Our clean energy vision

A fossil-free future for cleanly heating homes and businesses

nationalgrid

We are committed to playing a leading role enabling and accelerating the transition to a clean energy future, while ensuring all customers and communities continue to have affordable and reliable options to heat their homes and run their businesses.

For more information visit:

nationalgrid.com/fossilfree

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1. Mobilizing to help our customers and communities reach net zero

At National Grid we believe achieving a fossil-free future and addressing climate change is not just a shared responsibility, but one where we must lead. We are undertaking a bold initiative that will set a new climate standard for energy companies across America. From today forward, we are working to enable a future where every time our customers use energy – to turn on their lights, charge their phones, cook for their families, or heat their homes and businesses – it can be done without fossil fuels.

National Grid is announcing our vision to fully eliminate fossil fuels from both our gas and electric systems by 2050 – sooner if possible – setting clear and measurable milestones along the way.

We are making this fossil-free announcement because we share our communities' concerns about climate change.

National Grid is proud of our role in helping Massachusetts and New York consistently rank at or near the top nationally in energy efficiency programs, electric vehicles on roads, solar installations, planned offshore wind, and environmental stewardship. In addition to this track record of success, the states in which we operate have enacted some of the most progressive climate laws in the country, establishing future requirements for net zero emissions across their economies: New York passed the Climate Leadership and Community Protection Act in 2019 and Massachusetts adopted the *Next-Generation Roadmap for Massachusetts Climate Policy* in 2021.

National Grid is mobilizing to achieve net zero emissions in a way that ensures that all customers share in the benefits of a clean energy future. Our vision builds on our previous actions:

- **2018:** We released a *Northeast 80 x 50 Pathway* white paper exploring strategies for the region to reduce economy-wide emissions at least 80% below 1990 levels by 2050
- **2019:** We announced our *Net Zero by 2050 Plan* laying out our commitment to achieve net zero greenhouse gas (GHG) emissions by 2050 from both our own operations and the emissions resulting from the sale of electricity and gas to our customers
- **2020:** We launched our *Responsible Business Charter*
- **2021:** We are proud to be a Principal Partner for the UK's Presidency of COP26 – the United Nations Climate Change Conference that brought together 120 world leaders and over 40,000 registered participants to advance national plans to keep 1.5 degrees Celsius of global warming within reach
- **Over the past five years in the Northeast US:** We have connected 2,000 megawatts (MW) of distributed solar and 180 MW of battery storage, supported $3.1 billion in energy efficiency investments for our customers, and enabled over 4,400 electric vehicle charging ports in our Northeast service areas.

Winning the fight against climate change requires us to collectively achieve emissions reductions across multiple sectors of the economy – in how we generate electricity, fuel our vehicles, heat our buildings, and power our industries.

Reducing emissions from the building sector – predominantly space and water heating, but also cooking, washers and dryers, fireplaces, outdoor grills, and industrial processes – is one of the most important and challenging problems that must be solved to achieve net zero. Heat is essential to life, and keeping it affordable and reliable is critical for economic development and wellbeing. Underscoring our vision for fossil-free heat is a sincere belief that the net zero path we take must leave no customer behind, and our actions must be bold, smart and practical to build our shared clean energy future.

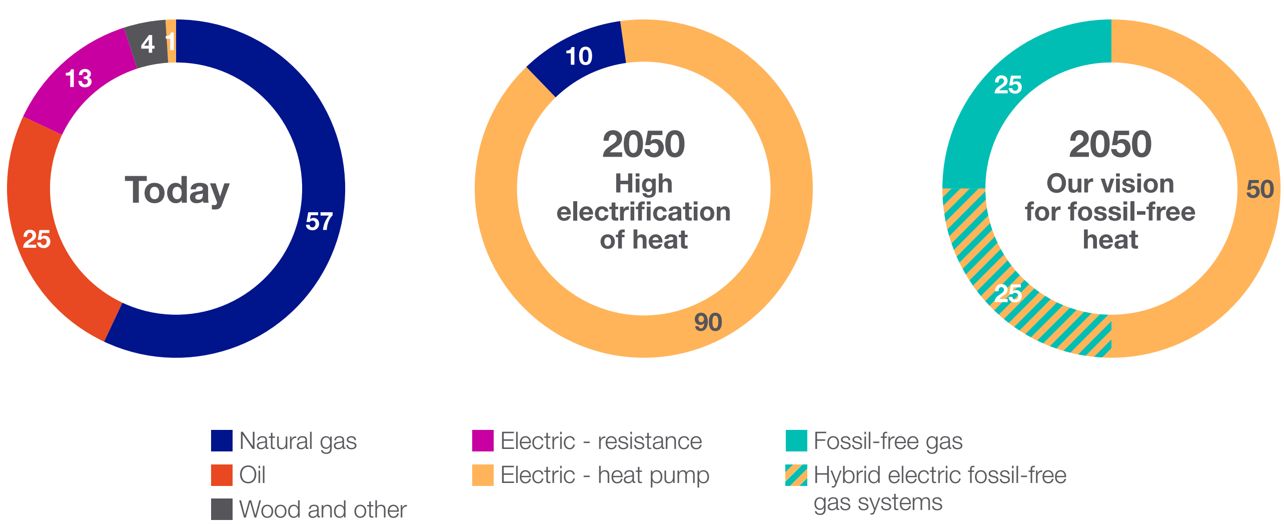
This report describes National Grid's vision and the steps we are taking to leverage our existing gas and electric networks to achieve fossil-free heat fairly, affordably, and reliably for our customers and communities.

2. Our vision for fossil-free heat

Today, heating makes up about 39% of GHG emissions in Massachusetts and New York.[1] Heating is provided by a diverse set of fuels and heating systems. Of the roughly 10 million households in Massachusetts and New York, nearly 6 million (57%) have a gas furnace or boiler system, 2.5 million (25%) use a boiler fueled by oil or propane, and 1.4 million (14%) use electricity.[2] Of those using electricity, most use electric resistance, an inefficient heating source, and about 100,000 (1%) use a heat pump – a type of efficient air conditioning unit that can also provide heat.[3]

Draft climate action plans from the Massachusetts and New York state agencies propose that nearly 10 million households change their heating systems to electric heat pumps by 2050 (see Figure 1). In Massachusetts and New York, this would require over 340,000 customers per year converting their current heating source to electricity, every year until 2050.

Figure 1. Buildings heating systems in Massachusetts and New York (% of total).



National Grid's vision for fossil-free heat targets a hybrid approach. Just as we have decarbonized electricity with wind and solar, we can decarbonize the gas system with renewable natural gas and green hydrogen. This will enable customers to have choices in how to become fossil-free. And, by utilizing our existing gas and electric networks, our vision will more quickly deliver a reliable and cost-effective transition to a net zero future for the entire energy system.

At National Grid, we believe that electrification of heat will play an important role for some of our customers in achieving net zero. We also believe that we need to offer a diverse and practical range of cleaner heating solutions enabling customers to choose what best addresses their needs for performance and cost, without compromising our shared climate goals.

While converting to electric heating may be viable for some customers, others may have challenges due to the upfront cost of making this switch or the difficulty of retrofitting their building. Today, fully electrifying a typical home in Massachusetts or New York costs roughly $20,000-60,000.[4] Additionally, our analysis finds that – given the physical limitations of existing buildings – it is technically difficult to electrify 30-70% of building space in the urban areas of New York City and Boston and 5-40% outside of those major cities.[5]

National Grid's vision for fossil-free heat will enable our customers to have clean heating solutions available to them. Along the way, we can build an integrated energy network that is clean, renewable, and achieves zero emissions.

A better way to net zero

Our analysis shows that using a balanced and diversified approach to heating is the most practical, expedient, and affordable path to reducing emissions for all our customers. This is consistent with findings from Energy + Environmental Economics (E3), an energy industry consulting firm, who in their 2022 report developed for the Massachusetts "Future of Gas" proceeding state "A coordinated gas and electric decarbonization strategy, utilizing a diverse set of technologies and strategies, is likely to be better able to manage the costs and feasibility risks of decarbonization than scenarios that rely more heavily on single technologies or strategies."[6] Much like how we are creating a clean electricity network through the adoption of renewable electric generation sources, such as wind and solar, we can achieve a fossil-free gas system through the adoption of renewable natural gas and green hydrogen.

Our fossil-free vision rests on four pillars of action that will enable all homes and businesses we serve to meet their heating needs without the use of fossil fuels by 2050, if not sooner, achieving net zero emissions while keeping energy affordable and preserving customer choice.

Figure 2. Pillars of our vision for fossil-free heat.

Pillar one

Energy efficiency in buildings

We will continue to provide programs for our customers to accelerate energy efficiency improvements to buildings, including deep retrofits and measures that reduce peak gas and electric demand; and support more rigorous building codes for new buildings.

Pillar two

100% fossil-free gas network

We will eliminate fossil fuels from our existing gas network no later than 2050 by delivering renewable natural gas and green hydrogen to our customers.

Pillar three

Hybrid electric-gas heating systems

We will support our customers by providing them strategies and tools to capture and maximize the benefits of pairing electric heat pumps with their gas appliance.

Pillar four

Targeted electrification and networked geothermal

We will support cost-effective targeted electrification on our gas network, including piloting new solutions like networked geothermal. We will support customers who heat with oil and propane with strategies and tools to convert to heat pumps.

Pillar one
Energy efficiency in buildings

We will continue to provide programs for our customers to accelerate energy efficiency improvements to buildings, including deep retrofits and measures that reduce peak gas and electric demand; and support more rigorous building codes for new buildings.

Energy efficiency is a cornerstone of our vision – we expect it can deliver one-third of needed emissions reductions from heating. Wider adoption of measures to better insulate and weatherize buildings and replace old appliances with more efficient ones can significantly lower the amount of fuel required to keep buildings warm and comfortable as well as provide other services such as cooking. This not only lowers direct costs for customers but also reduces peak demand and infrastructure that needs to be built. National Grid will maximize energy efficiency's potential by continuing our nation-leading programs that provide rebates and incentives to customers to adopt these measures in existing buildings. We must also construct all new buildings to be highly energy efficient and ready for a net zero future.

Scaling up insulation (pictured) and other buildings energy efficiency improvements are foundational to keeping energy affordable and achieving our net zero future.

Pillar two
100% fossil-free gas network

We will eliminate fossil fuels from our existing gas network no later than 2050 by delivering renewable natural gas and green hydrogen to our customers.

Today, nearly 6 million households in Massachusetts and New York are heated with natural gas. In many homes, gas is also used for hot water, cooking, dryers, fireplaces, and outdoor grills (see Figure 3). Natural gas also fulfills important needs for businesses in delivering high quality goods and services: a storable and immediate source of fuel for power plants, process heat for industries and manufacturing, cooking for restaurants, washing and drying at laundromats, and others. Hospitals, for example, are required by federal law to have two sources of energy; gas plays a critical role as an emergency back-up source when the power is out. Many universities and schools have their own plants onsite that generate both power and heat from natural gas and have existing infrastructure to distribute it to their buildings on campus.

Our vision replaces fossil natural gas with fossil-free – renewable natural gas and green hydrogen – enabling all our customers to have a clean solution for heating their homes and operating their businesses in the way they determine is most affordable and practical for their needs.

Figure 3: Uses of gas in homes and businesses.

What is renewable natural gas?

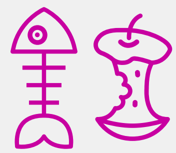
Renewable natural gas (RNG) captures biogases that naturally emit from society's recurring waste streams. RNG turns a liability that negatively impacts the environment into a climate solution that can be carried in our existing gas network and used in existing customer equipment.

Society will always produce waste, which naturally emits surface-level methane as it decomposes. RNG reduces emissions by capturing this potent GHG before it can escape into the atmosphere (and contribute to our changing climate) and putting it to productive use as an energy resource. In that process, it provides a **double benefit of reducing methane emissions while providing a source of renewable energy**. By simultaneously capturing methane and displacing fossil natural gas, **RNG has the lowest lifecycle carbon intensity of any energy source available today**. Additionally, RNG is a reliable source of energy that can be easily stored and delivered to customers when and where they need it. And, it is a "drop-in" fuel – able to be transported through existing gas networks, ensuring customers will not need to make changes to their existing appliances.

RNG facilities (pictured) capture methane from waste – preventing emissions into the atmosphere – and create a valuable product to use in heating.

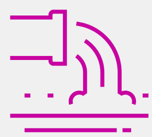
RNG can be sourced from a vast number of existing waste streams and renewable biomass. Sources are all around us: landfills, farms, wastewater treatment plants, food waste, and biomass waste residues (see Figure 4). As the global population grows, the World Bank projects solid waste to increase nearly 70% by 2050.[7] RNG helps improve society's response to waste and the emissions created from it.

Figure 4: Waste streams that can produce renewable natural gas.

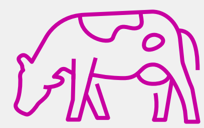


More than **144** million metric tons of food waste each year

4,400 landfills



17,000 waste water facilities



19,000 large farms and dairies

RNG is a readily available solution and we have successfully been injecting RNG into our gas system since 1981. RNG supply is growing rapidly, increasing by more than six times nationwide since 2015. Today, there are over 150 plants in operation in the US and Canada and thousands of additional sites waiting to be developed. Using the existing gas network that connects us to the broader region, this resource can supply fossil-free gas to heat our homes and businesses. Our fossil-free vision assumes that National Grid eventually procures 10%-20% of RNG annual supply potential in the Eastern US for our customers, roughly in line with our customers' share of Eastern US residential and commercial gas demand today.

What is green hydrogen (H2)?

Hydrogen, the most abundant chemical element on earth, offers enormous potential as a source of clean energy and fossil-free heat. **When hydrogen gas is burned to release its energy, the main byproduct is water vapor**. Hydrogen produced using renewable feedstocks is known as green hydrogen. One of the most promising green hydrogen pathways is the process of electrolysis using renewable electricity from wind and solar, which is carbon free.

Hydrogen can help decarbonize multiple sectors, including heat, power generation, and transport. For heating, hydrogen can be blended with natural gas or RNG up to 20% by volume, run through our existing gas networks, and used in customer appliances without significant upgrades to infrastructure or equipment. In areas with high levels of gas demand, pure hydrogen also has potential to serve fossil-free heating and other energy needs in dedicated 100% hydrogen clusters. These may be part of "hydrogen hubs" – clusters of local hydrogen production, storage, and demand – such as those in which the US Department of Energy is investing $8 billion to establish around the country to support innovation and to scale up a hydrogen economy.[8] The Northeast is well positioned to host one of these hubs, and New York, Massachusetts, together with Connecticut and New Jersey, are developing a proposal to implement a hydrogen hub in the region [9]. Driven both by federal government support and by growing interest from companies seeking to replace fossil fuels, costs of hydrogen are expected to fall rapidly. In 2021, the US Department of Energy announced its "Hydrogen Shot" target to reduce the cost of green hydrogen by 80% over the next 10 years, which would bring the cost in line with today's costs for natural gas.

Green hydrogen complements growing renewable electricity capacity due to its ability to be stored and its flexibility to be used across different sectors. Hydrogen can be made during periods when wind or solar resources are able to produce more electricity than the grid needs, and then stored for later use, thereby maximizing the benefits of renewable energy resources. Already, a significant number of offshore wind projects are proposing hydrogen production through electrolysis as a form of long-duration storage of renewable energy.

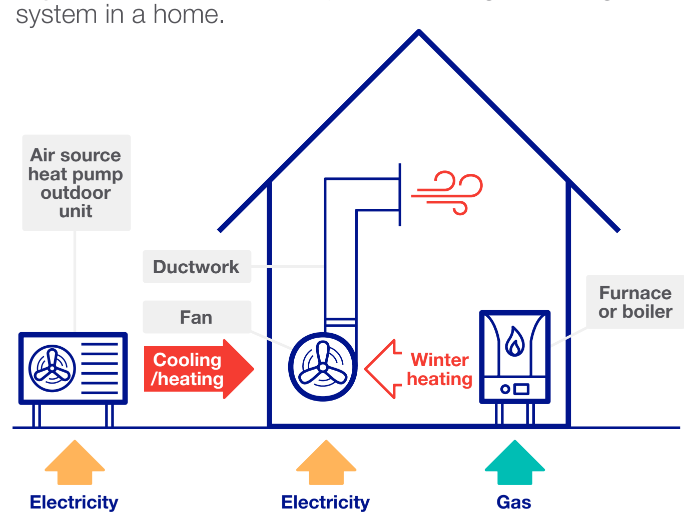
Pillar three

Hybrid electric-gas heating systems

We will support our customers by providing them strategies and tools to capture and maximize the benefits of pairing electric heat pumps with their gas appliances.

Hybrid heating systems utilize both electricity and gas for providing year-round comfort in homes and buildings. For example, heat pumps in the Northeast today are mainly installed for cooling to replace old and inefficient air-conditioning. As a result, many customers have hybrid heating systems, where the heat pump covers cooling and heating during part of the year, and a gas system provides heat during the coldest months (see Figure 5). **Of customers adopting heat pumps today, approximately 80%[10] choose hybrid configurations over full electrification.** Hybrid systems provide a more affordable and reliable mix of heating and cooling throughout the year, allowing installation of smaller and cheaper heat pump systems, while avoiding large and costly modifications to buildings and heating systems.

Figure 5: Schematic of a hybrid electric-gas heating system in a home.



Hybrid heating systems utilize both electricity and gas for providing year-round comfort in homes and buildings.

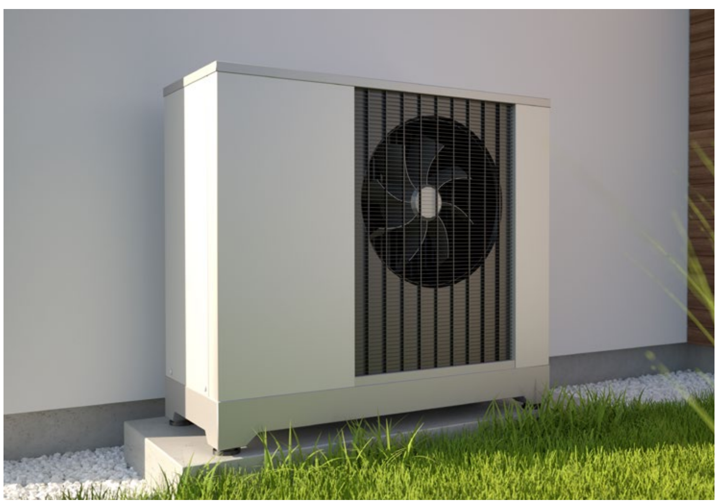
Pillar four

Targeted electrification and networked geothermal

We will support cost-effective targeted electrification on our gas network, including piloting new solutions like networked geothermal. We will support our customers who heat with oil and propane to convert to electric heat pumps.

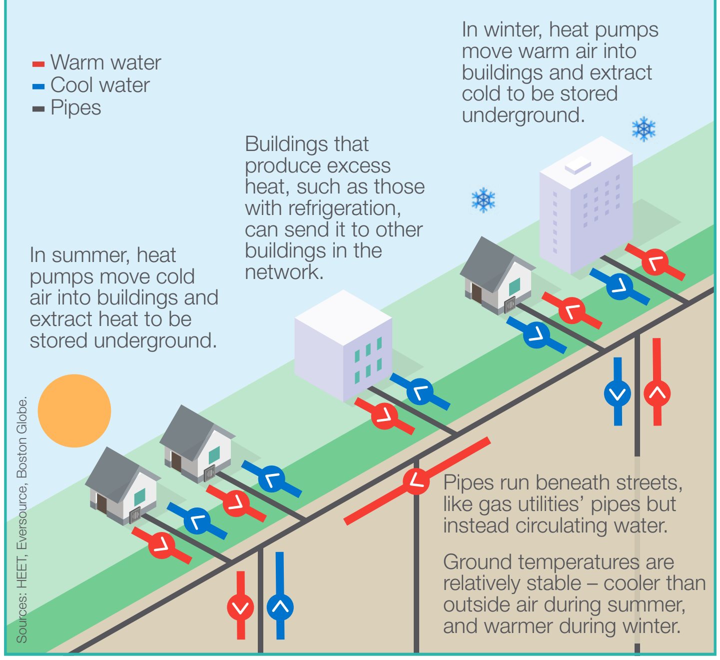
Under any heating sector net zero vision, there is an important and critical role for electrification. Air-source heat pumps move heat from the outside air into buildings, and also provide cooling. When paired with 100% renewable electricity, electric air-source heat pumps can play an important role in achieving net zero for heat, especially where cost-effective. **For example, today it is cost-effective for customers who heat with oil, propane, or old electric resistance systems to convert to heating with electric air-source heat pumps.**

Ground-source heat pumps are another electric heating technology that can help reduce GHG emissions. Ground-source heat pumps efficiently draw heat from the ground and can reduce strain on electric grids compared to air-source heat pumps, because they are able to more efficiently heat homes using consistent heat from the earth instead of variable heat from the air. Whenever possible, ground-source heat pumps should be encouraged, because they minimize electric peak impacts and can fully replace traditional heating more easily than air-source heat pumps.



Air-source heat pumps (pictured) move heat from the outside air into buildings, and also provide cooling in the summer.

Figure 6: Schematic of networked geothermal street.

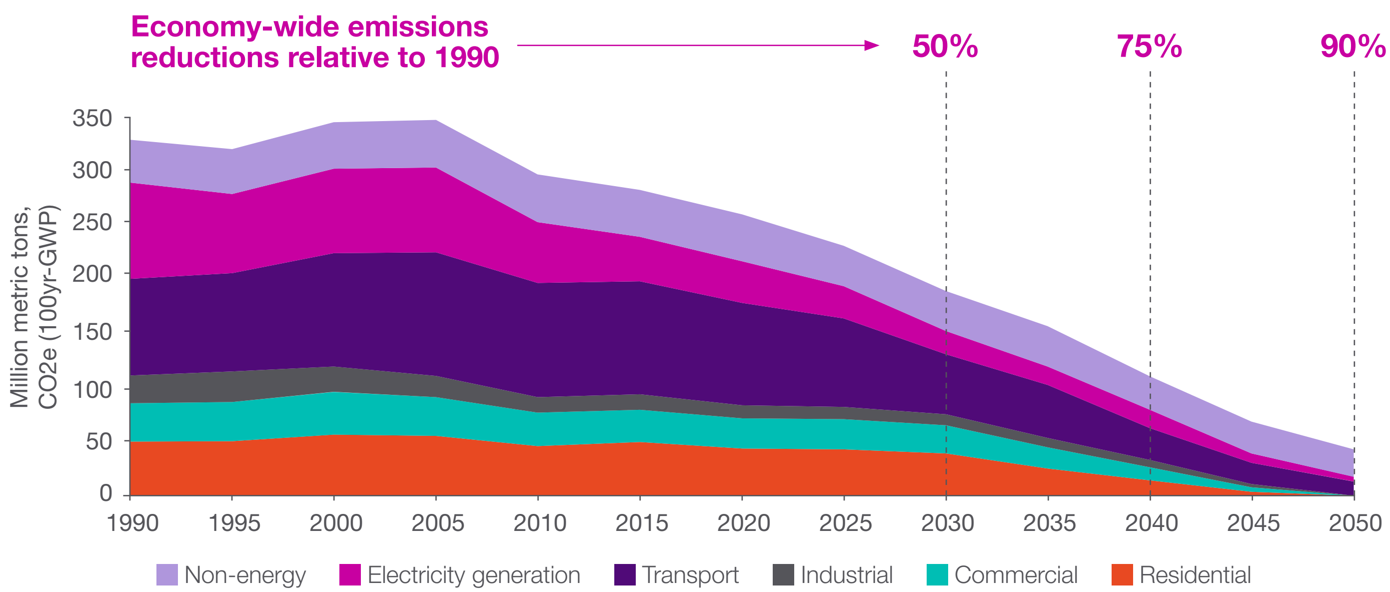


Ground-source heat pumps can also be connected via geothermal networks (see Figure 6) to allow customers to share heating and cooling, making geothermal networks even more efficient than standalone ground-source heat pumps. Installing and maintaining geothermal networks also makes sense as part of the gas utility transformation, as it utilizes our skilled workforce who understands underground construction and it leverages our existing customer relationships.

Summary of how our vision reduces emissions

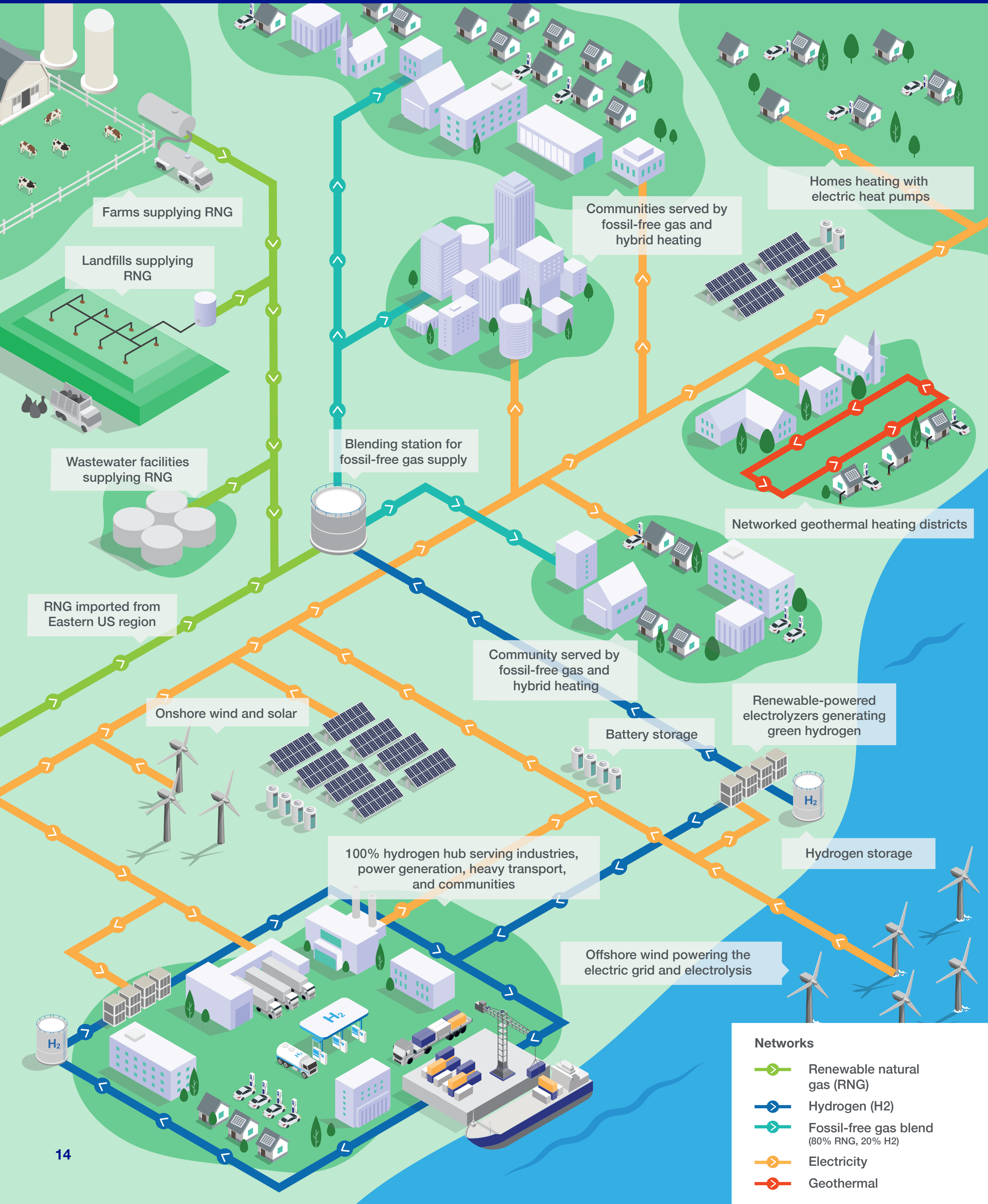
At the center of our vision is an integrated, fossil-free gas and electric system that will enable us to serve all our customers and communities with fair, affordable, and reliable heat. Our vision provides a practical path to a clean energy future, **where economy-wide emissions fall 50% by 2030 and 90% by 2050** (see Figure 7).

Figure 7: Economy-wide emissions in Massachusetts and New York in our vision for fossil free heat.



Our clean energy vision

A fossil-free future for cleanly heating homes and businesses



Roadmap to achieve our vision

2050

100% fossil-free heat

2045

Net zero economy-wide emissions

- Continue to accelerate deployment of fossil-free gas, clean electricity solutions, and energy efficiency.

2040

Wide adoption of fossil-free heating solutions

- Blend 20% green hydrogen and 30% RNG in our network
- Build 100% hydrogen hubs serving multiple uses
- Deploy hybrid heating systems widely
- Support communities with networked geothermal heating districts and targeted electrification
- Convert all customers heating with oil to electric heat pumps
- Significantly advance building efficiency.

2030

Scale a broad set of solutions

- Invest in infrastructure to deliver fossil-free gas and electric solutions
- Serve 10-20% of gas demand with RNG
- Promote adoption of hybrid heating
- Run community-scale pilots of H2 blending
- Support deployment of H2-ready appliances
- Progress neighborhood adoption of networked geothermal heating and targeted electrification
- Convert a majority of customers who heat with oil to electric heat pumps
- Continue to support states' progress toward zero-emission and renewable electricity goals.

2022-2025

Set foundation to transition to fossil-free heat

- Support legislative and regulatory policies to grow fossil-free gas, including adoption of a renewable heating portfolio standard
- Develop voluntary tariffs for customer participation in fossil-free gas offerings
- Continue to convert customers who heat with oil to electric heat pumps at pace
- Run neighborhood pilots for green H2 network blending, networked geothermal, and targeted electrification
- Promote adoption of hybrid heating
- Demonstrate technical feasibility and scalability of fossil-free gas networks
- Continue innovation in nation-leading energy efficiency programs.

Today

Delivering safe, affordable, and reliable heat

- Investing in network modernization to reduce fugitive methane emissions and increase safety and reliability
- Providing nation-leading energy efficiency and demand response programs to help customers lower energy bills and usage
- Accelerating conversion customers who heat with oil to electric heat pumps
- Partnering with NY and MA to propose a regional Hydrogen (H2) Hub
- Participating in university-led H2 blending studies
- Interconnecting renewable natural gas (RNG) projects to our network
- Seeking regulatory approval for RD&D to transition the gas network to net zero, including piloting fossil-free gas and networked geothermal.

3. How our vision benefits all our customers and society

As we build toward a fossil-free future, it is essential that we leave no customer behind. All customers must benefit from the clean energy transition. Our vision enables customers to continue choosing affordable heating options while achieving our states' emissions reduction targets and supporting safe, reliable, and equitable outcomes for society.

We believe an integrated, fossil-free gas and electric system will provide our customers and society, clear benefits:

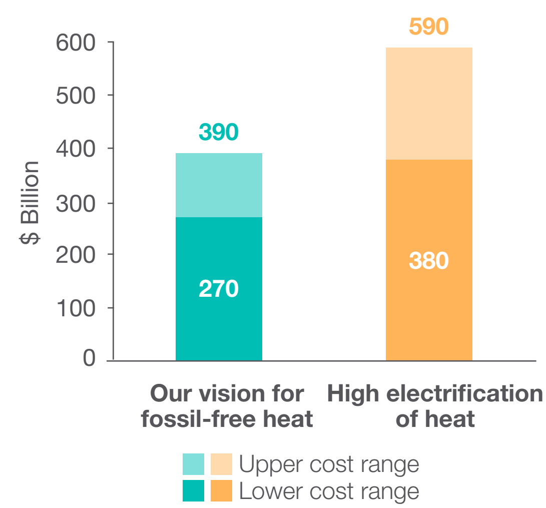
- lowest cost for society
- provides customers affordable choices to heat their homes and businesses
- results in more equitable outcomes, keeping energy affordable for everyone
- gives customers smarter, practical heating choices
- utilizes the skills of our existing workforce
- supports a reliable and resilient energy system by not having "all our eggs in one basket"
- allows a more manageable build out of electric infrastructure
- more likely to achieve our shared net zero goals by embracing all options.

Most affordable and practical for our customers to reduce emissions

Lowest cost for society

Given concern over inflation and economic inequality, the issue of affordability is one of the most important factors when determining the best path toward net zero. On average, we estimate our vision will save our communities $110-200 billion dollars in economy-wide costs by 2050 compared to a high electrification approach, which is similar to the "All Options" pathway developed in the *Massachusetts 2050 Decarbonization Roadmap* and "Scenario 3: Accelerated Transition Away from Combustion" scenario developed in the New York State *Climate Action Council Draft Scoping Plan* (see Figure 8).[11] These cost savings are a direct result of leveraging existing gas system infrastructure, including customer heating equipment, to both achieve net zero targets and keep customers warm during the coldest times of the year.

Figure 8: Relative economy-wide costs to reduce emissions in Massachusetts and New York, 2020-2050.



The issue of affordability is one of the most important factors when determining the best path toward decarbonization.

Provides customers affordable choices to heat their homes and businesses

The answer to "what heating choice is most affordable for me?" will vary depending on the unique circumstance of each of our customers and the timing of that choice. In our service area today, heating with gas is the most cost-effective option for virtually all customers. Especially for low to moderate income customers, affordable heating is crucial.

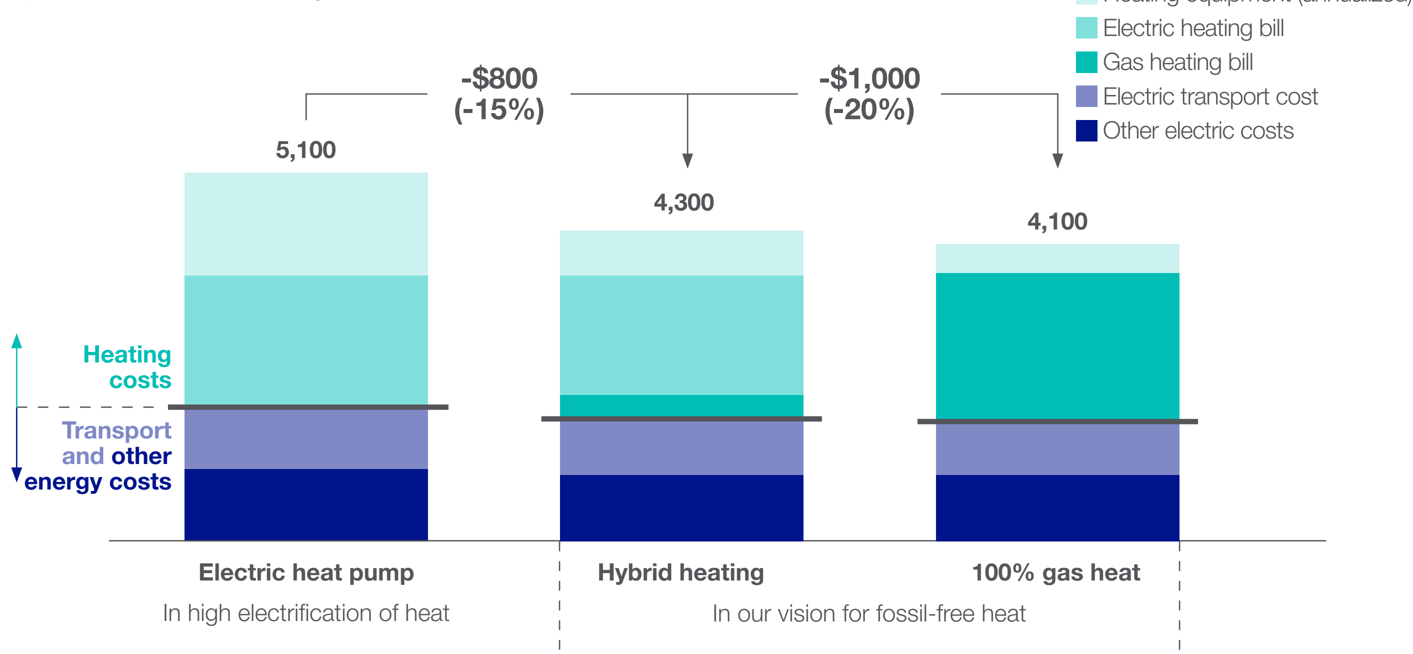
As heating technologies and net zero policies evolve, it will be possible to continue delivering affordable heating options without endangering sustainability goals.

For residential customers living in older, multi-unit buildings and for many of our commercial and industrial customers, findings from external studies show that reducing emissions through efficient, fossil-free gas heat is likely to be the most affordable option for the next three decades. Electrifying heat in these building types will require more expensive heating equipment or more significant building retrofits.[12, 13,14]

For residential customers living in single-family homes, hybrid heating systems have been shown to be the most cost-effective solution for the next decade.[15] Hybrid heating systems are able to lower customer costs by utilizing the strengths of both the gas and electric systems – they can run on renewable electricity when it's available and switch to fossil-free gas for the winter months, leveraging the gas system that has already been built to heat our customers' homes. Hybrid heating systems also significantly lower upfront equipment and building energy efficiency upgrade costs for customers who want some heating electrification.

Not only does our fossil-free vision bring lower heating costs, it also keeps electricity rates lower by avoiding significant overbuilding of generation supply and network upgrades. Compared to a high electrification pathway, electricity rates under our vision are expected to be approximately 5-10% lower in 2040 and 10-15% lower in 2050 than high electrification approaches because it requires less generation, transmission, and distribution infrastructure buildout. By keeping overall rates for electricity lower, it will make it more affordable to use heat pumps, charge electric vehicles, and power everyday appliances. As a result, the average consumer is expected to save 15-20% on their overall energy costs in a given year compared to a high electrification approach (see Figure 9). This is significant savings and real money for an average household. By saving $800-1,000 per year on energy costs, families will have more money for other essentials such as food and housing.

Figure 9: Annual total energy spend for a typical customer in 2040 (2021$).



Results in more equitable outcomes, keeping energy affordable for everyone

Ensuring energy equity must be an important goal for all of us who care about our customers and communities.

Relative to a high electrification approach, our vision to eliminate emissions from heating results in fairer outcomes for society. For example, our customers should not have to spend $20,000-60,000 in upfront costs to fully electrify their homes in order to have clean energy.[16] In our vision, access to clean heating is more equitable because more customers can have clean energy with their existing appliances and heating equipment.

In short, utilizing both renewable electricity and a fossil-free gas system to achieve net zero will significantly reduce upfront cost barriers for customers and keep customer energy bills more affordable by avoiding significant amounts of new infrastructure.

Gives customers smarter, more practical heating choices

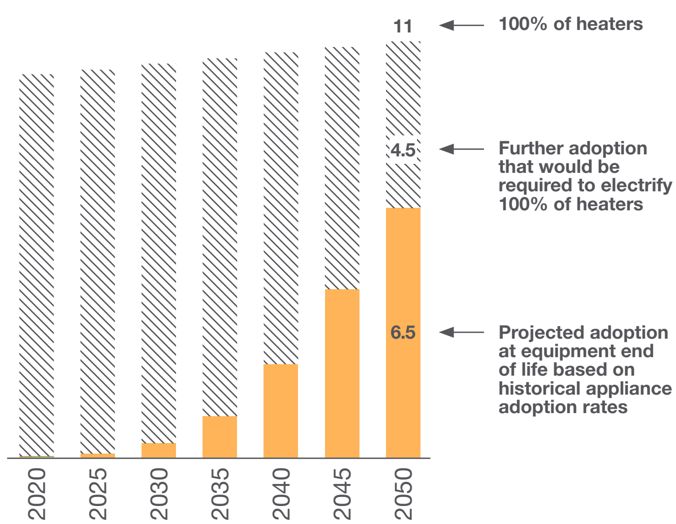
The reality is that a large share of buildings in the Northeast are difficult to electrify – and this will remain an enduring problem. **Our fossil-free vision allows customers to use existing equipment and appliances to achieve net zero and provides an invaluable option for customers who have trouble electrifying**.

In addition to the challenges mentioned above, there may also be other practical challenges that make electrification difficult, such as a renter's ability to convince their landlord to install a new heating system, the availability of equipment, or finding the skilled labor to install an electric heat pump at the time it is needed. Our vision provides more options for renters and disadvantaged communities to have access to clean energy.

Our vision allows for adoption of new cleaner and fossil-free empowered heating technologies to happen on a timeline that is more practical for customers. In contrast, a high electrification approach would require 90,000 homes to electrify per year in Massachusetts and 250,000 homes to electrify per year in New York. What does this mean in reality? This means roughly 2,000 full electric conversions per week in Massachusetts and 5,000 in New York, every week from now until 2050. Either household electrification rates would need to increase by roughly 15-20 times, or half of households would need to replace their gas appliances and heaters before their useful end of life in order to achieve net zero by 2050.[17]

At normal levels of heating equipment turnover, Massachusetts and New York cannot come close to electrifying everything by 2050. Adoption rates similar to historical home appliance adoption levels imply a 40-50% shortfall (see Figure 10). A strategy that relies on customers' willingness to spend thousands of dollars to replace heating equipment that is currently working well is unlikely to succeed. Instead, a better and more equitable way to achieve net zero emissions by 2050 is to transition the gas network to fossil-free fuels. This ensures all our customers will have fossil-free heating regardless of their choice in heating appliances.

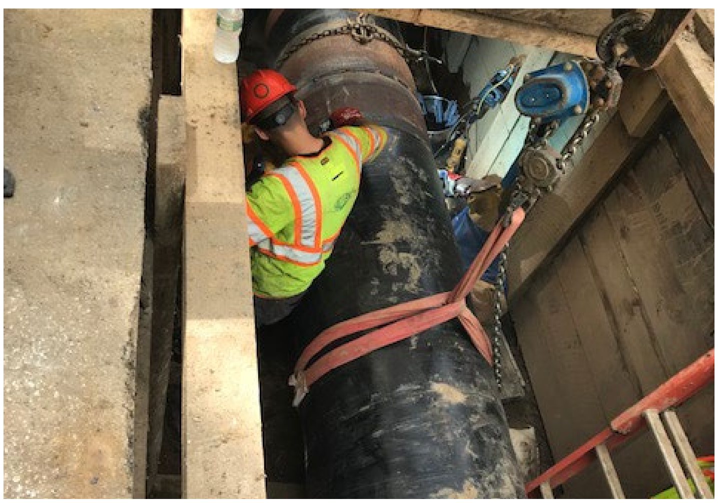
Figure 10: Heating appliances that could be electrified in Massachusetts and New York with normal levels of turnover (millions).



Utilizes the skills of our existing workforce

Our fossil-free vision puts the existing skill set of our gas workforce, including over four thousand union workers, at the heart of the clean energy transition. Empowering our gas workers to play a crucial role in ensuring states achieve their net zero targets will keep important jobs available and leverage the skill sets we already have within our talent pool today. Our workforce is uniquely skilled to transform our existing gas system to deliver RNG and green hydrogen, as well as install new heating technologies such as networked geothermal loops.

It will also help retain the talent necessary for ensuring the safe and reliable operation of the gas network throughout the energy transition while providing robust training opportunities for individuals interested in transitioning to roles within the electric industry. Maintaining a role for the gas network in a net zero future reinforces the enduring value of our frontline union gas workforce as we build this new energy future.



The gas industry provides tens of thousands of good-paying union jobs across the Northeast.

A complementary but diversified electric and gas system is safe, reliable, and more resilient

Supports a reliable and resilient energy system by not having "all our eggs in one basket"

Relying on one system for everything – heat, transport, and power – is riskier than a system with redundancy. An underground pipeline system doesn't have storm-related outages, and can be leveraged to improve the reliability of the overall energy system.

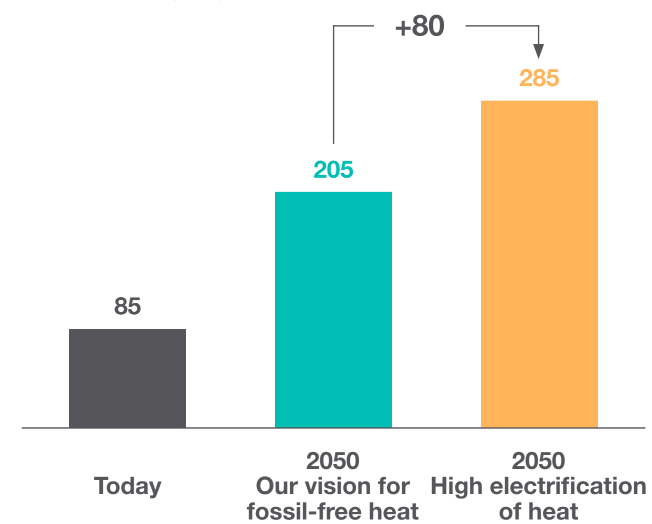
Utilizing both a fossil-free gas system and electric network can reduce the risk of relying on a single energy system for the region's heating capacity, and the fundamental health, security, and safety issues that result from heating service interruptions, such as storms. Our fossil-free vision supports reliability by reducing dependence on high gas volumes during peak times – E3's *Technical Analysis of Decarbonization Pathways* report for Massachusetts showed that a high electrification scenario would need 50% more total gas volume on a peak day to generate electricity as compared to scenarios that utilize the gas network for heat and 15% more gas volume than peak day gas consumption today.[18] This is because gas generation is required on days when there is little sunshine for solar and variable amounts of wind for renewable electricity generation. We expect similar trends to hold true for New York, given similar levels of electrification needed.

Allows a more manageable build out of electric infrastructure

By utilizing an existing energy network, our fossil-free vision supports a more manageable energy transition by relieving pressure to site, permit, and build electric infrastructure at unprecedented rates. The reality is that we would need more electric infrastructure to electrify transport and heating than we have today. Why would such infrastructure be needed? In a high electrification future, winter peak demand would be double today's summer peak and 2.5 times greater than the current peak demand for electricity in the winter.[19] Due to a shift in reliance toward renewables that vary with the sun and the wind, some of which do not perform well in winter (*e.g.* solar), we would need to **increase the amount of electric supply capacity by about 3.5 times** to cover a cold winter day in an all-electric scenario (see Figure 11). This would also require approximately 6,500 miles of new or upgraded high voltage electric transmission lines across New York and New England – requiring the siting and permitting of approximately 40 to 50 new high voltage transmission lines in the Northeast before 2050 (as pictured).[20]

A high electrification of heat approach will require building significant additional electric infrastructure, such as high voltage transmission lines (pictured) to supply greater amounts of electricity at peak times.

Figure 11: Electricity supply capacity in New England and New York (GW)



In contrast, using fossil-free gas avoids the additional costs and challenges of 80 gigawatts (GW) of new generation and associated transmission and distribution networks – 25 GW in New England and 55 GW in New York. **This avoids the siting, permitting, and construction of one third of these challenging projects, which typically take 4-8 years to permit and build.**

More likely to achieve our shared net zero goals by embracing all options

Achieving net zero targets over the next few decades will be challenging, but we have a higher chance of succeeding if we embrace all options versus picking winners and losers. Although net zero models and scenarios help us make informed decisions, we will undoubtedly face a number of unknowns that will shape our path to net zero that are out of our control. For example, what impact will recent global and geopolitical events have on energy prices or energy security? How vulnerable is an energy system that is fully electric to outside attack by a foreign actor? Reducing our dependence on fossil fuels further insulates us from geopolitical volatility.

Our fossil-free vision improves reliability by providing a critical redundancy and preserves and provides options for customers without sacrificing or jeopardizing our net zero goals. In our vision, there are clear 'offramps' available. For example, if low carbon gas prices evolve differently than expected, higher electrification could be leveraged. In contrast, taking steps that remove clean gas options today would shut down a wide range of options that would be difficult to re-open later.

4. Public policies to enable our vision

Many of the policies to enable our vision for fossil-free heat are already in place, such as renewable electricity portfolio standard (RPS), energy efficiency programs and targets, and heat pump incentives. To complete the picture, a few additional state and federal policies would allow greater progress towards net zero, such as:

Scaling supply and demand for renewable fuels

New York and Massachusetts should drive toward net zero gas by establishing renewable gas procurement standards for utilities. Following the successful examples of state renewable electricity portfolio standards, renewable gas standards should:

- require gas utilities to procure a growing proportion of their gas from RNG and renewable green hydrogen over time – by creating a RPS for the gas network, as was done for the electric network, or evolving the way regulators evaluate gas supply plans to include consideration of environmental benefits
- allow further voluntary options to allow customers seeking to decarbonize faster to choose higher blends of renewable gas (up to 100%), much like they can choose varying percentages of renewable electricity.

Complementing these portfolio standards, state and federal incentives should be put in place to support growing investment in equipment to capture biogas (*e.g.* "digesters") and clean and condition it to RNG to make hydrogen (*e.g.* "electrolyzers"). Other states with emissions reduction goals have already implemented these complementary policies, such as California and Washington.

Driving investment in buildings and renewable heating equipment

State and local building codes are essential drivers of efficient and fossil-free-ready new construction, and should prioritize highly-efficient building envelope improvements to reduce the amount of energy required to provide comfortable heat. Energy efficiency policies should increasingly incentivize measures that reduce both annual heating demand as well as peak demand on the gas network, including in targeted gas network locations.

Existing utility incentives for renewable heating equipment should be expanded, supporting more customers with lower-carbon options best suited to their needs – including hybrid/dual-fuel, all-electric, and high-efficiency gas configurations. Where possible, ground-source heat pumps should be encouraged, including networked geothermal (or "district") systems, because they minimize peak electric impacts and can fully replace traditional heating more easily than air-source heat pumps. Appliance standards for high-hydrogen gas blends should likewise be developed. Finally, market-based carbon pricing mechanisms should be established to provide long-term price signals for cleaner heating and provide an additional source of revenue for efficiency and heating incentive programs.

Evolving infrastructure planning and investment

Regulatory planning processes should support long-term network strategies that promote the most efficient use of the gas and electric systems for heating, including geographically targeted fossil-free strategies (*e.g.* hydrogen clusters or electrified neighborhoods). Current planning processes only look out 2-5 years. This horizon should be expanded for gas and electric utilities.

Gas planning practices, service regulations and cost recovery should support both the delivery of renewable gas and the reduction in overall gas demand over time. Sufficient regulatory funding should be provided for the research, development, and demonstration (RD&D) of innovative technologies required to meet state climate targets. In addition, policy frameworks should be established to guide utility investment in renewable district thermal networks, providing an additional tool for achieving fossil-free heat.

Ensuring consistent greenhouse gas accounting methods

Transparent and consistent GHG accounting methods are essential across all sectors of the economy, including the energy sector. Accounting methods should be standardized across our state and federal jurisdictions, and they should be as consistent as possible with international standards. New York and Massachusetts accounting should evolve to properly account for the life cycle carbon of different forms of RNG, recognizing the environmental benefits of RNG from waste and of displacing fossil gas in end-use equipment. In addition, standard approaches are needed across the Northeast for measuring the impact of fugitive emissions from our gas distribution network.

5. Conclusion: What our vision means for the Northeast

How does our vision meet state and regional decarbonization goals?

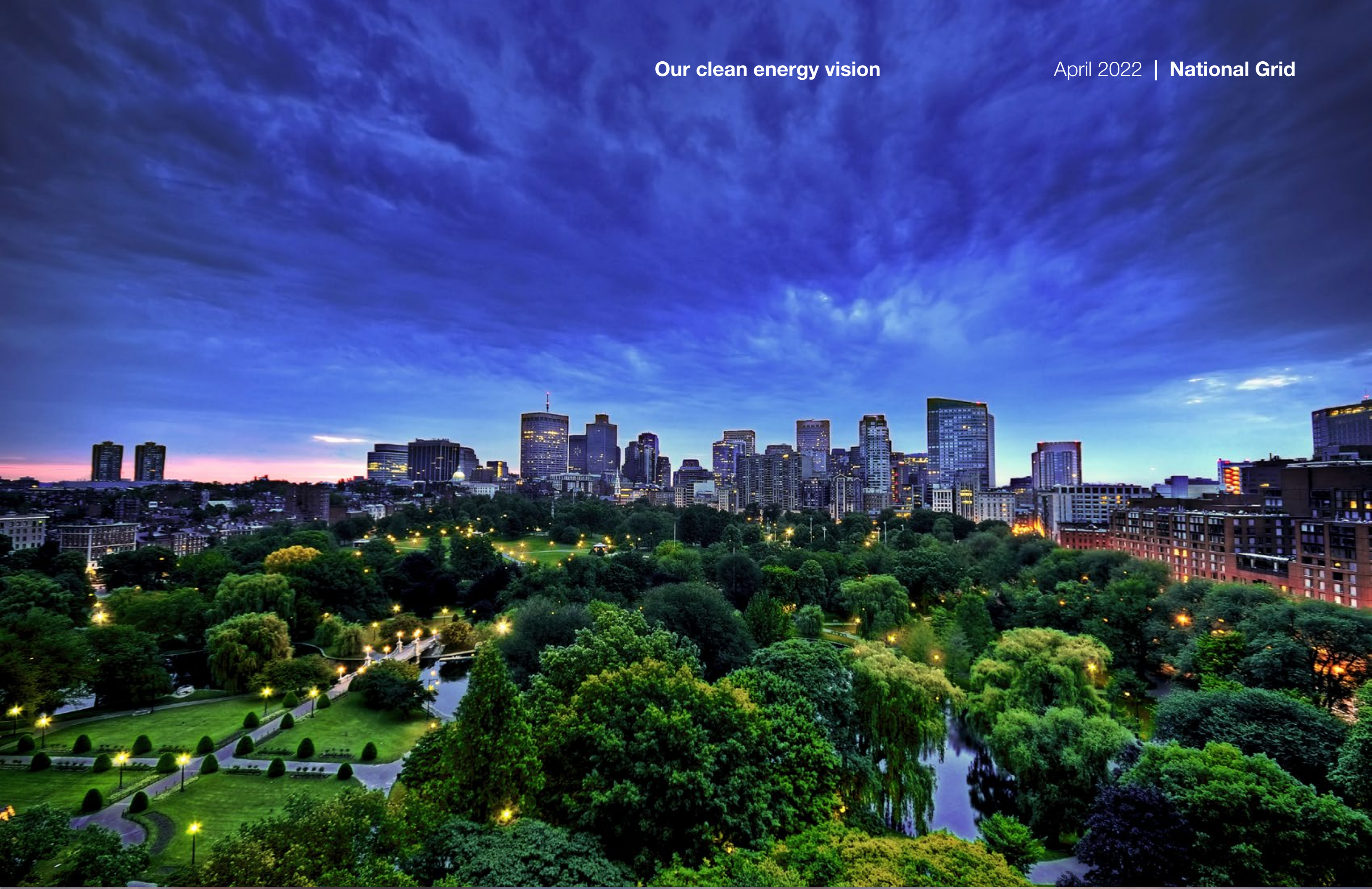
- **It fully eliminates reliance on fossil fuels for heat** and achieves this at lower cost and hassle for customers than high electrification proposals under consideration in Massachusetts and New York.
- **It improves our likelihood of achieving our climate goals** by reducing the amount of new infrastructure required and enabling customers to have multiple options for clean energy and heating their homes and businesses, instead of being mandated to switch to all-electric.

How does our Pathway better achieve the climate goals of the region?

- **Lower heating costs:** It delivers 15-20% lower home heating costs than a high-electrification approach. This will help keep energy costs more affordable.
- **Leaves no customer behind:** It supports equitable outcomes for disadvantaged communities. By avoiding large upfront investments, our vision enables all customers to have access to clean energy.
- **Preserves customer choice:** Our vision is a practical approach that gives customers choice in their heating options to reach net zero, and suits the diversity of buildings in the region. Under our pathway, customers will not have to purchase all new appliances.
- **Leverages existing Infrastructure:** It requires significantly less generation, transmission, and distribution infrastructure. By leveraging existing infrastructure, it reduces the challenge of achieving net zero.
- **Puts the existing workforce at the heart of the clean energy transition:** Our workforce is uniquely skilled to transform our existing gas system to deliver RNG and green hydrogen, as well as install new technologies such as networked geothermal.
- **Strengthens resiliency and reliability:** Our vision is a more resilient and reliable solution. A high electrification approach puts all our eggs in one basket, relying on one system for power, transport, and heating. By decarbonizing the gas system in parallel with the electric system, it creates a more resilient energy system.
- **Practical and achievable pathway to net zero:** Our vision includes tangible and near-term milestones to make clean heat solutions accessible to all our customers.

What we will do in the near-term to enable a fossil-free future?

- **Provide input to Massachusetts and New York state climate plans.** We will engage in the public feedback sessions for our state climate action plans, highlighting the benefits of our fossil-free vision for all residents and businesses.

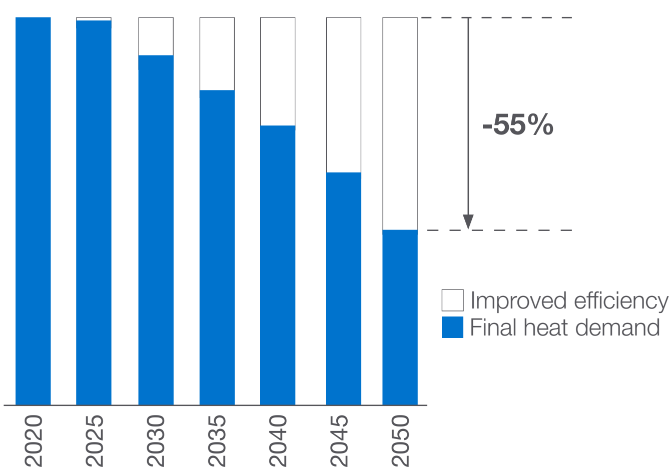


6. Appendix: More about the pillars of our vision

Energy efficiency in buildings

Continued deployment and scaling up of energy efficiency measures will be foundational to keeping energy affordable, avoiding the need to build additional infrastructure and achieving our shared net zero energy future. In our vision, improved energy efficiency reduces final demand for heat by more than half relative to today – through a combination of buildings thermal envelope efficiency, heat pump efficiency, and gas appliance efficiency (see Figure 12).

Figure 12: Final demand for heat in buildings in our vision for fossil-free heat (relative to today).



100% fossil-free gas network

Renewable natural gas

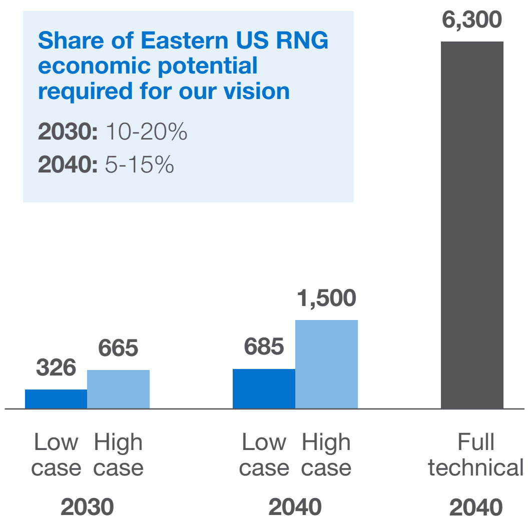
Renewable natural gas (RNG) is surface methane captured from the natural decomposition of organic waste. It has all the same characteristics of and can be used interchangeably with traditional natural gas – to heat buildings, generate electricity or fuel vehicles. Whereas traditional natural gas is sourced from fossilized organic material underground, RNG can be sourced from a vast number of existing waste streams. Potential sources of supply are in every community, including at our landfills, farms, dairies, and wastewater treatment plants, and in everyday sources like our food waste and biomass waste residues, like lawn clippings.

RNG contains biogenic carbon that is part of the planet's natural carbon cycle and does not release additional carbon into the atmosphere when consumed, unlike traditional natural gas which contains geologic carbon. By capturing RNG, we eliminate emissions at the source and, by using it, we displace emissions of geologic carbon. Because biogenic carbon is part of the natural carbon cycle, emissions from RNG use are considered carbon neutral.[21, 22]

RNG offers value in converting waste into a climate solution that can reliably serve diverse energy needs using existing infrastructure. It reduces emissions by providing an economic incentive for local communities to capture methane before it can escape into the atmosphere and exploits an otherwise unused energy source to offset use of traditional natural gas.[23] RNG is a reliable source of renewable energy that can be easily stored and delivered to customers when and where they need it. And it is also considered a "drop-in" fuel – able to be transported through existing gas infrastructure and used in existing customer equipment without modifications.

Large accessible RNG resources are untapped and could be developed to meet the residential and commercial fossil-free heating needs of the Northeast. The most comprehensive study to date on the availability and costs of RNG in the United States, completed by ICF for the American Gas Foundation in 2019 [24], estimated a maximum technical potential – with no economic constraints – of 6,300 TBtu in the Eastern US. With economic considerations taken into account, the supply potential was estimated to be between 685 – 1,500 TBtu in 2040 in US regions already connected by pipeline to the Northeast (see Figure 13).

Figure 13: Eastern US renewable natural gas (RNG) resource potential (Tbtu).



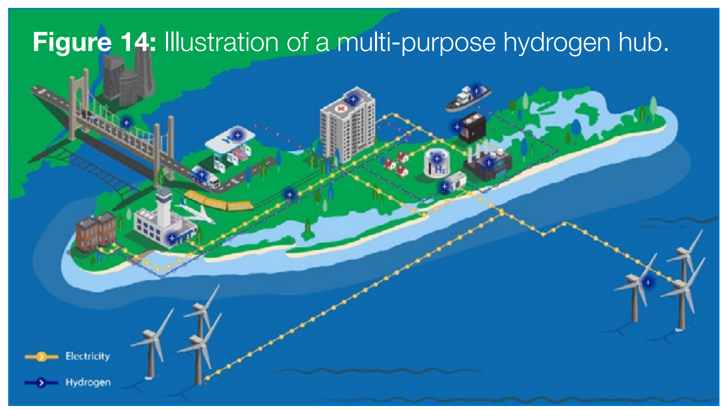
Our fossil-free vision assumes National Grid eventually procures 10-20% of RNG annual supply potential in the Eastern US for our customers, roughly in line with our customers' share of gas demand today in the supplying geography.[25] Sources of RNG supply are rapidly developing and being contracted as utilities and individual customers seek fossil-free options to decarbonize heating and other uses. In the US and Canada, over 250 RNG facilities are in operation today, more than 110 are under construction and growing interest by end-users and developers indicate an accelerating pipeline of supply ahead.

Green hydrogen

Hydrogen, the most abundant chemical element on earth, offers enormous potential as a source of clean energy. When hydrogen is converted to useable energy in a fuel cell or burned to release its energy, the only byproduct is water vapor. And when hydrogen is produced with renewable feedstocks it is known as green hydrogen, and is carbon free.

Hydrogen has the potential to help decarbonize multiple sectors, including power generation, transport, and heating. For heating, hydrogen can be blended with natural gas or RNG up to 20% by volume and run through gas networks and used in customer appliances without significant upgrades to infrastructure or equipment. In areas with high levels of gas demand, pure hydrogen also has potential to serve fossil-free heating and other energy needs in dedicated 100% hydrogen clusters. These may be part of hydrogen hubs – clusters of local hydrogen production, storage, and demand (see Figure 14).

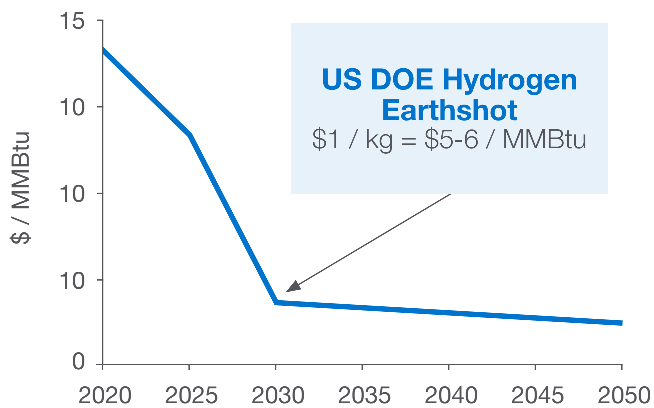
Figure 14: Illustration of a multi-purpose hydrogen hub.



Hydrogen is a valuable option for its complementarity to growing renewable electricity capacity, its ability to be stored and its flexibility to be used across different sectors. Green hydrogen can be made during periods when wind or solar resources are able to produce more electricity than the grid needs, and then stored for later use, thereby maximizing the benefits of renewable energy resources. Already, a significant number of offshore wind projects are proposing green hydrogen production through electrolysis as a form of long-duration storage of renewable electricity. The gas network itself can serve as a large storage reserve by carrying hydrogen.

Hydrogen development to enable the energy transition is receiving strong government support and interest from industry. The US Department of Energy's Earthshot Initiative aims to reduce the cost of green hydrogen to $6-7 per MMBtu in the next 10 years [26] – a target that we assume is reached and would bring the cost in line with today's costs for natural gas (see Figure 15). The Bipartisan Infrastructure Investment and Jobs Act passed by Congress in February 2022 allocated $8 billion to establish regional clean hydrogen hubs, one or more of which could be sited in the Northeast; $1 billion for RD&D to reduce costs of hydrogen produced from clean electricity; and another $500 million to support hydrogen equipment manufacturing and domestic supply chains.[27]

Figure 15. Hydrogen commodity cost estimate 2020-2050.



Pilot projects are proliferating across the US – covering production, storage, pipeline transmission and distribution, end uses, and use in power generation.[28] In New York, National Grid has launched the HyGrid Project to build one of the first and largest clean hydrogen projects in the country to blend green hydrogen into existing gas networks, and Plug Power is investing in a large green hydrogen production facility to supply fuel for multiple uses.[29]

Hydrogen to supply our customers could be sourced from a mix of renewable generation and electrolyzer capacity in the Northeast as well as imports. If we relied only on dedicated offshore windfarms to produce the amount of hydrogen in our vision, it would require 7-11 GWs of additional capacity, compared to existing plans in the Northeast to build about 40 GW of offshore wind by 2050.

While existing customer heating and cooking appliances could use low blends of hydrogen, higher blends or 100% hydrogen require new units with modifications to burners, fittings and sensors. 100% hydrogen-ready appliances are already being demonstrated commercially in the UK, where manufacturers are supporting a hydrogen-ready standard for all equipment sold by 2025 and have pledged to match the price to conventional gas equipment.

Hybrid electric-gas heating systems

Hybrid – or dual-fuel – heating systems pair an electric heat pump and gas heater in a building. The electric heat pump provides cooling in the summer and heating during the more temperate "shoulder" seasons. The gas heater provides heating during the coldest months of the year, when temperatures fall below a threshold temperature. Depending on gas during these coldest periods allows customers to install a smaller, more affordable heat pump than would otherwise be needed if the heat pump was sized to cover the customer's full heat load. Heating needs served by the gas component of the hybrid system vary according to heat pump specifications (size and balance point temperature) and climate.

For many customers, hybrid systems can offer a clean solution that is more comfortable, cost-effective and practical for serving cold weather heating needs compared with an all-electric installation. They avoid using inefficient and costly electric resistance as the supplemental heating source during the coldest months. They also allow customers who use gas today to continue using their existing gas heater and avoid larger building changes that might be required for an all-electric system, while still capturing the summer cooling and shoulder season heating benefits of heat pumps. For the broader energy system, hybrid heating adoption across the customer base can help to lessen electric supply and network infrastructure challenges by avoiding high electric peak loads during winter.

Hybrid heating systems are already being adopted in our region today. Nearly all gas customers in the Northeast who have installed an electric heat pump to date have retained their existing heater, effectively gaining cooling and hybridizing their heating. Sustainability advisors like E3[30] and McKinsey & Co. have suggested hybrid systems as an important option to decarbonize heat in the Northeast and other regions.

Targeted electrification and networked geothermal

National Grid's vision embraces our role as a leader in evaluating opportunities for non-pipe alternatives, including consideration of targeted electrification and networked geothermal systems. In specific instances, it may be possible to coordinate electrification of heat across multiple streets or neighborhoods. The main difference between networked geothermal and targeted electrification through air-source heat pumps is that the former has better winter performance and places lower strain on the electric grid. This is because networked geothermal systems exchange heat with the ground (which stays at a constant temperature below a certain depth) instead of with the outside air, which fluctuates more widely. For this reason, ground-source heat pumps have higher efficiency and lower electric needs.

This targeted approach can have positive impacts, provided that the benefits of avoided gas infrastructure outweigh the incremental electric system upgrade costs. While this approach has not yet been piloted at scale in the Northeast, and there are likely to be a range of regulatory issues, there are affordability, safety, and reliability criteria that can guide our approach.

For example:

Reliability and critical loads

Targeted electrification should minimize impact on gas network performance. For example, mains that supply multiple lower-pressure distribution networks or critical customers (*e.g.* hospitals) would be difficult to electrify, while smaller segments that do not serve critical system requirements would be easier.

System economics

Targeted electrification should optimize the economics of avoided gas network investment and additional electric grid investment. For example, it would be preferable to target electrification in areas where substantial leak-prone-pipe investment is required, rather than in areas where new main has been recently installed. Similarly, it should aim to minimize significant electric grid investment, for example where costs are high or siting issues are acute. In such areas, for example, upgrading to hydrogen-readiness is likely to be preferable. This optimization would require understanding key gas and electric network characteristics, for example: capacity 'headroom' on the electric system, cost of electric upgrades in different parts of the network, cost and expected timing of pipe replacement in different parts of the network, and customer density (*e.g.* meters per mile) as a proxy for customer contributions to system investment. In sum, a paradigm shift toward whole system optimization is likely to be required, to minimize costs on the path to net zero.

Customer economics and practicality

Targeted electrification should minimize customer cost and disruption. This could be achieved by focusing on areas with a prevalence of building types that can be electrified at relatively lower cost (*e.g.* newer, detached homes) and where customer disruption could be minimized.

7. Notes and sources

1 Sum of Residential, Commercial, and Industrial million metric tons of energy-related carbon dioxide emissions divided by economy-wide Total emissions from U.S. Energy Information Administration, "Summary Table 4. State energy-related carbon dioxide emissions by sector," 2018, available at https://www.eia.gov/environment/emissions/state/

2 U.S. Census, "American Community Survey B25040 House Heating Fuel" for Massachusetts and New York, 2020, available at https://data.census.gov/cedsci/table?t=Heating%20and%20Air%20Conditioning%20%28HVAC%29&g=0400000US25,36&tid=ACSDT5Y2020.B25040

3 Estimated 1% electric heat pump adoption in Massachusetts from low historical adoption rate from Mass Save, "Massachusetts Energy Efficiency Program Administrators Quarterly Report" section titled Bi-Annual Data at 3, 2019-2021, available at https://ma-eeac.org/results-reporting/quarterly-reports/. Estimated 1% electric heat pump adoption in New York from VEIC, "Ramping Up Heat Pump Adoption in New York State" at 4, September 2018, available at https://www.veic.org/Media/default/documents/resources/reports/veic-ramping-up-heat-pump-adoption-in-new-york-state.pdf

4 Upfront air-source heat pump and building retrofit costs estimated as $29,000 - $36,000 in Massachusetts from Energy + Environmental Economics ("E3"), "The Role of Gas Distribution Companies in Achieving the Commonwealth's Climate Goals: Technical Analysis of Decarbonization Pathways" ("E3 Decarbonization Pathways Report") at 102, March 2022, available at https://thefutureofgas.com/content/downloads/2022-03-21/3.18.22%20-%20Independent%20Consultant%20Report%20-%20Decarbonization%20Pathways.pdf. Upfront air-source heat pump and building retrofit costs estimated as $21,087 (Residential Single Family Basic Shell + Air Source Heat Pump) - $59,814 (Residential Single Family Deep Shell + Air Source Heat Pump) from Climate Action Council Draft Scoping Plan, "Appendix G: Annex 1: Inputs and Assumptions [XLSX]" at Bldg_Res Device Cost tab, February 2022, available at https://climate.ny.gov/Our-Climate-Act/Draft-Scoping-Plan

5 National Grid estimate based on Arup analysis of existing state and municipal building data.

6 E3 Decarbonization Pathways Report at 19.

7 World Bank, "Brief: Solid Waste Management," February 2022, available at https://www.worldbank.org/en/topic/urbandevelopment/brief/solid-waste-management

8 U.S. Department of Energy, "DOE Establishes Bipartisan Infrastructure Law's $9.5 Billion Clean Hydrogen Initiatives," February 2022, available at https://www.energy.gov/articles/doe-establishes-bipartisan-infrastructure-laws-95-billion-clean-hydrogen-initiatives

9 New York State, "Governor Hochul Announces Multi-State Agreement Signed with Major Hydrogen Ecosystem Partners to Propose a Regional Clean Energy Hydrogen Hub," March 2022, available at https://www.governor.ny.gov/news/governor-hochul-announces-multi-state-agreement-signed-major-hydrogen-ecosystem-partners

10 (16,235 total ASHP - 2,933 total full ASHP replacements) / 16,235 total ASHP customers = 82% partial ASHP installations from Mass Save, "Massachusetts Energy Efficiency Program Administrators Quarterly Report, Fourth Quarter, 2021", section titled Bi-Annual Data, at 3 of 75, 2021, available at https://ma-eeac.org/results-reporting/quarterly-reports/

11 Massachusetts values for "Our vision for fossil-free heat" based on cost range for "Hybrid Electrification" and "Efficient Gas Equipment" scenarios and "High electrification" based on "High Electrification," "2030 CECP," and "100% Gas Decommissioning" scenarios from E3 Decarbonization Pathways Report at 12-13. New York values for "High electrification" based on NPV of Net Direct Costs for "Accelerated Transition" from Climate Action Council Draft Scoping Plan, "Appendix G: Integration Analysis Technical Supplement" at 66, February 2022, available at https://climate.ny.gov/Our-Climate-Act/Draft-Scoping-Plan. A fossil-free gas pathway has not been publicly modeled for New York, so values for "Our vision for fossil-free heat" scale New York costs proportionally based on scenario costs calculated for Massachusetts.

12 E3 Decarbonization Pathways Report at 41-42.

13 New York City Mayor's Office of Sustainability, "Pathways to Carbon-Neutral NYC: Modernize, Reimagine, Reach" at 38, April 2021, available at https://www1.nyc.gov/assets/sustainability/downloads/pdf/publications/Carbon-Neutral-NYC.pdf

14 BloombergNEF, "New Energy Outlook 2020," at 59, available at https://about.bnef.com/new-energy-outlook-2020/

15 E3 Decarbonization Pathways Report at 102.

16 Upfront air-source heat pump and building retrofit costs estimated as $29,000 - $36,000 in Massachusetts from E3 Decarbonization Pathways Report at 102, March 2022, available at https://thefutureofgas.com/content/downloads/2022-03-21/3.18.22%20-%20Independent%20Consultant%20Report%20-%20Decarbonization%20Pathways.pdf. Upfront air-source heat pump and building retrofit costs estimated as $21,087 (Residential Single Family Basic Shell + Air Source Heat Pump) - $59,814 (Residential Single Family Deep Shell + Air Source Heat Pump) from Climate Action Council Draft Scoping Plan, "Appendix G: Annex 1: Inputs and Assumptions [XLSX]" at Bldg_Res Device Cost tab, February 2022, available at https://climate.ny.gov/Our-Climate-Act/Draft-Scoping-Plan

[17] 4,000 homes estimated to have adopted air-source heat pumps in Massachusetts from E3 Decarbonization Pathways Report at 98. Massachusetts would need to install roughly 90,000 heat pumps a year to electrify 2.5 million buildings that aren't already electrically heated in the next 28 years. Of 43,418 homes estimated to have adopted air-source heat pumps in New York, half estimated to be for NEEP's Cold Climate Specification and assumed to be maximum number of full-home heaters from VEIC, "Ramping Up Heat Pump Adoption in New York State" at 4, September 2018, available at https://www.veic.org/Media/default/documents/resources/reports/veic-ramping-up-heat-pump-adoption-in-new-york-state.pdf. New York would need to install roughly 250,000 heat pumps a year to electrify 7.1 million buildings that aren't already electrically heated in the next 28 years.

[18] E3 Decarbonization Pathways Report at 65.

[19] ISONE 22 GW summer peak and 20 GW winter peak in 2020 and 59 GW winter peak in the "High Electrification" scenario in 2050 from E3 Decarbonization Pathways Report at 59. NYISO 31 GW summer peak and 24 GW winter peak in 2020 and 50 GW winter peak in 2050 in the "Accelerated Transition Away from Combustion" pathway from Climate Action Council Draft Scoping Plan, "Appendix G: Annex 2: Key Drivers and Outputs [XLSX]" at All_Peak by Scenario tab, February 2022, available at https://climate.ny.gov/Our-Climate-Act/Draft-Scoping-Plan

[20] Estimated 4,500 miles overloaded from ISO New England, "2050 Transmission Study" at 15, available at https://www.iso-ne.com/static-assets/documents/2022/03/a4_2050_transmission_study_preliminary_n_1_and_n_1_1_thermal_results_presentation.pdf. Internal estimate of 2,000 miles for NYISO assumes build out of 1,400 miles of West – East and North – South transmission and 600 miles of local transmission.

[21] Intergovernmental Panel on Climate Change, "2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories," Chapter 2: Stationary Combustion, Section 2.3.3.4 Treatment of Biomass, 2019, available at https://www.ipcc-nggip.iges.or.jp/public/2019rf/pdf/2_Volume2/19R_V2_2_Ch02_Stationary_Combustion.pdf

[22] CDP,"Guidance & questionnaires," available at https://guidance.cdp.net/

[23] MJ Bradley, "Renewable Natural Gas: The RNG Opportunity for Natural Gas Utilities" at 1, April 2017, available at https://www.mjbradley.com/sites/default/files/MJB%26A_RNG_Final.pdf

[24] ICF, "Renewable Sources of Natural Gas: Supply and Emission Reduction Assessment" at 68-69, December 2019, available at https://gasfoundation.org/2019/12/18/renewable-sources-of-natural-gas/

[25] U.S. Energy Information Administration, "Natural Gas Consumption by End Use" for Residential and Commercial, available at https://www.eia.gov/dnav/ng/ng_cons_sum_a_EPG0_vgt_mmcf_a.htm

[26] U.S. Department of Energy, "Hydrogen Shot," available at https://www.energy.gov/eere/fuelcells/hydrogen-shot

[27] U.S. Department of Energy, "DOE Establishes Bipartisan Infrastructure Law's $9.5 Billion Clean Hydrogen Initiatives," February 2022, available at https://www.energy.gov/articles/doe-establishes-bipartisan-infrastructure-laws-95-billion-clean-hydrogen-initiatives

[28] S&P Global Market Intelligence, "US hydrogen pilot projects build up as gas utilities seek low-carbon future," October 2021, available at https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/us-hydrogen-pilot-projects-build-up-as-gas-utilities-seek-low-carbon-future-65570349

[29] Plug Power, "Plug Power To Build North America's Largest Green Hydrogen Production Facility In Western New York," February 2021, available at https://www.ir.plugpower.com/Press-Releases/Press-Release-Details/2021/Plug-Power-to-Build-North-Americas-Largest-Green-Hydrogen-Production-Facility-in-Western-New-York/default.aspx

[30] E3 Decarbonization Pathways Report. E3, "Philadelphia Gas Works Diversification Study," December 2021, available at https://www.phila.gov/media/20211207134817/PGW-Business-Diversification-Study-2021-12.pdf. E3, "New England Reliability Under Deep Decarbonization," November 2020, available at https://www.ethree.com/wp-content/uploads/2020/11/E3-EFI_Report-New-England-Reliability-Under-Deep-Decarbonization_Full-Report_November_2020.pdf

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April 2022. NG13251/WS.