Kurt Adams

Testimony in Opposition to LD 2077

1.23.24

Chairman Lawrence, Zeigler, and members of the Energy and Utilities Committee,

I am Kurt Adams, President and CEO of Summit Utilities. I am proud to lead the great teams at Summit Natural Gas of Maine and Peaks Renewables, as well as energy companies in four other states.

I was raised in Kittery and now live in Yarmouth. My kids are the 15th generation of my family to fish Maine waters and hunt in our forests. There is no greater risk to our way of life than climate change. It is a crisis that demands all of our attention and the reason we are here today.

I have been an attorney representing renewable energy companies, Chair of the Maine Public Utilities Commission, and for nearly a decade, the Chief Development Officer of one of the nation's leading wind and solar developers. Through my work, it became evident to me that while renewables like wind and solar are crucial, they alone won't achieve our climate goals.

Put simply, we have not developed even a fraction of the tools we need to reduce GHGs. The challenges of intermittency, interconnection and storage – that this committee has worked valiantly to address – still stand before us as major obstacles to progress. Green molecules can help.

Through our investments in Maine, Summit Utilities' infrastructure provides a model for another powerful tool in the climate change toolbox.

Today, Summit Natural Gas of Maine delivers mostly conventional energy, providing Mainers with a cost-effective way to warm their homes and fuel their businesses. However, we are taking steps and preparing to transition Summit's Maine distribution system. For example, we were one of the first gas utilities in the country to enable customers to offset their energy usage with renewable natural gas credits. And our Peaks Renewables affiliate invested more than $25 million developing a renewable natural gas digester in Clinton at Flood Brother's Farm. Today, that facility supplies 45% of Summit Natural Gas of Maine's residential energy supply with locally generated gas, while selling the renewable attributes to third parties.

In addition, clean hydrogen can also play a zero carbon role in modern pipeline systems. Peaks Renewables is proud to have been awarded a nearly $5 million grant from the Department of Energy to develop a first in the nation bio-green hydrogen project to be co-located at our facility in Clinton.

A recent study by McKinsey & Company found that if national pipeline companies transitioned existing infrastructure into a clean fuels network, we could reduce the cost of decarbonizing up to 80% when compared to the cost of an electrification-only approach to emissions reduction[1].

Bans like LD 2077 punish companies like Summit that are investing in emissions reduction technologies, creating jobs, and offering lower cost energy solutions to families and industry throughout the state.

And it is wholly unnecessary.

There are several proceedings in Maine where the next stage of climate policy is already being formulated. From the Climate Council, the Governor's Energy Office study on emissions reduction pathways, to a current PUC proceeding on RNG, and a hydrogen bill before this very committee, dialogue around how best to achieve our climate goals at the lowest cost is occurring. Green molecules, hybrid

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[1] Decarbonizing US gas utilities: The potential role of a clean-fuels system in the energy transition | McKinsey

heat, and other symbiotic efforts between our electric and gas grids will continue to be important pieces of that dialogue. This bill adds nothing to those thoughtful proceedings and is nothing more than a painful distraction.

Mainers are resilient and resourceful. We can develop an energy system that is cost-effective, reliable, and clean but not if we ignore, or worse, ban, powerful tools to help get us there. Please oppose LD2077.

McKinsey & Company

Electric Power & Natural Gas

Decarbonizing US gas utilities: The potential role of a clean-fuels system in the energy transition

March 2, 2022 | Article

US natural gas utilities and combined electric and gas utilities have an opportunity to convert their infrastructure into clean-fuels networks—a move that could help enable a decarbonized energy system.

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Many players across the energy sector face a common challenge: reimagine businesses as usual now or risk falling behind in the transition to net-zero carbon emissions. In the United States, local natural gas distribution companies (or gas utilities) and combination electric and gas utilities have a unique opportunity to help enable this transition.

Today, natural gas combustion contributes about 20 percent of global CO_2 emissions.[1] The industry also contributes about 30 percent of total methane emissions, another greenhouse gas, typically from pipeline leakage (see sidebar, "Fugitive methane emissions"). In the United States, some municipalities and states have imposed an outright ban on new gas connections or made them more difficult to obtain.[3] At the federal level, there has been an increase in spending proposals to shift away from natural gas as a power and heat source and move toward renewables and electrification.[4] But at the same time, natural gas is being recognized for its necessary role for backup and resiliency in a wide variety of systems, from the Northeast to Texas to California.

Uncertainties are inevitable in decarbonization planning on a system-wide level, as technologies, customer needs, and policies continually evolve. Gas utilities could face a range of scenarios, including high rates of electrification with significantly declining gas consumption, or more moderated electrification with transitions to biogas,[5] carbon capture, or hydrogen. As gas utilities consider different decarbonization pathways, they will need to plan for different business trajectories amid the uncertainty, while keeping the immediate needs of society and customers, as well as their obligations to shareholders, top of mind.

To solve for these challenges, some US gas utilities are considering the role their resources and infrastructure will play in a decarbonized future. According to our research, gas utilities are uniquely positioned to develop and invest in a clean-fuels system (see sidebar, "About our research"). Such a system could deliver a mix of biofuels and hydrogen to a subset of the customers the gas utilities already serve; supply new sources of demand such as shipping and aviation; transport carbon to and from carbon capture, utilization, and storage (CCUS) sites; and support an expanded low-carbon electricity grid.

Gas utilities own and operate infrastructure that can be partially repurposed to deliver clean fuels. They have the deep energy-systems knowledge and expertise that's needed to develop new infrastructure, comply with regulatory processes, and bring together the necessary stakeholders. In addition, they have the touchpoints needed to help educate customers on the broader energy-system transition and facilitate the changes customers might need to make. Many gas utilities also operate beyond the local natural gas distribution business—for example, with businesses in liquefied natural gas, electric-power production or distribution, or in natural gas midstream operations—that can have synergies with a clean-fuels network. Gas utilities that take the lead toward a clean-fuel future may be positioned to also help drive the innovations needed for the transition to a clean-fuels system—instead of protecting the existing asset base without a decarbonization plan. Our findings, as discussed below, are based on economy-wide decarbonization analyses conducted for a range of United States–based utilities that have examined the role of gas in enabling a decarbonized future for their service territories.

Since a clean-fuels system is tied directly to current fossil-fuel infrastructure and resources, the question of what to do with that infrastructure stirs debate. Some argue for the outright decommissioning of fossil-fuel infrastructure and a full-on transition to electrification. Others might dismiss electrification as too difficult, since a drop-in replacement fuel like biogas could meet current gas demand. Our research suggests that both positions miss the critical complexity of the problem and that a hybrid approach will likely be more feasible.

A clean-fuels future could provide some gas utilities with an opportunity to repurpose certain assets, invest in new ones, and work with electric utilities, policy makers, commercial and industrial customers, investors, and other stakeholders on system-wide decarbonization. In this article, we'll outline the potential value of regional clean-fuels networks, different options for what the infrastructure shift would look like, and a path forward.

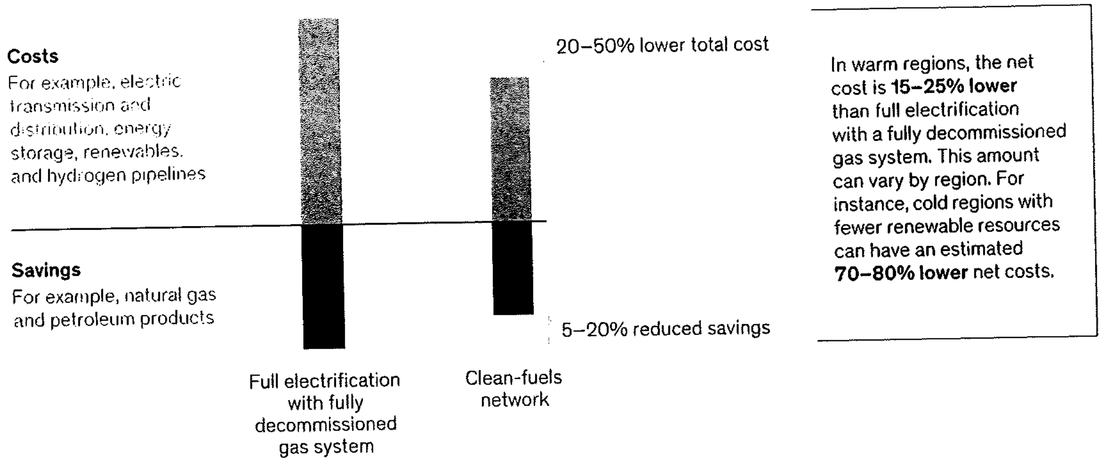
The value of a clean-fuels system

A clean-fuels system has the potential to support and help facilitate a decarbonized US energy system. Green hydrogen (made with renewables), blue hydrogen (made using natural gas and CCUS), and biogas are low-carbon energy sources that can complement renewable sources on an electric grid—which is important, since electricity demand from transportation, building-heat electrification, and the industrial sector is expected to increase in the coming years. Pipelines in a clean-fuels system can also transport carbon from points of capture to sites for sequestration or utilization. Our modeling shows that a decarbonization pathway for the energy system based solely on electrification, renewables, and storage, without clean fuels or carbon sequestration, results in a net higher societal cost (Exhibit 1). An energy system with a clean-fuels network would lower overall cost to society and create potential opportunities for gas utilities to invest in the energy transition. Investments in a clean-fuels infrastructure could be suited for a regulated utility since first, they will require a long horizon—potentially several decades—and second, they must be made early enough to accelerate the market transition.

Exhibit 1

Modeling shows that converting a regional, US gas system into a clean-fuels network could reduce societal costs for deep decarbonization.

Net present value of societal costs and savings comparing a fully decommissioned gas system with the conversion to a clean-fuels network,[1] illustrative



[1]Based on a clean-fuels system that is built and operated at the lowest societal cost.

McKinsey & Company

A clean-fuels system could potentially create value by supporting an affordable and resilient net-zero electric system; shifting demand to new customers to enable decarbonization in hard-to-abate sectors; transporting carbon from sources to sinks; and diversifying pathways to decarbonization.

Supporting an affordable and resilient net-zero electric system.

Numerous studies and our own analysis have shown that, in a decarbonized energy system, thermal-generation capacity is the most affordable pathway to maintain power-system reliability and resiliency when renewable supply is low or demand is high over multiple days.[6] Clean fuels like green or blue hydrogen or biogas can potentially be used in these same generators. Natural gas can also be used in the system if needed to meet demand. But to achieve full decarbonization, the associated emissions, including fugitive emissions across the value chain, must be negated in other areas—with carbon capture and sequestration, for example.

Shifting demand to new customers to enable decarbonization in hard-to-abate sectors. McKinsey analysis has found that up to 30 percent of energy-related CO_2 emissions are hard to abate solely with electrification. Heavy-duty transportation, marine, shipping, aviation, and high-temperature industrial processes (for example, steel production), which have historically relied on burning fossil fuels, can be challenging to electrify given high-power requirements. Many of these industries are exploring hydrogen and other clean fuels as potential decarbonization solutions.

Parts of the building sector are also challenging to decarbonize. For example, in colder climates, the electrification of heating may be cost-effective in the mildly cold seasons (fall, spring) but can be cost-prohibitive in the winter, when heating demand would require very high electric-system capacity. Additionally, certain types of buildings are more expensive to electrify, including old buildings that could require costly rewiring and panel upgrades, or multifamily structures that require building-wide retrofits. As an alternative to electrification, hydrogen blended with other low-carbon fuels could be combusted on a building's site for steam-based heating, although this would require technology and infrastructure upgrades and measures to resolve current cost and energy inefficiencies. Pilots of such heating systems are already under way in other countries, such as the United Kingdom. [7]

Transporting carbon from sources to sinks. Carbon emissions can be captured directly from hard-to-abate sources, such as large power plants and industrial users. Or, to generate negative emissions, carbon can be withdrawn from ambient air via direct air capture (DAC) or from bioenergy production. In instances where carbon capture sites are not colocated with sequestration or utilization sites, pipelines can be used to cost effectively transport large volumes of carbon. To date, the use of carbon capture has been limited due to high costs and high energy requirements. But new technologies are emerging, and increasing investment is going toward CCUS.

Diversifying pathways to decarbonization. There are many unknowns and uncertainties inherent in system-wide decarbonization planning. Overreliance on a singular pathway could lead to an increased concentration of risk. For example, if a grid with energy-storage technology cannot provide enough capacity for longer durations, then sole reliance on electrification, renewables, and storage would threaten the reliability of that grid. Diversification could help reduce such risk—and clean fuels offer a pathway for decarbonization, particularly as an energy-delivery network that works alongside the electricity system.

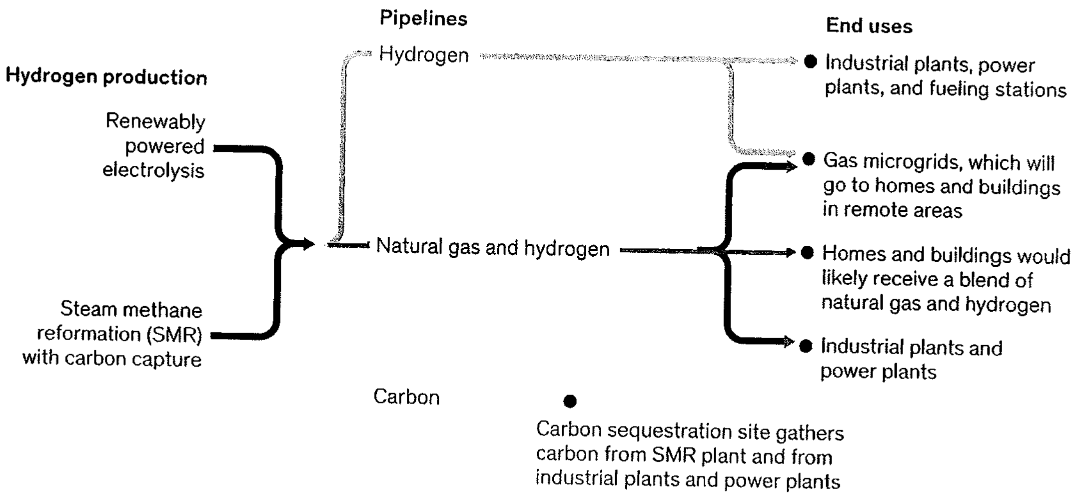
The infrastructure shift for gas utilities

Gas utilities will need the right clean-fuels infrastructure to deliver on these value propositions (Exhibit 2). Gas utilities with experience in pipeline development and maintenance, operating in accordance with regulatory structures, and financing large-scale infrastructure projects may be well positioned to build and own the required assets. A clean-fuels system could present opportunities for other players as well, such as those that have experience in energy infrastructure development.

Exhibit 2

A different system architecture could emerge to support a decarbonized gas network.

Example of a clean-fuels network[1]



[1]Our analysis shows that there will likely be scenarios [illegible] existing pipelines are no longer needed. These pipelines can potentially be [illegible] stakeholders.

McKinsey & Company

The infrastructure options for gas utilities could include the following:

Repurposing infrastructure. Today's gas-delivery infrastructure—including transmission and distribution (T&D) pipelines, compressor stations, and other equipment—could be used to transport certain renewable fuels, such as biogas.[8]

Transporting hydrogen, however, would require changes to the existing infrastructure. Existing pipelines could be repurposed, with varying levels of retrofits, to transport limited amounts of hydrogen blended with natural gas. The more hydrogen transported, the greater the retrofit required, which in turn depends on the ability of end users to accommodate hydrogen, pipeline age and operating conditions, pipeline materials, and location of the pipeline within the system. With respect to materials, polyethylene plastic distribution lines can accommodate 100 percent hydrogen with limited upgrades,[9] whereas high-pressure steel pipelines—particularly those with higher tensile strength—will likely require extensive upgrades even at lower hydrogen blend levels. New technologies for hydrogen delivery would be required too, such as membranes for hydrogen extraction from blended gas pipelines and new ways of tracking pipeline safety. Beyond pipelines, other equipment in the network—like compressor stations—could require expensive upgrades or replacements, depending on the level of hydrogen.

Gas utilities are already making commitments and investments. Southern California Gas Company (SoCalGas), the largest gas utility in the United States, has committed to achieving net-zero emissions by 2045. To achieve this goal, SoCalGas is working on a number of initiatives, including developing standards for hydrogen blending.[10]

Decommissioning. In some regions, the existing gas infrastructure may no longer justify the ongoing cost of safe and reliable maintenance or may be too expensive to upgrade for clean fuels. In such cases, communities and utilities can explore options for decommissioning safely and affordably while still meeting customer needs—for example through electrification, enhanced energy storage, and clean-fuel microgrids for resiliency or backup. Decommissioning more expensive portions of the existing network could also allow for more room for expanded investments in clean-fuels infrastructure. Decommissioning is more likely for distribution pipelines that serve primarily residential areas, as compared with transmission pipelines that serve generators and industrial customers or transport gas through a utility's territory.

Decommissioning will likely require stakeholder buy-in, regulatory direction, and rigorous planning and communication with customers. For example, customers whose appliances previously relied on gas will likely need ample warning, time, and resources to convert their appliances to electric power. Poor planning and communication during conversion could lead to service interruptions or rushed and expensive equipment replacement. Such experiences could create customer backlash that slows buy-in to decarbonization efforts. Furthermore, to ensure that adequate investment is made to maintain the safety and reliability of assets up until the point of decommissioning, gas-infrastructure owners and regulators may want to consider mechanisms such as accelerated depreciation and securitization, financial tools that have been explored in the decommissioning of coal assets.

Building new hydrogen transport infrastructure. As demand potentially increases in some regions, a dedicated hydrogen transportation network can deliver to high-volume end uses, such as industrial customers and transportation hubs (airports and ports, hydrogen-fuel stations for long-haul trucking). Depending on location, pure hydrogen infrastructure could be a more cost-effective investment than infrastructure that supports blended hydrogen.

Building new carbon transport infrastructure. Carbon management may rely on pipeline transportation to move CO_2 from sources (power plants, large industrial customers) to sinks (sequestration sites, industrial carbon consumers) where they are not colocated.

Variation by regions

Throughout our in-depth modeling in different regions, one thing became clear: there is no one-size-fits-all clean-fuels solution. However, clean-fuels hubs could be built in select areas to support heavy industry, clean-fueling stations could support heavy-duty long-haul transportation, and clean fuels could provide electric-grid resiliency in locations that need it. The optimal clean-fuels system configuration could be influenced by a series of factors, including the following:

- *Climate.* In warmer regions, like the Southwest and Southeast, building heat could become increasingly electrified, which means that a pipeline system could be much leaner than it is today—versus the Northeast and Midwest, where fuels might be more necessary to meet heat demands in the winter.

- *Renewable resource availability.* Regions with high-wind resources, like the Midwest, or ample solar resources, like the Southwest, could be better positioned to produce green hydrogen—meaning certain areas could become hydrogen hubs that support hard-to-electrify sectors.

- *T&D system constraints.* Large, dense urban centers can have challenges meeting electricity demand. Although urban gas system upgrades are not low cost, in some instances they could be more feasible than adding electric-system capacity, particularly new transmission. Buildings in areas like Los Angeles and New York City could potentially rely on clean fuels to help balance demand, compared with regions that have excess electric-grid capacity or the ability to build additional capacity at relatively low cost.

- *Carbon sequestration availability.* Regions with access to safe and relatively low-cost carbon sequestration sites can in some cases more cost effectively continue to use natural gas, capturing and sequestering the carbon that's emitted. Given state-focused decarbonization targets, states without carbon sequestration potential will likely rely more heavily on renewables.

- *Customer makeup.* As mentioned above, some sectors, like heavy industry and heavy-duty transportation, can be harder to electrify than others. Clean-fuels hubs could potentially support regional industrial clusters, for example, areas around ports, airports, and along freight transit corridors.

- *Building stock.* Regions with significantly old building stock can compare the costs of making upgrades to accommodate electrified heating with the costs of implementing a clean-fuels system.

Planning given uncertainty

As mentioned earlier, any system-wide decarbonization planning is inevitably uncertain due to evolving technologies, customer needs, and policy. To set strategy under uncertainty, ongoing assessment and reassessment of potential trajectories is key and requires analysis and pilots to test hypotheses and to understand costs and feasibility. As gas utilities plan for and begin to move along decarbonization pathways, critical sensitivities—such as technology cost, performance trajectories, and customer adoption rates—will need to be identified so risk-mitigation plans can be put into place and signposts can be monitored. While there are likely to be some "no regret" opportunities across different scenarios, plans could be designed to cost effectively preserve optionality. For example, while the ultimate role and scale of carbon sequestration is not yet known, utilities could be assessing the viability of potential technologies, sequestration sites, and the cost and feasibility of CO_2 pipelines in their territories.

Furthermore, players across the system, including regulators, are recognizing the need to have more integrated planning across electric, gas, and transport systems but have yet to conclude how to solve the decarbonization issue. This may be a significant barrier to delivering the energy transition that requires urgent attention. Take building electrification, for example. Electric utilities could consider planning for a range of scenarios to make sure their systems have adequate capacity. If capacity upgrades cannot be cost effectively or practically achieved at a particular building, such challenges could be communicated with the gas utilities in the same territory so that an integrated energy-delivery plan can be developed. Planners across the energy system will likely need to work toward a collective view on how to ensure reliability and resiliency across their territories and consider a range of different decarbonization scenarios.

The path forward

Working with stakeholders, gas utility leaders can develop a strategy to evolve today's natural gas system into a clean-fuels network that enables economy-wide decarbonization while meeting the critical system needs of affordability, safety, reliability, and resiliency. To enable this transition, engaged and informed utilities can consider the following steps.

Invest in needed infrastructure. The transformation of the current natural gas system to a clean-fuels system will likely require billions of dollars of investments at the state and utility level. For example, in Europe, the estimated cost to convert the natural gas system into a "hydrogen backbone" is €27 billion to €64 billion, based on estimates that 75 percent of the system can be built from existing natural gas pipelines and 25 percent will require new pipelines.[11] While these investments are significant, our modeling suggests that they often result in a more affordable decarbonization pathway than scenarios that rely solely on the electric system and decommissioning of the gas system. In addition, there are likely opportunities to drive capital efficiency, which will be critical to maintaining affordability for customers.

Reevaluate planned investments. As natural gas consumption declines, gas utilities, in collaboration with regulators and other stakeholders, will likely need to assess potential spend reductions where appropriate (subject to regional safety needs and standards). Utilities can consider paths to minimize new gas connections, evaluate planned investments, and potentially make headroom for investments elsewhere. Additionally, gas utilities and stakeholders can conduct analyses on whether parts of the existing network can be cost effectively decommissioned.

Catalyze new markets. Public- and private-sector support will likely be needed to accelerate a market transformation and help scale the necessary new market players such as hydrogen producers, carbon-capture players, owners and operators of carbon sequestration technologies, downstream hydrogen players (fueling-station operators, fuel cell companies, hydrogen turbine manufacturers) and contractors that implement building efficiency and electrification. Some utilities are already investing in biogas procurement or development, for example. Given supply limitations, our research suggests that biogas is likely to be a relatively small part of the ultimate deep-decarbonization solution, but it is a lever gas utilities can consider in the near term, given that the technology to produce it at scale exists today and that, with proper conditioning, biogas can be a drop-in fuel for existing gas delivery infrastructure.

Early investments and commitments from utilities to build the interconnections and the fuel-delivery infrastructure could attract more market players and additional investment, helping to drive down the cost curve for critical clean-fuel technologies. Utilities can also pilot such technologies within the context of their service territories. In this instance, the clean-fuels industry can learn from the renewable-power industry in that early mandates and utility commitments to procure renewable generation helped scale the utility solar industry, driving down costs and encouraging new private investment in the market.

Support innovation. To facilitate a lower-cost and more rapid transition to a clean-fuels system, gas utilities can consider supporting the development and testing of needed technologies, working with researchers, technology companies, and policy makers to refine assumptions and pathways as these technologies evolve. Technology innovations could be required, such as for electrolysis for hydrogen production; hydrogen delivery and use; hydrogen-fueling-station infrastructure; large-scale fuel cells; carbon capture, including DAC; carbon sequestration; and bioenergy production.

Reallocate costs and redesign rates. According to our modeling, declining gas consumption will likely result in increased customer gas rates under current cost-allocation and rate-design structures—unless the gas-system spend is scaled back commensurately. Increasing gas rates could motivate some customers to opt for electrification, leaving customers who are unable to pay the up-front cost of electrifying their homes paying the fixed infrastructure cost for the gas system. To manage the system in a way that provides reliable, affordable energy to all system users, integrated system planning and rates analyses can be conducted to evaluate how costs can be allocated equitably across gas and electric systems.

Support customer transitions. Utilities could help manage the customer transition—whether that transition is a change to new fuels like hydrogen, a shift to electrification, or some combination of the two. In many regions, for example, electrification will likely be a cost-effective decarbonization lever for buildings. Several policies and new building codes already exist or are expected to be put in place to drive adoption of electric appliances for space and water heating, such as New York's efficiency and electrification order,[12] which sets utility targets for heat-pump adoption. Utilities can actively help facilitate such local transitions by developing incentive-based programs, similar to existing energy-efficiency programs, that help customers transition to electric appliances or, where appropriate, appliances that have higher hydrogen-blending thresholds. Utilities can also work with their contractor networks to help upskill installers and electricians to install heat pumps or other needed equipment.

Utilities, working with regulators and other stakeholders, can intentionally assess impacts on low-income communities and develop the policies and programs needed to ensure an equitable transition.

Participate in cross-stakeholder discussions, including integrated system planning. The scale and impact of these transitions will require gas utilities to navigate a complex energy landscape with multiple stakeholders—electric utilities, customers, and policy makers, to name a few. Considering the electric utility in particular, gas leaders can help move "gas versus electric" decarbonization debates—which can happen among utilities, regulators, and other stakeholders—into conversations about system-wide solutions. Gas utilities can consider collaborating with policy makers and other stakeholders to drive this dialogue, bringing proposals forward that define the value of a clean-fuels system and outline its role in a net-zero economy.

Understand the implications. For gas utilities to take these actions and establish themselves as enablers of the energy transition, it's important to understand how decarbonization pathways impact the region, customers, and the utility business. To achieve this, utilities can undertake detailed modeling that does the following:

- takes a cross-sectoral view—integrating not just the electric and gas systems but also transportation, buildings, and industry

- considers the long view, going past conventional planning horizons of 2025 or 2030 to evaluate what's needed to meet long-term (2040, 2050) decarbonization targets
- models at a regional or national level so that territory-specific dynamics are captured within the context of broader decarbonization, with implications for resource availability and cost

Create a road map. Utilities can consider developing a road map and investment plan for different decarbonization pathways, to help guide them during times of uncertainty. This road map can be used as a starting point to engage stakeholders and coordinate across interconnected systems. The energy transition will arguably create the biggest change for gas utilities since their formation. It's critical to understand what investments are required by when, what signposts to monitor, and to have an analytics-backed viewpoint for stakeholder discussions.

Act now. The transition to a clean-fuels system will likely take decades. Many stakeholders and regulators will need to align around a path forward. From there, planning, piloting, testing, and demonstration could take many years, based on the nascency of the technology and how the technology evolves over time. Once technologies are validated, the timeline for large-scale infrastructure development can take decades and will require investors, permitting agencies, unions, and other stakeholders to work together on design and construction. Historically the industry has been slow to move on large-scale transformations. Utilities must act now to help achieve net-zero goals and manage affordability in the future.

For gas utilities, the transition to a clean-fuels network would be a full transformation. The physical environment, utility business models, regulatory structure, and customer experiences would all shift. While executing this transformation rapidly, cost effectively, and safely will be a monumental challenge, it is also an opportunity for gas utilities to lead system-wide improvements, provide higher levels of service to their customers, and enable the decarbonization of the economy.

1. *Global Energy Review 2021*, International Energy Agency, April 2021.
2. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2019*, US Environmental Protection Agency, April 2021.
3. "Mayor de Blasio signs landmark bill to ban combustion of fossil fuels in new buildings," City of New York, December 22, 2021; "Mayor Durkan announces ban on fossil fuels for heating in new construction to further electrify buildings using clean energy," City of Seattle, December 3, 2020.
4. "Fact sheet: Biden administration accelerates efforts to create jobs making American buildings more affordable, cleaner, and resilient," White House, May 17, 2021.
5. For more detail on the impact of methane emissions, see Curbing methane emissions: How five industries can counter a major climate threat, September 23, 2021.
6. Biogas (or renewable natural gas), when processed for injection into pipeline infrastructure, is commonly referred to as biomethane. Throughout this article, we use the term biogas.
7. For more on how the US power sector can potentially match power supply and demand in a decarbonized energy system, see "Net zero by 2035: A pathway to rapidly decarbonize the US power system," October 14, 2021.
8. The HyDeploy project in the United Kingdom started with a pilot from 2019 to 2021, which demonstrated hydrogen blending in the natural gas system of Keele University. The second phase of HyDeploy proposes to blend hydrogen into a public gas network in the northeast of England.
9. Producing and delivering biogas results in fugitive methane emissions, just like fossil natural gas. To enable a low emissions system, even with biogas in the pipelines, a clean-fuels network would need to minimize fugitive emissions. For more on managing fugitive methane emissions, see sidebar, "Fugitive methane emissions."
10. Olga Antonia, Marc W. Melaina, and Michael Penev, *Blending hydrogen into natural gas pipeline networks: A review of key issues*, National Renewable Energy Laboratory, March 2013.
11. "SoCalGas begins hydrogen blending tests," SoCalGas, October 1, 2021.
12. Maud Buseman et al., *2020 European hydrogen backbone*, Gas for Climate, July 2020.
13. "Order authorizing utility energy efficiency and building electrification portfolios through 2025," State of New York Public Service Commission, effective January 16, 2020.