Brookfield
Renewable U.S.

February 28, 2022

Joint Committee on Environment and Natural Resources
Cross Building, Room 216
Augusta, ME 04333
ENR@legislature.maine.gov

Public Testimony of Brookfield Renewable on LD 1979

An Act To Sustain Good-paying Jobs in the Forest Products Industry by Ensuring Consistency between Comprehensive River Resource Management Plans and State Water Quality Standards

---

Chair Brenner, Chair Tucker and Members of the Joint Committee on Environment and Natural Resources:

Brookfield Renewable[1] submits these comments in **support of LD 1979**.

Brookfield Renewable owns and operates the Lockwood and Hydro-Kennebec dams in Winslow and Waterville, the Shawmut Dam in Fairfield and the Weston Dam in Skowhegan. Collectively, these four facilities contribute more than $2 million annually in local property taxes and generate enough renewable energy annually to power more than 35,000 Maine homes with clean energy. We are separately distributing a white paper that details the substantial public benefits produced by these facilities.

To balance continued operations with the protection and restoration of several species, including Atlantic salmon, Brookfield Renewable completed construction in 2017 of a $15 million fish lift at the Hydro-Kennebec project. Brookfield Renewable has separately proposed construction of more than $40 million in additional fish passage infrastructure projects at the Lockwood, Shawmut and Weston projects as well over the course of many years, through multiple rounds of extensive

[1] As used herein, Brookfield Renewable refers to Brookfield Renewable Partners L.P. and its managed affiliates. Throughout Maine Brookfield Renewable owns and operates 38 hydropower stations and approximately 620MW of installed capacity as well as 219MW of wind power and a 20MW battery storage facility. Brookfield Renewable has over 100 employees in Maine and supports 275 indirect jobs across the State. Brookfield Renewable's operations contribute more than $20 million in property taxes in Maine annually, which provides critical funds for local schools, fire departments and public services.

engagement with state and federal wildlife agencies. Despite these efforts, these four dams continue to be targeted by unilateral state agency actions aimed to obstruct and subvert federal and state administrative process and compel dam decommissioning and removal through imposition of unreasonable and uneconomic fish passage requirements and standards.

These agency actions have included an effort to illegally amend the existing Comprehensive River Resource Management Plan for the Kennebec River to recommend decommissioning and removal of each of the lower Kennebec River dams. The state's efforts risk the unreasonable denial of permitting approvals necessary for continued operations of the Shawmut Dam or, more cynically, approval conditioned on satisfaction of burdensome conditions that would likely render the Shawmut Dam uneconomic. Unfortunately, much of these efforts have been designed behind closed doors with little consideration of input from, or the impacts on, surrounding communities and stakeholders.

In response, LD 1979 would impose important guardrails on the modification of state river resource plans to ensure that all future efforts to amend critical river resource management plans, which impact not only operators of dams, but all river users and stakeholders dependent on the state's waters throughout Maine, follow a public and thorough process that appropriately balances all interests and communities. LD 1979 would achieve this by establishing that the development of new Comprehensive River Resource Management Plans, as authorized under 12 M.R.S. § 407, or any amendment to an existing plan, requires the review and approval of the Legislature prior to adoption. LD 1979 would also require that new and amended Comprehensive River Resource Management Plans adequately consider impacts to existing users – including mills, water treatment facilities, renewable energy facilities, and recreational users. Finally, LD 1979 would establish that, for water quality certification of hydropower resources, the actions required of a licensee by state agencies to protect a species listed under the federal Endangered Species Act be no more stringent or burdensome than actions recommended by the federal agencies who are tasked with responsibility for administering and enforcing the federal statute.

Comprehensive River Resource Management Plans

The directives in LD 1979 relevant to the development of a new Comprehensive River Resource Management Plan or amendments to existing plans would introduce necessary oversight and balance to a process that has significant implications for local communities. Evidence of the critical need for these changes is best highlighted by the Department of Marine Resources' (DMR) illegal and subsequently withdrawn *Kennebec River Management Plan Diadromous Resources Amendment*, introduced in December 2020 (2020 Amendment)[2] and developed in an effort to

[2] The 2020 Amendment was later withdrawn by the DMR following a lawsuit by Brookfield when a state review concluded that the agency lacked statutory authority to implement such an amendment.

influence future federal and state licensing determinations with respect to Brookfield's Lower Kennebec dams and most urgently the Shawmut Dam, which is in the midst of a federal relicensing process. The 2020 Amendment included the following recommendation:

> *"MDMR recommends that the Shawmut Project and the Lockwood Project be decommissioned, and the dams removed. MDMR also recommends that the Hydro-Kennebec and Weston projects be considered for decommissioning and removal pending further investigation of fish passage performance at Hydro-Kennebec and further technical assessments and community outreach at the Weston project."* [3]

Despite the considerable direct local, environmental and economic benefits provided to the state and its residents by the operations of these four dams[4] and the Somerset Mill's reliance on critical water intake infrastructure provided by the Shawmut Dam, the 2020 Amendment, including its proposed removal of these dams, was identified by the DMR as a "routine technical" change to the initial plan, untethered from legislative review.

The ongoing Shawmut Dam relicensing is instructive for the potential consequences of these critical plan amendments being developed without legislative oversight. Last July, the Federal Energy Regulatory Commission (FERC), acting in consultation with the National Marine Fisheries Service, issued a Draft Environmental Assessment for the dam that determined that building a new fish lift, designed to pass at least 96% of Atlantic salmon approaching the dam, would be sufficient to support species restoration. This fish passage requirement would be higher than any similar such percentage imposed on any other dam in Maine. Importantly, FERC's draft determination considered the many other factors benefitting from the continued operations of the dam. Brookfield Renewable was and remains amenable to the operating conditions and infrastructure requirements proposed by FERC's Draft Environmental Assessment, which would include capital expenditures upwards of $20 million to support fish passage and mitigation at Shawmut Dam alone. However, in August 2021, the Department of Environmental Protection (DEP) issued a draft order denying Water Quality Certification for the Shawmut Dam, uncritically adopting wholesale the unreasonable and impracticable fish passage recommendations that the DMR had proposed in its illegal river plan amendment as the basis of its denial.[5] These recommendations, developed without public input or scrutiny of the Legislature, included imposition of a performance standard requiring upstream and downstream passage of 99% of Atlantic salmon – an unrealistic and likely

[3] Kennebec River Management Plan Diadromous Resources Amendment at pg. 34.
[4] For additional information related to the contributions of these four dams, see attachment: "The Value of Maine Hydro"
[5] In response to the publication of the draft denial, Brookfield Renewable withdrew its water quality certification application before a final order was issued and has since filed a new application incorporating new and additional data from the FERC licensing process into the state water quality certification process which the state did not appear to consider in its draft denial. The DEP process is expected to conclude with a ruling later this fall.

unachievable requirement that would effectively force dam removal and elimination of the Somerset Mill's water supply.

Based on current annual salmon returns to the Lockwood Dam, the difference between the FERC-approved 96% survival standard and DEP's unreasonable 99% standard amounted to upstream passage of only approximately 5 additional salmon annually.

Given the highly politicized nature of these administrative processes, the potential loss of existing dam and renewable hydroelectric infrastructure, which provides ample benefits to so many private and public interests, clearly requires closer consideration and review. This is particularly true given current state policy mandates to achieve carbon reduction requirements by 2030 and the Joint Committee's recent endorsement of a 2045 net zero target (LD 1429). In addition, the related substantial impacts of dam removal on legacy industries, regional economies and local communities, including the potential loss of the Somerset Mill and more than 700 skilled union jobs, and millions of dollars of property tax revenues for towns and cities which have already seen significant loss of tax base in recent decades, is anything but routine and surely highlights a glaring gap in process that LD 1979 would rightfully address. Actions of such magnitude as the creation or amendment of state river resource plans, with meaningful local and statewide implications, demand close and careful examination, including the review and input of the Legislature, as the elected body representing the many river stakeholders directly and indirectly impacted by such plans. This clear directive from the Legislature, coupled with more defined consideration of existing uses in the development of new or amended plans, would ensure appropriate checks and balances in decision-making influencing significant state policy and permitting decisions for the Kennebec River and other river systems throughout the state.

Conditions for State Water Quality Certification

The second section of LD 1979 would establish that, for a species listed as endangered under the federal Endangered Species Act, satisfaction of mitigation and protection conditions imposed by federal agencies charged with enforcing the federal statute would be sufficient to meet state water quality standards. In the case of the Shawmut relicensing and Atlantic salmon, which is *not a state-listed* species, this would establish that state water quality standards would be met through satisfaction of the conditions imposed by the National Marine Fisheries Service and the Federal Energy Regulatory Commission, the federal agencies tasked with administering and enforcing the federal Endangered Species Act to protect Atlantic salmon. This change would not limit the jurisdiction of the DEP on issues specific to water quality and would not reduce the potential for a science-based decision, but would ensure that state agencies do not intrude upon the primary jurisdiction of the federal agencies.

Take, for example, the current status of the Shawmut Dam relicensing process. After issuance of its Draft Environmental Assessment, the Federal Energy Regulatory Commission, acting in consultation with the National Marine Fisheries Service, the federal wildlife agency responsible for protecting Atlantic salmon under the federal Endangered Species Act, indicated it is pursuing an Environmental Impact Statement (EIS) of Shawmut Dam, which will include an even more comprehensive review of environmental impacts and possible species protection measures. The recommendations resulting from this process are expected to be issued through a draft EIS in August and a final EIS in early 2023. This process will be robust and can credibly be relied upon to determine required conditions for protection of Atlantic salmon – particularly given the review framework employed by the federal agencies, the support of this process by NGOs, and the status of Atlantic salmon as a federally-listed species.

The status quo alternative may otherwise have severe implications for the surrounding communities. In the face of public opposition to its 99% standard, communications from the DMR have recently pivoted toward a very late "Hail Mary" proposal for a "nature-like fishway" at Shawmut Dam, *in addition to* the fish lift proposed, to heap economic loss and cost on the Shawmut Dam and render it uneconomic. The DMR's proposal is unhelpfully short on details, making response in full to the DMR's proposal very difficult; however, preliminary analysis suggests there are considerable logistical and environmental limitations to constructing this *second* fishway. In addition, there is good reason to believe that installation of a nature-like fishway alongside the proposed fish lift would be *less effective* at passing fish upstream than installation of just the proposed fish lift. This is because the nature-like fishway is likely to lack necessary resting pools and to have water velocities well in excess of the ability of many fish to pass, and its introduction will create so-called "false attractions" that will divert fish from the functioning fish lift. But what is understood is the addition of a nature-like fishway is likely to add an additional $20 million in infrastructure costs, likely more than doubling required fishway costs to approximately $40 million for Shawmut Dam alone, in addition to the perpetual loss of generation revenues from required minimum flows to operate the nature-like fishway. The requirement to build a fish lift and a nature-like fishway together would render the Shawmut Dam uneconomic, thereby raising the potential for decommissioning and, ultimately, removal. This would impose the same collateral damage to other stakeholders and important state interests, with no scientific basis to expect any improvement in fish passage performance as compared to Brookfield's single-lift proposal.

Each of these actions and strategies pursued by the DMR – comprising explicit and implicit removal efforts – are occurring without any guarantee that such actions will facilitate the desired outcome of Atlantic salmon restoration, both because its proposals offer no reasonable prospect of improved passage, and because the great challenge to Atlantic salmon restoration is primarily rooted in addressing the adverse impacts of climate change on salmon marine survival. Ironically, a rational solution to address those climate change impacts is more likely to include the

Brookfield
Renewable U.S.

preservation and financial support of renewable hydroelectric facilities like Shawmut than their removal. As such, any determination for the requirement of one or multiple fishways and technologies should rest with the expert federal agencies charged by law to protect Atlantic salmon under the federal Endangered Species Act and whose recommendations will reflect a robust record and broad stakeholder considerations free from local political influences.

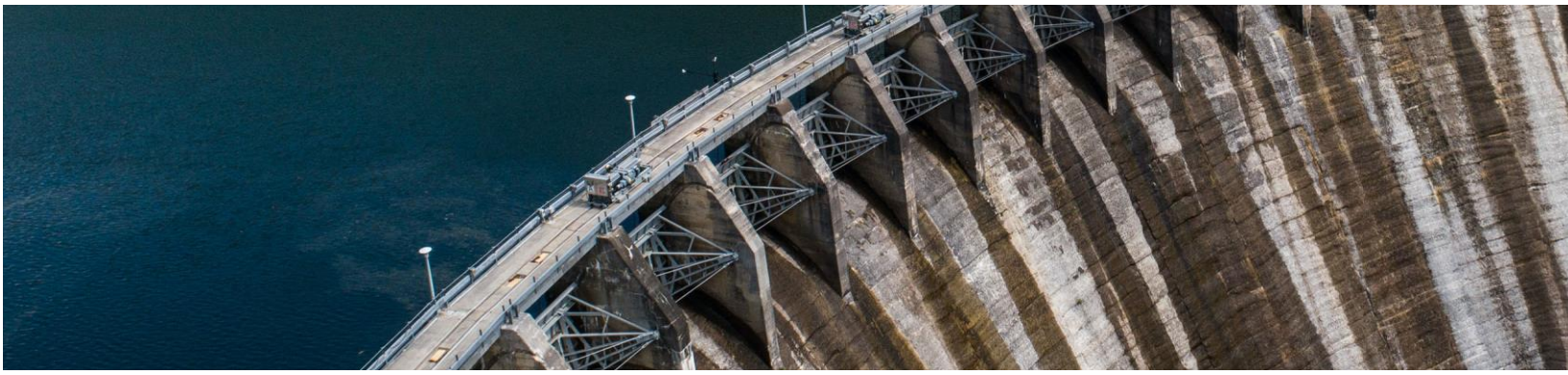
Brookfield Renewable urges the Committee to pass LD 1979 and help bring reason, structure and balance to the forefront of the ongoing discussions related to use of Maine's rivers, including the Shawmut Dam and the lower Kennebec River.

Thank you for your consideration of our comments. Please don't hesitate to contact me directly to discuss these issues further.

Sincerely,

Steve Zuretti
Senior Director, Government Affairs and Policy
Brookfield Renewable
steven.zuretti@brookfieldrenewable.com
323-400-9715

Attachment: The Value of Maine Hydro



The Value of Maine Hydro

White Paper

January 2022

Summary

Maine's electric history began with the early development of hydroelectric power in the state. By the late 1800s, hydroelectric generation became one of the primary resource types to power Maine's rich lumber industry. Since then, Maine's energy mix has undergone substantial changes with the coming (and going) of several nuclear, oil, and natural-gas fired generators, and now the introduction of wind and solar renewable generation and battery storage.

Today approximately 70 FERC-licensed hydroelectric power plants are left in Maine, representing over 700 megawatts ("MW") of generation capacity, compared to nearly 12,700 MW of non-hydro resources.[6] These hydroelectric resources not only provide energy that serve in-state homes and businesses, but they also reduce greenhouse gas ("GHG") emissions, provide system reliability to the grid, and help Maine achieve its goal of 100% renewable generation by 2050. The aim of this paper is to quantify some of these benefits[7] using the 47.2 MW of aggregate nameplate capacity provided by Brookfield's Lockwood, Hydro-Kennebec, Shawmut, and Weston hydroelectric facilities (collectively "Brookfield Hydros") as examples. In doing so, the general public, policy-makers, regulators, interest groups, and hydro asset owners can better evaluate the economic value that is at risk from additional decommissioning of hydro in Maine.

The key findings of this paper are as follows:

- **Production Cost Savings:** The Brookfield Hydros' 47 MW of hydro generation reduced the ISO New England ("ISO-NE") system production costs (related to fuel and other variable costs) over the past five years by **$5.9 million per year** compared to costs displaced by generation from 47 MW of solar or **$3.8 million per year** for 47 MW of wind. Approximately 173 MW of solar or 90 MW of wind would be needed to reduce system production costs an equivalent amount as the 47 MW provided by the Brookfield Hydros.

- **Social Benefit of Avoided CO_2 Emissions:** Using an estimate for the marginal CO_2 emitted by the ISO-NE system to generate 1 MWh of energy, the Brookfield Hydros' 47 MW of hydro generation displaces an amount of CO_2 annually equal to removing roughly **26,800 passenger vehicles** from the road per year compared to only **8,300 passenger vehicles** per year for 47 MW of solar and **14,000 passenger vehicles** per year for 47 MW of wind. The social value from a reduction of 26,800 passenger vehicles in CO_2 is approximately **$6.2 million per year** based on the social cost of carbon of $50/metric ton**.** By contrast, the 8,300 passenger vehicles' worth of CO_2 displaced each year by 47 MW of solar generation represent a CO_2 reduction social benefit of only approximately **$1.9 million per year** and the 14,000 passenger vehicles' worth of CO_2 displaced each year

[6] ISO-NE, 2021 CELT Report. Numbers are based on a nameplate basis, meaning solar and wind has not been de-rated to reflect their claimed seasonal capability.
[7] The scope of this paper does not address other environmental costs and benefits such as reduction in downstream flooding, erosion reduction, or impacts to recreation.

by 47 MW of wind generation represent a CO_2 reduction social benefit of approximately **$3.2 million per year**. Conservatively, if the Brookfield Hydros were decommissioned, an additional 170 MW of solar *plus* 90 MW of battery storage would be needed to reduce system CO_2 emissions equal to the 47 MW provided by the Brookfield Hydros, costing roughly **$338 million**. This cost would typically be socialized across Maine ratepayers if procured through a state RFP.

- **Reliability Benefits:** The reliability value from the Brookfield Hydros' 47 MW of hydro capacity is approximately **$15.9 million** per year based on parameters and cleared supply in New England's most recent Forward Capacity Auction ("FCA" 15). This is an estimate of the system's willingness to pay for the marginal reliability benefit the 18.71 MW of capacity supply obligations Brookfield Hydros qualify for.

- **RPS Compliance for Maine:** Hydroelectric facilities, such as the Brookfield Hydros, that earn Maine Class II Renewable Energy Credits ("RECs") help meet Maine compliance targets and serve in-state load, unlike new resources that qualify for and often sell Massachusetts Class I RECs and serve Massachusetts load. The Brookfield Hydros' 47 MW of hydro generation in Maine produces more than **200,000 Maine RECs annually, nearly 4 times the amount produced by the same MW of solar**.

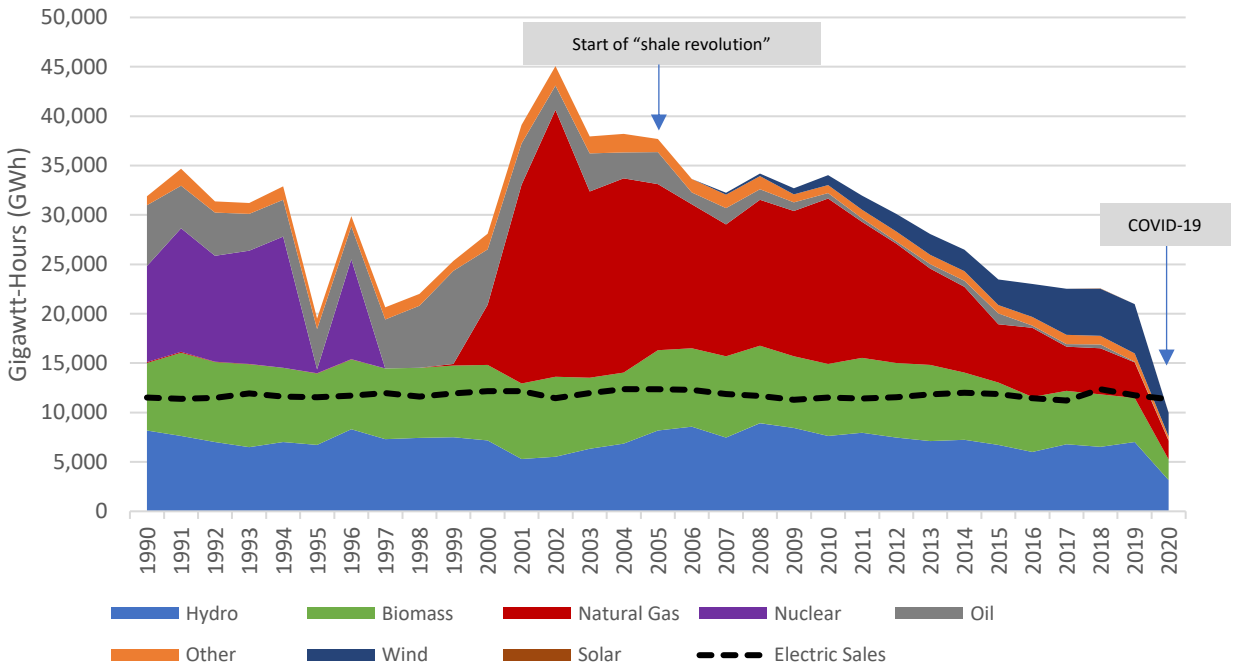
While solar, wind and battery storage are all important for meeting Maine's decarbonization goals, replacing the Brookfield Hydros with these technologies would increase ratepayers costs related to electricity supply and the achievement of state policy goals.

Background

Historically, Maine has produced more energy than it consumed, and total in-state generation has declined considerably over the last 20 years, as shown in **Figure 1**. This result stems largely from the loss of the Maine Yankee nuclear facility in 1996, as well as the build out of significant new natural gas plants and other resources in southern New England states.

Hydro and biomass generation, on the other hand, have been much more consistent over this timeframe as *baseload resources* (resources that generate dependable power to consistently meet demand). By contrast, generation from intermittent solar and wind resources can vary considerably throughout the day and year, which is not necessarily coincident with peak loads. Baseload hydro resources will, therefore, continue to play an important role in the state's economy – not only as long-lasting assets, but also as assets that provide low-cost, locally-sourced, and reliable generation. The need to retain existing reliable baseload hydro resources to support solar and wind development will only grow as the power sector across the Northeast transitions away from fossil fuel generation.

Figure 1. In-State Generation (Excludes Behind-the-Meter Generation)



Source: EIA Detailed State Data (Maine)

Since existing hydroelectric resources are considered to be "existing baseload resources" and new hydro dams are unlikely to be built in the Northeast US, it is easy to overlook the *marginal benefits* to the system that is typically quantified for new solar, wind, or storage resources. Marginal benefits, as applied to existing resources, are best understood as the *value that the system loses without a particular resource in service*. It is also useful to understand what the replacement cost would be to develop other resources to provide an equivalent amount of lost value.

We can calculate the marginal benefits by looking at several metrics discussed in the following sections:

1. **Production costs ($million):** the cost that the system spends on fuel and variable O&M to produce electricity
2. **CO_2 emissions (metric tons):** the volume of CO_2 in system emissions avoided or displaced (also expressed in terms of annual passenger vehicles emission equivalents)
3. **Social benefit from avoided CO_2 emissions reductions ($million):** calculated as displaced CO_2 emissions multiplied by the social cost of carbon (i.e. estimated costs related to CO_2 emissions)
4. **Replacement costs ($million):** the cost to build other resources that provide the same baseload energy volume
5. **Reliability value ($million):** the marginal benefit of reliability based on parameters set by ISO-NE
6. **REC compliance:** the amount of RECs that are generated to comply with Maine Tier II RPS targets

Production Costs

ISO-NE oversees and administers competitive wholesale electricity markets for the six states of New England (serving approximately 14.8 million people).[8] Operating as a single grid, all New England states share generation resources that deliver power through 9,000 miles of high voltage transmission lines (115 kV and above). As a result of significant transmission investments[9] over the past decade, congestion costs in the system have nearly been eliminated.[10] This means that from a generation perspective, most generating resources in Maine have nearly the exact same impact on the overall energy market as a generating resource in any other New England state.

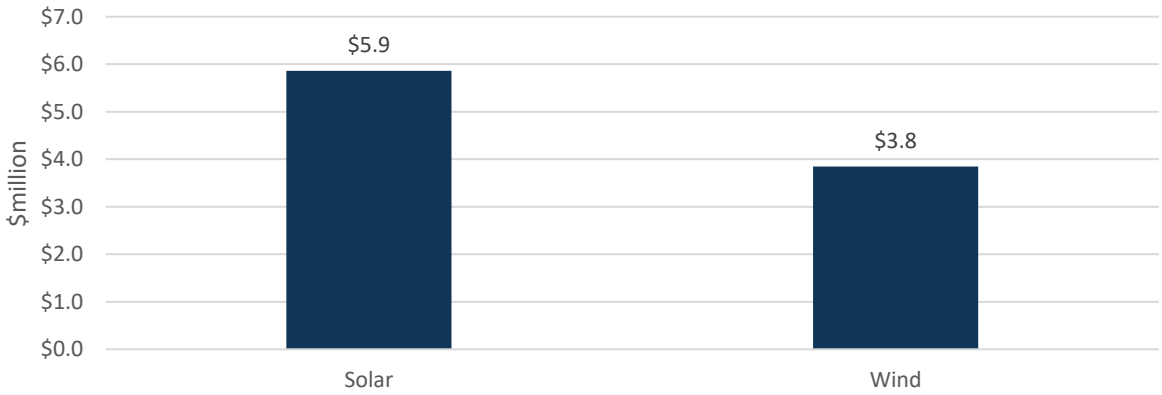
While a single megawatt-hour ("MWh") of energy may be geographically fungible, the impact of clean energy on the system (in terms of system cost and reliability and GHG emissions) varies significantly throughout the day and season. In other words, costs passed on to ratepayers and GHG emissions are more impacted by *when* clean energy is being produced rather than *where* it is being produced. Clean energy resources generally have no variable costs to produce one extra MWh. Therefore, when clean energy resources displace fossil fuel-fired generation resources, which have fuel and other variable costs associated with producing an additional MWh of energy, *production cost* savings are generated in the service of that marginal load.[11] Hydro, solar, or wind would all result in production cost savings, but as a result of the specific generation profile of each resource, the actual annual production cost savings will vary by technology relied upon.

[8] The exception is Aroostook and Washington counties in Maine (approximately 130 MW of load) which is administered by the Northern Maine Independent System Administrator ("NMISA")
[9] Cumulative investment since 2022 through March 2020 was $11 billion.
[10] Congestion arises when one or more restrictions on the transmission system prevents the economic dispatch of electric energy from serving load. While congestion along the major internal interfaces is minimal, some pockets of local congestion still occur throughout the system. These are typically on lower voltage transmission lines.
[11] Production cost savings can be calculated by multiplying the capacity factor (i.e. the percentage of the nameplate capacity) by energy price for a given asset in each hour. The capacity factors for Brookfield Hydros are based on hourly historical generation between 2017 and 2021 and solar and wind capacity factors are based on hourly generation for Maine solar and Wind based on the National Renewable Energy Laboratory's ("NREL") System Advisor Model. https://sam.nrel.gov

To illustrate this, we observed hourly energy prices over the last five years (2017 – 2021) and estimated the annual average reduced production costs.

Figure 2 below shows that by replacing the Brookfield Hydros' 47.2 MW of hydro generation with 47.2 MW of solar or wind, New England would have spent approximately $5.9 million and $3.8 million annually in additional fuel and O&M costs, respectively. In order to reach equivalence in terms of the avoided system production costs, approximately 173 MW of solar or 90 MW of wind would be needed to replace the 47.2 MW provided by the Brookfield Hydros. For an appreciation of scale, that much solar would require approximately 865 acres of cleared land, which is roughly the size of 655 football fields.

Figure 2. Annual Average Increase in System Production Costs by Replacing Brookfield Hydros with 47.2 MW of Solar or Wind

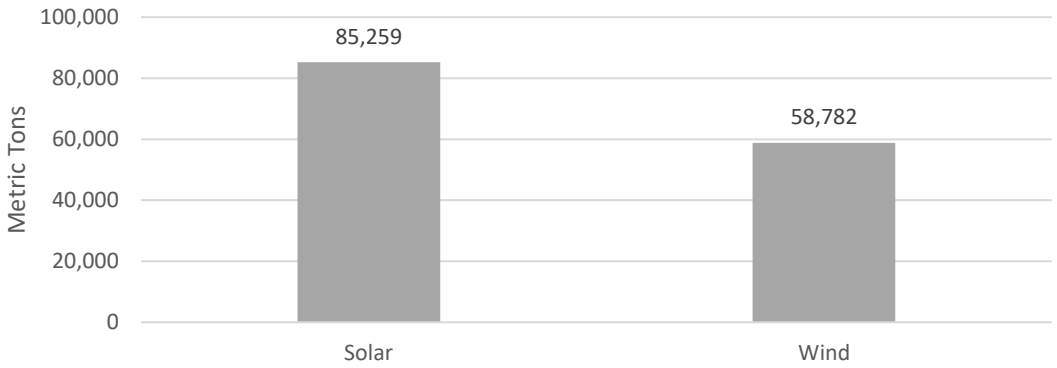


Source: ISO-NE, NREL SAM Model, Brookfield Generation Data

CO_2 Emissions Reduction

Clean resources, such as the Brookfield Hydros, will also reduce the total carbon emissions that would be produced from ISO-NE reliance on fossil fuel generators. In New England, the marginal fuel type is usually natural gas generation, but can sometimes be coal or oil-fired generators. By dividing the hourly energy price by the daily price of natural gas, we can estimate the implied market heat rate of the system. Multiplying the hourly implied market heat rate by the emissions factor for natural gas (117 lbs/MMBtu), we can roughly estimate the amount of CO_2 emissions in the system that are avoided by existing hydro, solar, or wind generation. Over the past five years, the Brookfield Hydros' 47.2 MW of hydro generation have displaced approximately 123,300 metric tons of CO_2 per year. This offsets the annual impact from 26,800 passenger vehicles – a major contributor to Maine's carbon emissions. By comparison, 47.2 MW of solar generation displaces only 38,000 metric tons of CO_2 per year (equivalent to approximately 8,500 passenger vehicles), and 47.2 MW of wind generation displaces only 64,500 metric tons of CO_2 per year (equivalent to approximately 14,000 passenger vehicles). Accordingly, replacing the Brookfield Hydros with 47.2 MW of solar or wind generation would result in increased annual system CO_2 emissions of approximately 85,300 and 58,800 metric tons, respectively.

Figure 3. Annual Average Increase in System CO_2 Emissions by Replacing Brookfield Hydros with 47.2 MW of Solar or Wind



Source: ISO-NE, S&P Global, NREL SAM Model, Brookfield Generation Data

Societal value from CO_2 emissions reductions

There is now abundant evidence and research to suggest that both manmade and natural producers of GHG are causing adverse effects on our health, ecosystems, and long-term economic sustainability. The Interagency Working Group on GHG has conducted substantial research on the total costs associated with carbon emissions, known as the social cost of GHG emissions.[12] Federal agencies quantify and use the estimates of the social cost of carbon and other GHG to allow "agencies to understand the social benefits of reducing emissions of each of these greenhouse gases, or the social costs of increasing such emissions, in the policy making process."

Figure 4. Social Cost of CO2 in 2020 dollars per metric ton

	Discount Rate and Statistic			
Emissions Year	5% Average	3% Average	2.5% Average	3% 95th Percentile
2020	14	51	76	152
2025	17	56	83	169
2030	19	62	89	187
2035	22	67	96	206
2040	25	73	103	225
2045	28	79	110	242
2050	32	85	116	260

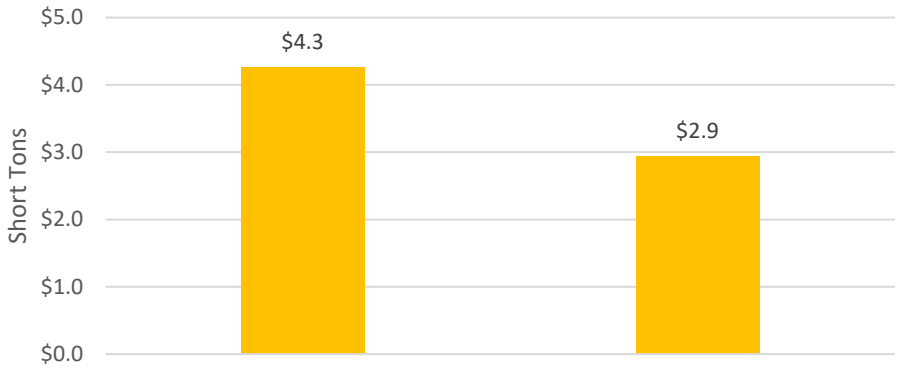
Source: Interagency Working Group on Social Cost of Greenhouse Gases

To calculate the social value of avoided CO_2 emissions, we can simply multiply the volume emissions reduced by the social cost of carbon estimate. By conservatively using the midpoint of $50/metric ton as an estimate of the social cost of carbon, over the past five years, and the

[12] https://www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf

avoided annual CO_2 emission amounts described above, the Brookfield Hydros have reduced global social costs associated with CO_2 emissions by roughly $6.2 million per year. By comparison, 47.2 MW of solar generation in ISO-NE reduced global costs associated with CO_2 emissions by only approximately $1.9 million per year ($4.3 million lower than the Brookfield Hydros), and 47.2 MW of wind generation in ISO-NE reduced global costs associated with CO_2 emissions by only approximately $3.2 million per year (or $2.9 million lower than the Brookfield Hydros).

Figure 5. Annual Average Increase in Societal Costs from CO_2 Emissions by Replacing the Brookfield Hydros with 47.2 MW of Solar or Wind

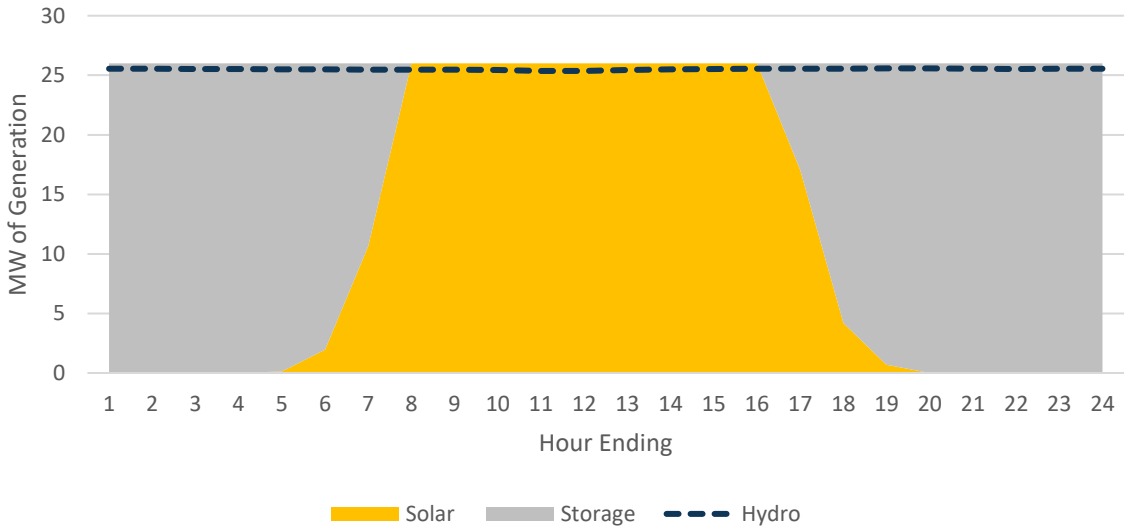


Source: ISO-NE, S&P Global, NREL SAM Model, Brookfield Generation Data

Replacement Costs

One way to close the gap between the CO_2 emissions reduction between hydro and other variable renewables is to pair them (co-locate) with energy storage. The most common type of new energy storage systems being built today utilize batteries. Lithium-ion battery systems, for example, are typically sized to hold between 2-4 hours' worth of dispatch capability. For illustrative purposes, however, we conservatively remove this duration constraint and assume that battery storage can discharge all the energy it can hold over many hours, without round trip efficiency losses (which is typically 15%, meaning it consumes 15% more than it releases on average). Because the average hourly generation profile of the Brookfield Hydros is very flat, to get an equivalent firm "baseload" amount of energy from solar plus storage, the system would need approximately 170 MW of solar *and* nearly 90 MW of energy storage (to hold over 350 MWh of excess solar energy, which is required to keep the generation profile flat). Figure 5 below shows what the generation from this hypothetical facility would look like between solar and storage. If we include the operation constraints for physical battery systems and round-trip efficiency losses described above, the amount of storage required, and related costs, would increase materially.

Figure 6. Firm Baseload Equivalent of Solar + Storage



Source: NREL SAM Model, Brookfield Generation Data

According to NREL, the average capital costs of a four-hour lithium ion battery storage system as well as utility scale solar is approximately $1,300/kW each (excluding grid interconnection costs). This means that the total capital cost for an equivalent baseload solar and a storage system – required to maintain the same system emissions reductions as the Brookfield Hydros' 47.2 MW of capacity – would be roughly $338 million in replacement costs financed through long-term arrangements paid for by electricity ratepayers. Furthermore, because hydroelectric facilities like the Brookfield Hydros have very long useful lives, with many in Maine more than 100 years in age, while solar and wind assets have expected useful lives of only 25-30 years,[13] that $338 million solar-with-storage facility would have to be built and rebuilt successively every 25-30 years to fully replicate the benefits provided the Brookfield Hydros over time.

Reliability

Energy markets are designed to ensure that when homes need to turn on their lights or manufacturers need to fire up their factories, power is available in real-time to meet that demand. When it comes to planning for the future, the grid operator needs to ensure that generation *capacity* will be sufficient to meet days with the highest expected demand plus an additional buffer. Each MW on the system, whether it is producing energy or not, provides *reliability value*.

This value is calculated by ISO-NE as part of their Forward Capacity Auction ("FCA"), which is an annual auction to procure capacity three years in advance of the delivery year. ISO-NE employs

[13] https://www.seia.org/initiatives/recycling-end-life-considerations-photovoltaics
https://www.epa.gov/sites/default/files/2019-08/documents/wind_turbines_fact_sheet_p100il8k.pdf

a demand curve, which represents (in $/kW-month terms), how much reliability each MW provides.

The Brookfield Hydros, with their nameplate capacity of 47.2 MW, provide 18.71 MW of firm capacity value year-round. This represents valuable reliability contributions that can be relied on when system conditions are tightest. Solar and wind, however, are de-rated to lower levels than hydro given their substantially lower expected availability during periods of peak demand.

Unlike this White Paper's assessment of production costs and emissions, it would not be appropriate to use the last five years of demand curves to assess the reliability value lost if the Brookfield Hydros were decommissioned. The capacity market has undergone a number of changes over the last five years, and those benefits would be overstating expected reliability value going forward. For a more conservative analysis, we should observe the demand curve for the most recent auction at the time of this analysis (FCA 15, delivery year 2024/2025). In FCA 15, 15,988.7 MW of capacity cleared at a price of $2.61/kW-month in the Rest-of-Pool zone. In Northern New England (where Maine is located) 8,277 MW of capacity cleared at a price of $2.48/kW-month. If we removed the Brookfield Hydros' 18.71 MW from FCA 15, this would impact both the Rest-of-Pool price and Maine price by approximately 5.6 cents/kW-month. While this impact appears to be small, this would represent approximately $15.9 million (approximately 1.3% of the total $1.24 billion market) in increased capacity market costs due to lower reliability and higher prices.[14]

RPS Compliance

New England states have some of the most aggressive clean energy goals in the country. Maine specifically has established a Renewable Portfolio Standard ("RPS") mandate equal to 80% of annual electricity sales by 2030. While the 2030 goal must rely heavily on installation of new solar and wind power, which largely comprise eligible Class I/IA generation, satisfaction of current and future directives will also depend on existing renewable generation (Class II), including Maine-located hydropower, in an amount equivalent to 30% of annual electricity sales, or approximately 38% of the overall 2030 requirement.[15]

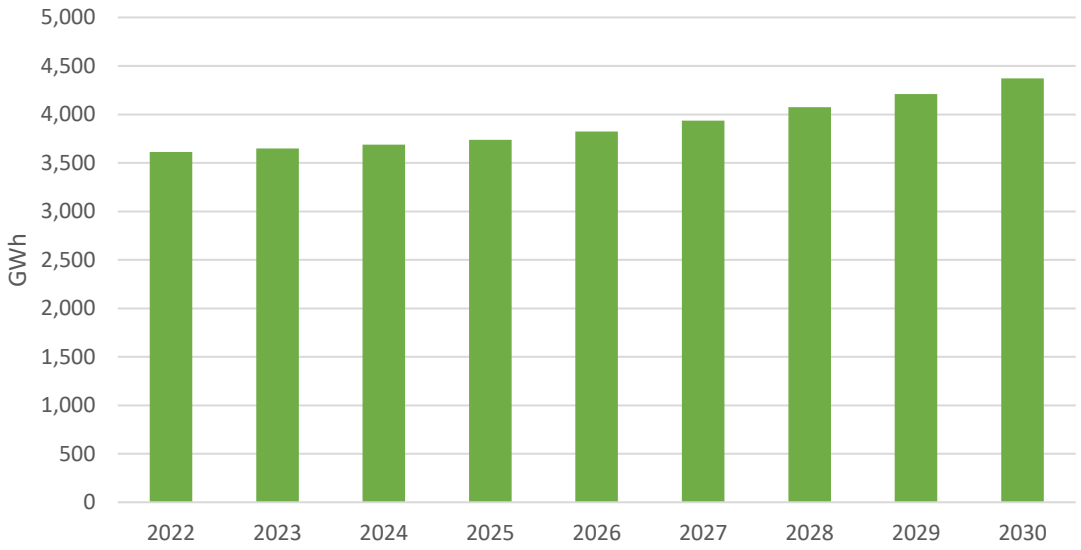
Notably, because the RPS Class II program is limited to existing resources, including the Brookfield Hydros, it is inherently limited in supply. By contrast, program requirements are based on a percentage of annual electricity sales, and annual demand will likely increase substantially in future years, particularly as electrification of transportation systems and residential and commercial cooling and heating expands. Furthermore, voluntary buyers, including medium and large corporate buyers with sustainability and carbon reduction goals, will compete with the state for these same resources. In simplest terms, static supply and expanding demand will likely drive up compliance costs for the Class II program.

The loss of the Brookfield Hydros in particular would remove well in excess of 200,000 Class II Renewable Energy Credits (the mechanism that conveys the "renewable" claim) from the

[14] Values derived by calculating the elasticity of the demand curve and finding the difference in RoP capacity prices. Prices were then multiplied by the appropriate supply levels (with and without the Brookfield Hydro) to arrive at differences in total costs for Rest of Pool and the Northern New England zone. < https://www.iso-ne.com/static-assets/documents/2020/09/a2_fca_15_demand_curves.xlsx>
[15] https://www.maine.gov/energy/initiatives/renewable-energy/renewable-portfolio-standards

compliance market each year, creating additional upward pressure on annual RPS costs borne by ratepayers. This supply represents approximately 5% of total Maine II demand, which demand will continue to increase (see Figure 7). Depending on electricity demand growth trajectory, resource retirements and expanded competition from voluntary markets, the loss of the Brookfield Hydros' Class II RECs could result in hundreds of thousands or even millions of dollars in added annual costs to Maine ratepayers.

Figure 7. Projected Maine Class II Demand



Source: Demand data based on net demand forecast in ISO-NE's CELT 2021 Forecast

New solar and wind, however, cannot replace or offset this Class II supply and in many cases will not be available to Maine ratepayers at all. Consider, for example, the results from recent long-term Class IA procurements administered by the Maine Public Utilities Commission per directives of LD 1494 (2019).[16] Awards for new solar and wind were almost exclusively energy-only.[17] The reason for this is that new solar and wind RECs are fungible across each of the Class I/Tier I New England states' RPS markets, including Massachusetts, which has historically realized higher prices for Class I RECs than the Maine RPS program. In other words, project developers convey project RECs to the market with the highest pricing – a rational economic decision that is not impacted by the location of the resource. Maine will therefore be in direct, and disadvantageous, competition with other New England states better positioned to pay higher prices for RECs for new resources, even for those flowing from new renewable generation sources located in Maine.

The result in this case is that Maine will find it very costly to claim the renewable attributes and meet its carbon reduction/RPS mandates with these new resources. In other words, although the loss of Brookfield Hydros would have a clear impact on the ability of Maine to meet its policy goals, and the cost associated with doing so, Maine will not be able to rely on newly constructed

[16] http://www.mainelegislature.org/legis/bills/getPDF.asp?paper=SP0457&item=3&snum=129
[17] 2020 and 2021 Class IA RFP awards available here: https://mpuc-cms.maine.gov/CQM.Public.WebUI/Common/CaseMaster.aspx?CaseNumber=2020-00033

solar and wind resources as a one-to-one replacement of the Brookfield Hydros given the aggressive competition for RECs from those resources across the New England state markets, resulting in higher prices for RECs.

Finally, it is worth highlighting that – as has been widely reported[18] – considerable challenges remain for the deployment of new renewable energy in Maine. This includes land use restrictions, shifting policies limiting new resource opportunities[19] and, most significant, barriers and costs associated with interconnection to the electricity grid. Interconnection challenges, in particular, will delay many projects and will, in all likelihood, add significant project costs that could threaten project economics and viable deployment. While improving the ability for these projects to advance is laudable and, indeed, critical to meeting Maine's and the region's goals, these limitations cannot be ignored or dismissed and the available and known contributions of existing renewable resources, including from the Brookfield Hydros, must be considered comparatively.

As mentioned above, replacement of the Brookfield Hydros with a solar project that would yield the same reduction in system costs would require a solar project covering a total of 865 acres of cleared (likely forested) land. Given the regulatory climate and environmental sensitivities in Maine, obtaining approval for such amount of solar will likely prove challenging.

Conclusion

To summarize, solar, wind and storage are all critical to helping Maine achieve its decarbonization goals. Resource diversity however, especially baseload renewable energy, is also a major key to achieving those goals. This paper demonstrates the substantial societal value that would be lost from decommissioning 47 MW of hydro in Maine, equivalent to the Brookfield Hydros, as well as the replacement cost needed to recover that lost value through construction of new solar or wind generation. The key finding is that not all resources are equal when it comes to *value* for the system and replacing that lost hydro value will come at significant expense for Maine ratepayers.

[18] https://www.pressherald.com/2021/02/08/mills-calls-on-maine-puc-to-investigate-cmp-solar-snafu/
[19] An Act to Amend State Laws Relating to Net Energy Billing and the Procurement of Distributed Generation (2021): https://legislature.maine.gov/legis/bills/getPDF.asp?paper=HP0692&item=6&snum=130. In addition to prior policy changes, it is possible that future Administrations and Legislatures could pursue even more restrictive policies to solar deployment.