nationalgrid

Northeast 80x50 Pathway

Clean Energy, Efficiency, and Electrification: National Grid's Northeast 80x50 Pathway

This paper presents National Grid's integrated blueprint for New York and New England to reduce greenhouse gas emissions deeply below 1990 levels while supporting economic growth and maintaining affordability and customer choice. Our approach combines several mutually-reinforcing strategies that together provide a clear pathway to significant emissions reductions and signal a paradigm shift in the way we all relate to energy. National Grid is keen to achieve greater collaboration within the Northeast on this pressing and critical issue.

EXECUTIVE SUMMARY

Climate change threatens our quality of life and the livability of planet earth. To reduce the risk that global temperature increases more than 2 degrees Celsius above pre-industrial levels, greenhouse gas (GHG) emissions in developed countries must fall by approximately 80% below 1990 levels by 2050 ("80x50"). Commitments to reduce GHG emissions by this level are in place across the Northeast U.S., spanning New York and all New England states. Similar targets are in place in the European Union, the United Kingdom, and in other U.S. states such as California, Oregon, and Washington.

The Northeast has emerged as a leader in achieving these targets, with the electric sector leading the way. 2015 emissions from power generation were nearly 50% below 1990 levels, driven mainly by energy efficiency, conversion from coal and oil-based generation to natural gas, and deployment of renewable electricity. The most recent data (2015) shows that the Northeast has achieved a 16% economy-wide GHG reduction below 1990 levels. Emissions in 2015 related to heating (for space and water heat in homes and businesses as well as industrial heat processes) were roughly 12% below 1990 levels driven by energy efficiency and oil-to-gas conversions. Reducing transportation emissions has proven more difficult, with emissions still at 1990 levels (or even higher) across the region.

As one of the largest energy companies in the Northeast, we play a vital role in connecting millions of people to the energy they use. Believing in the science of climate change, we take the climate change challenge to heart, and are keenly aware of both the economic costs of inaction as well as the economic opportunities associated with low-carbon innovation. For these reasons, we've developed an approach that will propel our region forward toward greater greenhouse gas emission reductions. The *National Grid Northeast Pathway ("the Pathway")* is an integrated approach to taking action across the three dominant sectors of combustion-related CO_2 emissions: electricity generation, transportation, and heat.

Importantly, the emissions reductions realized to date relied largely on shifts in the electricity generation fuel mix. In contrast, the reductions required from here to 2030 and 2050 become far more personal. The Pathway begins with the electric generation sector, but by necessity moves beyond this and requires modifications to individual behavior and choices in transportation and how we heat our homes and businesses.

The Pathway calls for three big shifts in our energy systems by 2030:

- Accelerating the zero-carbon electricity transition, by ramping up renewable electricity deployment to achieve 67% zero-carbon electricity supply;
- A transformation of the transport sector, by reaching more than 10 million electric vehicles on Northeast roads (roughly 50% of all vehicles); and
- A transformation of the heat sector, by doubling the rate of efficiency retrofits and converting nearly all of the region's 5 million oil-heated buildings to electric heat pumps or natural gas.

Beyond 2030, the Pathway calls for deeper and more sustained technological innovation, coupled with increasingly ambitious policy action. In this period, significant challenges and opportunities will emerge in fully decarbonizing transportation, achieving a very low-carbon electricity sector, and transitioning to next-generation heating systems. Because many of the technologies for achieving 80x50 require significant cost and performance advancement, the full Pathway beyond 2030 remains unsolved. Multiple options are on the table in all three sectors, and identifying the right mix will require commitment to rigorous analysis as well as investment along multiple technology development fronts.

To guide these transformations, the Pathway proposes three overarching principles: target the highest emitting fuels and sectors first; optimize the utilization of existing networks; and avoid price shocks through strategic use of electricity and natural gas use. Building on these principles, this paper lays out the analytical basis for the Pathway and proposes policy and regulatory approaches to help the region achieve its emissions targets reliably and affordably.




INTRODUCTION

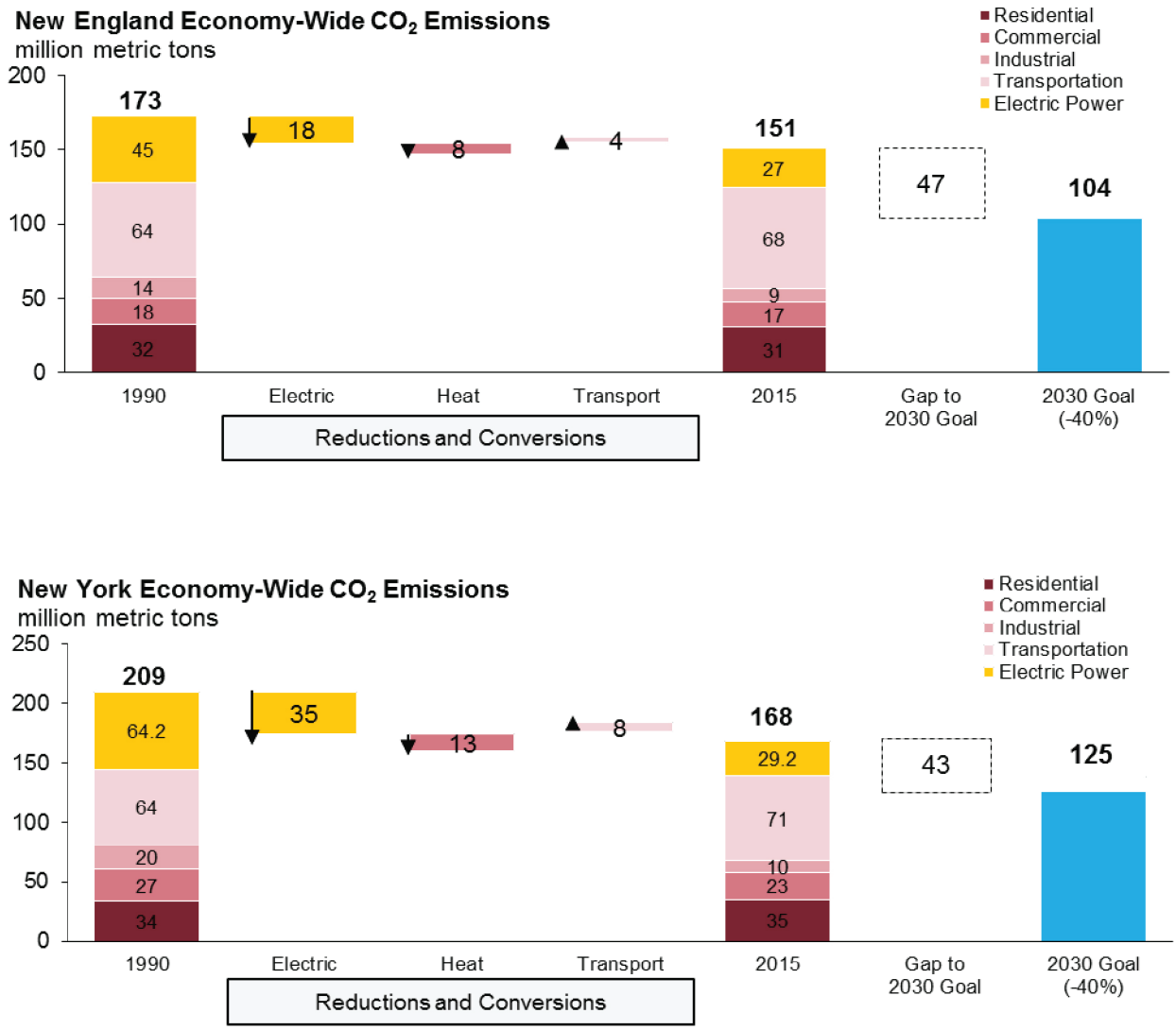
The Northeast is committed to achieving deep reductions in GHG emissions by 2050. All seven states in the Northeast region have adopted targets of 80% CO_2 emission reductions by 2050 across their entire economies. In National Grid service territory, the legal basis for the 80x50 targets includes the Massachusetts Global Warming Solutions Act (GWSA) (2008), New York Executive Order No. 24 (2009), and the Resilient Rhode Island Act (2014).

Annual 1990 CO_2 emissions across the Northeast totaled approximately 382 million metric tons CO_2 equivalent (MMTCO2). The 80x50 target implies an annual 2050 emissions budget of 77 MMTCO2. A "40% by 2030" interim target has also emerged as a common reference point, and corresponds to an annual budget of 230 MMTCO2.

While the region is acknowledged as a leader nationally, the Northeast is not currently on track to achieve either the 2030 or 2050 emissions targets. In fact, extending the rate of emissions reduction observed over the 1990-2015 period, the region will not even achieve a 40% reduction by 2050, let alone 2030. Achieving the 2030 and 2050 targets implies tripling the pace of gains made between 1990 and 2015.

Given these realities, meeting regional emissions targets requires immediate, proactive decisions by regulators, policymakers, utilities, automakers, and community leaders. Furthermore, given the relatively clean electricity in the region, the bulk of emissions reductions will be required in the transportation and buildings sectors (see Figure 1). This implies not only continuing to reduce coal and oil use for power, but also dramatically reducing our reliance on petroleum fuels in the transportation and building sectors.

Figure 1: New England and New York economy-wide emissions progress achieved and required



All data from EIA 2017; Combustion emissions only; other GHGs total ~15%

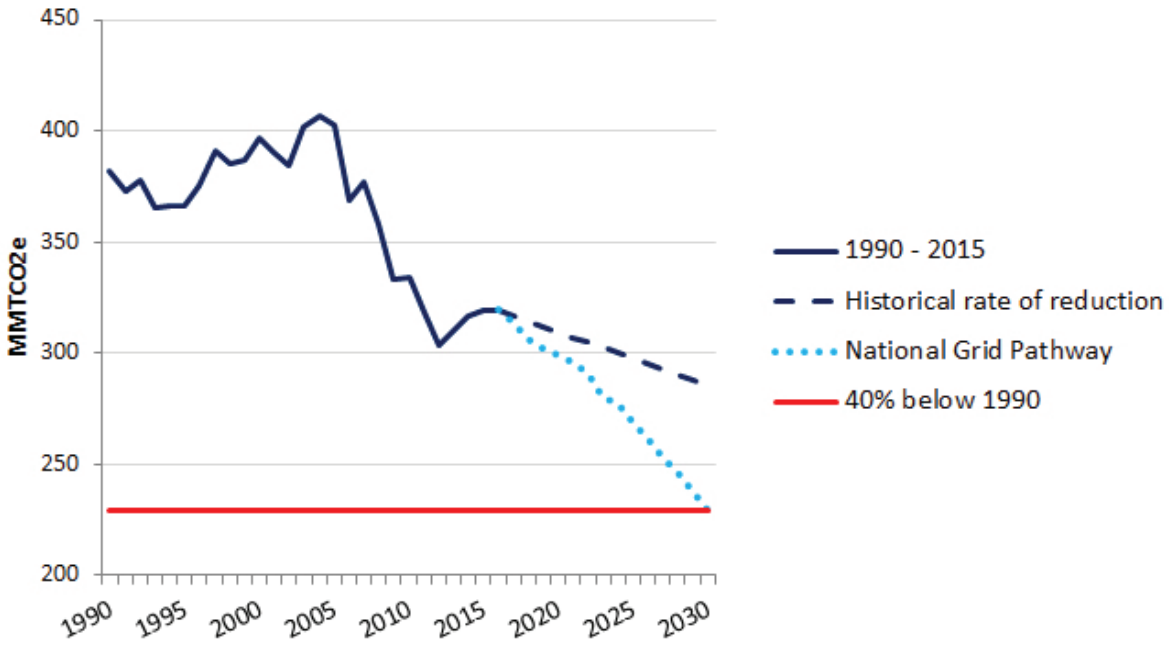
THE PATHWAY TO 2030

The Northeast has taken concrete steps to move toward a clean energy future, including the Regional Greenhouse Gas Initiative (RGGI, see Text Box), achievement of renewable portfolio standards (RPS) in all states, and nation-leading investments in energy efficiency. But much more will be required. Given the pace of emissions reduction required, strategic planning and a focus on cost-effectiveness have never been more critical.

The Pathway achieves the 40% by 2030 target (see Figure 2) by prioritizing three mutually-reinforcing transitions:

1. Accelerate decarbonization of the electric sector.
2. Transform the light-duty transportation sector through electrification.
3. Transform the heat sector through energy efficiency, electrification, and oil-to-gas conversion

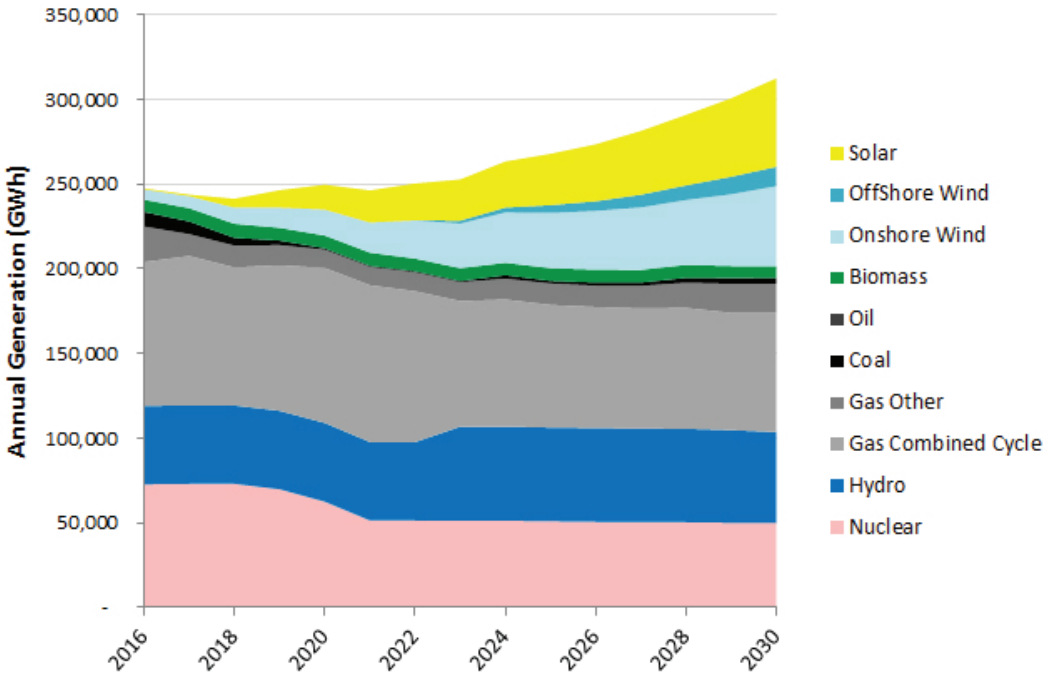
Figure 2: The National Grid Pathway compared to historical progress emissions reduction



Accelerate decarbonization of the electric sector.

Today, zero-carbon electricity comprises over 50% of Northeast electricity generation. About 25% is from renewable electricity, including large-scale hydro. To position the region to achieve 2030 targets, total zero-carbon generation must increase to 67% of supply, with the renewable electricity share rising to nearly 50%, outpacing both RGGI and targets set in state-level RPS (Figure 3). All major classes of renewable resources figure prominently in the *Pathway:* onshore and offshore wind, distributed and large-scale solar, and hydro power.

Figure 3: Electricity generation in the National Grid Pathway



What is RGGI?

Established in 2009, the Regional Greenhouse Gas Initiative is an 11-state program to reduce Greenhouse Gas emissions in the electric sector. RGGI establishes a regional cap on CO_2 emissions from power plants, which declines over time, and by issuing a limited number of tradable allowances. Tradable allowances provide market flexibility for states and emitting power plants to set their own compliance path. Proceeds from allowance auctions are returned to participating states, where they are invested according to state priorities, such as incentives for energy efficiency or electric vehicles.

What are heat pumps?

Heat pumps are very different from standard electric resistance heaters. Compared to traditional "baseboard" technologies, heat pumps achieve a 50-80% reduction in electricity use by moving heat rather than creating it. They use conventional refrigeration technology to absorb heat from one source (air, ground, or water), transfer it to another source, and raise it or lower it to a temperature suitable for space heating (or cooling) and hot water. Heat pumps still face major adoption challenges. In particular, ground-source heat pumps need to achieve cost declines to become more accessible to customers, and air-source heat pumps need to be paired with proper building insulation.

Transform the light-duty transportation sector through electrification.

In contrast to the electricity and heat sectors, emissions from transportation are effectively unchanged since 1990. Vehicle electrification provides a promising pathway, as cost and performance of the underlying battery technology has seen step-change improvements in recent years. The automotive industry is responding with scores of plug-in vehicle models arriving in the showrooms of most every manufacturer in the next few years. The good news is that, even with the current power generation mix in the Northeast, replacing a passenger car with an electric version reduces its carbon footprint on the order of 50%. This only improves as the grid becomes cleaner.

Achieving the 2030 target implies realizing a steep climb to nearly 10 million electric passenger cars and light trucks (known as light-duty vehicles or LDV), which is equivalent to 50% electrification by 2030. This penetration far exceeds adoption forecasts, and effectively requires 100% electric vehicle (EV) sales of LDV by 2028. Tapping opportunities to transition medium- and heavy-duty vehicles to lower-carbon alternatives will also be crucial, for example electric school and city bus fleets.

In the Pathway, annual electric use from all EVs will reach 8% of total electricity demand by 2030, significant but manageable. Maximizing the utilization of existing grids and keeping them in balance as more renewable generation gets added to the mix will be crucial to ensuring a cost-effective transition to an electrified transportation fleet. For example, a modernized and digitized network can support intelligent management of EV charging so that it doesn't overload the grid. Making electric rates more dynamic and transparent will facilitate this intelligent charging, and will increase savings for consumers opting to drive electric.

Transform the heat sector through energy efficiency, electrification, and oil-to-gas conversion.

Achieving the 2030 target economically implies dramatic reduction in the reliance on the most expensive and polluting heating fuels: fuel oil, propane, and kerosene. This entails a rapid transition from these fuels to heat electrification, reaching 28% electrification of residential space heat by 2030 through a mix of air- and ground-source heat pumps (see Table 1). By 2030, roughly 3.85 million homes are envisioned to be utilizing heat pumps, requiring an average annual rate of conversion of almost 300,000 homes and businesses. Today, adoption rates are more than 10 times lower, around 25,000 per year. Oil-to-gas conversions, which achieve GHG reductions of over 27% per home, will also need to accelerate over the period, bolstered by investment in growing the regional supply of renewable natural gas.

In contrast with warmer climates like California, heating contributes more to regional GHG emissions, and also occupies a large share of Northeast customers' total energy expenses. Accordingly, the Northeast heating transition requires scaling up energy efficiency investment, with a concerted focus on tightly insulating residential and commercial buildings. Table 1 summarizes the renewable electricity, transportation, and heating transitions envisioned in the Pathway.

Table 1: Electricity, Transport, and Heat Transitions in the National Grid Pathway

Category	Today	2030
Electricity Generation		
Solar (% of total electricity demand)	<1%	13%
Wind (% of total electricity demand)	2.5%	19%
Total renewable generation (% of total demand, including hydro)	21%	51%
Total zero-carbon generation including nuclear (% of total demand)	50%	67%
Transport		
Light- and medium duty EV adoption (% of annual sales)	<2%	100%
EV penetration (% of total light duty fleet)	<2%	50%
Total transportation electric demand (% of total electricity demand)	0%	8%
Heat		
Delivered fuel use (% of heating demand in residential buildings)	40%	10%
Natural gas use (% of heating demand in residential buildings)	55%	60%
Electric heat use (% of heating demand in residential buildings)	2%	28%
Other heating use, e.g. wood (% of residential heating demand)	3%	2%
Electric heat demand (% of total electricity demand)	2%	7%

From “Utility Bill” to “Total Energy Bill”

As the saying goes, “you can’t manage what you don’t measure.” Moving forward, customers and policy makers in the Northeast will begin to focus on the “total energy bill,” including not just utility bills but also expenditures for gasoline at the pump and for heating fuel deliveries. Broadening the lens to include the total energy bill will reveal billions in potential cost savings from switching away from petroleum products to cleaner energy sources.

AFFORDABILITY: ENSURING THE TRANSITION WORKS FOR CUSTOMERS

While the Pathway is feasible, the figures above demonstrate that meeting the 2030 climate goal affordably presents a significant challenge. This effort will require multiple interlocking market transformations requiring commitment, compromise, and consensus among stakeholders with diverse agendas and priorities. But perhaps the single largest challenge will be achieving the customer adoption paradigm shift implied by the 2030 and 2050 targets.

Crucially, enabling customer adoption will require that electricity and natural gas remain affordable alternatives to liquid petroleum fuels. Northeast electricity and natural gas rates today are currently higher than the national average, though widespread energy efficiency investment means that total energy bills are near the national average.

The good news is that, driven by zero-carbon electricity and the large-scale switch to cleaner transportation and heating fuels, the Pathway envisions dramatically reduced emissions while also saving money for customers. From a customer point of view, any cost increases on the electric or natural gas bill would be offset by reduced expenditures on petroleum products (see Table 1). Additionally, the cost of new electricity generation is largely offset by new demand from the transportation and heating sectors, keeping the transition affordable.

From a system point of view, the Pathway implies trends that are significantly different from what we see today. Electrifying more of the economy means that new electricity use from electric vehicles and heat pumps will eventually outstrip energy efficiency. As a result,

electricity demand growth will become the “new normal.” Efficiency investment will still be foundational since it lowers the total energy budget, but it must pivot to a holistic focus on emissions reduction rather than narrowly aiming to reduce electricity and natural gas use.

In the Northeast, natural gas will continue to play an important role as a reliable fuel source for heat and electricity generation. There are also important roles for natural gas in various industrial processes and heavy-duty transport sectors that are difficult to electrify. In the Pathway, new natural gas demand in the residentialsector is partially offset by accelerated energy efficiency investment, so even though the total number of residential natural gas customers rises significantly, total usage grows at a comparatively modest pace over the period.

Significant large scale renewable energy development, and electricity and natural gas transmission capacity growth, will be required to keep both electricity and natural gas affordable. Overall the carbon intensity of power generation falls significantly, conferring larger benefits to end-use electrification. Table 2 summarizes the system-level changes in the Pathway.

Table 2: System-level changes in the National Grid Pathway

Category	Change between today and 2030
Total electricity demand (terawatt hours - TWh)	+15%
Peak electricity demand (GW)	+15%
Carbon intensity of power generation (g CO2/kWh)	-44%
Total electricity sector GHG emissions (MMTCO2)	-29%

FROM 2030 TO 2050

Beyond the 40% reduction target for 2030, the 80% target for mid-century will require deeper and more sustained technological innovation on both the grid side and customer side of the meter, coupled with ambitious policy. While it's still too early to identify all of the leading options beyond 2030, some of the key pathways have begun to emerge:

Electricity. By 2050 the electricity sector will effectively need to be a zero-carbon system. The precise sources of supply are not yet clear, though renewables are poised to grow substantially. This will pose new challenges for the electric sector, including ensuring system flexibility and adequate year-round generation capacity, and ensuring effective market design and cost recovery. The role for energy storage will grow dramatically, both for short time scales (e.g. batteries) as well as long time scales (e.g. synthetic fuels or seasonal thermal storage). There is a strong case for supporting for R&D in these technologies.

Transportation. The post-2030 challenge will require broader progress across all transport sectors. Most importantly, new zero-carbon options will be required for medium- and heavy-duty vehicle fleets, as well as non-road uses such as marine ports and ships, rail, and aviation. Additionally, reducing travel distances will be crucial, through a mix of public transit, car-pooling, and mobility-as-a-service platforms. Wind and solar production patterns could open new opportunities for production of zero-carbon fuels such as hydrogen and synthetic methane that can be utilized in heavy-duty fleets.

Heat. Beyond 2030, the heat sector will require sustained efficiency investment and conversion to heat pumps, the steady decarbonization of natural gas supply (through renewable natural gas, hydrogen, and synthetic fuels), and conversion of many natural gas homes to hybrid natural gas-heat pump configurations. Since periods of surplus renewable electricity generation will become much more common after 2030, utilizing that surplus to create zero-carbon fuels (e.g. hydrogen and synthetic fuels) not only serves to displace dirtier fuels but also provides much needed long-term energy storage. Existing pipelines can be utilized to carry these zero-carbon fuels. Since heat decarbonization is widely recognized as one of the most difficult long-range challenges, R&D efforts should be scaled up in this area. Additional incentives for heat electrification and green gas production will be important.

SUPPORTING THE PATHWAY THROUGH POLICY AND REGULATION

We propose guiding principles for policy and regulation to help the region achieve its targets on time while minimizing costs and maximizing customer benefits:

Improve policies to make zero carbon electricity affordable.

Meeting substantial new demands from the electrification of transportation and some of the heating sector requires focusing on the most affordable clean electricity sources. Residential solar, while cost effective for the home owner, is more costly to the broader consumer base per kWh than large scale solar, and also more costly than wind and other wholesale renewable resources. Policy makers should level the playing field among large-scale and distributed energy resources by equalizing compensation for the same clean energy whether provided to the bulk power system or at the distribution level, with any additional compensation based on demonstrable grid benefits delivered by those resources.

Regulatory changes can also achieve cost efficiencies. Cost-effective procurement of large-scale renewables will be crucial, and all options to achieve it are needed. When utility ownership of large-scale renewables can help drive down cost and promote speed and scale of adoption, it warrants consideration by regulators.

Finally, policy and regulatory changes must increase customer insights into their total energy bill. To ensure durable support for cost-effective fuel switching, customers should be provided useful visibility across their aggregate energy costs for transport, heat, and electricity.

Expand policies to promote transportation electrification.

Achieving the transportation challenge will necessitate perhaps some of the most substantial policy and regulatory changes. Beyond keeping in place existing fuel economy standards, the transition will require proliferation of user-friendly charging infrastructure so that drivers can feel confident making the switch. Customer range anxiety issues continue to drag on adoption levels, so proactive investments in charging infrastructure, system standardization, and education will be crucial to realizing the Pathway. Utilities should also be encouraged to invest in smart charging capabilities that optimize system performance and minimize to the degree possible incremental investments in generation and networks.

At present, accelerated adoption of EVs is being supported mainly by rebate programs. Funding for these programs can come from a variety of mechanisms, and one key issue will be to determine how long such incentives should be provided. There should be sunset provisions such that when the market matures, funding support declines proportionately but not prematurely.

Utilities will also play a key role in promoting open interoperability standards for EV charging infrastructure, mitigating the risk of obsolete and competing standards, and creating a more positive user experience.

Enhance policies to promote a low-carbon heating sector.

The Northeast has some of the largest heating requirements in the country, as well as one of the highest emitting heating fuel mixes, driven by continued reliance on liquid fuels. There is presently no significant policy to drive a systematic and ambitious increase in the deployment of heat pumps and deep energy efficiency retrofits. Until heat pump technology performance improves and policies develop and gain traction, there must be continued support for adoption of progressive building codes with an emphasis on net zero construction as well as oil-to-gas conversions to yield immediate carbon savings. Regulatory changes should be made to incentivize utilities to invest in low-carbon heating solutions — such as ground-source heat pumps — for customers without access to natural gas.

The existing natural gas distribution infrastructure is a valuable asset that serves customers well. There must be new policies to incent efforts to scale up low-carbon gas network options, especially renewable natural gas that leverages local feedstocks such as waste water treatment facilities and food and organic waste streams. More experience and investment is required so that these emerging technologies can be maximized.

Create carbon pricing market mechanisms.

Placing a price on carbon will be crucial for the Pathway. Carbon pricing should apply not just to electricity (as it currently does) but to all fuels. Improving the cost advantage of low-carbon fuels will appropriately incentivize customer choices towards cleaner transport and heating systems. Secondly, gathering carbon revenue from all sectors (not just electricity, as currently happens through RGGI) will provide a more robust and balanced revenue source for supporting the necessary changes envisioned in the Pathway. A significant portion of the revenue from carbon pricing should be used to mitigate adverse financial impacts for vulnerable populations. Key to any revenue generating mechanism must be an exit mechanism where once markets are established, funds are returned to the consumer.

Create a new regulatory framework for a new utility-customer relationship.

An innovative and forward-looking utility regulatory framework will be required, one that rewards utilities for cost-effectively delivering outcomes valued by customers, policymakers, and other stakeholders. For example, the Pathway will require pricing structures that fairly compensate energy resources for value they deliver, fairly allocate costs, and accelerate the energy transition. “Smart meters” and associated grid modernization systems will enable the customer to take advantage of new price signals, and will also be crucial to ensuring efficient system utilization, renewable electricity integration and beneficial electrification. Finally, it will be essential to invest in system resiliency to minimize negative impacts from increasing storm events and a changing climate.

Utilities will increasingly serve new roles in affordably delivering energy efficiency, renewable electricity, beneficial electrification, and resiliency. Incentives should be put in place to further encourage investment in these areas. These incentives should be targeted toward achieving long-term cost control while delivering tangible outcomes (e.g. GHG reduction in the transport and heating sectors) and scaling up the availability of innovative technologies for customers.

CONCLUSIONS

The Northeast has already achieved significant energy decarbonization. Yet achieving the region's emissions targets will require dramatic acceleration in all facets of the transition. National Grid is well-positioned and committed to facilitating all parts of the transition – from infrastructure to grid intelligence, from energy efficiency deployment to renewable energy integration, and from EV charging to cleaner home heating options. But National Grid cannot do it alone. Active customer engagement, aggressive industry partnerships, and comprehensive policy and regulatory frameworks will be necessary to guide the economy-wide transformation.

Guiding principles for the Northeast include addressing the highest emitting fuels and sectors first while optimizing the utilization of existing networks, with a primary objective of avoiding price shocks to the customer. This means the strategic use of both electricity and natural gas energy networks – both wires and pipes – which form the backbone of this transition.

It equally requires the improvement of the end-use technologies that efficiently use the energy delivered by these networks. The primary policy and regulatory changes will center on aligning customer, utility, and third-party incentives to speed adoption of these end-use technologies. National Grid is ready to innovate together with our stakeholders in pursuit of decarbonization.

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