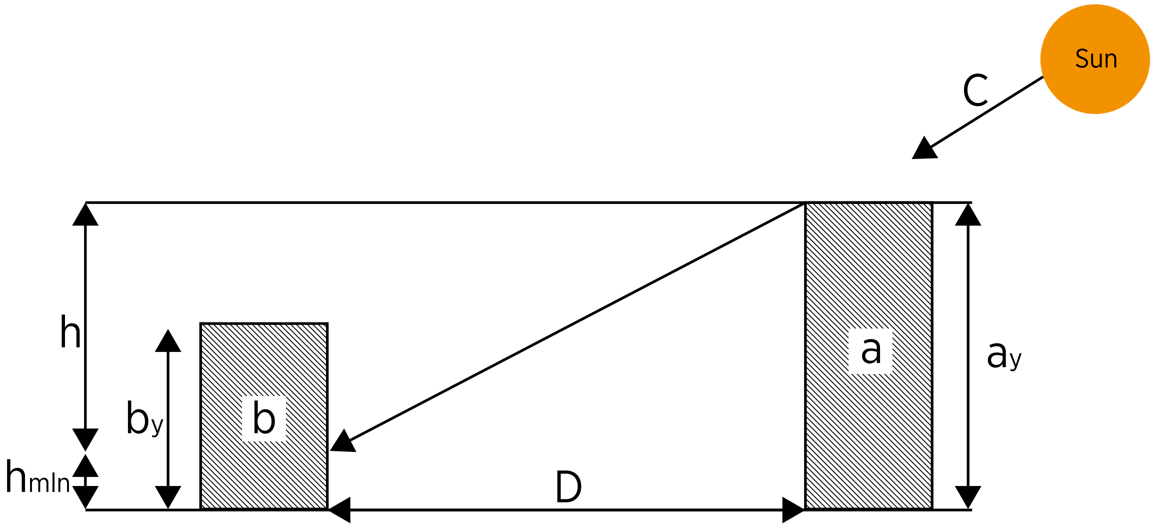
» DTI and DHI have previously been transposed from their horizontal components to the tilted surface (i.e. the rooftop surface or PV panel surface) using a transposition model. The model discussed here includes the direct and diffuse irradiance components and does not include the reflected component due to the albedo of the ground surface, which is assumed to be negligible.

4. See https://grass.osgeo.org/grass74/manuals/r.sun.html (accessed April 2018).
5. See PV Performance Modeling Collaborative at *https://pvpmc.sandia.gov/modeling-steps/1-weather-design-inputs/plane-of-array-poa-irradiance/calculating-poa-irradiance/poa-sky-diffuse/* (accessed on March 2018).

The GTI is calculated for each unit of time and, therefore, the daily irradiation value is the integral of the values between sunrise and sunset. The annual potential is the average daily insolation throughout the year.

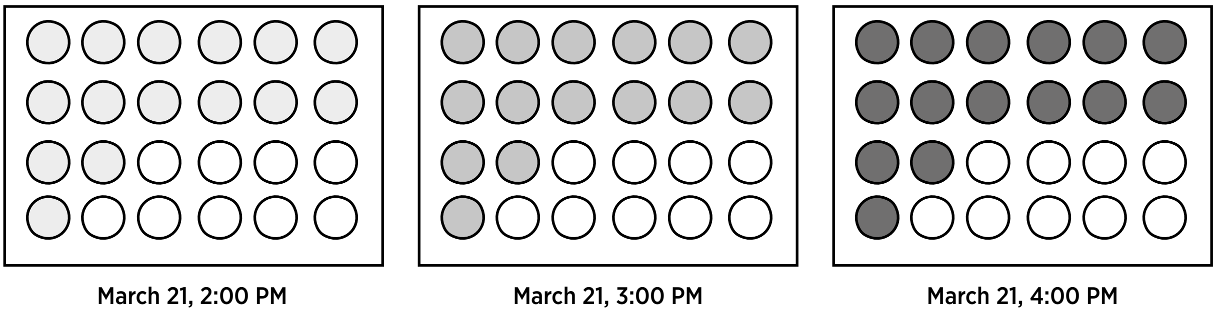
In addition, the shadowing effect from neighbouring buildings is calculated by simulating the sun's position over time. The model will test if a particular map cell is casting shadows onto other cells. A shadowing flag is raised for that particular cell at that particular point in time if shadowing is detected (Figure A2.3). The shadowing analysis is performed at various resolution levels to account for shadowing from terrain and from smaller objects. The calculation of shadows at every point produces hourly shadowing maps, similar to those presented in Figures A2.4 and A2.5. Boz, Calvert and Brownson (2015) and Gagnon et al. (2016) limit the computational requirements by selecting specific days, representative of a single month or season.

Figure A2.3: Illustration of the shadowing approach



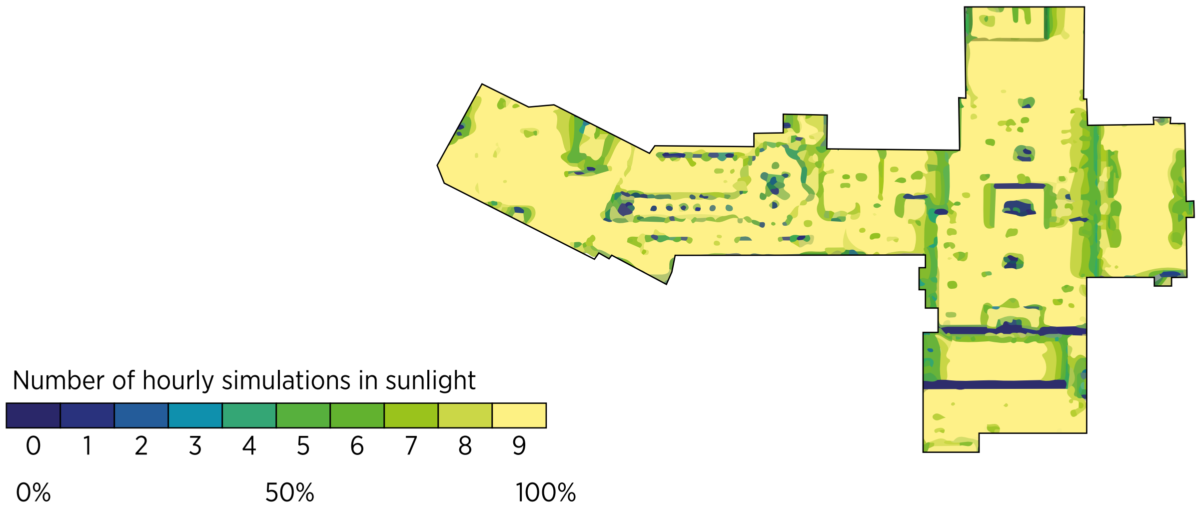
Note: The sun's position is simulated to assess if cell (b) is being shadowed by cell (a) at a given time.
Source: Lukač, N. et al. (2013), "Rating of roofs' surfaces regarding their solar potential and suitability for PV systems, based on LiDAR data", Applied Energy, Vol. 102, pp 803–12.

Figure A2.4: Example of hourly shading and sunlight availability



Source: Gagnon et al. (2016), "Rooftop solar photovoltaic technical potential in the United States: A detailed assessment", NREL/TP P-6A20-65298, *www.nrel.gov/docs/fy16osti/65298.pdf.*

Figure A2.5: Example of average daily hours of sunlight



Based on Gagnon et al. (2016), "Rooftop solar photovoltaic technical potential in the United States: A detailed assessment", NREL/TP P-6A20-65298, www.nrel.gov/docs/fy16osti/65298.pdf.

The shadowing from vegetation takes into consideration categories of canopies, either deciduous or coniferous. Deciduous vegetation drops its leaves during winter. A light absorption coefficient, varying between 0 and 1, is used to simulate the light absorption by the canopy.

At the exclusion of detailing the methodologies developed in the literature, it should be highlighted that calculating a solar cadastre requires a run of the solar irradiance models and the shading model for every rooftop at a time interval of 30 minutes to one hour over a period of one year.

Having calculated the solar irradiation, selecting the rooftop areas suitable for deployment is the final step in the process of estimating the potential. In practice, the most common constraints relate to the azimuth, the tilt of the rooftop surface. Complex decision points include:

- the definition of flat rooftops, as well as the optimal tilt angle that will be assigned to this category (the optimal angle will vary with latitude and is therefore city-dependent)
- PV system performance, usually ranging from 14% to 18%.

The total potential for the city is obtained by aggregating the values obtained for each rooftop. Practically, this would require extensive consultation with the final recipient of the modelling results since it is possible to change the perspective according to selected thresholds.

www.irena.org

Deriving Chemicals of High Concern

Process Documentation

June 27, 2012

Environmental & Occupational Health Programs
Maine Center for Disease Control and Prevention
286 Water Street, 3rd Floor, Augusta, ME 04333
207.287.4311 ● 866.292.3474

Maine Center for Disease Control and Prevention
An Office of the Department of Health and Human Services

Paul R. LePage, Governor   Mary C. Mayhew, Commissioner

Table of Contents

I. Executive Summary

The Maine Center for Disease Control and Prevention (MECDC), in consultation with the Maine Department of Environmental Protection (MEDEP) is required by Maine Title 38, Chapter 16-D Toxic Chemicals in Children's Products to develop a list of chemicals of high concern (CHC) from an existing list of 1384 Chemicals of Concern (CC) designated to be toxic by the State of Maine. The list of CHC is not to exceed 70 chemicals. In developing the list, MECDC is directed to make a finding that there is strong credible scientific evidence that a chemical is reproductive or developmental toxicant, endocrine disruptor or human carcinogen. A finding must also be made that the chemical has been found in the human body through biomonitoring studies, present in the home environment, or present in a consumer product used or present in the home.

MECDC used as a starting point a list of 184 "Chemicals of High Concern for Children" developed by the State of Washington. Washington began with a list of over 2000 "high priority chemicals" that included all 1384 of Maine's CC. Washington then derived a separate list of over 2000 chemicals believe to have exposure potential. The intersection of these two lists yielded 476 chemicals with both toxicity and exposure information. The list of 476 was then reduced to 184 chemicals by excluding chemicals subject to overlapping regulatory initiatives, chemicals unlikely to be in consumer products, chemicals with limited toxicity data, and chemicals primarily of concern because of ecological toxicity.

MECDC followed a three step process to develop a list of Maine CHC from the Washington list of 184 chemicals: Step 1 – Identify and exclude any chemicals either not on Maine's list of 1384 chemicals of concern, already addressed by Maine or other regulatory frameworks, or unlikely to be added to consumer products; Step 2 – Identify chemicals on the list that may not meet the statutory definition of "credible scientific evidence" as defined by statute; Step 3 – Prioritize the remaining chemicals according to weight of evidence of toxicity and potential for exposure.

MECDC relied on many – though not all - of the same toxicity databases used by the state of Washington. One notable difference is that Maine statute does not authorize reliance on state databases of toxicity. MECDC applied a similar prioritizing scheme as Washington (e.g., including only carcinogens known to cause cancer in humans). MECDC and MEDEP worked collaboratively to update and expand Washington's assessment of exposure potential for candidate CHC. This included performing literature searches to obtain more data about presence of chemicals in the human body, indoor air, or household dust. It also included evaluating an expanded list of national and international databases to identify chemicals in consumer products.

The final list of Chemicals of High Concern consists of 49 chemicals. The majority of these chemicals are on the list either because they are known human carcinogens or endocrine disruptors. Nearly two-thirds of these chemicals had information indicating their presence in human body.

II. Introduction

Maine Title 38, Chapter 16-D Toxic Chemicals in Children's Products[1] requires the Maine Center for Disease Control (MECDC) to develop a list of chemicals of high concern (CHC) by July 1, 2012, in consultation with the Maine Department of Environmental Protection (MEDEP).

This list is to consist of no more than 70 chemicals. The list is to be based on "credible scientific evidence," defined in the statute "as the results of a study, the experimental design and conduct of which have undergone independent scientific peer review, that are published in a peer-reviewed journal or publication of an authoritative federal or international governmental agency, including but not limited to the United States Department of Health and Human Services, National Toxicology Program, Food and Drug Administration and Centers for Disease Control and Prevention; the United States Environmental Protection Agency; the World Health Organization; and the European Union, European Chemicals Agency." Note that authoritative lists are to be national or international (not state), and that peer-reviewed studies may also be considered in determining whether a chemical meets the criteria for "credible scientific evidence."

> **§1693 –A. Identification of chemicals of high concern**
>
> 1. List. By July 1, 2012, the department shall publish a list of no more than 70 chemicals of high concern. The Department of Health and Human Services, Maine Center for Disease Control and Prevention, in consultation with the department, shall develop the list. To be listed as a chemical of high concern, a chemical must be on the list of chemicals of concern pursuant to section 1693 and meet the eligibility criteria of subsection 2.
>
> 2. Criteria. A chemical of concern on the list of chemicals of concern pursuant to section 1693 may be included in the list published pursuant to subsection 1 if the department, in concurrence with the Department of Health and Human Services, Maine Center for Disease Control and Prevention, determines that there is strong credible scientific evidence that the chemical is reproductive or developmental toxicant, endocrine disruptor or human carcinogen, and there is strong credible scientific evidence that the chemical meets one or more of the following criteria:
>
>   a. The chemical has been found through biomonitoring studies to be present in human blood, human breast milk, human urine or other bodily tissues or fluids;
>
>   b. The chemical has been found through sampling and analysis to be present in household dust, indoor air or drinking water or elsewhere in the home environment; or
>
>   c. The chemical has been added to or is present in a consumer product used or present in the home.

The toxicity criteria used to develop the list are that there is strong credible scientific evidence that the chemical is a developmental or reproductive toxicant, endocrine disruptor, or human carcinogen. Further, there must be strong credible scientific evidence of one of the following exposure criteria: the chemical is present in the human body based on biomonitoring studies; it has been found to be present in household dust, indoor air, or drinking water based on sampling; it has been added or is present in a consumer product used or present in the home. The sources used for deriving the list of 70 or fewer chemicals were chosen to comply with these criteria.

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[1] http://www.mainelegislature.org/legis/statutes/38/title38sec1693-A.html

III. Starting Point for the MECDC Process: The State of Washington List of Potential Chemicals of High Concern for Children

The State of Washington passed **Chapter 70.240 RCW Children's Safer Products**[2] that in part required the state to develop a list of high priority chemicals to which children may be exposed. The State of Washington, through a publicly-reviewed process, first developed a list of 184 chemicals determined to have both toxicity and exposure information (referred to as Phase 1 assessment), referred to as a list of potential chemicals of high concern for children. These 184 chemicals then underwent further evaluation by a second set of criteria (referred to as Phase 2) to develop a prioritize list of 66 chemicals subject to reporting requirements.

MECDC has accepted the Phase 1 assessment carried out by the State of Washington as the starting point for Maine's prioritizing process to identify up to 70 chemicals of high concern (CHC). Washington's Phase 1 process is briefly summarized below and in Figure 1. For more information, visit the State of Washington's website where documents describing their process can be viewed.[3]

Washington began by assembling a list of "high priority chemicals" (HPC) defined by statute to have met one or more of the following criteria.[4]

(a) Harm the normal development of a fetus or child or cause other developmental toxicity

(b) Cause cancer, genetic damage, or reproductive harm

(c) Disrupt the endocrine system

(d) Damage the nervous system, immune system, or organs or cause other systemic toxicity

(e) Be persistent, bioaccumulative, and toxic

(f) Be very persistent and very bioaccumulative

In compiling their list of HPC chemicals, Washington relied upon the authoritative work of governmental agencies as the primary source of information, much as Maine did in compiling its list of "chemicals of concern". Because government sources identifying neurotoxicants are not

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[2] http://apps.leg.wa.gov/RCW/default.aspx?cite=70.240&full=true

[3] http://www.ecy.wa.gov/programs/swfa/rules/ruleChildPilotPhase.html . Also see: A Stone and D Delistraty, Sources of toxicity and exposure information for identifying chemicals of high concern to children, *Environmental Impact Assessment Review*, 30: 380-387, 2010

[4] These criteria are very similar to those required under Maine law for developing a list of "chemicals of concern". A chemical may be included on the list of chemicals of concern only if it has been identified by an authoritative governmental entity on the basis of credible scientific evidence as being: A. A carcinogen, a reproductive or developmental toxicant or an endocrine disruptor; B. Persistent, bioaccumulative and toxic; or C. Very persistent and very bioaccumulative (38 MRSA §1693)

available, Washington turned to scientific peer-reviewed literature as well. Through this process, Washington compiled a list of over 2044 chemicals from these sources that could be assigned a unique CAS registration number, a list that includes all 1380 chemicals on Maine's list of chemicals of concern.

In a parallel effort, Washington also compiled a list of chemicals with evidence of having been found in humans or that have a potential exposure route to children. The potential for exposure was considered established if a chemical met one or more of the flowing criteria.

(a) The chemical has been found through biomonitoring studies that demonstrate the presence of the chemical in human umbilical cord blood, breast milk, urine, or other bodily tissues or fluids.

(b) The chemical has been found through sampling and analysis to be present in household dust, indoor air, drinking water, or elsewhere in the home environment.

(c) The chemical has been added to or is present in a consumer product used or present in the home.

Data published both by authoritative governmental agencies and in peer reviewed scientific literature were considered by Washington in compiling the list of chemicals with exposure potential. Table 2 below, reproduced from the State of Washington Phase 1 report summarizes the major sources of authoritative governmental exposure information.

Table 1: Authoritative sources to identify exposure potential

Area	**Authoritative Sources**
Biomonitoring	Centers for Disease Control and Prevention (CDC) – National Health and Nutrition Examination Survey (NHANES)
	Danish Birth Cohort
Indoor Air and Dust	California Air Resources Board
Drinking Water	EPA Drinking Water Program
Consumer Products	Danish EPA
	Dutch Government

Washington expanded its search for data on the above by including chemicals identified in studies published in three peer-reviewed scientific journals searched using a set of specified keywords:

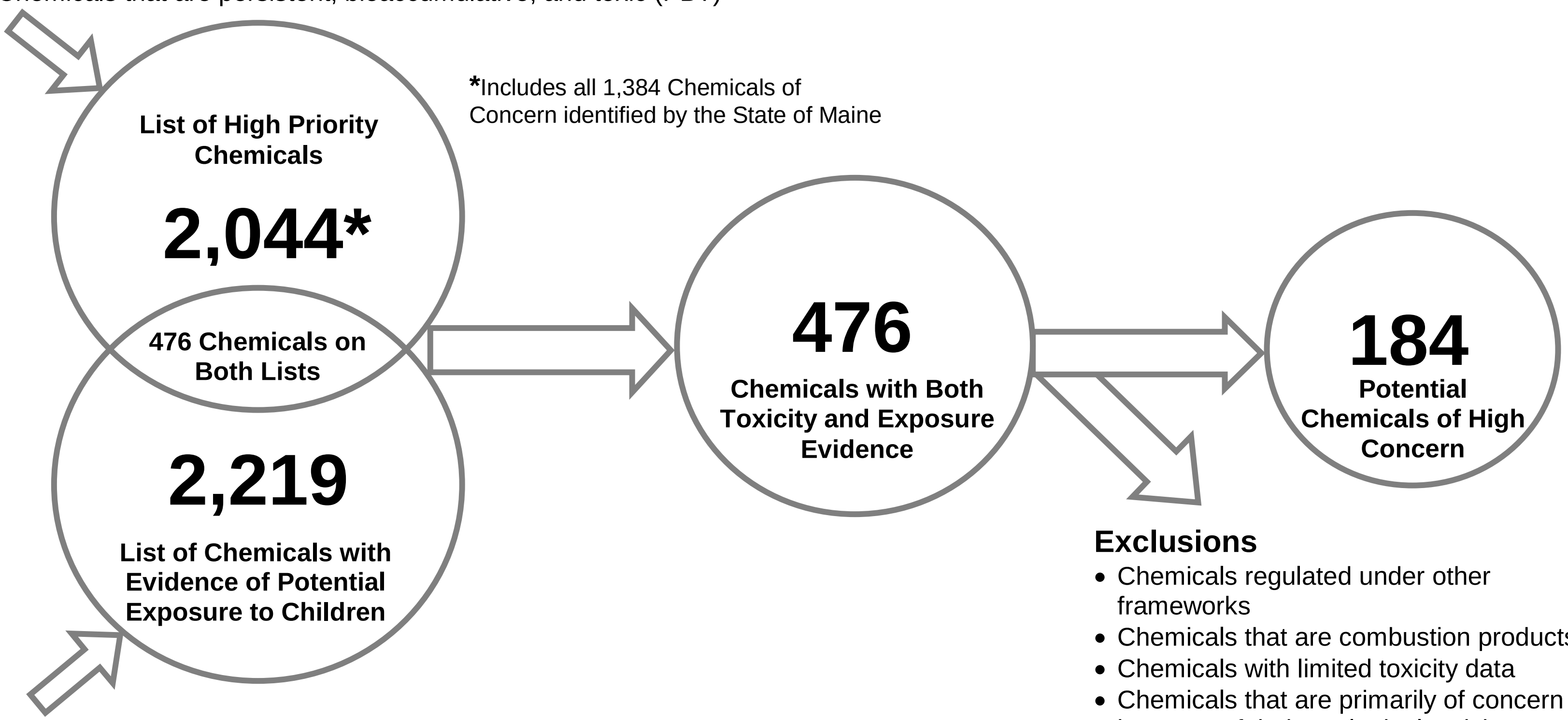
- Environmental Science and Technology: http://pubs.acs.org/search/advanced
- Environmental Health Perspectives: http://www.ehponline.org/
- Toxicological Sciences: http://toxsci.oxfordjournals.org/search.dtl

Through this process, about 2219 chemicals were identified as having the potential for exposure and a unique CAS registration number. Washington next identified those chemicals common to both their lists of "chemicals of high concern" and those with exposure potential, resulting in a list of 476 chemicals referred to as "potential chemicals of high concern for children" (CHCCs). Washington then excluded potential CHCCs they believed were already sufficiently addressed by overlapping regulatory frameworks, chemicals unlikely to be added to children's products because they were combustion products, emerging chemicals with only limited toxicity data, and chemicals of concern primarily due to their ecological (as opposed to human) toxicity. These decisions reduced Washington's list of potential CHCCs from 476 to 184 chemicals. These 184 chemicals are listed in Appendices 10A and 10B of their supporting documents and other accompanying appendices provide documentation of selection criteria and chemicals excluded.[3]

There were several reasons MECDC chose not to adopt the Washington's Phase 2 process used to develop a final prioritize list of 66 chemicals. Maine's authorizing law has certain requirements that differ in some important ways from Washington (e.g., Maine's law did not authorize reliance on state government lists of chemicals under its definition of credible scientific information). Maine's list of chemicals of concern is a subset of the Washington's list of CHC. Washington's consideration of overlapping regulatory frameworks did not consider any Maine specific regulations. Additionally, Washington's literature search for biomonitoring and other exposure potential data and its assessment of chemicals in products were now dated. Yet there were elements of Washington's Phase 2 process that Maine did decide to adopt; such as a prioritizing of chemicals based on a higher weight of evidence that a chemical was toxic to humans (e.g., a known human carcinogen; clear or some evidence a chemical was a reproductive or developmental toxicant). For more information on Washington's Phase 2 process, visit the State of Washington's website where documents describing their process can be viewed.[3]

Figure 1: Washington State Chemicals of High Concern for Children Identification Process

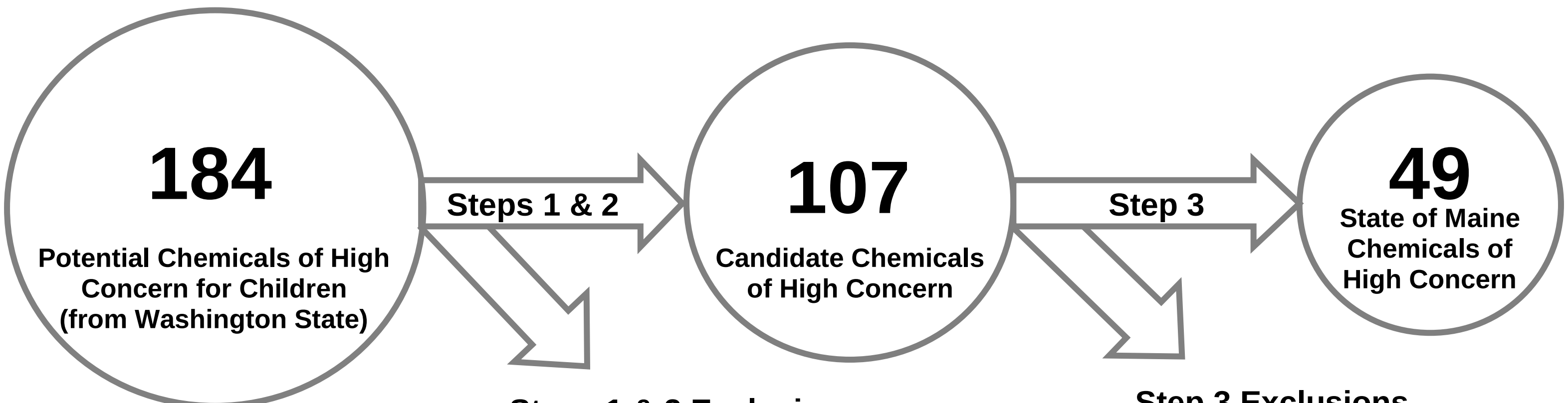
Inclusion Criteria
- Chemicals with developmental or reproductive toxicity
- Chemicals that cause cancer, genetic damage, or reproductive harm
- Chemicals that disrupt the endocrine system
- Chemicals with systemic toxicity
- Chemicals that are persistent, bioaccumulative, and toxic (PBT)



Exclusions
- Chemicals regulated under other frameworks
- Chemicals that are combustion products
- Chemicals with limited toxicity data
- Chemicals that are primarily of concern because of their ecological toxicity

Inclusion Criteria
- Present in indoor air and household dust
- Present in drinking water or elsewhere in the home environment
- Present in human body
- Present in consumer products

Figure 2: State of Maine Chemicals of High Concern for Children Prioritization Process



Steps 1 & 2 Exclusions

- Chemicals not on list of 1,384 Maine Chemicals of Concern
- Chemicals that are regulated by other frameworks
- Chemicals unlikely to be added to consumer products
- Chemicals only on California's Prop 65 list of carcinogens or reproductive/ developmental toxicants and no other authoritative lists

Step 3 Exclusions

- Chemicals only on Reprotext listing
- Chemicals with low toxicity values from U.S. EPA's IRIS data base
- Carcinogens from authoritative lists <u>not</u> listed as "known human carcinogen"
- Chemicals only on list of NTP reproductive or developmental toxicants without either "clear" or "some" evidence of adverse effects
- European Union category 2 endocrine disruptors
- Chemicals that do not meet State of Maine exposure criteria

IV. MECDC Process to Identify Chemicals of High Concern

Starting with Washington's list of 184 chemicals, MECDC conducted a three step process to meet the statutory mandate of identifying a list of Chemicals of High Concern consisting of 70 or fewer chemicals (Figure 2).

Step 1 – Identify and exclude any chemicals either not on Maine's list of 1380 chemicals of concern, already addressed by Maine or other regulatory frameworks, or unlikely to be added to consumer products;

Step 2 – Identify chemicals on the list that may not meet the statutory definition of "credible scientific evidence" and either exclude such chemicals or otherwise determine there is sufficient peer review literature to retain the chemical;

Step 3 – Prioritize the remaining chemicals according to weight of evidence of toxicity and potential for exposure.

A. Step 1 – Identify and exclude chemicals not on Maine's list of CC, already addressed by other regulatory frameworks, and unlikely to be added to consumer products.

MECDC identified 53 chemicals that were on the Washington list of 184 but not on the Maine list of CC (Table 2). These chemicals were excluded from further consideration.

Table 2: Chemicals not on the Maine CC list

57-55-6 Propylene glycol	101-68-8 Mono-/polymeric MDI	624-83-9 Methyl isocyanate
57-63-6 17-ethylnyestradiol	107-21-1 Ethylene glycol	822-06-0 Hexamethylene diisocyanate
60-29-7 Diethyl ether	108-91-8 Cyclohexylamine	7439-98-7 Molybdenum
64-18-6 Formic Acid	108-95-2 Phenol	7440-14-4 Radium
65-85-0 Benzoic acid	121-44-8 Triethylamine	7440-22-4 Silver compounds
71-36-3 n-Butanol	123-38-6 Propionaldehyde	7440-24-6 Strontium compounds
75-44-5 Phosgene	124-40-3 Dimethylamine	7440-36-0 Antimony compounds
75-60-5 Dimethylarsenic acid	131-11-3 Dimethyl phthalate	7440-42-8 Boron compounds
75-69-4 Trichlorofluromethane	137-17-7 Trimethylaniline	7440-40-8 Copper compounds
75-71-8 Dichlorodifluoromethane	142-82-5 n-Heptane	7440-61-1 Uranium compounds
76-13-1 Trichloro-trifluoroethane	142-83-6 Hexadienal	7647-01-0 Hydrochloric acid
78-83-1 Isobutyl alcohol	143-22-6 Triethylene glycol	7782-41-4 Fluorine
78-93-3 Methyl ethyl ketone	149-57-5 Ethylhexanoic acid	10049-04-4 Chlorine dioxide
85-44-9 Phthalic anhydride	156-59-2 Dichloroethylene	10102-43-9 Nitric oxide
92-52-4 Biphenyl	156-60-5 Trans-dichloroethylene	10102-44-0 Nitrogen dioxide
95-50-1 Dichlorobenzene	463-58-1 Carbonyl sulfide	14859-67-7 Radon 222
96-33-3 Methyl acrylate	506-77-4 Cyanogen chloride	28553-12-0 DiNP
98-86-2 Acetophenone	540-84-1 Trimethylpentane	

Five additional chemicals were eliminated based on a determination that there were other overlapping regulatory frameworks, with several already identified as a Maine priority chemical and one already regulated by federal and state laws (Table 3).

Table 3: Chemicals eliminated because of overlapping regulatory framework

64-17-5 ethanol: ingested voluntarily, regulated by FDA
80-05-7 BPA: Maine priority chemical
104-40-5 4-nonylphenol: Maine priority chemical
9016-45-9 nonylphenolethoxylate: Maine priority chemical
25154-52-3 nonylphenol: Maine priority chemical

Four chemicals were eliminated because they were viewed as unlikely to be added to consumer products (Table 4).

Table 4: Chemicals eliminated because unlikely to be added to consumer products

55-16-7 estrone: natural hormone
4376-20-9 Mono-2-ethyl hexylphthalate or MEHP: a mammalian metabolite of DEHP.[5]
22967-92-6 methylmercury: not added to products, included in 7439-97-6
64742-48-9 crude oil: unlikely to be added to a product in the home

B. Step 2 – Identify chemicals on the list that may not meet the statutory definition of "credible scientific evidence."

Maine law defines "credible scientific evidence" as " the results of a study, the experimental design and conduct of which have undergone independent scientific peer review, that are published in a peer-reviewed journal or publication of an authoritative federal or international governmental agency, including but not limited to the United States Department of Health and Human Services, National Toxicology Program, Food and Drug Administration and Centers for Disease Control and Prevention; the United States Environmental Protection Agency; the World Health Organization; and the European Union, European Chemicals Agency."

State agencies were not included in this definition, yet there are a number of chemicals included on the Washington list of 184 chemicals only on the basis of inclusion on an authoritative state government list. This includes chemicals on the California Prop 65 lists either as carcinogens or as reproductive and developmental toxicants. It also includes chemicals on Washington's list of persistant bioaccumulative toxins (PBTs). Chemicals on these state lists were therefore evaluated as to whether they should be excluded.

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[5] Mono-2-ethyl hexylphthalate or MEHP is a mammalian metabolite of DEHP: a compound already regulated under the federal CSPIA. http://www.ecy.wa.gov/programs/swfa/rules/pdf/p3doh.pdf

1. Chemicals on the California Proposition 65 list of carcinogens

Chemicals that were on the Prop 65 list as carcinogens, but were not on any of the national and international governmental carcinogen lists (i.e., IARC, NTP, or EPA) were excluded. Maine law does not recognize state databases as "credible scientific evidence". There are three separate authoritative national / international lists of carcinogens available for consideration. Washington also excluded Prop65 carcinogens in their Phase 2 assessment. The 17 chemicals excluded for this reason are listed in Table 5. All of these chemicals can be expected to have peer reviewed publications to support their classification of carcinogens by California. However a review of this peer reviewed literature was considered outside the scope of this current screening effort.

Table 5: Chemicals listed by the State of Washington as toxicants only on the CA PROP65 list as carcinogens

59-89-2 N-nitrosomorpholine	139-65-1 4,4'-thiobsbenzenamine
62-56-6 thiourea	140-82-5 heptane
84-65-1 anthraquinone	140-88-5 ethyl acrylate
93-15-2 methyleuganol	615-05-4 2,4-diaminoanisole
94-59-7 safrole	838-88-0 4,4'-methylene bis(methylanaline)
96-13-9 2,3-dibromo-1-propanol	1333-86-4 carbon black
97-56-3 o-aminoazotoluene	29082-74-4 octachlorostyrene
101-77-9 4,4'-diaminodipehnylmenthane	77439-76-0 3-chloro-4(dichloromethyl)-5-hydroxy-2(5H)-furanone
120-71-8 p-cresidene	

An exception was the chemical tris (2-chloroethyl) phosphate (TCEP, CAS# 115-96-8). TCEP is listed as a carcinogen under Proposition 65, but was retained because the Canadian Environmental Protection Act (CEPA) proposes to limit TCEP in products intended for children under 3 years of age under the Hazardous Products Act.[6] The Canadian government's screening assessment report published in August 2009 concluded TCEP may pose a danger to human life or health as it is a carcinogen for which there may be a probability of harm at any level of exposure and it may cause impaired fertility in males. Infants from 0-6 months old were the population with potentially the highest consumer product exposure estimates, resulting from mouthing of polyurethane foam cushioning.

2. Chemicals on the California Proposition 65 list for reproductive or developmental toxicants

MECDC excluded chemicals that appeared solely on Washington's list of potential CHCC because they were on the California Prop 65 list for reproductive and developmental toxicants. The rationale was similar to that of Prop 65 carcinogens; it is a State list and there already exists

[6] http://www.hc-sc.gc.ca/cps-spc/legislation/consultation/_2010tris_phosphate/index-eng.php

both a national (National Toxicology Program) and international authoritative governmental lists for reproductive and developmental toxicants (UN Globally Harmonized System of Classification and Labeling of Chemicals). Six chemicals were excluded based on this decision (Table 6). All of these chemicals likely have peer reviewed publications to support their classification of reproductive or developmental hazards by California. However a review of this peer reviewed literature was considered outside the scope of this current screening effort.

Table 6: Chemicals listed by the State of Washington as toxicants only because on the CA PROP65 list as reproductive or developmental toxicants

75-15-0 carbon disulfide	872-50-4 n-methylpyrrolidone (NMP)
84-75-3 di-*n*-hexyl phthalate (DnHP)	109-86-4 methoxyethanol
149-50-4 2-ethylhexanoic acid (2-EHA)	110-80-5 ethylene glycol monoethyl ether

3. Chemicals on the Washington PBT list

Persistent, bioaccumulative toxins (PBTs) are chemicals that are believed to represent a unique threat to human health and the environment, because they remain in the environment for long periods of time, are hazardous to the health of humans and wildlife, can build up in the food chain, and can be transported long distances and readily move between air, land and water media. Maine law clearly established persistent and bioaccumulative and toxic as criteria to be used in identifying chemicals of concern, yet MECDC could identify only one national / international governmental agency with a list of PBTs (Canada's). Several chemicals on the Washington PBT list are chemicals that MECDC has previously undertaken extensive reviews of the scientific literature is support of regulatory initiatives in Maine. These chemicals are listed below and were retained as potential candidates for CHC based on MECDC's determination that there is credible scientific evidence to support their inclusion.

(CAS# 79-94-7) tetrabromobisphenyl A (TBBPA) A review by the Maine CDC identified about two dozen studies documenting effects on reproductive, developmental, endocrine, or cancer endpoints. Studies were also identified with data on levels of TBBPA in humans.[7]

(CAS# 1163-19-5) deca brominated diphenyl ether (deca BDE) Reports to the Maine legislature by the MEDEP and MECDC reviewed numerous studies documenting adverse endocrine and developmental effects of deca BDE, including effects on thyroid hormones and developmental neurotoxicity.[8]

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[7] Rationale for Concurrence by Maine Center for Disease Control and Prevention on the Designation of Brominated Flame Retardants as a Priority Chemical, November 22, 2010

[8] Brominated Flame Retardants: A Report to the Joint Standing Committee on Natural Resources, 122nd Maine Legislature, Prepared by: Maine Bureau of Health (now the Maine Center for Disease Control and Prevention) and

(CAS# 25637-99-4) hexabromocyclododecane (HBCD). Maine CDC documents peer-reviewed studies reporting endocrine and developmental effects of HBCD, including developmental neurotoxicity in humans. Studies were also identified with data on levels of TBBPA in humans.[9] It is also noteworthy that the US EPA has an action plan for HBCD based on concerns for reproductive, developmental, and neurological effects.[10]

(CAS # 1763-23-1) perfluorooctanyl sulfuric acid and its salts (PFOS). MECDC is currently performing an assessment of the peer reviewed literature of PFOS in support of developing a maximum exposure guideline for drinking water. As part of this review, a recent scientific publication was identified that reported serum levels perfluorooctane sulfonate were positively associated with chronic kidney disease.[11] The authors examined the relation of serum PFOS (and PFOA) and chronic kidney disease in 4,587 adult participants from combined National Health and Nutritional Examination Surveys for whom serum measurements were available. Compared with subjects in the first quartile of serum level (referent), the multivariable odds ratio for chronic kidney disease among subjects in fourth quartile of serum levels of PFOS was 1.82 (95% confidence interval: 1.01, 3.27; P for trend = 0.019). The association was independent of confounders such as age, sex, race/ethnicity, body mass index, diabetes, hypertension, and serum cholesterol level. It is also noteworthy that the European Union designates PFOS as persisitent, bioaccumulative, and toxic to mammalian species, and recommends ultimate phase-out.[12]

C. Step 3 – Prioritize the remaining chemicals according to weight of evidence of toxicity and potential for exposure.

After the completion of Step 2, Washington's list of 184 chemicals was reduced to 101 chemicals. MECDC then implemented a prioritizing scheme similar to that undertaken by Washington in its Phase 2 prioritizing process, but with some differences with respect to toxicity databases considered, and more inclusive and up to date with respect to exposure databases.

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the Maine Department of Environmental Protection, February 2005. Brominated Flame Retardants: A report to the Committee on Natural Resources, 122nd Maine Legislature, Prepared by the Center for Disease Control and Prevention and Department of Environmental Protection, February 2006. Brominated Flame Retardants: Third annual report to the Maine Legislature, Prepared by the Maine Center for Disease Control & Prevention and the Maine Department of Environmental Protection, January 2007.

[9] Rationale for Concurrence by Maine Center for Disease Control and Prevention on the Designation of Brominated Flame Retardants as a Priority Chemical, November 22, 2010

[10] http://www.epa.gov/existingchemicals/pubs/actionplans/hbcd.html.
[11] Shankar, Anoop; Jie Xiao and Alan Ducatman (2011-10-15). "Perfluoroalkyl Chemicals and Chronic Kidney Disease in US Adults". American Journal of Epidemiology 174 (8): 893–900.
[12] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:372:0032:0034:en:PDF

1. Toxicity criteria used for prioritizing

A number of authoritative lists were considered by the MECDC to prioritize the remaining potential chemicals of high concern in order of toxicity. These databases are listed in Table 8. MECDC dropped the following two databases relied on by Washington in their prioritizing process.

- Reprotext is a non-government database owned by Reuters. It requires a subscription to access. It consists of evaluations of about 850 chemicals with respect to characteristics and uses of each chemical, as well as reviews of general and reproductive toxicity. A grading system indicating degree of hazard is included. Reviews are done by an expert reproductive and developmental toxicologist, with no peer review. Designation in Category A+ (human reproductive hazard with no known no-effect level) or A (human reproductive hazard with known no-effect dose) were the inclusion criteria by the State of Washington in their Phase 2 assessment. MECDC did not use this database as a means of prioritizing chemicals in part out of concern as to whether it met the statutory definition of credible scientific evidence, and lack of access to this database. Two chemicals were excluded for this reason: Aniline (CAS #62-53-3) and methylene chloride (CAS# 75-09-2).
- Washington included a number of reproductive and development chemicals with low toxicity values identified from databases maintained by either the U.S. Agency for Toxic Substances and Disease Registry (ATSDR) or CDC / NIOSH Registry of Toxic Effects of Chemical Substances (RTECs). The stated purpose was to identify chemicals with developmental or reproductive toxicity that are not on the authoritative lists, especially chemicals with newer information in this toxicity endpoint. While laudable in intent, Maine's definition of credible scientific evidence emphasizes the use of either published peer-reviewed journals articles or lists compiled by authoritative federal or international governmental agency. Consequently, chemicals on the list of 184 chemicals solely on the basis of a low toxicity value were excluded. Sixteen chemicals were excluded for this reason (Table 7).

Table 7: Chemicals listed by the State of Washington only due to low toxicity values

67-56-1 Methanol	100-41-4 Ethylbenzene
74-87-3 Methyl chloride	100-52-7 Benzaldehyde
75-00-3 Chloroethane; Ethyl chloride	106-47-8 para-Chloroaniline
78-87-5 1,2-Dichloropropane	107-13-1 Acrylonitrile
79-01-6 Trichloroethylene	110-86-1 Pyridine
79-06-1 Acrylamide	119-93-7 3,3´-Dimethylbenzidine
95-80-7 2,4-Diaminotoluene	127-18-4 Perchloroethylene
96-18-4 1,2,3-Trichloropropane	26471-62-5 Toluene diisocyanate; TDI

For the remaining databases, MECDC applied criteria fairly similar to those used by Washington in their Phase 2 assessment as follows.

- For chemicals identified as a carcinogen on an authoritative national or international government list, MECDC only included those classified as known human carcinogens or a similar level of evidence of carcinogenicity in humans (i.e., Category A, Category 1 carcinogens). Thus, chemicals classified as either an IARC 2a, or IRIS 86 B1, B2 or C carcinogens were excluded.

- For chemicals that were on the Washington list because they were listed by NTP as reproductive or developmental toxicants, MECDC only included those classified as having "clear evidence of adverse effects in humans" or "some evidence of adverse effects in humans". Chemicals not meeting this criterion were excluded.

- Chemicals identified as endocrine disruptors by the European Union were included if they were classified as Category 1 (evidence of endocrine disrupting activity in at least one species using intact animals), and excluded if Category 2 (at least some *in vitro* evidence of biological activity related to endocrine disruption).

Table 8: Databases and associated prioritizing criteria used by MECDC in prioritizing toxicity

DATA BASE	PRIORITIZING CRITERIA
National Toxicology Program Center for Evaluation of Risks to Human Reproduction (NTP CERHR)	"Clear" or "Some" evidence of adverse effect in humans
National Toxicology Program Report of Carcinogens	Known human carcinogen
Globally Harmonized System of Classification and Labelling of Chemicals (GHS)	Category 1A reproductive hazard Category 1 carcinogen
European Commission (EC) Endocrine Disruptor Program	Category 1 endocrine disruptor
Canadian PBiT	Present on list
Washington PBT	Present on list and confirmed with review of studies published in peer reviewed publications
U.S. Environmental Protection Agency Integrated Risk Information System (IRIS)	1986 category A, 1996, 1999, or 2005 known human carcinogen
European Union List of Carcinogens	Category 1A carcinogen
International Agency for Research of Cancer (IARC)	Category 1

Detailed description of these databases can be found at the end of this document.

2. Exposure criteria used for prioritizing

MECDC sought to both update and expand the search of published peer reviewed studies identifying chemicals present in biomonitoring studies and indoor air and dust. Washington gathered biomonitoring, drinking water, and indoor air and dust data from three scientific journals: *Environmental Health Perspectives, Environmental Science and Technology*, and *Toxicological Sciences*. In addition, biomonitoring results from the 2005 CDC NHANES study, which is representative of the US population, were included. For indoor air and dust, several reports from the California Air Bureau were also sources for exposure data. Only the 2005 report to the legislature was peer-reviewed, and so eligible to be considered by MECDC. MECDC updated the search of published peer reviewed studies identifying chemicals present in biomonitoring studies and indoor air and dust by searching for papers in recent years, and additionally expanded the journals searched to include all accessible through a PubMed search using search terms similar to those used by Washington and described at the end of this report. The publications found through this literature search are listed in Appendix IV.

The Maine Department of Environmental Protection (MEDEP) assumed responsibility for revisited databases evaluated by Washington for presence of chemicals in consumer products both to look for updates since Washington last evaluated them and to expand to allow for a broader inclusion of types of consumer products (Washington's law requires more focus on children's products). MEDEP additionally expanded the set of databases evaluated based on references identifying chemical compounds within consumer products were identified through the Washington process documents, chemical score sheets, and published spreadsheets outlining their exposure research efforts.

Table 9 lists product related databases used by MEDEP/MECDC to evaluate evidence of exposure to chemicals and viewed as permissible under Maine's definition of credible scientific evidence. A description of these databases and links to them are provided in the addendum to this report. A more complete description of the process used by MEDEP and associated databases and literature search is presented in Appendix V.

Table 9: Criteria used by MECDC/MEDEP as evidence of potential exposure

Danish and Dutch Environmental Protection Agency (DEPA) studies and reports	National Library of Medicine Hazardous Substances Data Bank (HSDB)
European chemical Substances Information System (ESIS) Risk Assessment Reports	National Library of Medicine Household Products Database (HPD)
Netherlands Food and Consumer Product Safety Authority (NL)	U.S. Environmental Protection Agency (EPA) Inventory Use and Reporting Database (IUR)
German Environmental Protection Agency	U.S. EPA Chemical Assessment and Management Program (ChAMP)
2012 ToSCA Work Plan for Consumer Products	U.S. EPA Voluntary Children's Chemical Evaluation Program (VCCEP)

Although not used for purposes of prioritizing, MECDC included information compiled by State of Washington regarding whether their priority chemicals were likely to be released into air, ingested by the child, or come in contact with skin for potential future use.

3. Application of Prioritizing Criteria

The list of 107 chemicals that went through the prioritization process were compiled into a table with separate columns for each toxicity exposure related database considered, and rows for each chemical (see Appendix I). Check boxes were used to denote that a chemical met the prioritizing scheme for toxicity (e.g., known human carcinogen, clear or some evidence of toxic effects in humans for developmental/reproductive toxicants). Cells left empty either do not meet the prioritizing criteria above, or do not have any information for that data source. Cells on the exposure section similarly use checks to indicate that a chemical was reported present in consumer products. For columns labeled biomonitoring and indoor air or household dust, a number is provided indicating the number of peer-reviewed journal articles identified through MECDC's literature search (e.g., number of biomonitoring papers with reference to a chemical being found in human tissue, number of governmental reports indicate a chemical present in a consumer product). Chemicals excluded based on the prioritizing scheme are identifiable as shaded rows.

The final prioritized list of CHC consists of 49 chemicals. A list of 49 CHC is provided in Table 10 with supporting information of results from applying prioritizing scheme tabulated in Appendix II and an accompanying narrative in Appendix III. The majority of listed chemicals were prioritized based on being either known human carcinogens or European Union Category 1 endocrine disruptors. Biomonitoring data indicating presence in the human body was identified for 30 chemicals, and 28 chemicals were identified as having been detected in indoor air or dust. Only five chemicals were excluded for lack of exposure information.

There is considerable overlap between Maine's list of Chemicals of High Concern and Washington's final list of Chemicals of High Concern for Children (66 chemicals). The two lists share 33 chemicals in common.

Table 10: List of Chemicals of High Concern

CAS	Chemical
50-00-0	Formaldehyde
71-43-2	Benzene
75-01-4	Vinyl chloride
79-94-7	Tetrabromobisphenol A
84-61-7	Dicyclohexyl phthalate; DCHP
84-66-2	Diethyl phthalate
84-74-2	DBP (Dibutyl phthalates); di-n-butyl phthalate
84-75-3	Di-n-Hexyl Phthalate
85-68-7	BzBP; Benzyl butyl phthalate; Butyl benzyl phthalate; BBzP
87-68-3	Hexachlorobutadiene
91-59-8	2-Naphthylamine
92-69-3	4-Hydroxybiphenyl; 4-Phenylphenol
92-87-5	Benzidine and its salts
94-13-3	Propyl paraben
94-26-8	Butyl paraben
95-53-4	2-Aminotoluene
99-76-3	Methyl paraben
99-96-7	p-Hydroxybenzoic acid
100-42-5	Styrene
101-14-4	4,4´-Methylenebis(2-Chloroaniline)
106-89-8	Epichlorohydrin
106-93-4	1,2-Dibromoethane
106-99-0	1,3-Butadiene
108-88-3	Toluene
115-96-8	Tris(2-chloroethyl) phosphate
117-81-7	DEHP (Di-(2-ethylhexyl) phthalate); bis(2-ethylhexyl) phthalate

118-74-1	Hexachlorobenzene
120-47-8	Ethyl paraben
131-55-5	Benzophenone-2 (Bp-2), 2,2',4,4'-tetrahydroxybenzophenone
131-56-6	2,4-Dihydroxybenzophenon; Resbenzophenone
131-70-4	Mono-n-butylphthalate
140-66-9	4-tert-Octylphenol; 1,1,3,3-Tetramethyl-4-butylphenol
556-67-2	Octamethylcyclotetrasiloxane
608-93-5	Benzene, pentachloro-
1163-19-5	2,2',3,3',4,4',5,5',6,6'-Decabromodiphenyl ether; BDE-209
1634-04-4	Methyl tert-butyl ether; MTBE
1763-23-1	perfluorooctanyl sulphonic acid and its salts; PFOS
1806-26-4	Phenol, 4-octyl-
2425-85-6	2-Naphthalenol, 1-[(4-methyl-2-nitrophenyl)azo]-
5466-77-3	2-ethyl-hexyl-4-methoxycinnamate
7439-97-6	Mercury & mercury compounds
7440-02-0	Nickel & nickel compounds
7440-38-2	Arsenic & Arsenic compounds
7440-41-7	Beryllium & Beryllium compounds
7440-43-9	Cadmium
14808-60-7	Quartz
25013-16-5	Butylated hydroxyanisole
25637-99-4	Hexabromocyclododecane
27193-28-8	Phenol, (1,1,3,3-tetramethylbutyl)-; Octylphenol

V. Description databases relied on in developing a list of Chemicals of High Concern

A. Toxicity databases

National Toxicology Program Center for the Evaluation of Risks to Human Reproduction
The National Toxicology Program (NTP) is an interagency program managed by the US Department of Health and Human Services (DHHS) whose mission is to evaluate agents of public health concern by developing and applying tools of modern toxicology and molecular biology. The NTP Center for the Evaluation of Risks to Human Reproduction (CERHR) was established in 1998 to serve as an environmental health resource to the public and regulatory and health agencies. CERHR publishes monographs that assess evidence that environmental chemicals, physical substances, or mixtures that cause adverse effects on reproduction and development and provides opinion on whether these substances are hazardous for humans. Chemicals for which the NTP issued a monograph and had concluded that there was clear or some evidence of adverse effects in humans were included by MECDC.

Globally Harmonized System of Classification and Labeling of Chemicals (GHS) The Globally Harmonized System of Classification and Labeling of Chemicals (GHS), published by the United Nations (UN) GHS sub-committee, addresses the classification of chemicals by hazard types and harmonized communication tools. The UN encourages countries to implement GHS worldwide. Japan launched the GHS Inter-ministerial Committee in 2001, and has published the GHS Classification Manual and the Technical Guidance used for GHS classification. The Committee has classified approximately 1,500 chemicals by GHS. Designation in Category 1A (human evidence is the main criterion for classification as a hazard) for reproductive toxicity was the inclusion criterion.

European Commission (EC) Endocrine Disruptor Program The mission of the EC is to promote the general interest of the European Union. The EC conducts work on a wide range of environmental issues and has established several databases that address chemical-specific issues undertaken by the EC to address chemical safety. On December 20, 1999, the EC adopted a Communication on a Community Strategy for Endocrine Disrupters: a range of substances suspected of interfering with the hormone systems of humans and wild life. The strategy focuses on man-made substances, including chemicals and synthetic hormones, which may harm health and cause cancer, behavioral changes and reproductive abnormalities. Designation of Category 1 for Humans (Appendix L) (evidence of endocrine disruptor activity) was the inclusion criterion.

International Agency for Research of Cancer (IARC) IARC is part of the World Health Organization. IARC's mission is to coordinate and conduct research on the causes of human cancer, the mechanisms of carcinogenesis, and to develop scientific strategies for cancer control. The Agency is involved in both epidemiological and laboratory research and disseminates scientific information through publications, meetings, courses, and fellowships. Designation of a chemical as belonging to Category 1 (known human carcinogen) was the inclusion criterion.

National Toxicology Program Report on Carcinogens The NTP is an interagency program managed by the US Department of Health and Human Services (DHHS) whose mission is to evaluate agents of public health concern by developing and applying tools of modern toxicology and molecular biology. The NTP publishes a list of carcinogens in its Report on Carcinogens (RoC). The RoC is an informational scientific and public health document first ordered by Congress in 1978 that identifies and discusses agents, substances, mixtures, or exposure circumstances that may pose a hazard to human health by virtue of their carcinogenicity. The category of known carcinogens was included.

U.S. Environmental Protection Agency Integrated Risk Information System The US Environmental Protection Agency (EPA) is the primary federal agency charged with protecting human health and the environment. As EPA states on its website "***IRIS*** (Integrated Risk Information System) is a compilation of electronic reports on specific substances found in the environment and their potential to cause human health effects". Designation as a chemical in category A (known) carcinogens under the 1986 Guideline, or known carcinogens under the 1996, 1999, and 2005 Guidelines were considered in the toxicity criteria.

European Union Carcinogen List EU Directive on Dangerous Substances (Directive 67/548/EEC) introduced EU-wide provisions on the classification, packaging and labeling of dangerous substances. The classification of dangerous substances places a substance into one of several defined classes of danger and characterizes the type and severity of the adverse effects that the substance can cause. The Directive categorizes chemicals as carcinogens and reproductive toxicants. Designation as Category 1 (known or presumed to be a human carcinogen or reproductive toxicant) was the inclusion criterion.

Washington State Persistent Bioaccumulative and Toxic Chemical List In 2006, the Department of Ecology as directed by the Governor adopted regulations specific to PBTs (WAC 173-333). The PBT (persistent, bioaccumulative, and toxic) Initiative is a key part of Ecology's efforts to reduce toxic threats. It names the 'worst of the worst' toxic substances and suggests ways to reduce or remove the threat posed by them. Twenty-seven PBTs are identified including 25 organic chemicals/chemical groups and two 'metals of concern.' The legislation also requires Ecology and Department of Health (DOH) to issue one Chemical Action Plan (CAP) each year until all of the PBTs are assessed. Ecology and DOH are also required to prioritize the PBTs and to address first those that pose the greatest threat to human health and the environment. As part of this process, Ecology and DOH issued a multiyear CAP Schedule in 2007. The Washington list of PBTs was included in the criteria for toxicity. The chemicals identified as potential CHC from this list were confirmed to be on national or international lists, or identified by the State of Maine on the basis of extensive peer review literature searches.

Canadian PBiT List The *Canadian Environmental Protection Act, 1999* (CEPA 1999) is Canada's federal environmental legislation aimed at preventing pollution and protecting the environment and human health. As part of this effort, the Canadian government evaluated all compounds imported or produced in Canada and prioritized them for various criteria. The results of these efforts are available on the web. Designation as PBiT (persistent, bioaccumulative and inherently toxic) was included as a criterion. In addition, one chemical on the Washington list of CHC was included on the basis of being banned in products for use by children under 3 years under the Canadian Hazardous Products Act.

B. Exposure Databases

Biomonitoring Studies

MECDC searched Pubmed (http://www.ncbi.nlm.nih.gov/pubmed/) for studies documenting the presence in humans in the general population for chemicals on the Washington list of 184 chemicals. Pubmed search terms included [chemical name] AND exposure, breast milk, blood, and/or urine. Occupational studies or studies from populations with an identified point source of exposure were not included. There was no attempt to do a comprehensive literature survey: one relevant paper was considered to be evidence of exposure. Nonetheless, a number of chemicals were identified in more than one study because the study contained other chemicals in the search. Therefore, a greater number of citations are not evidence of more exposure. The MECDC also updated the NHANES results to include the chemicals added in the 2009 National Biomonitoring Study.

Indoor Air and Dust Studies

MECDC searched Pubmed for studies documenting the presence in indoor air or dust for chemicals on the Washington list of 184 chemicals. Search terms included [chemical name] AND exposure, dust, and/or air. Occupational studies or studies from populations with an identified point source of exposure were not included. There was no attempt to do a comprehensive literature survey: one relevant paper was considered to be evidence of exposure. Nonetheless, a number of chemicals were identified in more than one study because the study contained other chemicals in the search. Therefore, a greater number of citations are not evidence of more exposure.

Product database

Danish EPA Reports

The Danish Environmental Protection Agency (DEPA) conducts a consumer products program. This includes a series of reports on chemicals present in consumer products as tested by the Danish EPA. This database was used to identify chemicals in children’s and other household products.

Dutch Reports

The Netherlands Food and Consumer Product Safety Authority (NL) monitors food and consumer products to safeguard public health. This Authority controls entire production chains, from raw materials and processing aids, to end products and consumption.

EU Risk Assessment

The ESIS (European chemical Substances Information System) of the European Commission Joint Research Centre Institute for Health and Human Protection Final RUR was used to identify use in children's products.

National Library of Medicine Hazardous Substances Database

The Toxicology and Environmental Health Information Program (TEHIP) of the National Library of Medicine maintains a comprehensive web site with access to resources produced by TEHIP and by other government agencies and organizations. Its flagship resource is TOXNET, an integrated database system of hazardous chemicals, toxic releases and environmental health. The State of Washington used this site to identify chemicals that may be used in children's products.

EPA Inventory Use and Reporting (IUR) Database

The IUR database includes chemicals that are manufactured or imported in quantities of 25,000 pounds or more at a single site. The 2006 IUR includes information about chemicals manufactured or imported during calendar year 2005. In addition to the basic manufacturing information collected in previous reporting cycles, the 2006 cycle is the first time EPA collected information to characterize exposure during manufacturing, processing and use of organic chemicals. This includes information on whether a chemical is present in products intended for use by children 14 and under. The State of Washington used this database in its assessment of the potential for exposure to children.

National Library of Medicine Household Products

The US Department of Health and Human Services National Library of Medicine maintains a database that links over 10,000 consumer brands to health effects. Information in the Household Products Database is from a variety of publicly available sources including brand-specific labels and Material Safety Data Sheets when available from manufacturers and manufacturers' web sites. The database can be searched by chemical, which contains a list of products that contain the chemical. The State of Washington used this list to identify chemicals that were present in children's products.

EPA ChAMP Program

The ChAMP program is no longer updated, and was superseded by other initiatives in 2009. Under ChAMP, EPA evaluated and assigned priority for follow-up action on high production volume (HPV) and medium production volume (MPV) chemicals. EPA produced a number of monograghs for a limited number of chemicals that included information on chemical properties, toxicity, and in some instances product information. The State of Washington used this database to identify chemicals with potential exposure for children.

Routes of exposure

The State of Washington also categorized chemicals with respect to the probability of exposure to children via specific routes. This information is provided for completeness. No chemical was included in the list of CHC based on this information.

Inhalation - Using information on the properties of an individual chemical, the State of Washington determined whether the chemical was likely to be released into air from products.

Ingestion or mouthed or sucked by children - The possibility of ingestion or mouthing by children was made by the State of Washington on the basis of the type of product containing the chemical.

Dermal exposure - The potential for dermal exposure was made by the State of Washington on the basis of the type of product containing the chemical and the properties of the chemical.

Candidate Chemicals for CHC List		Toxicity																Exposure																
CAS	Chemical	NTP_REP	GSH cat 1A repro	reprotex A+,A	Prop65_DEV	Prop65_MAL	Prop65_FEM	EU_END1	NTP_cancer	IRIS_86A	IRIS_96	GSH cat 1 cancer	EU carcinogen 1A	IARC_1	WA_PBT	CAN_PBiT or HAS	low tox value	Biomonitoring	Indoor air and dust	Danish EPA	Dutch (NL) Reports	German FEA	ESIS_RAR	HSDB_NLM	EPA Inventory Use (IUR)	HPD_NLM	ChAPM child exp	SPIN	2012 TSCA Work Plan Consumer Products	Peer reviewed journals	VCCEP	Released into air	Ingested by child	Applied to skin
50-00-0	Formaldehyde													✓					5	14		✓		✓	✓	74		✓	✓			✓		✓
55-18-5	N-nitrosodiethylamine																		1										✓				✓	
56-23-5	Carbon tetrachloride																	3	2							3		✓						
62-53-3	Aniline			✓														1	2	4		✓				1		✓	✓			✓		
62-75-9	N-Nitrosodimethylamine																			1	2								✓				✓	
67-56-1	Methanol																✓		1					✓	✓	128		✓						
67-66-3	Chloroform																	5	9	1						3								
71-43-2	Benzene				✓	✓			✓	✓	✓		✓	✓				8	9	6		✓	✓		✓	11		✓			✓	✓		
74-87-3	Methyl chloride				✓												✓		1							1								
75-00-3	Chloroethane; Ethyl chloride																✓																	
75-01-4	Vinyl chloride								✓	✓	✓	✓	✓	✓					nd	1			NF		✓			✓	✓					
75-07-0	Acetaldehyde																		3	8						9		✓	✓			✓		
75-09-2	Methylene chloride			✓														nd	4	7					✓	48		✓	✓					
75-15-0	Carbon disulfide				✓	✓	✓										✓		nd,1	2	1				✓								✓	
75-25-2	Bromoform																	2											✓					
75-27-4	Bromodichloromethane																	2	1															
75-34-3	1,1-Dichloroethane																	nd											✓					
78-87-5	1,2-Dichloropropane																✓	nd	nd,1										✓					
79-00-5	1,1,2-Trichloroethane																	nd,2	3						✓				✓					
79-01-6	Trichloroethylene																✓	nd,3	6	1		✓		✓	✓	12		✓	✓		✓			
79-06-1	Acrylamide																✓	3							✓	2		✓						
79-34-5	1,1,2,2-Tetrachloroethane																	nd		2														
79-43-6	Dichloroacetic acid																												✓					
79-94-7	Tetrabromobisphenol A														✓			2	1	1		✓	✓		✓									
84-61-7	Dicyclohexyl phthalate; DCHP							✓										nd,1	4						✓									
84-66-2	Diethyl phthalate							✓									✓	8	10	15	1				✓	41		✓		1		✓		✓
84-74-2	Dibutyl phthalate; DBP	✓			✓	✓	✓	✓									✓	8	9	21	1	✓	✓			32		✓		1				
84-75-3	Di-n-Hexyl Phthalate	✓				✓	✓												1					✓	✓					1			✓	
85-68-7	Benzyl butyl phthalate; BBP				✓			✓										8	9	7	1		✓		✓	42		✓						
86-30-6	N-Nitrosodiphenylamine																			1									✓				✓	
87-68-3	Hexachlorobutadiene														✓	✓			nd	1														
91-22-5	Quinoline										✓																							
91-59-8	2-Naphthylamine								✓				✓	✓					1	1														

Candidate Chemicals for CHC List		Toxicity																Exposure																
CAS	Chemical	NTP_REP	GSH cat 1A repro	reprotex A+,A	Prop65_DEV	Prop65_MAL	Prop65_FEM	EU_END1	NTP_cancer	IRIS_86A	IRIS_96	GSH cat 1 cancer	EU carcinogen 1A	IARC_1	WA_PBT	CAN_PBiT or HAS	low tox value	Biomonitoring	Indoor air and dust	Danish EPA	Dutch (NL) Reports	German FEA	ESIS_RAR	HSDB_NLM	EPA Inventory Use (IUR)	HPD_NLM	ChAPM child exp	SPIN	2012 TSCA Work Plan Consumer Products	Peer reviewed journals	VCCEP	Released into air	Ingested by child	Applied to skin
91-94-1	3,3'-Dichlorobenzidine																			1														
92-69-3	4-Hydroxybiphenyl							✔										3																
92-87-5	Benzidine and its salts									✔				✔						1														
92-88-6	4,4'-Dihydroxybiphenyl							✔																										
94-13-3	Propyl paraben							✔										3		6	1			✔		>400		✔					✔	✔
94-26-8	Butyl paraben							✔										2	1	6	1					65		✔		1				✔
95-53-4	2-Aminotoluene													✔						3													✔	
95-69-2	4-Chloro-ortho-toluidine																			1														
95-80-7	2,4-Diaminotoluene																✔			1	1												✔	
96-09-3	Styrene oxide																			1														
96-12-8	1,2-Dibromo-3-chloropropane		✔		✔	✔		✔									✔	nd																
96-18-4	1,2,3-Trichloropropane																✔																	
99-76-3	Methyl paraben							✔										3	1	10	2			✔		>400		✔		1				✔
99-96-7	p-Hydroxybenzoic acid							✔												1	1													
100-41-4	Ethylbenzene																✔	5	8	14					✔	375		✔	✔		✔	✔		
100-42-5	Styrene							✔									✔	5	9	11	1	✔			✔	14		✔	✔			✔		
100-52-7	Benzaldehyde																✔		1	13						4		✔				✔	✔	✔
101-14-4	4,4´-Methylenebis(2-Chloroaniline)													✔						1									✔					
103-33-3	Azobenzene																																	
106-47-8	para-Chloroaniline																✔	2		3														
106-89-8	Epichlorohydrin					✔		✔												1								✔						
106-93-4	1,2-Dibromoethane					✔		✔			✔								nd						✔						✔			
106-99-0	1,3-Butadiene				✔	✔	✔		✔				✔	✔			✔	1	4	1					✔	4		✔						
107-06-2	1,2-Dichloroethane																	nd	nd,2	1					✔						✔			
107-13-1	Acrylonitrile																✔	2	1	1					✔			✔	✔				✔	
108-88-3	Toluene		✔	✔	✔												✔	8	10	19		✔	✔		✔	>400	✔	✔			✔	✔		✔
109-86-4	2-Methoxyethanol				✔	✔											✔		nd	2								✔						
110-49-6	Methyl cellosolve acetate				✔	✔														1														
110-80-5	Ethylene glycol monoethyl ether				✔	✔											✔		1	4								✔				✔		
110-86-1	Pyridine																✔			1														
111-15-9	2-ethoxyethyl acetate				✔	✔														1														
115-96-8	Tris(2-chloroethyl) phosphate															✔			2	2	1	✔	✔		✔				✔	1		✔	✔	
117-81-7	Di-(2-ethylhexyl) phthalate; DEHP				✔	✔		✔										9	10	22	1	✔	✔	✔	✔	1		✔		1				

Candidate Chemicals for CHC List		Toxicity																Exposure																
CAS	Chemical	NTP_REP	GSH cat 1A repro	reprotex A+,A	Prop65_DEV	Prop65_MAL	Prop65_FEM	EU_END1	NTP_cancer	IRIS_86A	IRIS_96	GSH cat 1 cancer	EU carcinogen 1A	IARC_1	WA_PBT	CAN_PBiT or HAS	low tox value	Biomonitoring	Indoor air and dust	Danish EPA	Dutch (NL) Reports	German FEA	ESIS_RAR	HSDB_NLM	EPA Inventory Use (IUR)	HPD_NLM	ChAPM child exp	SPIN	2012 TSCA Work Plan Consumer Products	Peer reviewed journals	VCCEP	Released into air	Ingested by child	Applied to skin
117-84-0	Di-n-octyl phthalate; DOP																	3	2	5	1			✔				✔		1				
118-74-1	hexachlorobenzene		✔		✔			✔							✔			6																
119-90-4	3,3´-Dimethoxybenzidine																																	
119-93-7	3,3´-Dimethylbenzidine and Dyes Metabolized to 3,3´-Dimethylbenzidine																✔			3														
120-47-8	Ethyl paraben							✔										2	1	6	1					75		✔		1				✔
123-91-1	1,4-Dioxane																			2			✔	✔	✔	2		✔	✔		✔			✔
127-18-4	Perchloroethylene																✔	5	6	3		✔			✔	30		✔	✔		✔			
131-55-5	2,2',4,4'-tetrahydroxybenzophenone							✔												1						73								✔
131-56-6	2,4-Dihydroxybenzophenon							✔										1						✔		25				1				
131-70-4	Mono-n-butylphthalate							✔										4		2														
140-66-9	1,1,3,3-Tetramethyl-4-butylphenol							✔										5		1	1			uk					✔				✔	
140-67-0	Estragole																			3				✔			✔	✔						
149-57-5	2-Ethylhexanoic acid				✔															4	1	✔		✔	✔	4		✔					✔	
556-67-2	Octamethylcyclotetrasiloxane							✔								✔			1	4				✔	✔	26		✔	✔	1		✔		✔
608-93-5	Benzene, pentachloro-							✔							✔	✔	✔	2																
842-07-9	C.I. Solvent Yellow 14																				1							✔						
872-50-4	N-Methylpyrrolidone				✔															10					✔	42		✔	✔				✔	
924-16-3	N-Nitroso-di-n-butylamine																			1	2													
930-55-2	N-Nitrosopyrrolidine																																✔	
1163-19-5	2,2',3,3',4,4',5,5',6,6'-Decabromodiphenyl ether; BDE-209														✔			1	2	2			✔		✔						✔			
1327-53-3	Diarsenic trioxide												✔																					
1461-25-2	Tetrabutyltin																			1		✔												
1634-04-4	Methyl tert-butyl ether; MTBE							✔									✔	4	4						✔									
1763-23-1	perfluorooctanyl sulphonic acid and its salts; PFOS														✔			5	3	1										2				
1806-26-4	Phenol, 4-octyl-							✔										nd,2	1		1									1			✔	
2425-85-6	2-Naphthalenol, 1-[(4-methyl-2-nitrophenyl)azo]-															✔				1						4		✔						
4376-20-9	Mono 2 ethyl hexylphthalate; MEHP							✔										3																
5466-77-3	2-ethyl-hexyl-4-methoxycinnamate							✔												1				✔		109								✔
7439-97-6	Mercury & mercury compounds		✔		✔										✔			3	1	3				✔		2		✔	✔					
7440-02-0	Nickel & nickel compounds				✔				✔								✔	3	2	9		✔			✔	3			✔	1				
7440-38-2	Arsenic & Arsenic compounds		✔						✔	✔		✔		✔				6	5	4						5		✔	✔					
7440-41-7	Beryllium & Beryllium compounds								✔		✔	✔		✔				4																

Candidate Chemicals for CHC List		Toxicity																Exposure																	
CAS	Chemical	NTP_REP	GSH cat 1A repro	reprotex A+,A	Prop65_DEV	Prop65_MAL	Prop65_FEM	EU_END1	NTP_cancer	IRIS_86A	IRIS_96	GSH cat 1 cancer	EU carcinogen 1A	IARC_1	WA_PBT	CAN_PBiT or HAS	low tox value	Biomonitoring	Indoor air and dust	Danish EPA	Dutch (NL) Reports	German FEA	ESIS_RAR	HSDB_NLM	EPA Inventory Use (IUR)	HPD_NLM	ChAPM child exp	SPIN	2012 TSCA Work Plan Consumer Products	Peer reviewed journals	VCCEP	Released into air	Ingested by child	Applied to skin
7440-43-9	Cadmium				✔	✔			✔					✔				8	2	5	1	✔				6		✔	✔					
7440-48-4	Cobalt & Cobalt compounds																	3	1	5		✔				1		✔	✔					
14808-60-7	Quartz								✔			✔		✔											✔	>400		✔	✔					✔
15541-45-4	Bromate										✔																							
25013-16-5	Butylated hydroxyanisole							✔																✔		41		✔						✔
25637-99-4	Hexabromocyclododecane														✔			1	2				✔	✔									✔	
26471-62-5	Toluene diisocyanate; TDI																✔			1								✔						
26761-40-0	Diisodecyl Phthalate; DIDP				✔													1		3		✔	✔		✔			✔						
27193-28-8	(1,1,3,3-tetramethylbutyl)-Phenol							✔												1														

Legend

✔	Found to be present
nd	chemical not detected

Toxicology Data Sources

NTP_REP	National Toxicology Program Evaluation of Risks to Human Reproduction - Clear or Some Evidence of adverse reproductive or developmental effects
GSH cat 1A repro	Global Harmonization System - Category 1A for reproductive or germ cell mutagenicity, known
reprotext A+, A	REPROTEXT® database for reproductive and developmental toxicants - A+,A
Prop 65 dev	California Proposition 65 Program - Impact to development
Prop65_FEM	California's Proposition 65 Program - Impact to females
Prop65_MAL	California's Proposition 65 Program - Impact to males
EU_END1	European Union Endocrine Disruptor Program - Category 1, probable
NTP_cancer	National Toxicology Prrogram. Report on Carcinogens - Known human carcinogen
IRIS_86A	EPA Integrated Risk Information System-1986 critera, Known human carcinogen
IRIS 96	EPA Integrated Risk Information System-1996 Known human carcinogen
GSH category 1A cancer	Global Harmonization System Catergory 1A, Known human carcinogen
EU carcinogen 1A	European Union Carcinogen List, Category 1, Known carcinogen
IARC_1	IARC - Group 1 - Known human carcinogen
WA_PBT	Washington State PBT Program with supporting ME-CDC review of peer-reviewd publications
CAN PBiT or HAS	Canadian Environmental Protection Act PB & inherently Toxic chemicals or Hazardous Substances Act
Low tox value	Low toxicity values for selected endpoints based on ATSDR and RTEC

Exposure Studies

Biomonitoring	Identified as present in human tissue by US CDC or pubmed search, numbers refer to number of studies in which chemical was identified.
Indoor air and dust	Identified as present in indoor air or dust by Pubmed search, numbers refer to number of studies in which chemical was identified.

Consumer Product Data

Danish EPA	Identifed as present in consumer products by the Danish EPA
Dutch reports	Identified as present in consumer products by the Dutch government
German Federal Environment Agency	
ESIS Risk Assessment Report	EU or other authoritative risk assesment indicating use in consumer products
HSDB_NLM	Listed in National Library of Medicine Hazardous Substances Database
EPA_Inventory Use Report	EPA Inventory Use and Reporting database indicating use in consumer products
HPD_NLM household products	Household Products Database, National Library of Medicine used in consumer products
SPIN	Substances in Products in Nordic Countries Database
TSCA Work Plan Chemicals	
Peer Reviewed Journals	
VCCEP	
ChAMP child exp	EPA ChAMP program indicating potential exposure to children
Released into air	Potential release into air based on properties of chemical
Ingested by child	Potential ingestion, mouthing, or sucking by child based on product type
Applied to skin	Product is applied to skin

List of Chemicals of High Concern		Toxicity											Exposure																
CAS	Chemical	NTP_REP	GSH cat 1A repro	EU_END1	NTP_cancer	IRIS_86A	IRIS_96	GSH cat 1 cancer	EU carcinogen 1A	IARC_1	WA_PBT	CAN_PBiT or HAS	Biomonitoring	Indoor air and dust	Danish EPA	Dutch (NL) Reports	German FEA	ESIS_RAR	HSDB_NLM	EPA Inventory Use (IUR)	HPD_NLM	ChAMP child exp	SPIN	2012 TSCA Work Plan Consumer Products	Peer Reviewed Journals	VCCEP	Released into air	Ingested by child	Applied to skin
50-00-0	Formaldehyde									✓				5	14		✓		✓	✓	74		✓	✓					✓
71-43-2	Benzene				✓	✓	✓		✓	✓			8	9	6		✓	✓		✓	11		✓			✓	✓		
75-01-4	Vinyl chloride				✓	✓	✓	✓	✓	✓				nd	1			NF		✓			✓	✓					
79-94-7	Tetrabromobisphenol A										✓		2	1	1		✓	✓		✓									
84-61-7	Dicyclohexyl phthalate; DCHP			✓									nd,1	4						✓									
84-66-2	Diethyl phthalate			✓									8	10	15	1				✓	41		✓		1		✓		✓
84-74-2	Dibutyl phthalate, DBP	✓		✓									8	9	21	1	✓	✓			32		✓		1				
84-75-3	Di-n-Hexyl Phthalate	✓												1					✓	✓					1			✓	
85-68-7	Benzyl Butyl phthalate; BBP			✓									8	9	7	1		✓		✓	42		✓						
87-68-3	Hexachlorobutadiene										✓	✓		nd	1														
91-59-8	2-Naphthylamine				✓				✓	✓				1	1														
92-69-3	4-Hydroxybiphenyl			✓									3																
92-87-5	Benzidine and its salts					✓				✓					1														
94-13-3	Propyl paraben			✓									3		6	1			✓		>400		✓					✓	✓
94-26-8	Butyl paraben			✓									2	1	6	1					65		✓		1				✓
95-53-4	2-Aminotoluene									✓					3													✓	
99-76-3	Methyl paraben			✓									3	1	10	2			✓		>400		✓		1				✓
99-96-7	p-Hydroxybenzoic acid			✓											1	1												✓	
100-42-5	Styrene			✓									5	9	11	1	✓			✓	14		✓	✓			✓		
101-14-4	4,4´-Methylenebis(2-Chloroaniline)									✓					1									✓					
106-89-8	Epichlorohydrin			✓											1								✓						
106-93-4	1,2-Dibromoethane			✓			✓							nd						✓						✓			
106-99-0	1,3-Butadiene				✓				✓	✓			1	4	1					✓	4		✓						

List of Chemicals of High Concern		Toxicity											Exposure																
CAS	Chemical	NTP_REP	GSH cat 1A repro	EU_END1	NTP_cancer	IRIS_86A	IRIS_96	GSH cat 1 cancer	EU carcinogen 1A	IARC_1	WA_PBT	CAN_PBiT or HAS	Biomonitoring	Indoor air and dust	Danish EPA	Dutch (NL) Reports	German FEA	ESIS_RAR	HSDB_NLM	EPA Inventory Use (IUR)	HPD_NLM	ChAMP child exp	SPIN	2012 TSCA Work Plan Consumer Products	Peer Reviewed Journals	VCCEP	Released into air	Ingested by child	Applied to skin
108-88-3	Toluene		✓										8	10	19		✓	✓		✓	>400		✓			✓	✓		✓
115-96-8	Tris(2-chloroethyl) phosphate											✓		2	2	1	✓	✓		✓				✓	1		✓	✓	
117-81-7	Di-(2-ethylhexyl) phthalate, DEHP			✓									9	10	22	1	✓	✓	✓	✓	1		✓		1				
118-74-1	Hexachlorobenzene		✓	✓							✓		6																
120-47-8	Ethyl paraben			✓									2	1	6	1					75		✓		1				✓
131-55-5	2,2',4,4'-tetrahydroxybenzophenone, BP-2			✓											1						73								✓
131-56-6	2,4-Dihydroxybenzophenon			✓									1						✓		25				1				
131-70-4	Mono-n-butylphthalate			✓									4		2														
140-66-9	1,1,3,3-Tetramethyl-4-butylphenol			✓									5		1	1			uk					✓				✓	
556-67-2	Octamethylcyclotetrasiloxane			✓								✓		1	4				✓	✓	26		✓	✓	1		✓		✓
608-93-5	Benzene, pentachloro-			✓							✓	✓	2																
1163-19-5	2,2',3,3',4,4',5,5',6,6'-Decabromodiphenyl ether; BDE-209										✓		1	2	2			✓		✓						✓			
1634-04-4	Methyl tert-butyl ether; MTBE			✓									4	4						✓									
1763-23-1	perfluorooctanyl sulphonic acid and its salts; PFOS										✓		5	3	1										2				
1806-26-4	Phenol, 4-octyl-			✓									nd,2	1		1									1			✓	
2425-85-6	2-Naphthalenol, 1-[(4-methyl-2-nitrophenyl)azo]-											✓			1						4		✓						
5466-77-3	2-ethyl-hexyl-4-methoxycinnamate			✓											1				✓		109								✓
7439-97-6	Mercury & mercury compounds		✓								✓		3	1	3				✓		2	✓	✓	✓					
7440-02-0	Nickel & nickel compounds				✓								3	2	9		✓			✓	3			✓	1				
7440-38-2	Arsenic & Arsenic compounds		✓		✓	✓		✓		✓			6	5	4						5		✓	✓					
7440-41-7	Beryllium & Beryllium compounds				✓		✓	✓		✓			4																
7440-43-9	Cadmium				✓					✓			8	2	5	1	✓				6		✓	✓					
14808-60-7	Quartz				✓			✓		✓										✓	>400		✓	✓					✓
25013-16-5	Butylated hydroxyanisole			✓															✓		41		✓						✓

List of Chemicals of High Concern		Toxicity											Exposure																
CAS	Chemical	NTP_REP	GSH cat 1A repro	EU_END1	NTP_cancer	IRIS_86A	IRIS_96	GSH cat 1 cancer	EU carcinogen 1A	IARC_1	WA_PBT	CAN_PBiT or HAS	Biomonitoring	Indoor air and dust	Danish EPA	Dutch (NL) Reports	German FEA	ESIS_RAR	HSDB_NLM	EPA Inventory Use (IUR)	HPD_NLM	ChAMP child exp	SPIN	2012 TSCA Work Plan Consumer Products	Peer Reviewed Journals	VCCEP	Released into air	Ingested by child	Applied to skin
25637-99-4	Hexabromocyclododecane										✔		1	2				✔	✔									✔	
27193-28-8	(1,1,3,3-tetramethylbutyl)-phenol			✔											1														

Note: Please see text for further description of data sources and evaluation process.

Legend

✔	Found to be present
C	information is confidential in SPIN

Toxicology Data Sources

NTP_REP	National Toxicology Program Evaluation of Risks to Human Reproduction - Clear or some evidence for of adverse reproductive or developmental effects
GSH cat 1A repro	Global Harmonization System - Category 1A for reproductive or germ cell mutagenicity, known
EU_END1	EU Endocrine Disruptor Program - Category 1, probable
NTP_cancer	Nat. Tox. Prg. Report on Carcinogens - Known human carcinogen
IRIS_86A	EPA Integrated Risk Information System -1986 critera - Known human carcinogen
IRS 96	EPA Integrated Risk Information System -1996 Known carcinogenic to humans
GSH category 1A cancer	Global Harmonization System Catergory 1A - Known human carcinogen
EU carcinogen 1A	European Union Carcinogen List, Category 1, Known carcinogen
IARC_1	IARC - Group 1 - Known human carcinogen
WA_PBT	Washington State PBT Program with supporting ME-CDC review of peer-reviewd publications
CAN PBiT or HAS	Canadian Environmental Protection Act PB & inherently Toxic chemicals or Hazardous Substances Act - Present on list

Exposure Studies

Biomonitoring	Identified as present in human tissue by biomonitoring studies identified by a Pubmed search, numbers refer to number of studies in which chemical was identified.
Indoor air and dust	Identified as present in indoor air or dust by Pubmed search, numbers refer to number of studies in which chemical was identified.

Consumer Product Data

Danish EPA	Identifed as present in consumer products by the Danish EPA
Dutch reports	Identified as present in consumer products by the Dutch government
German Federal Environment Agency	
ESIS Risk Assessment Report	EU or other authoritative risk assesment indicating use in consumer products
HSDB_NLM	Listed in National Library of Medicine Hazardous Substances Database
EPA_Inventory Use Report	EPA Inventory Use and Reporting database indicating use in consumer products
HPD_NLM household products	Household Products Database, National Library of Medicine used in consumer products
SPIN	Substances in Products in Nordic Countries Database
TSCA Work Plan Chemicals	
Peer Reviewed Journals	
VCCEP	
ChAMP child exp	EPA ChAMP program indicating potential exposure to children
Released into air	Potential release into air based on properties of chemical
Ingested by child	Potential ingestion, mouthing, or sucking by child based on product type
Applied to skin	Product is applied to skin

Deriving Chemicals of High Concern
Process Documentation

Appendix III
Chemical Specific Inclusion Criteria
July 1, 2012

This document presents the rationale for inclusion and support for each chemical on the CHC list, as presented in the Maine CDC Chemicals of High Concern Process Documentation.

Environmental & Occupational Health Programs
Maine Center for Disease Control and Prevention
286 Water Street, 3rd Floor, Augusta, ME 04333
207.287.4311 • 866.292.3474

Maine Center for Disease Control and Prevention
An Office of the Department of Health and Human Services

Paul R. LePage, Governor   Mary C. Mayhew, Commissioner

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Formaldehyde (CAS 50-00-0)

Criteria for inclusion of formaldehyde in the CHC List: IARC - Group 1 known human carcinogen.

The presence of formaldehyde in humans was not identified in biomonitoring studies (preliminary literature search).

The presence of formaldehyde was identified in 5 indoor air and/or dust studies (preliminary literature search).

1. California Air Resources Board (2005). Indoor Air Pollution in California - Report to the California Legislature. California Environmental Protection Agency.
2. Guo, H.,Kwok, N. H.,Cheng, H. R.,Lee, S. C.,Hung, W. T.,Li, Y. S. (2009). "Formaldehyde and volatile organic compounds in Hong Kong homes: concentrations and impact factors." Indoor Air 19: 206-217.
3. Hodgson, A.T., Rudd, A.F., Beal, D., Chandra, S. (2000). "Volatile organic compound concentrations and emission rates in new and site-built houses." Indoor Air 10: 178-192.
4. Koziel, J.,Noah, J.,Pawliszyn, J. (2001). "Field sampling and determination of formaldehyde in indoor air with solid-phase microextraction and on-fiber derivatization." Environmental Science & Technology 35: 1481-1486.
5. Serrano-Trespalacios, P. I.,Ryan, L.,Spengler, J. D. (2004). "Ambient, indoor and personal exposure relationships of volatile organic compounds in Mexico City Metropolitan Area." Journal of Exposure Analysis and Environmental Epidemiology 14: S118-S132.

Benzene (CAS 71-43-2)

Criteria for inclusion of benzene in the CHC List: NTP Report on Carcinogens - known carcinogen, EPA Integrated Risk Information System - 1986 criteria, known carcinogen, EPA Integrated Risk Information System – 1996 known carconogen, IARC - Group 1 known human carcinogen, European Union carcinogen list, Category 1, known carcinogen.

The presence of benzene in humans was identified in 8 biomonitoring studies (preliminary literature search).

1. CDC (Centers for Disease Control and Prevention) (2009). Fourth National Report on Human Exposure to Environmental Chemicals. Centers for Disease Control and Prevention, Atlanta, Ga.
2. Elliott, L.,Longnecker, M. P.,Kissling, G. E.,London, S. J. (2006). "Volatile organic compounds and pulmonary function in the Third National Health and Nutrition Examination Survey, 1988-1994." Environmental Health Perspectives 114(8): 1210-1214.
3. Kim, S. R.,Halden, R. U.,Buckley, T. J. (2007). "Volatile organic compounds in human milk: Methods and measurements." Environmental Science Technology 41(5): 1662-1667.
4. Lin, Y. S.,Egeghy, P. P.,Rappaport, S. M. (2008). "Relationships between levels of volatile organic compounds in air and blood from the general population." Journal of Exposure Science and Environmental Epideniology 18: 421-429.
5. Pellizzari, E. D.,Smith, D. J.,Clayton, A.,Michael, L. C.,Quackenboss, J. J. (2001). "An assessment of the data quality for NHEXAS-Part I: Exposure to metals and volatile organic chemicals in Region 5." Journal of Exposure Analysis and Environmental Epidemiology 11: 140-154.

6. Sexton, K.,Adgate, J. L.,Church, T. R.,Ashley, D. L.,Needham, L. L.,Ramachandran, G.,Fredrickson, A. L.,Ryan, A. D. (2005). "Children's exposure to volatile organic compounds as determined by longitudinal measurements in blood." Environmental Health Perspectives 113(3): 342-348.
7. Sexton, K.,Adgate, J. L.,Fredrickson, A. L.,Ryan, A. D.,Needham, L. L.,Ashley, D. L. (2006). "Using biologic markers in blood to assess exposure to multiple environmental chemicals for inner-city children 3 - 6 years of age." Environmental Health Perspectives 114(3): 453-459.
8. Woodruff, T.J., Zota, A.R., Schartz, J.M. (2011). Environmental chemicals in pregnant women in the United States: NHANES 2003-2004. Environmental Health Perspectives 119:878-885.

The presence of benzene was identified in 9 indoor air and/or dust studies (preliminary literature search).

1. Adgate, J. L.,Church, T. R.,Ryan, A. D.,Ramachandran, G.,Fredrickson, A. L.,Stock, T. H.,Morandi, M. T.,Sexton, K. (2004). "Outdoor, indoor and personal exposure to VOCs in children." Environmental Health Perspectives 112(14): 1386-1392.
2. California Air Resources Board (2005). Indoor Air Pollution in California - Report to the California Legislature. California Environmental Protection Agency.
3. Kim, S. R.,Halden, R. U.,Buckley, T. J. (2007). "Volatile organic compounds in human milk: Methods and measurements." Environmental Science Technology 41(5): 1662-1667.
4. Liu, J.,Drane, W.,Liu, X.,Wu, T. (2009). "Examination of the relationships between environmental exposures to volatile organic compounds and biochemical liver tests: application of canonical correlation analysis." Environmental Research 109(2): 193-199.
5. Miller, S. L.,Branoff, S.,Nazaroff, W. W. (1998). "Exposure to toxic air contaminants in environmental tobacco smoke: An assessment for California based on personal monitoring data." Journal of Exposure Analysis and Environmental Epidemiology 8(3): 287-311.
6. Pellizzari, E. D.,Smith, D. J.,Clayton, A.,Michael, L. C.,Quackenboss, J. J. (2001). "An assessment of the data quality for NHEXAS-Part I: Exposure to metals and volatile organic chemicals in Region 5." Journal of Exposure Analysis and Environmental Epidemiology 11: 140-154.
7. Serrano-Trespalacios, P. I.,Ryan, L.,Spengler, J. D. (2004). "Ambient, indoor and personal exposure relationships of volatile organic compounds in Mexico City Metropolitan Area." Journal of Exposure Analysis and Environmental Epidemiology 14: S118-S132.
8. Weisel, C. P.,Alimokhtari, S.,Sanders, P. F. (2008). "Indoor air VOC concentrations in suburban and rural New Jersey." Environmental Science & Technology 42(22): 8231-8238.
9. Zhu, J.,Laifeng, Y.,Shoeib, M. (2007). "Detection of dechlorane plus in residential indoor dust in the city of Ottawa, Canada." Environmental Science & Technology 41: 7694-7698.

Vinyl chloride (CAS 75-01-4)

Criteria for inclusion of vinyl chloride in the CHC List: NTP Report on Carcinogens - known carcinogen, EPA Integrated Risk Information System - 1986 criteria, known carcinogen, EPA Integrated Risk Information System - 1996, IARC - Group 1 known human carcinogen, European Union carcinogen list, Category 1, known carcinogen, Global Harmonization System - Category 1A known human carcinogen.

The presence of vinyl chloride in humans was not identified in biomonitoring studies (preliminary literature search).

The presence of vinyl chloride was not identified in indoor air and/or dust studies (preliminary literature search).

Compound detected in consumer products.

Tetrabromobisphenol A (CAS 79-94-7)

Criteria for inclusion of tetrabromobisphenol A in the CHC List: Washington State PBT Program and confirmed by ME-CDC with review of peer-reviewed scientific publications. A review by the Maine CDC identified about two dozen studies documenting effects on reproductive, developmental, endocrine, or cancer endpoints. Studies were also identified with data on levels of TBBPA in humans.

1. Rationale for Concurrence by Maine Center for Disease Control and Prevention on the Designation of Brominated Flame Retardants as a Priority Chemical, November 22, 2010

The presence of tetrabromobisphenol A in humans was identified in 2 biomonitoring studies (preliminary literature search).

1. Peters,R.J.B. (2005) Man-made chemicals in maternal and cord blood. TNO Report. B&O-A R 2005/129.
2. Thomsen, C.,Lundanes, E.,Becher, G. (2002). "Brominated flame retardants in archived serum samples from Norway: A study on temporal trends and the role of age." Environmental Science & Technology 36(7): 1414-1418.

The presence of tetrabromobisphenol A was identified in 1 indoor air and/or dust study (preliminary literature search).

1. Peters,R.J.B. (2005) Man-made chemicals in maternal and cord blood. TNO Report. B&O-A R 2005/129.

Dicyclohexyl phthalate; DCHP (CAS 84-61-7)

Criteria for inclusion of dicyclohexyl phthalate in the CHC List: EU Endocrine Disruptor Program - Category 1 probable.

The presence of dicyclohexyl phthalate in humans was identified in 2 biomonitoring studies (preliminary literature search).

1. CDC (Centers for Disease Control and Prevention) (2005). Third National Report on Human Exposure to Environmental Chemicals. Centers for Disease Control and Prevention, Atlanta, Ga.
2. Peters,R.J.B. (2005) Man-made chemicals in maternal and cord blood. TNO Report. B&O-A R 2005/129.

The presence of dicyclohexyl phthalate was identified in 4 indoor air and/or dust studies (preliminary literature search).

1. Fromme, H.,Lahrz, T.,Piloty, M.,Gebhart, H.,Oddoy, A.,Ruden, H. (2004). "Occurrence of phthalates and musk fragrances in indoor air and dust from apartments and kindergartens in Berlin (Germany)." Indoor Air 14: 188-195.
2. Otake, T.,Yoshinga, J.,Yanagisawa, Y. (2001). "Analysis of organic esters of plasticizer in indoor air by GC-MS and GC-FPD." Environmental Science & Technology 35(15): 3099-31002.
3. Roberts, J. W.,Wallace, L. A.,Camann, D. E.,Dickey, P.,Gilbert, S. G.,Lewis, R. G.,Takaro, T. K. (2009) "Monitoring and reducing exposure of infants to pollutants in house dust." Reviews of Environmental Contamination & Toxicology 201: 1-39.

4. Rudel, R. A.,Camann, D. E.,Spengler, J. D.,Korn, L. R.,Brody, J. G. (2003). "Phthalates, alkylphenols, pesticides, polybrominated diphenyl ethers, and other endocrine-disrupting Ccmpounds in indoor air and dust." Environmental Science & Technology 37(20): 4543-4553.

Diethyl phthalate (CAS 84-66-2)

Criteria for inclusion of diethyl phthalate in the CHC List: EU Endocrine Disruptor Program - Category 1 probable.

The presence of diethyl phthalate in humans was identified in 8 biomonitoring studies (preliminary literature search).

1. Adibi, J. J.,Whyatt, R. M.,Williams, P. L.,Calafat, A. M.,Camann, D.,Herrich, R.,Nelson, H.,Bhat, H. K.,Perera, F. P.,Silva, M. J.,and Hauser, R. (2008). "Characterization of phthalate exposure among pregnant women assessed by repeat air and urine samples." Environmental Health Perspectives 116(4): 467-473.
2. Adibi, J. J.,Pepera, F. P.,Jedrychowski, W.,Camann, D. E.,Barr, D.,Jacek, R.,Whyatt, R. M. (2003). "Prenatal epposures to Phthalates among women in New York City and Krakow, Poland." Environmental Health Perspectives 111(14): 1719-1722.
3. CDC (Centers for Disease Control and Prevention) (2005). Third National Report on Human Exposure to Environmental Chemicals. Centers for Disease Control and Prevention, Atlanta, Ga.
4. Guo, Z. Y.,Gai, P. P.,Duan, J.,Zhai, J. X.,Zhao, S. S. (2010). "Simultaneous determination of phthalates and adipates in human serum using gas chromatography-mass spectrometry with solid-phase extraction." Biomedical Chromatography 24: 1094-1099.
5. Main, K.,Mortensen, G. K.,Kaleva, M. M.,Boisen, K. A.,Damgaard, I. N.,Chellakooty, M.,Schmidt, I. M.,Suomi, A. M.,Virtanen, H. E.,Petersen, J. H.,Andersson, A. M.,Toppari, J.,Skakkebæk, N. E. (2006). "Human breast milk contamination with phthalates and alterations of endogenous reproductive hormones in infants three months of age." Environmental Health Perspective 114(2): 270-276.
6. Peters,R.J.B. (2005) Man-made chemicals in maternal and cord blood. TNO Report. B&O-A R 2005/129.
7. Weuve, J.,Hauser, R.,Calafat, A. M.,Missmer, S. A.,Wise, L. A. (2010). "Association of exposure to phthalates with endometriosis and uterine leiomyomata: Findings from NHANES, 1999-2004." Environmental Health Perspectives 118(6): 825-832.
8. Wolff, M. S.,Teitelbaum, S. L.,Windham, G.,Pinney, S. M.,Britton, J. A.,Chelimo, C.,Godbold, J.,Biro, F.,Kushi, L. H.,Pfeiffer, C. M.,Calafat, A. M. (2007). "Pilot study Of urinary biomarkers Of phytoestrogens, phthalates, and phenols In girls." Environmental Health Perspectives 115 (1): 116-121

The presence of diethyl phthalate was identified in 10 indoor air and/or dust studies (preliminary literature search).

1. Adibi, J. J.,Pepera, F. P.,Jedrychowski, W.,Camann, D. E.,Barr, D.,Jacek, R.,Whyatt, R. M. (2003). "Prenatal epposures to Phthalates among women in New York City and Krakow, Poland." Environmental Health Perspectives 111(14): 1719-1722.
2. Adibi, J. J.,Whyatt, R. M.,Williams, P. L.,Calafat, A. M.,Camann, D.,Herrich, R.,Nelson, H.,Bhat, H. K.,Perera, F. P.,Silva, M. J.,and Hauser, R. (2008). "Characterization of phthalate exposure among pregnant women assessed by repeat air and urine samples." Environmental Health Perspectives 116(4): 467-473.

3. Bornehag, C. G.,Lundgren, B.,Weschler, C. J.,Sigsfaard, T.,Hagerhed-Engman, L.,Sundell, J. (2005). "Phthalates in indoor dust and their association with building characteristics." Environmental Health Perspectives 113(10): 1399-1404.
4. California Air Resources Board (2005). Indoor Air Pollution in California - Report to the California Legislature. California Environmental Protection Agency.
5. Fromme, H.,Lahrz, T.,Piloty, M.,Gebhart, H.,Oddoy, A.,Ruden, H. (2004). "Occurrence of phthalates and musk fragrances in indoor air and dust from apartments and kindergartens in Berlin (Germany)." Indoor Air 14: 188-195.
6. Just, A. C.,Adibi, J. J.,Rundle, A. G.,Calafat, A. M.,Camann, D.,Hauser, R.,Silva, M. J.,Whyyatt, R. M. (2010). "Urinary and air phthalate concentrations and self-reported use of personal care products among minority pregnant women in New York city." Journal of Exposure Science and Environmental Epideniology 20: 625-633.
7. Kolarik, B.,Naydenov, K.,Larsson, M.,Bornehag, C. G.,Sundell, J. (2008). "The association between phthalates in dust and allergic diseases among Bulgarian children." Environmental Health Perspective 116(1): 98-103.
8. Otake, T.,Yoshinga, J.,Yanagisawa, Y. (2001). "Analysis of organic esters of plasticizer in indoor air by GC-MS and GC-FPD." Environmental Science & Technology 35(15): 3099-31002.
9. Roberts, J. W.,Wallace, L. A.,Camann, D. E.,Dickey, P.,Gilbert, S. G.,Lewis, R. G.,Takaro, T. K. (2009) "Monitoring and reducing exposure of infants to pollutants in house dust." Reviews of Environmental Contamination & Toxicology 201: 1-39.
10. Rudel, R. A.,Camann, D. E.,Spengler, J. D.,Korn, L. R.,Brody, J. G. (2003). "Phthalates, alkylphenols, pesticides, polybrominated diphenyl ethers, and other endocrine-disrupting Ccmpounds in indoor air and dust." Environmental Science & Technology 37(20): 4543-4553.

Dibutyl phthalates; DBP (CAS 84-74-2)

Criteria for inclusion of DBP (dibutyl phthalates) in the CHC List: NTP – clear evidence of adverse reproductive and developmental effects, EU Endocrine Disruptor Program - Category 1 probable.

The presence of DBP (dibutyl phthalates); di-n-butyl phthalate in humans was identified in 8 biomonitoring studies (preliminary literature search).

1. Adibi, J. J.,Whyatt, R. M.,Williams, P. L.,Calafat, A. M.,Camann, D.,Herrich, R.,Nelson, H.,Bhat, H. K.,Perera, F. P.,Silva, M. J.,and Hauser, R. (2008). "Characterization of phthalate exposure among pregnant women assessed by repeat air and urine samples." Environmental Health Perspectives 116(4): 467-473.
2. Adibi, J. J.,Pepera, F. P.,Jedrychowski, W.,Camann, D. E.,Barr, D.,Jacek, R.,Whyatt, R. M. (2003). "Prenatal epposures to Phthalates among women in New York City and Krakow, Poland." Environmental Health Perspectives 111(14): 1719-1722.
3. CDC (Centers for Disease Control and Prevention) (2005). Third National Report on Human Exposure to Environmental Chemicals. Centers for Disease Control and Prevention, Atlanta, Ga.
4. Guo, Z. Y.,Gai, P. P.,Duan, J.,Zhai, J. X.,Zhao, S. S. (2010). "Simultaneous determination of phthalates and adipates in human serum using gas chromatography-mass spectrometry with solid-phase extraction." Biomedical Chromatography 24: 1094-1099.
5. Main, K.,Mortensen, G. K.,Kaleva, M. M.,Boisen, K. A.,Damgaard, I. N.,Chellakooty, M.,Schmidt, I. M.,Suomi, A. M.,Virtanen, H. E.,Petersen, J. H.,Andersson, A. M.,Toppari, J.,Skakkebæk, N. E. (2006). "Human breast milk contamination with phthalates and alterations of endogenous reproductive hormones in infants three months of age." Environmental Health Perspective 114(2): 270-276.
6. Peters,R.J.B. (2005) Man-made chemicals in maternal and cord blood. TNO Report. B&O-A R 2005/129.

7. Wolff, M. S.,Teitelbaum, S. L.,Windham, G.,Pinney, S. M.,Britton, J. A.,Chelimo, C.,Godbold, J.,Biro, F.,Kushi, L. H.,Pfeiffer, C. M.,Calafat, A. M. (2007). "Pilot study Of urinary biomarkers Of phytoestrogens, phthalates, and phenols In girls." Environmental Health Perspectives 115 (1): 116-121
8. Woodruff, T.J., Zota, A.R., Schartz, J.M. (2011). Environmental chemicals in pregnant women in the United States: NHANES 2003-2004. Environmental Health Perspectives 119:878-885.

The presence of DBP (dibutyl phthalates); di-n-butyl phthalate was identified in 9 indoor air and/or dust studies (preliminary literature search).

1. Adibi, J. J.,Pepera, F. P.,Jedrychowski, W.,Camann, D. E.,Barr, D.,Jacek, R.,Whyatt, R. M. (2003). "Prenatal epposures to Phthalates among women in New York City and Krakow, Poland." Environmental Health Perspectives 111(14): 1719-1722.
2. Adibi, J. J.,Whyatt, R. M.,Williams, P. L.,Calafat, A. M.,Camann, D.,Herrich, R.,Nelson, H.,Bhat, H. K.,Perera, F. P.,Silva, M. J.,and Hauser, R. (2008). "Characterization of phthalate exposure among pregnant women assessed by repeat air and urine samples." Environmental Health Perspectives 116(4): 467-473.
3. Bornehag, C. G.,Lundgren, B.,Weschler, C. J.,Sigsfaard, T.,Hagerhed-Engman, L.,Sundell, J. (2005). "Phthalates in indoor dust and their association with building characteristics." Environmental Health Perspectives 113(10): 1399-1404.
4. Fromme, H.,Lahrz, T.,Piloty, M.,Gebhart, H.,Oddoy, A.,Ruden, H. (2004). "Occurrence of phthalates and musk fragrances in indoor air and dust from apartments and kindergartens in Berlin (Germany)." Indoor Air 14: 188-195.
5. Just, A. C.,Adibi, J. J.,Rundle, A. G.,Calafat, A. M.,Camann, D.,Hauser, R.,Silva, M. J.,Whyyatt, R. M. (2010). "Urinary and air phthalate concentrations and self-reported use of personal care products among minority pregnant women in New York city." Journal of Exposure Science and Environmental Epideniology 20: 625-633.
6. Kolarik, B.,Naydenov, K.,Larsson, M.,Bornehag, C. G.,Sundell, J. (2008). "The association between phthalates in dust and allergic diseases among Bulgarian children." Environmental Health Perspective 116(1): 98-103.
7. Otake, T.,Yoshinga, J.,Yanagisawa, Y. (2001). "Analysis of organic esters of plasticizer in indoor air by GC-MS and GC-FPD." Environmental Science & Technology 35(15): 3099-31002.
8. Roberts, J. W.,Wallace, L. A.,Camann, D. E.,Dickey, P.,Gilbert, S. G.,Lewis, R. G.,Takaro, T. K. (2009) "Monitoring and reducing exposure of infants to pollutants in house dust." Reviews of Environmental Contamination & Toxicology 201: 1-39.
9. Rudel, R. A.,Camann, D. E.,Spengler, J. D.,Korn, L. R.,Brody, J. G. (2003). "Phthalates, alkylphenols, pesticides, polybrominated diphenyl ethers, and other endocrine-disrupting Ccmpounds in indoor air and dust." Environmental Science & Technology 37(20): 4543-4553.

Di-n-Hexyl phthalate (CAS 84-75-3)

Criteria for inclusion of di-n-hexyl phthalate in the CHC List: NTP – clear evidence of adverse reproductive effects.

The presence of di-n-hexyl phthalate in humans was not identified in biomonitoring studies (preliminary literature search).

The presence of di-n-hexyl phthalate was identified in 1 indoor air and/or dust study (preliminary literature search).

1. Rudel, R. A.,Camann, D. E.,Spengler, J. D.,Korn, L. R.,Brody, J. G. (2003). "Phthalates, alkylphenols, pesticides, polybrominated diphenyl ethers, and other endocrine-disrupting Ccmpounds in indoor air and dust." Environmental Science & Technology 37(20): 4543-4553.

Benzyl butyl phthalate; Butyl benzyl phthalate; BBzP (CAS 85-68-7)

Criteria for inclusion of Benzyl butyl phthalate; BBP in the CHC List: EU Endocrine Disruptor Program - Category 1 probable.

The presence of benzyl butyl phthalate; BBP in humans was identified in 8 biomonitoring studies (preliminary literature search).

1. Adibi, J. J.,Whyatt, R. M.,Williams, P. L.,Calafat, A. M.,Camann, D.,Herrich, R.,Nelson, H.,Bhat, H. K.,Perera, F. P.,Silva, M. J.,and Hauser, R. (2008). "Characterization of phthalate exposure among pregnant women assessed by repeat air and urine samples." Environmental Health Perspectives 116(4): 467-473.
2. Adibi, J. J.,Pepera, F. P.,Jedrychowski, W.,Camann, D. E.,Barr, D.,Jacek, R.,Whyatt, R. M. (2003). "Prenatal epposures to Phthalates among women in New York City and Krakow, Poland." Environmental Health Perspectives 111(14): 1719-1722.
3. CDC (Centers for Disease Control and Prevention) (2005). Third National Report on Human Exposure to Environmental Chemicals. Centers for Disease Control and Prevention, Atlanta, Ga.
4. Guo, Z. Y.,Gai, P. P.,Duan, J.,Zhai, J. X.,Zhao, S. S. (2010). "Simultaneous determination of phthalates and adipates in human serum using gas chromatography-mass spectrometry with solid-phase extraction." Biomedical Chromatography 24: 1094-1099.
5. Main, K.,Mortensen, G. K.,Kaleva, M. M.,Boisen, K. A.,Damgaard, I. N.,Chellakooty, M.,Schmidt, I. M.,Suomi, A. M.,Virtanen, H. E.,Petersen, J. H.,Andersson, A. M.,Toppari, J.,Skakkebæk, N. E. (2006). "Human breast milk contamination with phthalates and alterations of endogenous reproductive hormones in infants three months of age." Environmental Health Perspective 114(2): 270-276.
6. Peters,R.J.B. (2005) Man-made chemicals in maternal and cord blood. TNO Report. B&O-A R 2005/129.
7. Weuve, J.,Hauser, R.,Calafat, A. M.,Missmer, S. A.,Wise, L. A. (2010). "Association of exposure to phthalates with endometriosis and uterine leiomyomata: Findings from NHANES, 1999-2004." Environmental Health Perspectives 118(6): 825-832.
8. Wolff, M. S.,Teitelbaum, S. L.,Windham, G.,Pinney, S. M.,Britton, J. A.,Chelimo, C.,Godbold, J.,Biro, F.,Kushi, L. H.,Pfeiffer, C. M.,Calafat, A. M. (2007). "Pilot study Of urinary biomarkers Of phytoestrogens, phthalates, and phenols In girls." Environmental Health Perspectives 115 (1): 116-121

The presence of butyl benzyl phthalate; BBP was identified in 9 indoor air and/or dust studies (preliminary literature search).

1. Adibi, J. J.,Pepera, F. P.,Jedrychowski, W.,Camann, D. E.,Barr, D.,Jacek, R.,Whyatt, R. M. (2003). "Prenatal epposures to Phthalates among women in New York City and Krakow, Poland." Environmental Health Perspectives 111(14): 1719-1722.
2. Adibi, J. J.,Whyatt, R. M.,Williams, P. L.,Calafat, A. M.,Camann, D.,Herrich, R.,Nelson, H.,Bhat, H. K.,Perera, F. P.,Silva, M. J.,and Hauser, R. (2008). "Characterization of phthalate exposure among pregnant women assessed by repeat air and urine samples." Environmental Health Perspectives 116(4): 467-473.
3. Bornehag, C. G.,Lundgren, B.,Weschler, C. J.,Sigsfaard, T.,Hagerhed-Engman, L.,Sundell, J. (2005). "Phthalates in indoor dust and their association with building characteristics." Environmental Health Perspectives 113(10): 1399-1404.

4. California Air Resources Board (2005). Indoor Air Pollution in California - Report to the California Legislature. California Environmental Protection Agency.
5. Fromme, H.,Lahrz, T.,Piloty, M.,Gebhart, H.,Oddoy, A.,Ruden, H. (2004). "Occurrence of phthalates and musk fragrances in indoor air and dust from apartments and kindergartens in Berlin (Germany)." Indoor Air 14: 188-195.
6. Kolarik, B.,Naydenov, K.,Larsson, M.,Bornehag, C. G.,Sundell, J. (2008). "The association between phthalates in dust and allergic diseases among Bulgarian children." Environmental Health Perspective 116(1): 98-103.
7. Otake, T.,Yoshinga, J.,Yanagisawa, Y. (2001). "Analysis of organic esters of plasticizer in indoor air by GC-MS and GC-FPD." Environmental Science & Technology 35(15): 3099-31002.
8. Roberts, J. W.,Wallace, L. A.,Camann, D. E.,Dickey, P.,Gilbert, S. G.,Lewis, R. G.,Takaro, T. K. (2009) "Monitoring and reducing exposure of infants to pollutants in house dust." Reviews of Environmental Contamination & Toxicology 201: 1-39.
9. Rudel, R. A.,Camann, D. E.,Spengler, J. D.,Korn, L. R.,Brody, J. G. (2003). "Phthalates, alkylphenols, pesticides, polybrominated diphenyl ethers, and other endocrine-disrupting Ccmpounds in indoor air and dust." Environmental Science & Technology 37(20): 4543-4553.

Hexachlorobutadiene (CAS 87-68-3)

Criteria for inclusion of hexachlorobutadiene in the CHC List: Canadian Environmental Protection Act - PersistentBioaccumulative & Inherently Toxic,

The presence of hexachlorobutadiene in humans was not identified in biomonitoring studies (preliminary literature search).

The presence of hexachlorobutadiene was not identified in indoor air and/or dust studies (preliminary literature search).

Compound detected in consumer products.

2-Naphthylamine (CAS 91-59-8)

Criteria for inclusion of 2-naphthylamine in the CHC List: NTP Report on Carcinogens - known carcinogen, IARC - Group 1 known human carcinogen, European Union carcinogen list, Category 1, known carcinogen.

The presence of 2-naphthylamine in humans was not identified in biomonitoring studies (preliminary literature search).

The presence of 2-naphthylamine was identified in 1 indoor air and/or dust study (preliminary literature search).

1. Wilson, W. E.,Lioy, P. J. (1994). "Sources of organic acids in indoor air: a field study." Journal of Exposure Analysis and Environmental Epidemiology 4(1): 25-47.

4-Hydroxybiphenyl; (CAS 92-69-3)

Criteria for inclusion of 4-hydroxybiphenyl in the CHC List: EU Endocrine Disruptor Program - Category 1 probable.

The presence of 4-hydroxybiphenyl in humans was identified in 3 biomonitoring studies (preliminary literature search).

1. Wolff, M. S.,Teitelbaum, S. L.,Windham, G.,Pinney, S. M.,Britton, J. A.,Chelimo, C.,Godbold, J.,Biro, F.,Kushi, L. H.,Pfeiffer, C. M.,Calafat, A. M. (2007). "Pilot study Of urinary biomarkers Of phytoestrogens, phthalates, and phenols In girls." Environmental Health Perspectives 115 (1): 116-121
2. Ye, X.,Kuklenyik, Z.,Bishop, A. M.,Needham, L. L.,Calafat, A. M. (2006). "Quantification of the urinary concentrations of parabens in humans by on-line solid phase extraction-high performance liquid chromatography-isotope dilution tandem mass spectrometry." Journal of Chromatography B 844: 53-59.
3. Ye, X., Bishop, A.M., Needham, L.L., Calafat, A.M. (2008). Automated on-line column-switching HPLC-MS/MS method with peak focusing for measuring parabens, triclosan, and other environmental phenols in human milk. Analytica Chimica Acta 622:150-156.

The presence of 4-hydroxybiphenyl; 4-phenylphenol was not identified in indoor air and/or dust studies (preliminary literature search).

Benzidine and its salts (CAS 92-87-5)

Criteria for inclusion of benzidine and its salts in the CHC List: EPA Integrated Risk Information System - 1986 criteria, known carcinogen, IARC - Group 1 known human carcinogen.

The presence of benzidine and its salts in humans was not identified in biomonitoring studies (preliminary literature search).

The presence of benzidine and its salts was not identified in indoor air and/or dust studies (preliminary literature search).

Compound detected in consumer products.

Propyl paraben (CAS 94-13-3)

Criteria for inclusion of propyl paraben in the CHC List: EU Endocrine Disruptor Program - Category 1 probable.

The presence of propyl paraben in humans was identified in 3 biomonitoring studies (preliminary literature search).

1. Calafat, A. M.,Yang Wong, L.,Ye, X.,Reidy, J. A.,Needham, L. L. (2008). "Exposure of the U.S. population to bisphenol A and 4-tertiary-octylphenol: 2003-2004." Environmental Health Perspectives 116(1): 39-44.

2. Ye, X.,Kuklenyik, Z.,Bishop, A. M.,Needham, L. L.,Calafat, A. M. (2006). "Quantification of the urinary concentrations of parabens in humans by on-line solid phase extraction-high performance liquid chromatography-isotope dilution tandem mass spectrometry." Journal of Chromatography B 844: 53-59.
3. Ye, X., Bishop, A.M., Needham, L.L., Calafat, A.M. (2008). Automated on-line column-switching HPLC-MS/MS method with peak focusing for measuring parabens, triclosan, and other environmental phenols in human milk. Analytica Chimica Acta 622:150-156.

The presence of propyl paraben was not identified in indoor air and/or dust studies (preliminary literature search).

Butyl paraben (CAS 94-26-8)

Criteria for inclusion of butyl paraben in the CHC List: EU Endocrine Disruptor Program - Category 1 probable.

The presence of butyl paraben in humans was identified in 2 biomonitoring studies (preliminary literature search).

1. Calafat, A. M.,Yang Wong, L.,Ye, X.,Reidy, J. A.,Needham, L. L. (2008). "Exposure of the U.S. population to bisphenol A and 4-tertiary-octylphenol: 2003-2004." Environmental Health Perspectives 116(1): 39-44.
2. Ye, X.,Kuklenyik, Z.,Bishop, A. M.,Needham, L. L.,Calafat, A. M. (2006). "Quantification of the urinary concentrations of parabens in humans by on-line solid phase extraction-high performance liquid chromatography-isotope dilution tandem mass spectrometry." Journal of Chromatography B 844: 53-59.

The presence of butyl paraben was identified in 1 indoor air and/or dust study (preliminary literature search).

1. Rudel, R. A.,Camann, D. E.,Spengler, J. D.,Korn, L. R.,Brody, J. G. (2003). "Phthalates, alkylphenols, pesticides, polybrominated diphenyl ethers, and other endocrine-disrupting Ccmpounds in indoor air and dust." Environmental Science & Technology 37(20): 4543-4553.

2-Aminotoluene (CAS 95-53-4)

Criteria for inclusion of 2-aminotoluene in the CHC List: IARC - Group 1 known human carcinogen.

The presence of 2-aminotoluene in humans was not identified in biomonitoring studies (preliminary literature search).

The presence of 2-aminotoluene was not identified in indoor air and/or dust studies (preliminary literature search).

Compound detected in consumer products.

Methyl paraben (CAS 99-76-3)

Criteria for inclusion of methyl paraben in the CHC List: EU Endocrine Disruptor Program - Category 1 probable.

The presence of methyl paraben in humans was identified in 3 biomonitoring studies (preliminary literature search).

1. Calafat, A. M.,Yang Wong, L.,Ye, X.,Reidy, J. A.,Needham, L. L. (2008). "Exposure of the U.S. population to bisphenol A and 4-tertiary-octylphenol: 2003-2004." Environmental Health Perspectives 116(1): 39-44.
2. Ye, X.,Kuklenyik, Z.,Bishop, A. M.,Needham, L. L.,Calafat, A. M. (2006). "Quantification of the urinary concentrations of parabens in humans by on-line solid phase extraction-high performance liquid chromatography-isotope dilution tandem mass spectrometry." Journal of Chromatography B 844: 53-59.
3. Ye, X., Bishop, A.M., Needham, L.L., Calafat, A.M. (2008). Automated on-line column-switching HPLC-MS/MS method with peak focusing for measuring parabens, triclosan, and other environmental phenols in human milk. Analytica Chimica Acta 622:150-156.

The presence of methyl paraben was identified in 1 indoor air and/or dust study (preliminary literature search).

1. A.,Camann, D. E.,Spengler, J. D.,Korn, L. R.,Brody, J. G. (2003). "Phthalates, alkylphenols, pesticides, polybrominated diphenyl ethers, and other endocrine-disrupting Ccmpounds in indoor air and dust." Environmental Science & Technology 37(20): 4543-4553.

p-Hydroxybenzoic acid (CAS 99-96-7)

Criteria for inclusion of p-hydroxybenzoic acid in the CHC List: EU Endocrine Disruptor Program - Category 1 probable.

The presence of p-hydroxybenzoic acid in humans was not identified in biomonitoring studies (preliminary literature search).

The presence of p-hydroxybenzoic acid was not identified in indoor air and/or dust studies (preliminary literature search).

Compound detected in consumer products.

Styrene (CAS 100-42-5)

Criteria for inclusion of styrene in the CHC List: EU Endocrine Disruptor Program - Category 1 probable.

The presence of styrene in humans was identified in 5 biomonitoring studies (preliminary literature search).

1. CDC (Centers for Disease Control and Prevention) (2009). Fourth National Report on Human Exposure to Environmental Chemicals. Centers for Disease Control and Prevention, Atlanta, Ga.

2. Elliott, L.,Longnecker, M. P.,Kissling, G. E.,London, S. J. (2006). "Volatile organic compounds and pulmonary function in the Third National Health and Nutrition Examination Survey, 1988-1994." Environmental Health Perspectives 114(8): 1210-1214.
3. Pellizzari, E. D.,Smith, D. J.,Clayton, A.,Michael, L. C.,Quackenboss, J. J. (2001). "An assessment of the data quality for NHEXAS-Part I: Exposure to metals and volatile organic chemicals in Region 5." Journal of Exposure Analysis and Environmental Epidemiology 11: 140-154.
4. Sexton, K.,Adgate, J. L.,Church, T. R.,Ashley, D. L.,Needham, L. L.,Ramachandran, G.,Fredrickson, A. L.,Ryan, A. D. (2005). "Children's exposure to volatile organic compounds as determined by longitudinal measurements in blood." Environmental Health Perspectives 113(3): 342-348.
5. Sexton, K.,Adgate, J. L.,Fredrickson, A. L.,Ryan, A. D.,Needham, L. L.,Ashley, D. L. (2006). "Using biologic markers in blood to assess exposure to multiple environmental chemicals for inner-city children 3 - 6 years of age." Environmental Health Perspectives 114(3): 453-459.

The presence of styrene was identified in 9 indoor air and/or dust studies (preliminary literature search).

1. Thomsen, C.,Lundanes, E.,Becher, G. (2002). "Brominated flame retardants in archived serum samples from Norway: A study on temporal trends and the role of age." Environmental Science & Technology 36(7): 1414-1418.
2. California Air Resources Board (2005). Indoor Air Pollution in California - Report to the California Legislature. California Environmental Protection Agency.
3. Guo, H.,Kwok, N. H.,Cheng, H. R.,Lee, S. C.,Hung, W. T.,Li, Y. S. (2009). "Formaldehyde and volatile organic compounds in Hong Kong homes: concentrations and impact factors." Indoor Air 19: 206-217.
4. Hodgson, A.T., Rudd, A.F., Beal, D., Chandra, S. (2000). “Volatile organic compound concentrations and emission rates in new and site-built houses.” Indoor Air 10: 178-192.
5. Miller, S. L.,Branoff, S.,Nazaroff, W. W. (1998). "Exposure to toxic air contaminants in environmental tobacco smoke: An assessment for California based on personal monitoring data." Journal of Exposure Analysis and Environmental Epidemiology 8(3): 287-311.
6. Pellizzari, E. D.,Smith, D. J.,Clayton, A.,Michael, L. C.,Quackenboss, J. J. (2001). "An assessment of the data quality for NHEXAS-Part I: Exposure to metals and volatile organic chemicals in Region 5." Journal of Exposure Analysis and Environmental Epidemiology 11: 140-154.
7. Serrano-Trespalacios, P. I.,Ryan, L.,Spengler, J. D. (2004). "Ambient, indoor and personal exposure relationships of volatile organic compounds in Mexico City Metropolitan Area." Journal of Exposure Analysis and Environmental Epidemiology 14: S118-S132.
8. Weisel, C. P.,Alimokhtari, S.,Sanders, P. F. (2008). "Indoor air VOC concentrations in suburban and rural New Jersey." Environmental Science & Technology 42(22): 8231-8238.
9. Zhu, J.,Laifeng, Y.,Shoeib, M. (2007). "Detection of dechlorane plus in residential indoor dust in the city of Ottawa, Canada." Environmental Science & Technology 41: 7694-7698.

4,4´-Methylenebis(2-Chloroaniline) (CAS 101-14-4)

Criteria for inclusion of 4,4´-methylenebis(2-chloroaniline) in the CHC List: IARC - Group 1 known human carcinogen.

The presence of 4,4´-methylenebis(2-chloroaniline) in humans was not identified in biomonitoring studies (preliminary literature search).

The presence of 4,4´-methylenebis(2-chloroaniline) was not identified in indoor air and/or dust studies (preliminary literature search).

Compound detected in consumer products.

Epichlorohydrin (CAS 106-89-8)

Criteria for inclusion of epichlorohydrin in the CHC List: EU Endocrine Disruptor Program - Category 1 probable.

The presence of epichlorohydrin in humans was not identified in biomonitoring studies (preliminary literature search).

The presence of epichlorohydrin was not identified in indoor air and/or dust studies (preliminary literature search).

Compound detected in consumer products.

1,2-Dibromoethane (CAS 106-93-4)

Criteria for inclusion of 1,2-dibromoethane in the CHC List: EU Endocrine Disruptor Program - Category 1 probable.

The presence of 1,2-dibromoethane in humans was not identified in biomonitoring studies (preliminary literature search).

The presence of 1,2-dibromoethane was not identified in indoor air and/or dust studies (preliminary literature search).

Compound detected in consumer products.

1,3-Butadiene (CAS 106-99-0)

Criteria for inclusion of 1,3-butadiene in the CHC List: NTP Report on Carcinogens - known human carcinogen, IARC - Group 1 known human carcinogen, European Union carcinogen list, Category 1, known carcinogen.

The presence of 1,3-butadiene in humans was identified in 1 biomonitoring study (preliminary literature search).

1. Schettgen, T.,Musiol, A.,Alt , E.,Ochsmann, E. (2009). "A Method for the quantification of biomarkers of exposure to acrylonitrile and 1, 3-butadiene in human urine by column-switching liquid chromatography- tandem mass spectrometry." Analytical and Bioanalytical Chemistry 393: 969-981.

The presence of 1,3-butadiene was identified in 4 indoor air and/or dust studies (preliminary literature search).

1. California Air Resources Board (2005). Indoor Air Pollution in California - Report to the California Legislature. California Environmental Protection Agency.
2. Serrano-Trespalacios, P. I.,Ryan, L.,Spengler, J. D. (2004). "Ambient, indoor and personal exposure relationships of volatile organic compounds in Mexico City Metropolitan Area." Journal of Exposure Analysis and Environmental Epidemiology 14: S118-S132.
3. Weisel, C. P.,Alimokhtari, S.,Sanders, P. F. (2008). "Indoor air VOC concentrations in suburban and rural New Jersey." Environmental Science & Technology 42(22): 8231-8238.
4. Zhu, J.,Laifeng, Y.,Shoeib, M. (2007). "Detection of dechlorane plus in residential indoor dust in the city of Ottawa, Canada." Environmental Science & Technology 41: 7694-7698.

Toluene (CAS 108-88-3)

Criteria for inclusion of toluene in the CHC List: Global Harmonization System - category 1A for known reproductive or germ cell mutagenicity.

The presence of toluene in humans was identified in 8 biomonitoring studies (preliminary literature search.

1. CDC (Centers for Disease Control and Prevention) (2009). Fourth National Report on Human Exposure to Environmental Chemicals. Centers for Disease Control and Prevention, Atlanta, Ga.
2. Elliott, L.,Longnecker, M. P.,Kissling, G. E.,London, S. J. (2006). "Volatile organic compounds and pulmonary function in the Third National Health and Nutrition Examination Survey, 1988-1994." Environmental Health Perspectives 114(8): 1210-1214.
3. Kim, S. R.,Halden, R. U.,Buckley, T. J. (2007). "Volatile organic compounds in human milk: Methods and measurements." Environmental Science Technology 41(5): 1662-1667.
4. Lin, Y. S.,Egeghy, P. P.,Rappaport, S. M. (2008). "Relationships between levels of volatile organic compounds in air and blood from the general population." Journal of Exposure Science and Environmental Epideniology 18: 421-429.
5. Pellizzari, E. D.,Smith, D. J.,Clayton, A.,Michael, L. C.,Quackenboss, J. J. (2001). "An assessment of the data quality for NHEXAS-Part I: Exposure to metals and volatile organic chemicals in Region 5." Journal of Exposure Analysis and Environmental Epidemiology 11: 140-154.
6. Sexton, K.,Adgate, J. L.,Church, T. R.,Ashley, D. L.,Needham, L. L.,Ramachandran, G.,Fredrickson, A. L.,Ryan, A. D. (2005). "Children's exposure to volatile organic compounds as determined by longitudinal measurements in blood." Environmental Health Perspectives 113(3): 342-348.

7. Sexton, K.,Adgate, J. L.,Fredrickson, A. L.,Ryan, A. D.,Needham, L. L.,Ashley, D. L. (2006). "Using biologic markers in blood to assess exposure to multiple environmental chemicals for inner-city children 3 - 6 years of age." Environmental Health Perspectives 114(3): 453-459.
8. Woodruff, T.J., Zota, A.R., Schartz, J.M. (2011). Environmental chemicals in pregnant women in the United States: NHANES 2003-2004. Environmental Health Perspectives 119:878-885.

The presence of toluene was identified in 10 indoor air and/or dust studies (preliminary literature search).

1. Thomsen, C.,Lundanes, E.,Becher, G. (2002). "Brominated flame retardants in archived serum samples from Norway: A study on temporal trends and the role of age." Environmental Science & Technology 36(7): 1414-1418.
2. California Air Resources Board (2005). Indoor Air Pollution in California - Report to the California Legislature. California Environmental Protection Agency.
3. Guo, H.,Kwok, N. H.,Cheng, H. R.,Lee, S. C.,Hung, W. T.,Li, Y. S. (2009). "Formaldehyde and volatile organic compounds in Hong Kong homes: concentrations and impact factors." Indoor Air 19: 206-217.
4. Hodgson, A.T., Rudd, A.F., Beal, D., Chandra, S. (2000). “Volatile organic compound concentrations and emission rates in new and site-built houses.” Indoor Air 10: 178-192.
5. Kim, S. R.,Halden, R. U.,Buckley, T. J. (2007). "Volatile organic compounds in human milk: Methods and measurements." Environmental Science Technology 41(5): 1662-1667.
6. Liu, J.,Drane, W.,Liu, X.,Wu, T. (2009). "Examination of the relationships between environmental exposures to volatile organic compounds and biochemical liver tests: application of canonical correlation analysis." Environmental Research 109(2): 193-199.
7. Pellizzari, E. D.,Smith, D. J.,Clayton, A.,Michael, L. C.,Quackenboss, J. J. (2001). "An assessment of the data quality for NHEXAS-Part I: Exposure to metals and volatile organic chemicals in Region 5." Journal of Exposure Analysis and Environmental Epidemiology 11: 140-154.
8. Serrano-Trespalacios, P. I.,Ryan, L.,Spengler, J. D. (2004). "Ambient, indoor and personal exposure relationships of volatile organic compounds in Mexico City Metropolitan Area." Journal of Exposure Analysis and Environmental Epidemiology 14: S118-S132.
9. Weisel, C. P.,Alimokhtari, S.,Sanders, P. F. (2008). "Indoor air VOC concentrations in suburban and rural New Jersey." Environmental Science & Technology 42(22): 8231-8238.
10. Zhu, J.,Laifeng, Y.,Shoeib, M. (2007). "Detection of dechlorane plus in residential indoor dust in the city of Ottawa, Canada." Environmental Science & Technology 41: 7694-7698.

Tris (2-chloroethyl) phosphate (CAS 115-96-8)

Criteria for inclusion of tris (2-chloroethyl) phosphate in the CHC List: Canadian Environmental Protection Act – Persistent bioaccumulative & inherently toxic.

The presence of tris(2-chloroethyl) phosphate in humans was not identified in biomonitoring studies (preliminary literature search).

The presence of tris(2-chloroethyl) phosphate was identified in 2 indoor air and/or dust studies (preliminary literature search).

1. HÅkan Carlsson, Ulrika Nilsson, Gerhard Becker, and Conny Östman (1997) Organophosphate Ester Flame Retardants and Plasticizers in the Indoor Environment: Analytical Methodology and Occurrence. Environ. Sci. Technol., 1997, 31 (10), pp 2931-2936
2. Otake, T.,Yoshinga, J.,Yanagisawa, Y. (2001). "Analysis of organic esters of plasticizer in indoor air by GC-MS and GC-FPD." Environmental Science & Technology 35(15): 3099-31002.

Di-(2-ethylhexyl) phthalate; DEHP (CAS 117-81-7)

Criteria for inclusion of DEHP (di-(2-ethylhexyl) phthalate) in the CHC List: EU Endocrine Disruptor Program - Category 1 probable.

The presence of DEHP (di-(2-ethylhexyl) phthalate); bis(2-ethylhexyl) phthalate in humans was identified in 9 biomonitoring studies (preliminary literature search).

1. Adibi, J. J.,Whyatt, R. M.,Williams, P. L.,Calafat, A. M.,Camann, D.,Herrich, R.,Nelson, H.,Bhat, H. K.,Perera, F. P.,Silva, M. J.,and Hauser, R. (2008). "Characterization of phthalate exposure among pregnant women assessed by repeat air and urine samples." Environmental Health Perspectives 116(4): 467-473.
2. Adibi, J. J.,Pepera, F. P.,Jedrychowski, W.,Camann, D. E.,Barr, D.,Jacek, R.,Whyatt, R. M. (2003). "Prenatal epposures to Phthalates among women in New York City and Krakow, Poland." Environmental Health Perspectives 111(14): 1719-1722.
3. Becker, K.,Seiwert, M.,Angerer, J.,Heger, W.,Koch, H. M.,Nagorka, R.,Robkamp, E.,Schluter, C.,Seifert, B.,Ullrich, D. (2004). "DEHP matabolites in urine of children and DEHP in house dust." International journal of Environmental Health 2007: 409-417.
4. CDC (Centers for Disease Control and Prevention) (2005). Third National Report on Human Exposure to Environmental Chemicals. Centers for Disease Control and Prevention, Atlanta, Ga.
5. Guo, Z. Y.,Gai, P. P.,Duan, J.,Zhai, J. X.,Zhao, S. S. (2010). "Simultaneous determination of phthalates and adipates in human serum using gas chromatography-mass spectrometry with solid-phase extraction." Biomedical Chromatography 24: 1094-1099.
6. Main, K.,Mortensen, G. K.,Kaleva, M. M.,Boisen, K. A.,Damgaard, I. N.,Chellakooty, M.,Schmidt, I. M.,Suomi, A. M.,Virtanen, H. E.,Petersen, J. H.,Andersson, A. M.,Toppari, J.,Skakkebæk, N. E. (2006). "Human breast milk contamination with phthalates and alterations of endogenous reproductive hormones in infants three months of age." Environmental Health Perspective 114(2): 270-276.
7. Peters,R.J.B. (2005) Man-made chemicals in maternal and cord blood. TNO Report. B&O-A R 2005/129.

8. Weuve, J.,Hauser, R.,Calafat, A. M.,Missmer, S. A.,Wise, L. A. (2010). "Association of exposure to phthalates with endometriosis and uterine leiomyomata: Findings from NHANES, 1999-2004." Environmental Health Perspectives 118(6): 825-832.
9. Wolff, M. S.,Teitelbaum, S. L.,Windham, G.,Pinney, S. M.,Britton, J. A.,Chelimo, C.,Godbold, J.,Biro, F.,Kushi, L. H.,Pfeiffer, C. M.,Calafat, A. M. (2007). "Pilot study Of urinary biomarkers Of phytoestrogens, phthalates, and phenols In girls." Environmental Health Perspectives 115 (1): 116-121

The presence of DEHP (di-(2-ethylhexyl) phthalate); bis(2-ethylhexyl) phthalate was identified in 10 indoor air and/or dust studies (preliminary literature search).

1. Adibi, J. J.,Pepera, F. P.,Jedrychowski, W.,Camann, D. E.,Barr, D.,Jacek, R.,Whyatt, R. M. (2003). "Prenatal epposures to Phthalates among women in New York City and Krakow, Poland." Environmental Health Perspectives 111(14): 1719-1722.
2. Adibi, J. J.,Whyatt, R. M.,Williams, P. L.,Calafat, A. M.,Camann, D.,Herrich, R.,Nelson, H.,Bhat, H. K.,Perera, F. P.,Silva, M. J.,and Hauser, R. (2008). "Characterization of phthalate exposure among pregnant women assessed by repeat air and urine samples." Environmental Health Perspectives 116(4): 467-473.
3. Becker, K.,Seiwert, M.,Angerer, J.,Heger, W.,Koch, H. M.,Nagorka, R.,Robkamp, E.,Schluter, C.,Seifert, B.,Ullrich, D. (2004). "DEHP matabolites in urine of children and DEHP in house dust." International journal of Environmental Health 2007: 409-417.
4. Bornehag, C. G.,Lundgren, B.,Weschler, C. J.,Sigsfaard, T.,Hagerhed-Engman, L.,Sundell, J. (2005). "Phthalates in indoor dust and their association with building characteristics." Environmental Health Perspectives 113(10): 1399-1404.
5. California Air Resources Board (2005). Indoor Air Pollution in California - Report to the California Legislature. California Environmental Protection Agency.
6. Fromme, H.,Lahrz, T.,Piloty, M.,Gebhart, H.,Oddoy, A.,Ruden, H. (2004). "Occurrence of phthalates and musk fragrances in indoor air and dust from apartments and kindergartens in Berlin (Germany)." Indoor Air 14: 188-195.
7. Kolarik, B.,Naydenov, K.,Larsson, M.,Bornehag, C. G.,Sundell, J. (2008). "The association between phthalates in dust and allergic diseases among Bulgarian children." Environmental Health Perspective 116(1): 98-103.
8. Otake, T.,Yoshinga, J.,Yanagisawa, Y. (2001). "Analysis of organic esters of plasticizer in indoor air by GC-MS and GC-FPD." Environmental Science & Technology 35(15): 3099-31002.
9. Roberts, J. W.,Wallace, L. A.,Camann, D. E.,Dickey, P.,Gilbert, S. G.,Lewis, R. G.,Takaro, T. K. (2009) "Monitoring and reducing exposure of infants to pollutants in house dust." Reviews of Environmental Contamination & Toxicology 201: 1-39.
10. Rudel, R. A.,Camann, D. E.,Spengler, J. D.,Korn, L. R.,Brody, J. G. (2003). "Phthalates, alkylphenols, pesticides, polybrominated diphenyl ethers, and other endocrine-disrupting Ccmpounds in indoor air and dust." Environmental Science & Technology 37(20): 4543-4553.

Hexachlorobenzene (CAS 118-74-1)

Criteria for inclusion of hexachlorobenzene in the CHC List: EU Endocrine Disruptor Program - Category 1 probable, Global Harmonization System - Category 1A for known reproductive or germ cell mutagenicity.

The presence of hexachlorobenzene in humans was identified in 7 biomonitoring studies (preliminary literature search).

1. CDC (Centers for Disease Control and Prevention) (2005). Third National Report on Human Exposure to Environmental Chemicals. Centers for Disease Control and Prevention, Atlanta, Ga.

2. Damgaard, I. N.,Skakkebaek, N. E.,Toppari, J.,Virtanen, H. E.,Shen, H.,Schramm, K. W.,Petersen, J. H.,Jensen, T. K.,Main, K. M.,Group, T. N. C. S. (2006). "Persistent pesticides in human breast milk and cryptorchidism." Environmental Health Perspectives 114(7): 1133-1138.
3. Muckle, G.,Ayotte, P.,Dewailly, E.,Jacobson, S. W.,Jacobson, J. L. (2001). "Prenatal exposure of the Northern Québec Inuit infants to environmental contaminants." Environmental Health Perspectives 109(12): 1291-1299.
4. Peters,R.J.B. (2005) Man-made chemicals in maternal and cord blood. TNO Report. B&O-A R 2005/129.
5. Ribas-Fitó, N.,Torrent, M.,Carrizo, D.,Júlvez, J.,Grimalt, J. O.,Sunyer, J. (2007). "Exposure to hexachlorobenzene during pregnancy andcChildren's social behavior at 4 years of age." Environmental Health Perspectives 115(3): 447-450.
6. Shen H, Main K, Andersson A, Damgaard I, Helena E. Virtanen H, Skakkebaek E, Toppari J, and Schramm K (2008). Concentrations of persistent organochlorine compounds in human milk and placenta are higher in Denmark than in Finland. Human Reproduction Vol.23, No.1 pp. 201–210
7. Woodruff, T.J., Zota, A.R., Schartz, J.M. (2011). Environmental chemicals in pregnant women in the United States: NHANES 2003-2004. Environmental Health Perspectives 119:878-885.

The presence of hexachlorobenzene was not identified in indoor air and/or dust studies (preliminary literature search).

Ethyl paraben (CAS 120-47-8)

Criteria for inclusion of ethyl paraben in the CHC List: EU Endocrine Disruptor Program - Category 1 probable.

The presence of ethyl paraben in humans was identified in 2 biomonitoring studies (preliminary literature search).

1. Calafat, A. M.,Yang Wong, L.,Ye, X.,Reidy, J. A.,Needham, L. L. (2008). "Exposure of the U.S. population to bisphenol A and 4-tertiary-octylphenol: 2003-2004." Environmental Health Perspectives 116(1): 39-44.
2. Ye, X.,Kuklenyik, Z.,Bishop, A. M.,Needham, L. L.,Calafat, A. M. (2006). "Quantification of the urinary concentrations of parabens in humans by on-line solid phase extraction-high performance liquid chromatography-isotope dilution tandem mass spectrometry." Journal of Chromatography B 844: 53-59.

The presence of ethyl paraben was identified in 1 indoor air and/or dust study (preliminary literature search).

1. Camann R, D. E.,Spengler, J. D.,Korn, L. R.,Brody, J. G. (2003). "Phthalates, alkylphenols, pesticides, polybrominated diphenyl ethers, and other endocrine-disrupting Ccmpounds in indoor air and dust." Environmental Science & Technology 37(20): 4543-4553

Benzophenone-2; (Bp-2), 2,2',4,4'-tetrahydroxybenzophenone (CAS 131-55-5)

Criteria for inclusion of benzophenone-2 (BP-2), 2,2',4,4'-tetrahydroxybenzophenone in the CHC List: EU Endocrine Disruptor Program - Category 1 probable.

The presence of benzophenone-2 (BP-2), 2,2',4,4'-tetrahydroxybenzophenone in humans was not identified in biomonitoring studies (preliminary literature search).

The presence of benzophenone-2 (BP-2), 2,2',4,4'-tetrahydroxybenzophenone was not identified in indoor air and/or dust studies (preliminary literature search).

Compound detected in consumer products.

2,4-Dihydroxybenzophenon; Resbenzophenone (CAS 131-56-6)

Criteria for inclusion of 2,4-dihydroxybenzophenon; resbenzophenone in the CHC List: EU Endocrine Disruptor Program - Category 1 probable.

The presence of 2,4-dihydroxybenzophenon; resbenzophenone in humans was identified in 1 biomonitoring study (preliminary literature search).

1. Muckle, G.,Ayotte, P.,Dewailly, E.,Jacobson, S. W.,Jacobson, J. L. (2001). "Prenatal exposure of the Northern Québec Inuit infants to environmental contaminants." Environmental Health Perspectives 109(12): 1291-1299.

The presence of 2,4-dihydroxybenzophenon; resbenzophenone was not identified in indoor air and/or dust studies (preliminary literature search).

Mono-n-butylphthalate (CAS 131-70-4)

Criteria for inclusion of mono-n-butylphthalate in the CHC List: EU Endocrine Disruptor Program - Category 1 probable.

The presence of mono-n-butylphthalate in humans was identified in 3 biomonitoring studies (preliminary literature search).

1. Main, K.,Mortensen, G. K.,Kaleva, M. M.,Boisen, K. A.,Damgaard, I. N.,Chellakooty, M.,Schmidt, I. M.,Suomi, A. M.,Virtanen, H. E.,Petersen, J. H.,Andersson, A. M.,Toppari, J.,Skakkebæk, N. E. (2006). "Human breast milk contamination with phthalates and alterations of endogenous reproductive hormones in infants three months of age." Environmental Health Perspective 114(2): 270-276.
2. Wolff, M. S.,Teitelbaum, S. L.,Windham, G.,Pinney, S. M.,Britton, J. A.,Chelimo, C.,Godbold, J.,Biro, F.,Kushi, L. H.,Pfeiffer, C. M.,Calafat, A. M. (2007). "Pilot study Of urinary biomarkers Of phytoestrogens, phthalates, and phenols In girls." Environmental Health Perspectives 115 (1): 116-121
3. Woodruff, T.J., Zota, A.R., Schartz, J.M. (2011). Environmental chemicals in pregnant women in the United States: NHANES 2003-2004. Environmental Health Perspectives 119:878-885.

The presence of mono-n-butylphthalate was not identified in indoor air and/or dust studies (preliminary literature search).

4-tert-Octylphenol; 1,1,3,3-Tetramethyl-4-butylphenol (CAS 140-66-9)

Criteria for inclusion of 4-tert-octylphenol; 1,1,3,3-tetramethyl-4-butylphenol in the CHC List: EU Endocrine Disruptor Program - Category 1 probable.

The presence of 4-tert-octylphenol; 1,1,3,3-tetramethyl-4-butylphenol in humans was identified in 5 biomonitoring studies (preliminary literature search).

1. Calafat, A. M.,Wong, L. Y.,Silva, M. J.,Samandar, E.,Preau, J. L. J.,Jia, L. T.,Needham, L. L. (2011). "Selecting adequate exposure biomarkers of diisononyl and diisodecyl phthalates: Data from the 2005-2006 National Health and Nutrition Examination Survey." Environmental Health Perspectives 119(1): 50-55.
2. CDC (Centers for Disease Control and Prevention) (2009). Fourth National Report on Human Exposure to Environmental Chemicals. Centers for Disease Control and Prevention, Atlanta, Ga.
3. Chen, G. W.,Ding, W. H.,Ku, H. Y.,Chao, H. R.,Chen, H. Y.,Huang, M. C.,Wang, S. L. (2010). "Alkylphenols in human milk and their relations to dietary habits in Central Taiwan " Food and Chemical Toxicology 48: 1939-1944.
4. Lopez-Espinosa, M. J.,Freire, C.,Arrebola, J. P.,Navea, N.,Taoufiki, J.,Fernandez, M. K.,Ballesteros, O.,Prada, R.,Olea, N. (2009). "Nonylphenol and octylphenol in adipose tissue of women in Southern Spain." Chemosphere 76: 847-852.
5. Wolff, M. S.,Teitelbaum, S. L.,Windham, G.,Pinney, S. M.,Britton, J. A.,Chelimo, C.,Godbold, J.,Biro, F.,Kushi, L. H.,Pfeiffer, C. M.,Calafat, A. M. (2007). "Pilot study Of urinary biomarkers Of phytoestrogens, phthalates, and phenols In girls." Environmental Health Perspectives 115 (1): 116-121

The presence of 4-tert-octylphenol; 1,1,3,3-tetramethyl-4-butylphenol was not identified in indoor air and/or dust studies (preliminary literature search).

Octamethylcyclotetrasiloxane (CAS 556-67-2)

Criteria for inclusion of octamethylcyclotetrasiloxane in the CHC List: EU Endocrine Disruptor Program - Category 1 probable, Canadian Environmental Protection Act – persistent bioaccumulative & inherently toxic.

The presence of octamethylcyclotetrasiloxane in humans was not identified in biomonitoring studies (preliminary literature search).

The presence of octamethylcyclotetrasiloxane was identified in 1 indoor air and/or dust study (preliminary literature search).

1. Lu, Y.,Yuan, T.,Yun, S. H.,Wang, W.,Gian Wu, G.,Kannan, K. (2010). "Occurrence of cyclic and lsnear Siloxanes in indoor dust from China, and implications for human exposures." Environmental Science Technology 44(16): 6081-6087.

Benzene, pentachloro- (CAS 608-93-5)

Criteria for inclusion of benzene, pentachloro- in the CHC List: EU Endocrine Disruptor Program - Category 1 probable, Canadian Environmental Protection Act - PersistentBioaccumulative & Inherently Toxic.

The presence of benzene, pentachloro- in humans was identified in 2 biomonitoring studies (preliminary literature search).

1. Damgaard, I. N.,Skakkebaek, N. E.,Toppari, J.,Virtanen, H. E.,Shen, H.,Schramm, K. W.,Petersen, J. H.,Jensen, T. K.,Main, K. M.,Group, T. N. C. S. (2006). "Persistent pesticides in human breast milk and cryptorchidism." Environmental Health Perspectives 114(7): 1133-1138.
2. Peters,R.J.B. (2005) Man-made chemicals in maternal and cord blood. TNO Report. B&O-A R 2005/129.

The presence of benzene, pentachloro- was not identified in indoor air and/or dust studies (preliminary literature search).

2,2',3,3',4,4',5,5',6,6'-Decabromodiphenyl ether; BDE-209 (CAS 1163-19-5)

Criteria for inclusion of 2,2',3,3',4,4',5,5',6,6'-decabromodiphenyl ether; BDE-209 in the CHC List: Washington State PBT Program and confirmed by ME-CDC with review of peer-reviewed scientific publications. Reports to the Maine State Legislature by the MEDEP and MECDC reviewed numerous peer-reviewed studies documenting adverse endocrine and developmental effects of deca BDE, including effects on thyroid hormones and developmental neurotoxicity.[1]

The presence of 2,2',3,3',4,4',5,5',6,6'-decabromodiphenyl ether; BDE -209 in humans was identified in 1 biomonitoring studiy (preliminary literature search).

1. Gomara, B.,Herrero, L.,Ramos, J. J.,Mateo, J. R.,Fernändez, M. A.,Garcıa, J. F.,Gonzälez, M. J. (2007). "Distribution of polybrominated diphenyl ethers in human umbilical cord serum, Paternal serum, maternal serum, placentas, and breast milk from Madrid population, Spain." Environmental Science & Technology 41(20): 6961-6968.

The presence of 2,2',3,3',4,4',5,5',6,6'-decabromodiphenyl ether; BDE -209 was identified in 2 indoor air and/or dust studies (preliminary literature search).

1. Allen, J. G.,McClean, M. D.,Stapleton, H. M.,Nelson, J. W.,Webster, T. F. (2007). "Personal exposure to polybrominated diphenyl ethers (PBDEs) in residential indoor air." Environmental Science & Technology 41(13): 4574-4579.

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[1] Brominated Flame Retardants: A Report to the Joint Standing Committee on Natural Resources, 122nd Maine Legislature, Prepared by: Maine Bureau of Health (now the Maine Center for Disease Control and Prevention) and the Maine Department of Environmental Protection, February 2005. Brominated Flame Retardants: A report to the Committee on Natural Resources, 122nd Maine Legislature, Prepared by the Center for Disease Control and Prevention and Department of Environmental Protection, February 2006. Brominated Flame Retardants: Third annual report to the Maine Legislature, Prepared by the Maine Center for Disease Control & Prevention and the Maine Department of Environmental Protection, January 2007.

2. Zhu, J.,Newhook, R.,Marro, L.,Chan, C. C. (2005). "Selected volatile organic compounds in residential air in the City of Ottawa, Canada." Environmental Science & Technology 39(11): 3964-3971.

Methyl tert-butyl ether; MTBE (CAS 1634-04-4)

Criteria for inclusion of methyl tert-butyl ether; MTBE in the CHC List: EU Endocrine Disruptor Program - Category 1 probable.

The presence of methyl tert-butyl ether; MTBE in humans was identified in 4 biomonitoring studies (preliminary literature search).

1. CDC (Centers for Disease Control and Prevention) (2009). Fourth National Report on Human Exposure to Environmental Chemicals. Centers for Disease Control and Prevention, Atlanta, Ga.
2. Kim, S. R.,Halden, R. U.,Buckley, T. J. (2007). "Volatile organic compounds in human milk: Methods and measurements." Environmental Science Technology 41(5): 1662-1667.
3. Lin, Y. S.,Egeghy, P. P.,Rappaport, S. M. (2008). "Relationships between levels of volatile organic compounds in air and blood from the general population." Journal of Exposure Science and Environmental Epideniology 18: 421-429.
4. Woodruff, T.J., Zota, A.R., Schartz, J.M. (2011). Environmental chemicals in pregnant women in the United States: NHANES 2003-2004. Environmental Health Perspectives 119:878-885.

The presence of methyl tert-butyl ether; MTBE was identified in 4 indoor air and/or dust studies (preliminary literature search).

1. Kim, S. R.,Halden, R. U.,Buckley, T. J. (2007). "Volatile organic compounds in human milk: Methods and measurements." Environmental Science Technology 41(5): 1662-1667.
2. Serrano-Trespalacios, P. I.,Ryan, L.,Spengler, J. D. (2004). "Ambient, indoor and personal exposure relationships of volatile organic compounds in Mexico City Metropolitan Area." Journal of Exposure Analysis and Environmental Epidemiology 14: S118-S132.
3. Weisel, C. P.,Alimokhtari, S.,Sanders, P. F. (2008). "Indoor air VOC concentrations in suburban and rural New Jersey." Environmental Science & Technology 42(22): 8231-8238.
4. Zhu, J.,Laifeng, Y.,Shoeib, M. (2007). "Detection of dechlorane plus in residential indoor dust in the city of Ottawa, Canada." Environmental Science & Technology 41: 7694-7698.

Perfluorooctanyl sulphonic acid and its salts; PFOS (CAS 1763-23-1)

Criteria for inclusion of perfluorooctanyl sulphonic acid and its salts; PFOS in the CHC List: Washington State PBT Program and confirmed by ME-CDC with review of peer-reviewed scientific publications. As part of ongoing review of PFOS at MECDC, a recent scientific publication was identified that reported serum levels perfluorooctane sulfonate were positively associated with chronic kidney disease.[2] The authors examined the relation of serum PFOS (and PFOA) and chronic kidney disease in 4,587 adult participants from combined National Health and Nutritional Examination Surveys for whom serum measurements were available. The association was independent of confounders such as age, sex, race/ethnicity, body mass index, diabetes, hypertension, and serum cholesterol level. It is also noteworthy that the European Union designates PFOS as persisitent, bioaccumulative, and toxic to mammalian species, and recommends ultimate phase-out.[3]

[2] Shankar, Anoop; Jie Xiao and Alan Ducatman (2011-10-15). "Perfluoroalkyl Chemicals and Chronic Kidney Disease in US Adults". American Journal of Epidemiology 174 (8): 893–900.
[3] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:372:0032:0034:en:PDF

The presence of perfluorooctanyl sulphonic acid and its salts; PFOS in humans was identified in 5 biomonitoring studies (preliminary literature search).

1. CDC (Centers for Disease Control and Prevention) (2009). Fourth National Report on Human Exposure to Environmental Chemicals. Centers for Disease Control and Prevention, Atlanta, Ga.
2. Fei, C.,McLaughlin, J. K.,Tarone, R. E.,Olsen, J. (2007). "Perfluorinated chemicals and fetal growth: A study within the Danish National Birth Cohort." Environmental Health Perspectives 115(11): 1677-1682.
3. Haug, L. S.,Huber, S.,Becher, G.,Thomsen, C. (2011). "Characterisation of human exposure pathways to perflourinated compounds - comparing exposure estimates with biomarkers of exposure." Environmental International 37: 687-693.
4. Peters,R.J.B. (2005) Man-made chemicals in maternal and cord blood. TNO Report. B&O-A R 2005/129.
5. Woodruff, T.J., Zota, A.R., Schartz, J.M. (2011). Environmental chemicals in pregnant women in the United States: NHANES 2003-2004. Environmental Health Perspectives 119:878-885.

The presence of perfluorooctanyl sulphonic acid and its salts; PFOS was identified in 3 indoor air and/or dust studies (preliminary literature search).

1. Bjorklund, J. A.,Thuresson, K.,De Wit, C. A. (2009). "Perfluoroalkyl compounds (PFCs) in indoor dust: Concentrations, human exposure estimates, and sources." Environmental Science & Technology 43(7): 2276-2281.
2. Haug, L. S.,Huber, S.,Becher, G.,Thomsen, C. (2011). "Characterisation of human exposure pathways to perflourinated compounds - comparing exposure estimates with biomarkers of exposure." Environmental International 37: 687-693.
3. Shoeib, M.,Harner, T.,Webster, G. M.,Lee , S. C. (2011). "Indoor sources of poly- and perfluorinated compounds (PFCS) in Vancouver, Canada: Implications for human exposure." Environmental Science and Technology 45 (19): 7999-8005

Phenol, 4-octyl- (CAS 1806264)

Criteria for inclusion of phenol, 4-octyl- in the CHC List: EU Endocrine Disruptor Program - Category 1 probable.

The presence of phenol, 4-octyl- in humans was identified in 2 biomonitoring studies (preliminary literature search).

1. CDC (Centers for Disease Control and Prevention) (2009). Fourth National Report on Human Exposure to Environmental Chemicals. Centers for Disease Control and Prevention, Atlanta, Ga.
2. Ye, X.,Kuklenyik, Z.,Needham, L. L.,Calafat, A. M. (2005). "Automated on-line column-switching HPLC_MS/MS method with peak focusing for the determination of nine environmental phenols in urine." Analytica Chemistry 77(16): 5407-5413.

The presence of phenol, 4-octyl- was identified in 1 indoor air and/or dust study (preliminary literature search).

1. Rudel, R. A.,Camann, D. E.,Spengler, J. D.,Korn, L. R.,Brody, J. G. (2003). "Phthalates, alkylphenols, pesticides, polybrominated diphenyl ethers, and other endocrine-disrupting Ccmpounds in indoor air and dust." Environmental Science & Technology 37(20): 4543-4553.

2-Naphthalenol, 1-[(4-methyl-2-nitrophenyl)azo]- (CAS 2425856)

Criteria for inclusion of 2-naphthalenol, 1-[(4-methyl-2-nitrophenyl)azo]- in the CHC List: Canadian Environmental Protection Act – persistent bioaccumulative & inherently toxic.

The presence of 2-naphthalenol, 1-[(4-methyl-2-nitrophenyl)azo]- in humans was not identified in biomonitoring studies (preliminary literature search).

The presence of 2-naphthalenol, 1-[(4-methyl-2-nitrophenyl)azo]- was not identified in indoor air and/or dust studies (preliminary literature search).

Compound detected in consumer products.

2-Ethyl-hexyl-4-methoxycinnamate (CAS 5466773)

Criteria for inclusion of 2-ethyl-hexyl-4-methoxycinnamate in the CHC List: EU Endocrine Disruptor Program - Category 1 probable.

The presence of 2-ethyl-hexyl-4-methoxycinnamate in humans was not identified in biomonitoring studies (preliminary literature search).

The presence of 2-ethyl-hexyl-4-methoxycinnamate was not identified in indoor air and/or dust studies (preliminary literature search).

Compound detected in consumer products.

Mercury & mercury compounds (CAS 7439976)

Criteria for inclusion of mercury & mercury compounds in the CHC List: Global Harmonization System - category 1A for known reproductive or germ cell mutagenicity, California Prop65 - developmental effects (substantiated by ME-CDC review), Washington State PBT Program (confirmed by ME-CDC).

The presence of mercury & mercury compounds in humans was identified in 3 biomonitoring studies (preliminary literature search).

1. CDC (Centers for Disease Control and Prevention) (2005). Third National Report on Human Exposure to Environmental Chemicals. Centers for Disease Control and Prevention, Atlanta, Ga.
2. Muckle, G.,Ayotte, P.,Dewailly, E.,Jacobson, S. W.,Jacobson, J. L. (2001). "Prenatal exposure of the Northern Québec Inuit infants to environmental contaminants." Environmental Health Perspectives 109(12): 1291-1299.
3. Woodruff, T.J., Zota, A.R., Schartz, J.M. (2011). Environmental chemicals in pregnant women in the United States: NHANES 2003-2004. Environmental Health Perspectives 119:878-885.

The presence of mercury & mercury compounds was identified in 1 indoor air and/or dust study (preliminary literature search).

1. California Air Resources Board (2005). Indoor Air Pollution in California - Report to the California Legislature. California Environmental Protection Agency.

Nickel & nickel compounds (CAS 7440020)

Criteria for inclusion of nickel & nickel compounds in the CHC List: NTP Report on Carcinogens – nickel compounds are known human carcinogens; metallic nickel is reasonably anticipated to cause cancer I humans.

The presence of nickel & nickel compounds in humans was identified in 3 biomonitoring studies (preliminary literature search).

1. Bernhard, D.,Rossmann, A.,Henderson, B.,Kind, M.,Seubert, A.,Wick , G. (2006). "Increased serum Cadmium and Strontium Levels in Young Smokers - Effects on Arterial Endothelial Cell Gene Transcription." Arterioscler Thrombosis Vascular Biology 26:833-838.
2. Guan, H.,Piao, F. Y.,Li, X. W.,Li, Q. J.,Xu, L.,Yokoyama, K. (2010). "Maternal and fetal exposure to four carcinogenic environmental metals." Biomedical and Environmental Sciences 23: 458-465.
3. Nunes, J. A.,Batista, B. L.,Rodrigues, J. L.,Caldas, N. M.,Neto, J. A. G.,Barbosa, F. J. (2010). "A simple method based on ICP-MS for estimation of background levels of arsenic, cadmium, copper, manganese, nickel, lead, and selenium in blood of the Brazilian population." Journal of Toxicology and Environmental Health, Part A 73: 878-887.

The presence of nickel & nickel compounds was identified in 2 indoor air and/or dust studies (preliminary literature search).

1. Lemus, R.,Abdelghani, A. A.,Akers, T. G.,Horner, W. E. (1996). "Health risk from exposure to metals in household." Reviews on Environmental Health 11(4): 179-189.
2. Roberts, J. W.,Wallace, L. A.,Camann, D. E.,Dickey, P.,Gilbert, S. G.,Lewis, R. G.,Takaro, T. K. (2009) "Monitoring and reducing exposure of infants to pollutants in house dust." Reviews of Environmental Contamination & Toxicology 201: 1-39.

Arsenic & Arsenic compounds (CAS 7440382)

Criteria for inclusion of arsenic & arsenic compounds in the CHC List: NTP Report on Carcinogens - known human carcinogen, EPA Integrated Risk Information System - 1986 criteria, known carcinogen, IARC - Group 1 known human carcinogen, Global Harmonization System - category 1A known human carcinogen, Global Harmonization System - category 1A for known reproductive or germ cell mutagenicity.

The presence of arsenic & arsenic compounds in humans was identified in 6 biomonitoring studies (preliminary literature search).

1. Caldwell K, Jones R, Verdon C, Jarrett J, Caudill S and Osterloh J (2008). Levels of urinary total and speciated arsenic in the US population: National Health and Nutrition Examination Survey 2003–2004. Journal of Exposure Science and Environmental Epidemiology (2009) 19, 59–68.
2. Clayton, C.,Pellizzari, E.,Quackenboss, J. (2002). "National Human Exposure Assessment Survey: Analysis of exposure pathways and routes for arsenic and lead in EPA Region 5." Journal of Exposure Analysis and Environmental Epidemiology 12(1): 29-43.
3. Guan, H.,Piao, F. Y.,Li, X. W.,Li, Q. J.,Xu, L.,Yokoyama, K. (2010). "Maternal and fetal exposure to four carcinogenic environmental metals." Biomedical and Environmental Sciences 23: 458-465.
4. Nunes, J. A.,Batista, B. L.,Rodrigues, J. L.,Caldas, N. M.,Neto, J. A. G.,Barbosa, F. J. (2010). "A simple method based on ICP-MS for estimation of background levels of arsenic, cadmium, copper, manganese, nickel, lead, and selenium in blood of the Brazilian population." Journal of Toxicology and Environmental Health, Part A 73: 878-887.

5. Pellizzari, E. D.,Smith, D. J.,Clayton, A.,Michael, L. C.,Quackenboss, J. J. (2001). "An assessment of the data quality for NHEXAS-Part I: Exposure to metals and volatile organic chemicals in Region 5." Journal of Exposure Analysis and Environmental Epidemiology 11: 140-154.
6. Seifert, B.,Becker, K.,Helm, D.,Krause, C.,Schulz, C.,Seiwert, M. (2000). "The German Environmental Survey 1990/1992 (GerES II): Reference concentrations of selected environmental pollutants in blood, urine, hair, house dust, drinking water and indoor air." Journal of Exposure Analysis and Environmental Epidemiology 10: 552-565.

The presence of arsenic & arsenic compounds was identified in 5 indoor air and/or dust studies (preliminary literature search).

1. Clayton, C.,Pellizzari, E.,Quackenboss, J. (2002). "National Human Exposure Assessment Survey: Analysis of exposure pathways and routes for arsenic and lead in EPA Region 5." Journal of Exposure Analysis and Environmental Epidemiology 12(1): 29-43.
2. Lemus, R.,Abdelghani, A. A.,Akers, T. G.,Horner, W. E. (1996). "Health risk from exposure to metals in household." Reviews on Environmental Health 11(4): 179-189.
3. Pellizzari, E. D.,Smith, D. J.,Clayton, A.,Michael, L. C.,Quackenboss, J. J. (2001). "An assessment of the data quality for NHEXAS-Part I: Exposure to metals and volatile organic chemicals in Region 5." Journal of Exposure Analysis and Environmental Epidemiology 11: 140-154.
4. Roberts, J. W.,Wallace, L. A.,Camann, D. E.,Dickey, P.,Gilbert, S. G.,Lewis, R. G.,Takaro, T. K. (2009) "Monitoring and reducing exposure of infants to pollutants in house dust." Reviews of Environmental Contamination & Toxicology 201: 1-39.
5. Seifert, B.,Becker, K.,Helm, D.,Krause, C.,Schulz, C.,Seiwert, M. (2000). "The German Environmental Survey 1990/1992 (GerES II): Reference concentrations of selected environmental pollutants in blood, urine, hair, house dust, drinking water and indoor air." Journal of Exposure Analysis and Environmental Epidemiology 10: 552-565.

Beryllium & Beryllium compounds (CAS 7440417)

Criteria for inclusion of beryllium & beryllium compounds in the CHC List: NTP Report on Carcinogens - known human carcinogen, EPA Integrated Risk Information System – 1996 B1 probable human carcinogen, IARC - Group 1 known human carcinogen, Global Harmonization System – Category 1A known human carcinogen.

The presence of beryllium & beryllium compounds in humans was identified in 4 biomonitoring studies (preliminary literature search).

1. CDC (Centers for Disease Control and Prevention) (2005). Third National Report on Human Exposure to Environmental Chemicals. Centers for Disease Control and Prevention, Atlanta, Ga.
2. Guan, H.,Piao, F. Y.,Li, X. W.,Li, Q. J.,Xu, L.,Yokoyama, K. (2010). "Maternal and fetal exposure to four carcinogenic environmental metals." Biomedical and Environmental Sciences 23: 458-465.
3. Navas-Acien, A.,Francesconi, K. A.,Silbergeld, E. K.,Guallar, E. (2011). "Seafood intake and urine concentrations of total arsenic, dimethlyarsinate and arsenobetaine in the US population." Environmental Research 111: 110-118.

4. Shirai, S.,Suzuki, Y.,YOshinaga, J.,Mizumoto, Y. (2010). "Maternal exposure to low-level heavy metals during pregnancy and birth size." Journal of Environmental Science and Health Part A 45: 1468-1474.

The presence of beryllium & beryllium compounds was not identified in indoor air and/or dust studies (preliminary literature search).

Cadmium (CAS 7440-43-9)

Criteria for inclusion of cadmium in the CHC List: NTP Report on Carcinogens - known human carcinogen, IARC - Group 1 known human carcinogen

The presence of cadmium in humans was identified in 8 biomonitoring studies (preliminary literature search).

1. Bernhard, D.,Rossmann, A.,Henderson, B.,Kind, M.,Seubert, A.,Wick , G. (2006). "Increased serum Cadmium and Strontium Levels in Young Smokers - Effects on Arterial Endothelial Cell Gene Transcription." Arterioscler Thrombosis Vascular Biology 26:833-838.
2. CDC (Centers for Disease Control and Prevention) (2005). Third National Report on Human Exposure to Environmental Chemicals. Centers for Disease Control and Prevention, Atlanta, Ga.
3. Guan, H.,Piao, F. Y.,Li, X. W.,Li, Q. J.,Xu, L.,Yokoyama, K. (2010). "Maternal and fetal exposure to four carcinogenic environmental metals." Biomedical and Environmental Sciences 23: 458-465.
4. Nunes, J. A.,Batista, B. L.,Rodrigues, J. L.,Caldas, N. M.,Neto, J. A. G.,Barbosa, F. J. (2010). "A simple method based on ICP-MS for estimation of background levels of arsenic, cadmium, copper, manganese, nickel, lead, and selenium in blood of the Brazilian population." Journal of Toxicology and Environmental Health, Part A 73: 878-887.
5. Padilla, M. A.,Elobeid, M.,Ruden, D. M.,Allison, D. B. (2010). "An examination of the association of selected toxic metals with total and central obesity indices: NHANES 99-02." International Journal of Environmental Research and Public Health 7: 3332-3347.
6. Pellizzari, E. D.,Smith, D. J.,Clayton, A.,Michael, L. C.,Quackenboss, J. J. (2001). "An assessment of the data quality for NHEXAS-Part I: Exposure to metals and volatile organic chemicals in Region 5." Journal of Exposure Analysis and Environmental Epidemiology 11: 140-154.
7. Seifert, B.,Becker, K.,Helm, D.,Krause, C.,Schulz, C.,Seiwert, M. (2000). "The German Environmental Survey 1990/1992 (GerES II): Reference concentrations of selected environmental pollutants in blood, urine, hair, house dust, drinking water and indoor air." Journal of Exposure Analysis and Environmental Epidemiology 10: 552-565.
8. Shirai, S.,Suzuki, Y.,YOshinaga, J.,Mizumoto, Y. (2010). "Maternal exposure to low-level heavy metals during pregnancy and birth size." Journal of Environmental Science and Health Part A 45: 1468-1474.

The presence of cadmium was identified in 2 indoor air and/or dust studies (preliminary literature search).

1. Lemus, R.,Abdelghani, A. A.,Akers, T. G.,Horner, W. E. (1996). "Health risk from exposure to metals in household." Reviews on Environmental Health 11(4): 179-189.
2. Seifert, B.,Becker, K.,Helm, D.,Krause, C.,Schulz, C.,Seiwert, M. (2000). "The German Environmental Survey 1990/1992 (GerES II): Reference concentrations of selected environmental pollutants in blood, urine, hair, house dust, drinking water and indoor air." Journal of Exposure Analysis and Environmental Epidemiology 10: 552-565.

Quartz (CAS 14808-60-7)

Criteria for inclusion of quartz in the CHC List: IARC - Group 1 known human carcinogen, Global Harmonization System - Category 1A known human carcinogen.

The presence of quartz in humans was not identified in biomonitoring studies (preliminary literature search).

The presence of quartz was not identified in indoor air and/or dust studies (preliminary literature search).

Compound detected in consumer products.

Butylated hydroxyanisole (CAS 25013-16-5)

Criteria for inclusion of butylated hydroxyanisole in the CHC List: EU Endocrine Disruptor Program - Category 1 probable.

The presence of butylated hydroxyanisole in humans was not identified in biomonitoring studies (preliminary literature search).

The presence of butylated hydroxyanisole was not identified in indoor air and/or dust studies (preliminary literature search).

Compound detected in consumer products.

Hexabromocyclododecane; HBCD (CAS 25637-99-4)

Criteria for inclusion of hexabromocyclododecane in the CHC List: Washington State PBT Program and confirmed by ME-CDC with review of peer-reviewed scientific publications. Maine CDC documents peer-reviewed studies reporting endocrine and developmental effects of HBCD, including developmental neurotoxicity in humans. Studies were also identified with data on levels of HBCD in humans.[4] It is also noteworthy that the US EPA has an action plan for HBCD based on concerns for reproductive, developmental, and neurological effects.[5]

The presence of hexabromocyclododecane in humans was identified in one biomonitoring study (preliminary literature search).

1. Covaci, A.,Gerecke, A. C.,Law, R. J.,Voorspoels, S.,Kohler, M.,Heeb, N. V.,Leslie, H.,Allchin, C. R.,Deboer, J. (2006). "Hexabromocyclododecanes (HBCDs) in the environment and humans: A review." Environmental Science & Technology 40(12): 3679-3688.

The presence of hexabromocyclododecane was identified in 2 indoor air and/or dust studies (preliminary literature search).

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[4] Rationale for Concurrence by Maine Center for Disease Control and Prevention on the Designation of Brominated Flame Retardants as a Priority Chemical, November 22, 2010

[5] http://www.epa.gov/existingchemicals/pubs/actionplans/hbcd.html.

1. Peters,R.J.B. (2005) Man-made chemicals in maternal and cord blood. TNO Report. B&O-A R 2005/129.
2. Stapleton, H. M.,Allen, J. G.,Kelly, S. M.,Konstantinov, A.,Klosterhaus, S.,Watkins, D.,McClean, M. D.,Webster, T. F. (2008). "Alternate and new brominated flame retardants detected in U.S. house dust." Environmental Science & Technology 42(18): 6910-6916.

Phenol, (1,1,3,3-tetramethylbutyl)-; Octylphenol (CAS 27193-28-8)

Criteria for inclusion of phenol, (1,1,3,3-tetramethylbutyl)-; octylphenol in the CHC List: EU Endocrine Disruptor Program - Category 1 probable.

The presence of phenol, (1,1,3,3-tetramethylbutyl)-; octylphenol in humans was not identified in biomonitoring studies (preliminary literature search).

The presence of phenol, (1,1,3,3-tetramethylbutyl)-; octylphenol was not identified in indoor air and/or dust studies (preliminary literature search).

Compound detected in consumer products.

Deriving Chemicals of High Concern
Process Documentation

Appendix IV
References for Candidate Chemicals
July 1, 2012

Part 1: Toxicology Databases

Part 2: MECDC References for Biomonitoring and Indoor Air and Dust Exposure Candidate Chemicals for List of Chemicals of High Concern

Environmental & Occupational Health Programs
Maine Center for Disease Control and Prevention
286 Water Street, 3rd Floor, Augusta, ME 04333
207.287.4311 • 866.292.3474

Paul R. LePage, Governor   Mary C. Mayhew, Commissioner

Part 1: Toxicology Databases

California Office of Environmental Health Hazard Assessment (OEHHA) Proposition 65 List of Chemicals. CA Environmental Protection Agency.
Available at http://www.oehha.ca.gov/prop65/prop65_list/Newlist.html

Canadian Environmental Protection Act, 1999 Publication of the final decision on the screening assessment of 145 substances on the Domestic Substances List (subsection 77(6) of the Canadian Environmental Protection Act, 1999) Canadian PBiT List. Persistent, bioaccumulative and inherently toxic Available at
http://canadagazette.gc.ca/rp-pr/p1/2008/2008-06-07/html/notice-avis-eng.html#d101

European Commission (EC) Endocrine Disruptor Program. Final Report: Towards the establishment of a priority list of substances for further evaluation of their role in endocrine disruption. November 10, 2000: Annex 13. Available at
http://ec.europa.eu/environment/endocrine/strategy/substances_en.htm

Environmental Protection Agency Integrated Risk Information System (IRIS)
http://cfpub.epa.gov/ncea/iris/index.cfm?fuseaction=iris.showSubstanceList

European Union Risk Assessment Report Tris (2-Chloroethyl) Phosphate, TCEP EINECS-No.: 204-118-5 July 2009.

European Union Commission Regulation (EU) No 757/2010 of 24 August 2010. Amending Regulation (EC) No 850/2004 of the European Parliament and of the Council on persistent organic pollutants as regards Annexes I and III. Available at http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:223:0029:0036:EN:PDF

European Union Regulation (EC) No 1272/2008 of the European Parliament and of the Council of 16 December 2008 on classification, labelling and packaging of substances and mixtures, amending and repealing Directives 67/548/EEC and 1999/45/EC, and amending Regulation (EC) No 1907/2006 European Union Directive on Dangerous Substances (Directive 67/548/EEC).
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:223:0029:0036:EN:PDF

Globally Harmonized System of Classification and Labeling of Chemicals (GHS). Third revised edition United Nations 2009.
Available at http://www.unece.org/trans/danger/publi/ghs/ghs_rev03/03files_e.html

International Agency for Research of Cancer Monographs
Available at http://monographs.iarc.fr/ENG/Monographs/PDFs/index.php

National Toxicology Program Report on Carcinogens. 12th Edition. U.S. Department of Health and Human Services 2011
Available at http://ntp.niehs.nih.gov/?objectid=72016262-BDB7-CEBA-FA60E922B18C2540

NTP-CERHR Monographs on the Potential Human Reproductive and Developmental Effects. Available at http://ntp.niehs.nih.gov/?objectid=974B2C24-030F-D308-60E11D088F83FADB

Washington State Department of Ecology Chapter 173-333 WAC Persistent, bioaccumulative toxins (PBT) list. January 2006. Available at http://www.ecy.wa.gov/programs/swfa/pbt/list.html

Part 2: MECDC References for Biomonitoring and Indoor Air and Dust Exposure Candidate Chemicals for List of Chemicals of High Concern

Abdallah, M. A. E.,Harrad, S.,Covaci, A. (2008). "Hexabromocyclododecanes and tetrabromobisphenol-A in indoor air and dust in Birmingham, UK: Implications for human exposure." Environmental Science & Technology **42**: 6855-6861.

Adgate, J. L.,Church, T. R.,Ryan, A. D.,Ramachandran, G.,Fredrickson, A. L.,Stock, T. H.,Morandi, M. T.,Sexton, K. (2004). "Outdoor, indoor and personal exposure to VOCs in children." Environmental Health Perspectives **112**(14): 1386-1392.

Adibi, J. J.,Pepera, F. P.,Jedrychowski, W.,Camann, D. E.,Barr, D.,Jacek, R.,Whyatt, R. M. (2003). "Prenatal epposures to phthalates among women in New York City and Krakow, Poland." Environmental Health Perspectives **111**(14): 1719-1722.

Adibi, J. J.,Whyatt, R. M.,Williams, P. L.,Calafat, A. M.,Camann, D.,Herrich, R.,Nelson, H.,Bhat, H. K.,Perera, F. P.,Silva, M. J.,and Hauser, R. (2008). "Characterization of phthalate exposure among pregnant women assessed by repeat air and urine samples." Environmental Health Perspectives **116**(4): 467-473.

Allen, J. G.,McClean, M. D.,Stapleton, H. M.,Nelson, J. W.,Webster, T. F. (2007). "Personal exposure to polybrominated diphenyl ethers (PBDEs) in residential indoor air." Environmental Science & Technology **41**(13): 4574-4579.

Barr, D. B.,Barr, J. R.,Bailey, S. L.,Lapeza, C. R. J.,Beeson, M. D.,Caudill, S. P.,Maggio, V. L.,Schecter, A.,Masten, S. A.,Lucier, G. W.,Needham, L. L.,Sampson, E. J. (2000). "Levels of methyleugenol in a subset of adults in the general U.S. population as determined by hgh resolution mass spectrometry " Environmental Health Perspectives **108**(4): 323-328.

Becker, K.,Seiwert, M.,Angerer, J.,Heger, W.,Koch, H. M.,Nagorka, R.,Robkamp, E.,Schluter, C.,Seifert, B.,Ullrich, D. (2004). "DEHP matabolites in urine of children and DEHP in house dust." International journal of Environmental Health **2007**: 409-417.

Bernhard, D.,Rossmann, A.,Henderson, B.,Kind, M.,Seubert, A.,Wick , G. (2006). "Increased serum cadmium and strontium levels in young smokers - effects on arterial endothelial cell gene transcription." Arterioscler Thrombosis Vascular Biology **26**:833-838.

Bjorklund, J. A.,Thuresson, K.,De Wit, C. A. (2009). "Perfluoroalkyl compounds (PFCs) in indoor dust: Concentrations, human exposure estimates, and sources." Environmental Science & Technology **43**(7): 2276-2281.

Bornehag, C. G.,Lundgren, B.,Weschler, C. J.,Sigsfaard, T.,Hagerhed-Engman, L.,Sundell, J. (2005). "Phthalates in indoor dust and their association with building characteristics." Environmental Health Perspectives **113**(10): 1399-1404.

Calafat, A. M.,Wong, L. Y.,Silva, M. J.,Samandar, E.,Preau, J. L. J.,Jia, L. T.,Needham, L. L. (2011). "Selecting adequate exposure biomarkers of diisononyl and diisodecyl phthalates: Data from the 2005-2006 National Health and Nutrition Examination Survey." Environmental Health Perspectives **119**(1): 50-55.

Calafat, A. M.,Yang Wong, L.,Ye, X.,Reidy, J. A.,Needham, L. L. (2008). "Exposure of the U.S. population to bisphenol A and 4-tertiary-octylphenol: 2003-2004." Environmental Health Perspectives **116**(1): 39-44.

Calafat, A. M.,Yang Wong, L.,Ye, X.,Reidy, J. A.,Needham, L. L. (2010). "Urinary concentrations of four parabens in the U.S. population: NHANES 2005-2006." Environmental Health Perspectives **118**(5): 679-685.

Caldwell K., Jones R., Verdon C., Jarrett J., Caudill S. and Osterloh J. (2008). “Levels of urinary total and speciated arsenic in the US population: National Health and Nutrition Examination Survey 2003–2004.” Journal of Exposure Science and Environmental Epidemiology, 1-10.

California Air Resources Board (2005). Indoor Air Pollution in California - Report to the California Legislature. California Environmental Protection Agency.

Carlsson H., Nilsson U., Becker G., Östman C. (1997) “Organophosphate Ester Flame Retardants and Plasticizers in the Indoor Environment: Analytical Methodology and Occurrence.” Environ. Sci. Technol., 1997, **31** (10), 2931–2936.

CDC (Centers for Disease Control and Prevention) (2005). Third National Report on Human Exposure to Environmental Chemicals. Centers for Disease Control and Prevention, Atlanta, Ga.

CDC (Centers for Disease Control and Prevention) (2009). Fourth National Report on Human Exposure to Environmental Chemicals. Centers for Disease Control and Prevention, Atlanta, Ga.

Chen, G. W.,Ding, W. H.,Ku, H. Y.,Chao, H. R.,Chen, H. Y.,Huang, M. C.,Wang, S. L. (2010). "Alkylphenols in human milk and their relations to dietary habits in Central Taiwan " Food and Chemical Toxicology **48**: 1939-1944.

Clayton, C.,Pellizzari, E.,Quackenboss, J. (2002). "National Human Exposure Assessment Survey: Analysis of exposure pathways and routes for arsenic and lead in EPA Region 5." Journal of Exposure Analysis and Environmental Epidemiology **12**(1): 29-43.

Covaci, A.,Gerecke, A. C.,Law, R. J.,Voorspoels, S.,Kohler, M.,Heeb, N. V.,Leslie, H.,Allchin, C. R.,Deboer, J. (2006). "Hexabromocyclododecanes (HBCDs) in the environment and humans: A review." Environmental Science & Technology **40**(12): 3679-3688.

Damgaard, I. N.,Skakkebaek, N. E.,Toppari, J.,Virtanen, H. E.,Shen, H.,Schramm, K. W.,Petersen, J. H.,Jensen, T. K.,Main, K. M.,Group, T. N. C. S. (2006). "Persistent pesticides in human breast milk and cryptorchidism." Environmental Health Perspectives **114**(7): 1133-1138.

Elliott, L.,Longnecker, M. P.,Kissling, G. E.,London, S. J. (2006). "Volatile organic compounds and pulmonary function in the Third National Health and Nutrition Examination Survey, 1988-1994." Environmental Health Perspectives **114**(8): 1210-1214.

Fei, C.,McLaughlin, J. K.,Tarone, R. E.,Olsen, J. (2007). "Perfluorinated chemicals and fetal growth: A study within the Danish National Birth Cohort." Environmental Health Perspectives **115**(11): 1677-1682.

Fromme, H.,Lahrz, T.,Piloty, M.,Gebhart, H.,Oddoy, A.,Ruden, H. (2004). "Occurrence of phthalates and musk fragrances in indoor air and dust from apartments and kindergartens in Berlin (Germany)." Indoor Air **14**: 188-195.

Gomara, B.,Herrero, L.,Ramos, J. J.,Mateo, J. R.,Fernändez, M. A.,Garcıa, J. F.,Gonzälez, M. J. (2007). "Distribution of polybrominated diphenyl ethers in human umbilical cord serum, paternal serum, maternal serum, placentas, and breast milk from Madrid population, Spain." Environmental Science & Technology **41**(20): 6961-6968.

Guan, H.,Piao, F. Y.,Li, X. W.,Li, Q. J.,Xu, L.,Yokoyama, K. (2010). "Maternal and fetal exposure to four carcinogenic environmental metals." Biomedical and Environmental Sciences **23**: 458-465.

Guo, H.,Kwok, N. H.,Cheng, H. R.,Lee, S. C.,Hung, W. T.,Li, Y. S. (2009). "Formaldehyde and volatile organic compounds in Hong Kong homes: Concentrations and impact factors." Indoor Air **19**: 206-217.

Guo, Z. Y.,Gai, P. P.,Duan, J.,Zhai, J. X.,Zhao, S. S. (2010). "Simultaneous determination of phthalates and adipates in human serum using gas chromatography-mass spectrometry with solid-phase extraction." Biomedical Chromatography **24**: 1094-1099.

Haug, L. S.,Huber, S.,Becher, G.,Thomsen, C. (2011). "Characterisation of human exposure pathways to perfluorinated compounds - comparing exposure estimates with biomarkers of exposure." Environmental International **37**: 687-693.

Hodgson, A.T., Rudd, A.F., Beal, D., Chandra, S. (2000). “Volatile organic compound concentrations and emission rates in new and site-built houses.” Indoor Air **10**: 178-192.

Jones, E. A.,Wright, J. M.,Rice, C.,Buckley, B. T.,Magsumbol, M. S.,Barr, D. B.,Williams, B. L. (2010). "Metal exposures in an inner-city neonatal population." Environment International **36**: 649-654.

Just, A. C.,Adibi, J. J.,Rundle, A. G.,Calafat, A. M.,Camann, D.,Hauser, R.,Silva, M. J.,Whyyatt, R. M. (2010). "Urinary and air phthalate concentrations and self-reported use of personal care products among minority pregnant women in New York city." Journal of Exposure Science and Environmental Epidemiology **20**: 625-633.

Kerger, B. D.,Schmidt, C. E.,Paustenbach, D. J. (2000). "Assessment of airborne exposure to trihalomethanes from tap water in residential showers and baths." Risk Analysis **20**(5): 637-651.

Kim, S. R.,Halden, R. U.,Buckley, T. J. (2007). "Volatile organic compounds in human milk: Methods and measurements." Environmental Science Technology **41**(5): 1662-1667.

Kolarik, B.,Naydenov, K.,Larsson, M.,Bornehag, C. G.,Sundell, J. (2008). "The association between phthalates in dust and allergic diseases among Bulgarian children." Environmental Health Perspectives **116**(1): 98-103.

Koziel, J.,Noah, J.,Pawliszyn, J. (2001). "Field sampling and determination of formaldehyde in indoor air with solid-phase microextraction and on-fiber derivatization." Environmental Science & Technology **35**: 1481-1486.

Kutting, B.,Goen, T.,Schwegler, U.,Fromme, H.,Uter, W.,Angerer, J.,Drexler, H. (2009). "Monoarylamines in the general population - A cross-sectional population-based study including 1004 Bavarian subjects." International Journal of Hygiene and Environmental Health **212**: 298-309.

Lakind, J. S.,Naiman, D. Q.,Hays, S. M.,Aylward, L. L.,Blount, B. C. (2010). "Public health interpretation of trihalomethane blood levels in the United States: NHANES 1999-2004." Journal of Exposure Science and Environmental Epidemiology **20**: 255-262.

Lemus, R.,Abdelghani, A. A.,Akers, T. G.,Horner, W. E. (1996). "Health risk from exposure to metals in households." Reviews on Environmental Health **11**(4): 179-189.

Lin, Y. S.,Egeghy, P. P.,Rappaport, S. M. (2008). "Relationships between levels of volatile organic compounds in air and blood from the general population." Journal of Exposure Science and Environmental Epidemiology **18**: 421-429.

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PATRICIA W. AHO
COMMISIONER

APPENDIX V

Chemicals of High Concern

Maine Department of Environmental Protection
Process Documentation for
Investigating Chemical Presence in Consumer Products

June 29, 2012

Maine Department of Environmental Protection
17 State House Station
Augusta, Maine 04333-0017
(207) 287-7688

Review Process

Maine law requires that development of Maine's list of Chemicals of High Concern (CHC) is to be cooperatively determined by the Maine Department of Health and Human Services, Maine Center for Disease Control and Prevention ("Maine CDC"), and the Maine Department of Environmental Protection ("Department"). (38 M.R.S.A. § 1693-A(1)). An agreement of shared responsibility for research of chemical classification criteria was established between the agencies. The Department assumed responsibility for research of evidence that chemicals are present in consumer products. Evidence of presence in consumer products exists if "…the chemical has been added to or is present in a consumer product used or present in the home." (38 M.R.S.A. § 1693-A(2)(C)).

The Department undertook an extensive review of publically available resources meeting the "credible scientific evidence" standard detailed in law. Maine law requires strong, credible scientific evidence as the standard for classifying chemicals of high concern and defines credible scientific evidence as, "the results of a study, the experimental design and conduct of which have undergone independent scientific peer review, that are published in a peer-reviewed journal or publication of an authoritative federal or international governmental agency…" (38 M.R.S.A. § 1691 (8-A)). Chemicals from the Maine chemicals of concern list meeting the criteria of evidence of presence in consumer products based upon the literature review were documented in the CHC list (details are provided in the Department's chemical candidate spreadsheet).

The Danish Environmental Protection Agency (DEPA) has a comprehensive consumer product chemical analysis program. Due to the comprehensive nature of the program and the analysis, the Department cites this reference extensively and includes the individual summary report numbers on the spreadsheet of candidate chemicals published on the Department's website (which includes citations for each reference described here).

References

The Department utilized the following references in the evaluation of the list of candidate chemicals for presence in consumer products:

Chemical Assessment and Management Program (ChAMP)

The Chemical Assessment and Management Program (ChAMP) is no longer updated, and was superseded by other initiatives in 2009. Under ChAMP, the U.S. EPA evaluated and assigned priority for follow-up action on high production volume (HPV) and medium production volume (MPV) chemicals. EPA produced a number of monograghs for a limited number of chemicals that included information on chemical properties, toxicity, and in some instances product information.

Danish Environmental Protection Agency (DEPA)

The Danish Environmental Protection Agency (DEPA) conducts a consumer products program. This includes a series of reports on chemicals present in consumer products as tested by the Danish EPA. This database was used to identify chemicals in children's and other household products. All Danish Ministry of the Environment references may be found at the end of this document and at the following internet address:
[http://www.mst.dk/English/Chemicals/consumers_consumer_products/]

Dutch Reports

The Netherlands Food and Consumer Product Safety Authority (NL) monitors food and consumer products to safeguard public health. This Authority controls entire production chains, from raw materials and processing aids, to end products and consumption. Dutch references cited may be found at the end of this document and at following internet address:
[http://www.vwa.nl/]

Environmental Health Perspectives (EHP)

A monthly journal of peer-reviewed research and news, EHP is published by the U.S. National Institute of Environmental Health Sciences, National Institutes of Health, and the Department of Health and Human Services. EHP serves as a forum for the discussion of the interrelationships between the environment and human health by publishing peer-reviewed research in a balanced and objective manner. EHP is the third-ranked monthly journal in environmental sciences. Receiving more than 1,200 research manuscripts each year, EHP has an acceptance rate of 22%. Research articles are published within 24 hours of acceptance as Ahead of Print (AOP) articles and are citable using the CrossRef DOI system. [http://dx.doi.org/10.1289/ehp.1104052]

Environmental Science and Technology (ES&T)

Published peer-reviewed studies provide added value to Maine's exposure research, to the extent that more current data strengthens evidence and develops the analysis of predetermined data sets. ES&T is an authoritative source of information utilized by a wide range of environmental disciplines. ES&T publishes original research, which is reviewed by the editor and other scientists who assess the significance, originality, and validity of the work, as well as its appropriateness for publication. Widely utilized as a reference across disciplines, ES&T ranks number one in total citations in the Environmental Engineering and Environmental Sciences categories (as reported by the 2010 Journal Citation Reports®). ES&T studies referenced are cited at the end of this document.

EPA Inventory Use and Reporting (IUR) Database

The IUR database, now known as Chemical Data Reporting (CDR), collects quality screening-level, exposure-related information on chemical substances and makes this information available for use by the U.S. EPA and the public. The CDR data are used to support risk screening assessment, priority setting and management activities, and constitute the most comprehensive source of basic screening-level, exposure-related information on chemicals available to the EPA. The CDR data bank may be found at the following internet address: [http://epa.gov/iur/index.html]

ESIS Risk Assessment Reports

The ESIS (European chemical Substances Information System) of the European Commission Joint Research Centre Institute for Health and Human Protection is a complex, heterogeneous information system that provides information on chemicals. Several aspects of the ESIS system are managed by the European Chemicals Agency (ECHA). This resource was used to identify chemical use in consumer products by review of Risk Assessment Reports (RAR). The ESIS website may be found at the following internet address: [http://esis.jrc.ec.europa.eu/]

German Federal Environment Agency (German FEA)

The German Federal Environment Agency (Umwelt Bundes Amt (UBA)) was founded within Germany's central federal authority on environmental matters and is the scientific environmental authority under the jurisdiction of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. The UBA is mandated to provide scientific support to the Federal Government of Germany, implement environmental laws, and inform the public regarding environmental protection efforts; experts within the UBA utilize in-house laboratories, in addition to commissioning research to scientific institutions. The agency has adopted an interdisciplinary approach in its activities, to include economists, chemists, biologists, and legal experts working in unison to outline whole solutions to environmental risks. The UBA is an acting partner for many of Germany's international organizations, including the World Health Organization. The UBA report reference may be found at the end of this document and at the following internet address: [http://www. umweltbundesamt.de/]

Hazardous Substances Data Bank

The Hazardous Substances Data Bank (HSDB) of the National Library of Medicine is a toxicology data file that focuses on the toxicology of potentially hazardous chemicals. All data are referenced and derived from a core set of books, government documents, technical reports and selected primary journal literature. HSDB is peer-reviewed by the Scientific Review Panel

(SRP), a committee of experts in the major subject areas within the data banks scope. The HSDB data bank may be found at the following internet address: [http://toxnet.nlm.nih.gov]

Household Products Database

The Household Products Database (HPD) is sponsored by the National Library of Medicine, uses information gathered from publicly available sources. Neither NLM nor its contractor (Database Providers) test products or investigate to determine if information listed is complete or accurate. The HPD database may be found at the following internet address: [http://hpd.nlm.nih.gov/]

Substances in Products in the Nordic Countries (SPIN)

SPIN is a database formulated by the combination of the Product Registries of Norway, Sweden, Denmark, and Finland. Financed by the Nordic Council of Ministers Chemical Group, the database provides information about the chemical compounds register. National legislation in these Nordic Countries requires manufacturers and importers to declare chemical substances and products to the product registers. Data compiled in the registers includes information on chemical function, industrial category, classification, composition, and quality. These registers provide a valuable reference for national authorities, and are generally used as support for risk assessments, statistical calculations, substance flow analysis, supervision activities, as well as poison information centers. SPIN is the result of a common Nordic initiative to gather non-confidential information from the Nordic product registers on the common use of chemical substances in different types of products and industrial areas. No specific product names are included within the data stored in SPIN, only the identity of commonly used chemical substances, their inherent properties and the product categories they are reported to have been used in are specified. It should be noted that each country comprising the Nordic group producing SPIN does not require registration of information equally. Denmark and Norway require information on all constituents for the products which mandate a declaration of ingredients. The Swedish government provides a provision allowing substances that are not classified as dangerous and make up less than 5% of a product to be omitted from the declaration of information. Finland registers information on the composition of products from safety data sheets. Therefore, complete information on the exact composition of all product categories is, consequently, not necessarily provided within SPIN. The SPIN database may be found at the following internet address: [http://188.183.47.4/dotnetnuke/Home/tabid/58/Default.aspx]

U.S. EPA Toxic Substances Control Act (TSCA) Work Plan Chemicals

The U.S. EPA uses its statutory authorities, including TSCA, as well as voluntary activities in implementing programs that address pollution prevention, risk assessment, hazard and exposure assessment and characterization, and risk management for chemical substances in commercial use. The U.S. EPA has evolved its approach to its chemicals management program to include an identified group of TSCA Work Plan Chemicals ("Work Plan") for risk assessment under TSCA. The screening process for identifying chemicals for the Work Plan list include the following factors: potentially of concern to children's health; neurotoxic effects; persistent, bioaccumulative, and toxic; probable or known carcinogens; used in children's products; detected in biomonitoring programs. In March 2012, the U.S. EPA identified a work plan of 83 chemicals for further assessment under TSCA, seven of these for risk assessment during the year 2012. Each of the 83 chemicals identified in the Work Plan scored high in this screening process based on their combined hazard, exposure, and persistence and bioaccumulation characteristics. The TSCA Work Plan Chemicals may be found at the following internet address: [http://www.epa.gov/opptintr/existingchemicals/pubs/workplan.html]

Voluntary Children's Chemical Evaluation Program (VCCEP)

This program, sponsored by the U.S. EPA, asks companies that manufacture or import selected chemicals, to voluntarily provide information on health effects, exposure, risk, and data needs. Companies involved collect and/or develop health effects and exposure information on their selected chemical(s) and integrate that information in a risk assessment. The VCCEP data referenced may be found at the following internet address: [http://www.epa.gov/oppt/vccep/]

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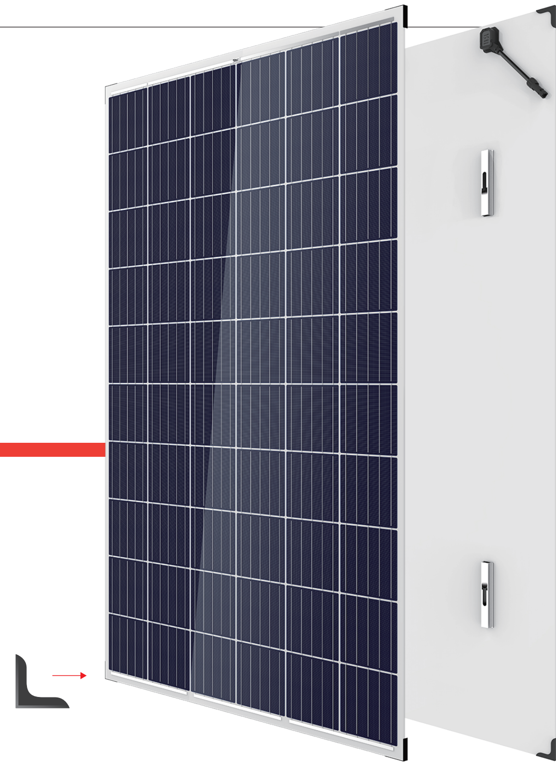
THE DUOMAX

DUAL GLASS 60-CELL MODULE



60 CELL
MULTICRYSTALLINE MODULE

260-280W
POWER OUTPUT RANGE

17.0%
MAXIMUM EFFICIENCY

0~+5W
POSITIVE POWER TOLERANCE

Founded in 1997, Trina Solar is the world's leading comprehensive solutions provider for solar energy. we believe close cooperation with our partners is critical to success. Trina Solar now distributes its PV products to over 60 countries all over the world. Trina is able to provide exceptional service to each customer in each market and supplement our innovative, reliable products with the backing of Trina as a strong, bankable partner. We are committed to building strategic, mutually beneficial collaboration with installers, developers, distributors and other partners.

Comprehensive Products And System Certificates

IEC61215/IEC61730/UL1703/IEC61701/IEC62716
ISO 9001: Quality Management System
ISO 14001: Environmental Management System
ISO14064: Greenhouse gases Emissions Verification
OHSAS 18001: Occupation Health and Safety Management System

Trinasolar

Highly reliable due to stringent quality control

- PID resistant and free of snail trails
- Increased module robustness to minimize micro-cracks
- 100% EL double inspection

Enhanced safety

- Fire class A certified by TUV Rheinland according to fire test IEC 61730-2/MST 23
- Certified for fire type13 (UL 1703)

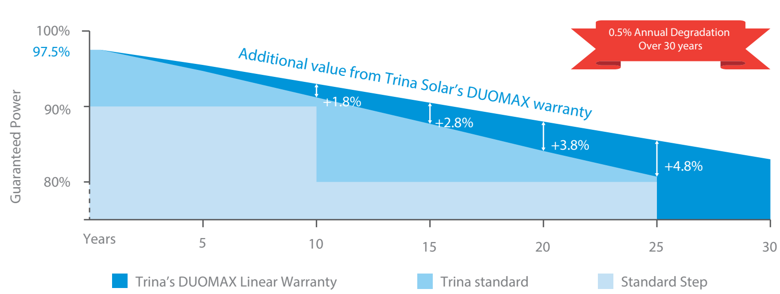
Increased value

- Higher maximum system voltage reduces BOS costs
- 30 year linear warranty
- 0.5% annual degradation
- Low thermal coefficents for more energy production at higher temperatures

Certified to withstand the most challenging environmental conditions

- Module coating resistant to sand, acid, and alkali
- 2400 Pa wind load
- 5400 Pa snow load
- 35 mm hail stones at 97 km/h

Trina Solar's DUOMAX Linear Performance Warranty

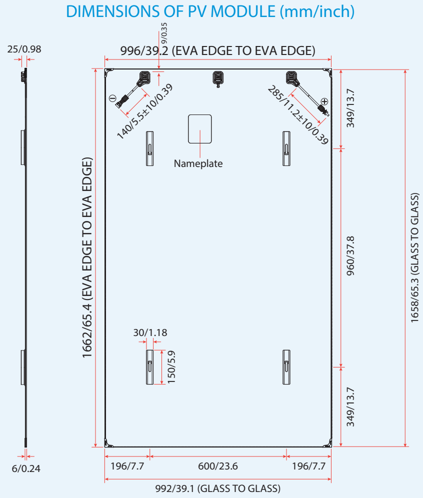


DUOMAX

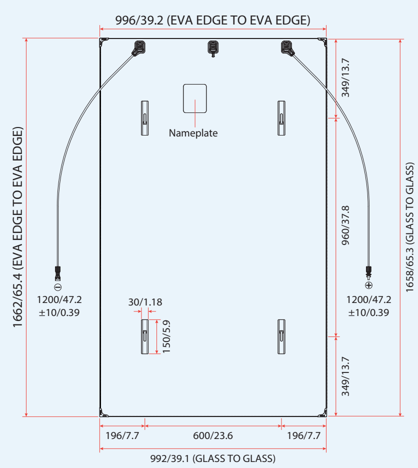
DUAL GLASS 60-CELL MODULE

PRODUCTS	INSTALLATION METHOD	POWER RANGE
TSM-PEG5	Clamp	265-280W
TSM-PEG5.40	Gecko Grip	265-280W
TSM-PEG5.07	Clamp	260-275W
TSM-PEG5.47	Gecko Grip	260-275W

DIMENSIONS OF PV MODULE (mm/inch)

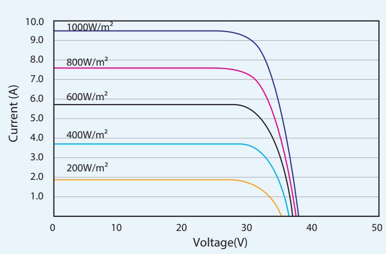


Back View (Portrait)

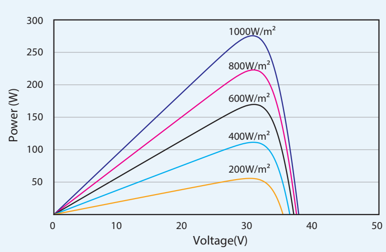


Back View (Landscape)

I-V CURVES OF PV MODULE(280W)



P-V CURVES OF PV MODULE(280W)



ELECTRICAL DATA (STC)

Peak Power Watts-P_{MAX} (Wp)*	260	265	270	275	280
Power Output Tolerance-P_{MAX} (W)			0 ~ +5		
Maximum Power Voltage-V_{MPP} (V)	30.5	30.8	31.1	31.3	31.6
Maximum Power Current-I_{MPP} (A)	8.52	8.60	8.69	8.78	8.87
Open Circuit Voltage-V_{OC} (V)	37.6	37.6	37.6	37.7	37.7
Short Circuit Current-I_{SC} (A)	9.10	9.20	9.26	9.34	9.42
Module Efficiency η_m (%)	15.8	16.1	16.4	16.7	17.0

STC: Irradiance 1000W/m², Cell Temperature 25°C, Air Mass AM1.5.
*Measuring tolerance: ±3%.

ELECTRICAL DATA (NOCT)

Maximum Power-P_{MAX} (Wp)	193	197	201	204	208
Maximum Power Voltage-V_{MPP} (V)	28.0	28.2	28.3	28.5	28.7
Maximum Power Current-I_{MPP} (A)	6.89	6.98	7.11	7.19	7.25
Open Circuit Voltage-V_{OC} (V)	34.9	34.9	34.9	34.9	35.0
Short Circuit Current-I_{SC} (A)	7.35	7.43	7.49	7.55	7.62

NOCT: Irradiance at 800W/m², Ambient Temperature 20°C, Wind Speed 1m/s.

MECHANICAL DATA

Solar Cells	Multicrystalline 156.75 × 156.75 mm (6 inches)
Cell Orientation	60 cells (6 × 10)
Module Dimensions	1658 × 992 × 6 mm (65.3 × 39.1 × 0.236 inches) 1662 × 996 × 6 mm with edge banding (65.4 × 39.2 × 0.236 inches) 1664 × 998 × 7.6 mm with corner protector (65.5 × 39.3 × 0.299 inches) (Default)*
Weight	23.5 kg (51.8 lb)
Front Glass	2.5 mm (0.10 inches), High Transmission, AR Coated Heat Strengthened Glass
EVA	White (PEG5, PEG5.40); Transparent (PEG5.07, PEG5.47)
Back Glass	2.5 mm (0.10 inches), Heat Strengthened Glass
Frame	Frameless
J-Box	IP 67 or IP 68 rated
Cables	Photovoltaic Technology Cable 4.0 mm² (0.006 inches²) Portrait: 140/285 mm (5.5/11.2 inches) Landscape: 1200/1200 mm (47.2/47.2 inches)
Connector	MC4 or Amphenol H4/UTX (1500V)
Fire Type	Type 13

TEMPERATURE RATINGS

NOCT(Nominal Operating Cell Temperature)	44°C (±2°C)
Temperature Coefficient of P_{MAX}	- 0.41%/°C
Temperature Coefficient of V_{OC}	- 0.32%/°C
Temperature Coefficient of I_{SC}	0.05%/°C

MAXIMUM RATINGS

Operational Temperature	-40~+85°C
Maximum SystemVoltage	1500V DC (IEC) 1000V DC (UL)
Max Series Fuse Rating	15A

(DO NOT connect Fuse in Combiner Box with two or more strings in parallel connection)

WARRANTY

10 year Product Workmanship Warranty
30 year Linear Power Warranty

(Please refer to product warranty for details)

PACKAGING CONFIGURATION

Modules per box: 30 pieces
Modules per 40' container: 780 pieces

MORE OPTIONS

More Options Available	☐ 2.0mm Glass: 19.7 kg (43.4 lb) (Only for PEG5.40/PEG5.47) ☐ Compact AR Coating ☐ POE (Polyolefin Elastomer) Adhesive

*Not applicable to slide-in racking solution

Trinasolar

CAUTION: READ SAFETY AND INSTALLATION INSTRUCTIONS BEFORE USING THE PRODUCT.

Version number: TSM_EN_2017_A

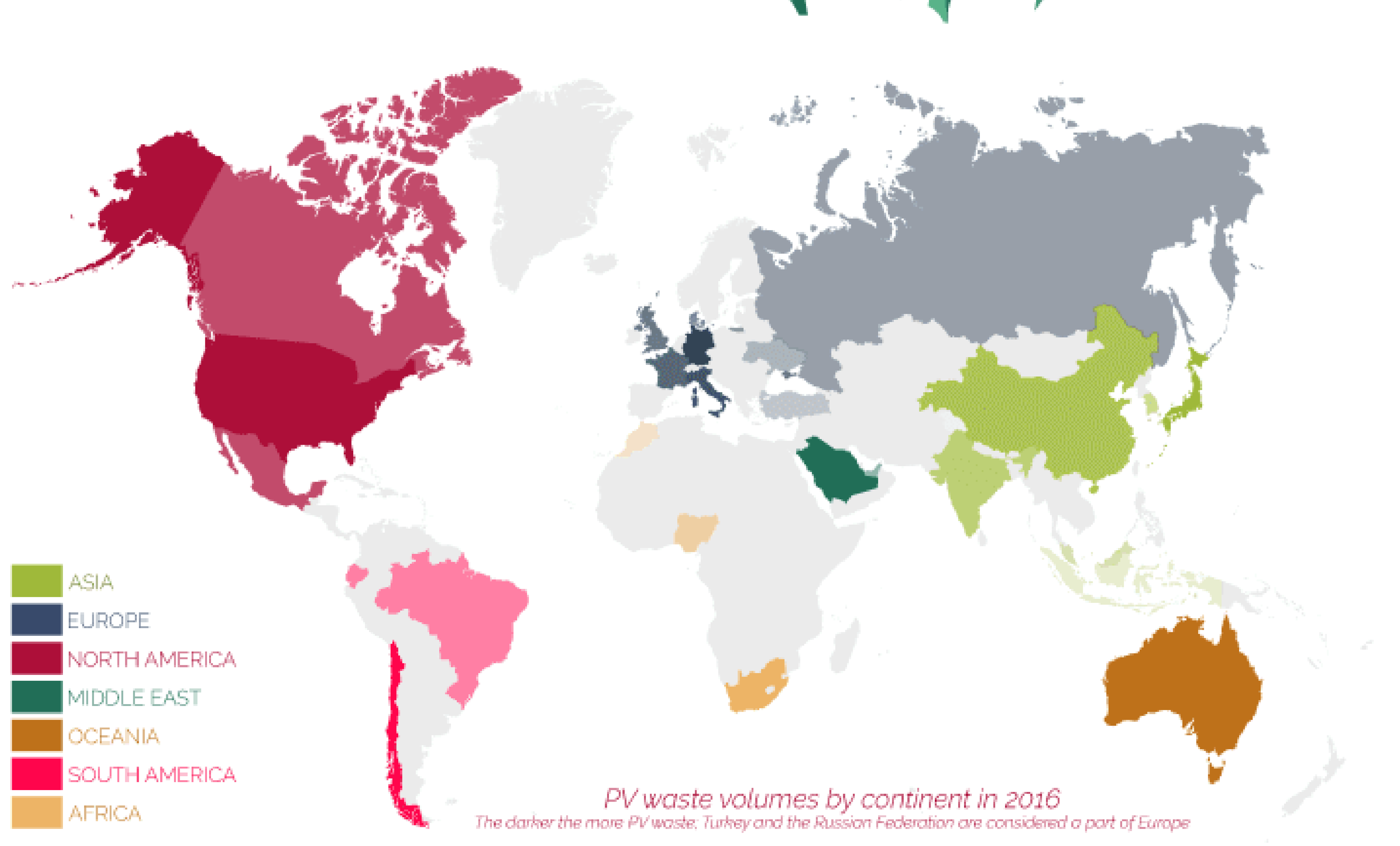
www.trinasolar.com

A Solar Panel's **Life after Death**

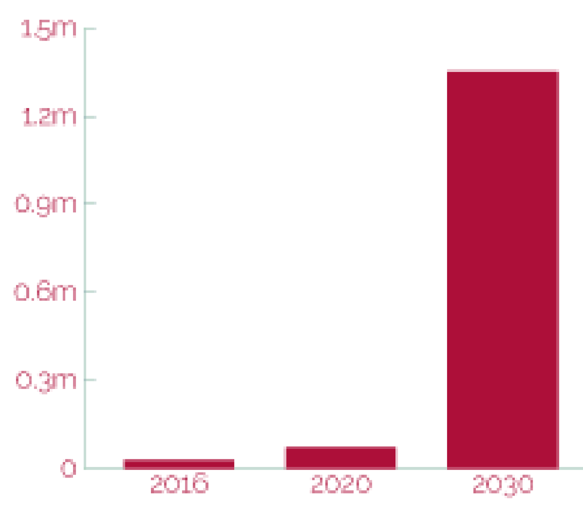
4 million
tons of PV installed in Europe

43,500
tons of PV waste by 2017

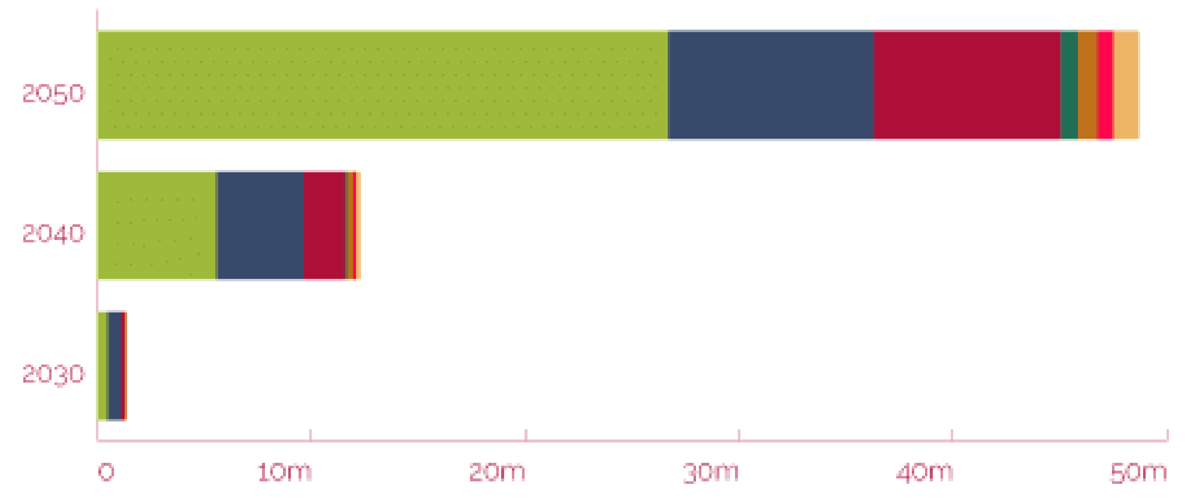
60 million
tons of PV waste by 2050



PV waste volumes by continent in 2016
The darker the more PV waste; Turkey and the Russian Federation are considered a part of Europe



Estimated PV waste increase (t)



Estimated PV waste volumes by continent in the coming decades (t)

The Solar Panel **Resurrection Process**

Over 70% of European PV manufacturers are part of the global PV CYCLE network which offers tailor-made waste management for companies. All producers fall under legal obligations of WEEE legislation, and PV CYCLE helps them fulfil all requirements. Due to this initiative, members of the network show commitment to create a product which is sustainable during both the production and after the purchase. They realise this through mindful eco-design, the elimination of toxic materials usage, and recycling. Technologies are constantly improved so that recycling can occur upon all types of PV panel failures, including malfunctioning modules, glass breakage, laminate and electrical defects, wrong designs, process losses, or decommissioning.

Silicon based PV panels

76% glass
10% plastic
8% aluminium
5% silicon
1% metals

Thin-film based PV panels

1% metals
6% aluminium
4% plastic
89% glass

The **Recycling** Process

collecting materials

disassembling the aluminium and glass parts

95% glass reused

thermal processing at 500°C

100% metal reused

the covering plastic **evaporates**

reused as **heat** source

physically **separating** cell modules

etching away silicon wafers

80% modules reused

melting broken wafers

85% silicon reused

shredding the PV panels into 4-5mm pieces to remove lamination

separating solid and liquid with a rotating screw

removing film using acid and peroxide

precipitation and **dewatering**

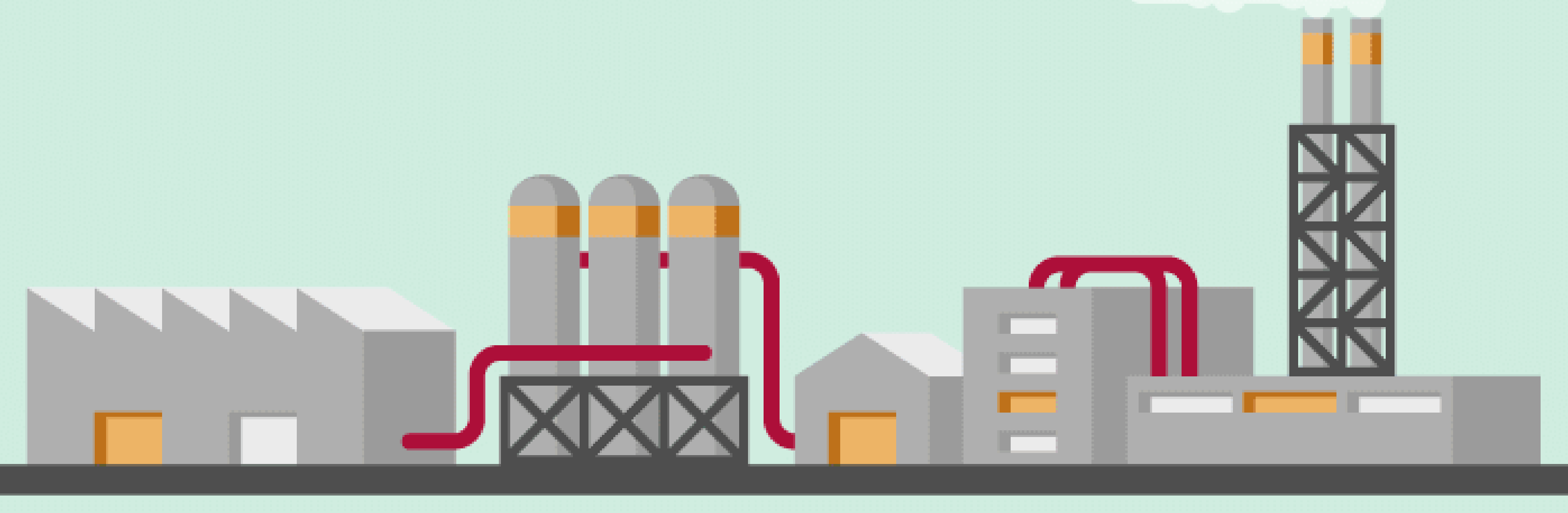
removing interlayer materials with **vibration**

separating and **processing** metals

rinsing the glass

95% semiconductor material reused

90% glass reused



A Step Into **The Future**

If solar power is to be a genuine environmental benefit to us, then it cannot be left to accumulate as waste in a landfill. End-of-life recycling will help finance the future growth of solar power industry. 96 per cent of the materials can be reused for producing new solar panels. Potential material influx could produce **2 billion new panels by 2050.** Recycling units will create additional employment opportunities. PV panels will become 'double green' products by both serving as a source of renewable energy generation, and being able to be reused for the same or different purposes after their life cycle ends.

2030

$450m recycled materials

60 million new panels from recycling

18 GW extra capacity by recycled panels

2050

$15bn recycled materials

2 billion new panels from recycling

630 GW extra capacity by recycled panels

GREENMATCH

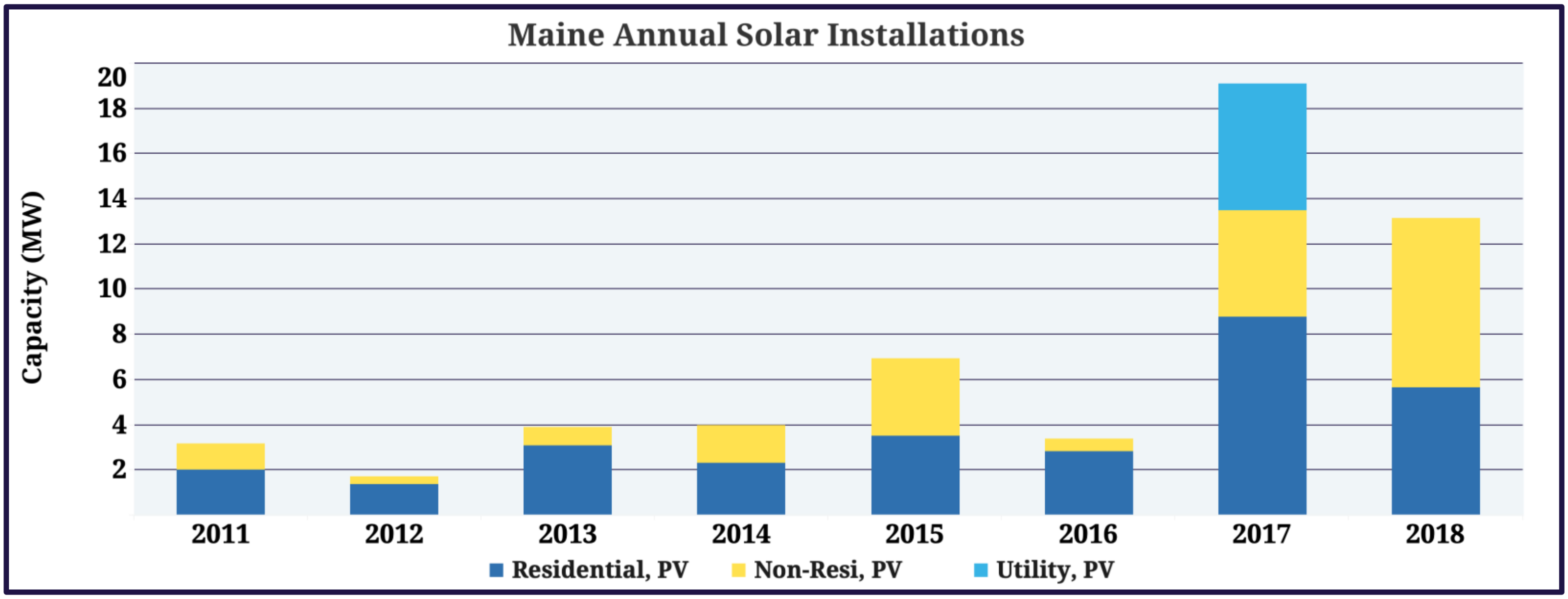
By **Bára Sýkorová**,
Alexandru Lascăr,
Attila Tamás Vékony, 2017

Sources:
1 irena.org/DocumentDownloads/Publications/RENA_IEAPVPS_End-of-Life_Solar_PV_Panels_2016.pdf
2 pvcycle.org
3 ec.europa.eu/environment/waste/weee/
4 bnl.gov/pv/files/PRS_Agenda/2_Krueger_IEEE-Presentation-Final.pdf

Solar Spotlight – Maine

At A Glance

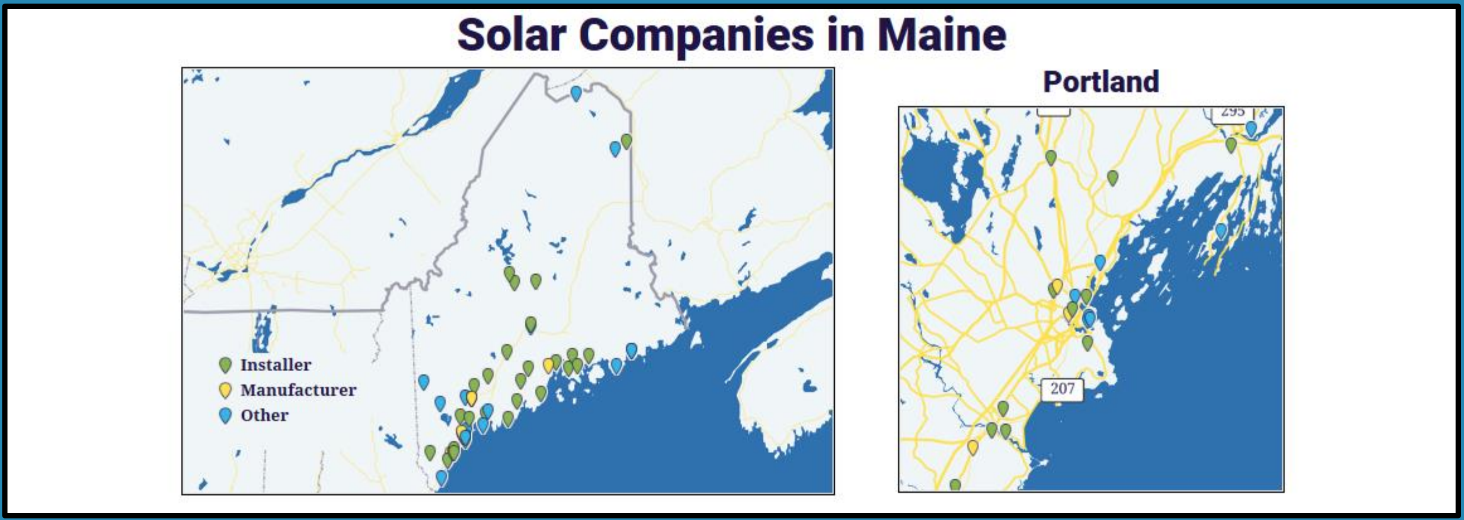
- **Solar Installed:** 55.3 MW (13.1 MW in 2018)[i]
- **Enough Solar Installed to Power:** 10,000 homes
- **National Ranking:** 43rd (40th in 2018)
- **Percentage of State's Electricity from Solar:** 0.56%[ii]
- **Solar Jobs and Ranking:** 635 (41st in 2018)[iii]
- **Solar Companies in State:** 70 companies total; 6 Manufacturers, 36 Installers, 28 Others[iv]
- **Total Solar Investment in State:** $ 158.01 million ($28.81 million in 2018)
- **Price Declines:** 47% over the last 5 years



Notable Projects

- IOS - MEW Phase 1 has the capacity to generate 4.1 MW of electricity -- enough to power over 530 Maine homes.[v]
- At 1 MW, NRG Solar Mule, LLC is among the largest solar installations in Maine. Completed in 2017, this photovoltaic project has enough electric capacity to power more than 194 homes.[vi]
- Rocky's Stove Shoppe & Target have both gone solar in Maine. Target has installed a 0.73 MW project at their location in Bangor.[vii]

Solar Spotlight – Maine



About SEIA

The Solar Energy Industries Association (SEIA®) is the driving force behind solar energy and is building a strong solar industry to power America through advocacy and education. As the national trade association for the U.S. solar energy industry, which employs more than 242,000 Americans, we represent all organizations that promote, manufacture, install and support the development of solar energy. SEIA works with its 1,000 member companies to build jobs and diversity, champion the use of cost-competitive solar in America, remove market barriers and educate the public on the benefits of solar energy.

References

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[i] All data from SEIA/GTM Research *U.S. Solar Market Insight* unless otherwise noted: http://www.seia.org/research-resources/us-solar-market-insight
[ii] Energy Information Administration, Electric Power Monthly: http://www.eia.gov/electricity/monthly/#generation
[iii] The Solar Foundation, State Solar Jobs Census: http://www.thesolarfoundation.org/solar-jobs-census/states/
[iv] SEIA, National Solar Database: http://www.seia.org/research-resources/national-solar-database
[v] SEIA, Major Solar Projects List: http://www.seia.org/research-resources/major-solar-projects-list
[vi] Ibid
[vii] SEIA, *Solar Means Business*: http://www.seia.org/campaign/solar-means-business-2016

Solar Panel Disposal: Exploring Your Options and Knowing the Risks

JUL, 2017BY JENNIFER D. ACKERMAN, CIC, CRIS

Solar energy is a relatively new technology, so standards for disposal of solar panels and photovoltaic (PV) modules are still uncharted waters. However, if you are considering buying a green building that uses solar energy, or involved in the installation of solar panels or PV cell manufacturing, it is important to think 30 years down the road to your potential solar energy liabilities when it comes to disposal. One of the biggest questions in the industry right now is who should be held responsible for solar panel disposal. Until officials answer this question, consider the following points before you decide to take part in the green movement.

Solar Panel Life Cycle

The average lifespan of a PV module is between 25 and 30 years. Since the first large-scale installations of solar panels did not occur until the early 1990s, the first concerns about the dangers of solar panel disposal will not emerge for another 10 or 15 years. However, it is still an important point to address. According to the U.S. Department of Energy, the industry will skyrocket by 2020 and produce an ever-growing PV waste stream for years to come. Think about these risks before you sell your PV product, begin installation or decide to purchase green facilities for your business.

Recycling Programs

You could be held liable for any hazards PV modules cause during the disposable process, even if the product is out of your hands and in a landfill at the time the incident occurs. Therefore, if you know your business is responsible for the disposal of PV products, consider recycling as a less risky option.

Industry leaders are calling for producers and manufacturers to consider the environmental impacts of the green movement at all stages of the product life cycle. According to the PV Cycle Association, PV modules contain materials that can be recovered and reused to make new modules or other products. This holds true for both types of products in production today, the thin-film and silicon modules.

Since there are currently no concrete guidelines to determine which party is responsible for solar panel disposal, play it safe—opt for recycling panels where possible. If the manufacturer takes the panels back for disposal, ask the company whether they will be thrown away or recycled to ensure you know your risks when handing the product back.

Landfill Dangers

Whole panels or smaller parts that cannot be recycled will inevitably end up in a landfill. In general, experts say that solar panels and other PV products are safe for landfills because the PV materials themselves are encased in glass or plastic. However, there is some debate about the amount of damage PV panels could cause should the encasing crack or break while buried. If you are responsible for disposal, you must decide how large of a risk you want to take.

PV semiconductor manufacturing involves extremely toxic, carcinogenic materials, including arsine, cadmium, dichloromethane, trichloroethylene and selenium. If the heavy metals leach into surrounding soil and into the groundwater, someone will inevitably be held liable. Given the lack of governmental standards on the matter as of now, and without proper coverage, it could very well be you or your business. If you opt for disposal rather than recycling, talk to The Safegard Group, Inc. about what kind of coverage you currently have to protect you if something goes wrong in the landfill down the road.

Get Covered

Whether you are a business owner going green, a contractor performing solar panel installations or a PV module manufacturer, seeking out the proper coverage for your green risks is crucial. You will need to protect yourself against the added hazards of green building if green systems fail to meet standards and against possible design defects in green systems. In addition, do not forget to seek coverage for disposal or recycling liabilities, even though it may not affect you directly for years to come. Read all contracts carefully to determine whether you are responsible for safe disposal to avoid devastatingly costly claims down the road.

If your current policy does not specifically address green risks, contact The Safegard Group, Inc. today to find out what the limits are and whether you will need to have a more inclusive policy.