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The critical role of hydrogen in our clean energy future

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Clean hydrogen will play an important role in the decarbonization of the Northeast. It has the potential to decarbonize multiple sectors of the economy by providing a cleaner residential heating fuel, an energy resource for industries that are hard to decarbonize, a zero-carbon transportation fuel for larger vehicles and an on-demand, carbon-free fuel for power generation.

- **A low-cost solution to a clean energy future:** Hydrogen will allow for a balanced and resilient pathway to decarbonization, requiring less buildout of new assets and ultimately minimizing the impact on customer energy bills, all while achieving regional net zero goals. By delivering a blend of hydrogen and renewable natural gas (RNG) in existing networks, customers can access clean heat without making costly investments in new electric appliances or upgrading their electrical systems. This is especially important for renters who don't have the option to upgrade.
- **A safe alternative.** Incorporating hydrogen into the energy mix is part of our plan to eliminate fossil fuels from our systems by 2050 or sooner. It is a clean and safe fuel that will begin to ramp up throughout the decade and eventually scale to meet the needs of the communities we serve. The U.S. gas network has seen hydrogen before. Prior to the mid-1950s before the advent of natural gas, some gas systems including our own networks had as much as 50 percent hydrogen blend flowing in the system.
- **Improved resiliency and reliability of the entire energy system.** Because hydrogen can be stored for long periods of time (analogous to battery storage of electricity), it can be used to generate electricity and heat, and it will help to decarbonize the integrated gas and electric system.

We understand our customers and stakeholders have questions about the use of hydrogen and the role it will play going forward, and we have compiled the following Q&A to address many of these topics.

National Grid's Hydrogen Vision

1. What is clean hydrogen and why is it important to a clean energy future?

Clean hydrogen is a renewable fuel that can be produced emissions-free from water and renewable electricity. This process is part of a nearly-perfect renewable cycle; electricity splits water into hydrogen and oxygen, and when hydrogen is used as a fuel, it combines with oxygen to form water, emitting no carbon dioxide. Clean hydrogen is valuable because it can store energy from renewable sources like solar and wind, either for using directly as a fuel or for generating clean power at another time.

We believe that clean hydrogen is key to a clean energy future and to ensuring we fully eliminate fossil fuels from our electric and gas system by 2050. It plays two major roles:

- Clean hydrogen will help remove emissions from sectors that are hard to decarbonize like heat, certain industries, and heavy transport. In many cases, fully electrifying these sectors would be prohibitively expensive or technically not feasible. Hydrogen provides a clean, carbon-free fuel for these sectors that will replace the carbon-intensive fuels they use today.
- By using clean hydrogen to fuel power generation, we will make a fully-renewable power grid more reliable with less infrastructure build-out (transmission lines, substations, etc.). During times when renewables like solar and wind

are producing less power than is needed (for example, when winds are low or the sky is cloudy), on-demand power generation using clean hydrogen will fill the gaps. And when renewables are making more power than can be used, clean hydrogen can be produced from excess renewable energy and stored for later use in power generation.

2. How and when does National Grid expect to integrate hydrogen into our gas networks?

National Grid is a leader when it comes to delivering clean energy solutions to our customers. We are proactively finding ways to help society transition to a low-carbon and ultimately carbon-free future through research and development, and planning for the evolution of our networks to deliver carbon-free fuels.

Our vision for hydrogen is to create an ecosystem that includes blending hydrogen with renewable natural gas into the existing gas networks, developing 100% hydrogen-fueled use cases for campuses and specific buildings, creating hydrogen clusters anchored by large commercial and industrial customers in a distinct network of hydrogen users, and fueling our power generators.

We are accelerating the energy transition through pilot demonstrations in the next five years to position our assets and operational processes to safely deliver low-carbon energy, like hydrogen. By 2030, we intend to scale up low-carbon energy significantly in conjunction with our existing capital investment plans. With increasing availability of clean hydrogen over time, we will increase the volume of hydrogen blends to displace fossil gas delivered to our customers, with plans to have 20% hydrogen on our gas networks by 2040.[1] In certain sections of our networks, we will deploy 100% hydrogen clusters for customers and communities that will cater to diverse needs. This includes energy usage delivered through fuel cells, district heating, and other uses.

Displacing fossil fuel with hydrogen will be implemented concurrently with our existing programs of energy efficiency, demand response, renewable natural gas, and electrification of heat. Integrating hydrogen with other programs will safeguard the reliable energy that our customers depend on.

In parallel, we are replacing existing gas distribution networks across our service territory as part of long-term programs to modernize its infrastructure, ensure public safety and reduce methane emissions. These programs plan to replace all leak-prone mains by the time high-hydrogen blends are expected to be available and economical.

3. What has National Grid done to ensure that hydrogen is safe?

Working with partners such as Northeast Gas Association's NYSEARCH, GTI Energy, Operations Technology Development (OTD) and Utilization Technology Development (UTD), and other joint industry collaboratives, National Grid has supported nearly 40 research projects covering topics such as personnel and customer safety, pipeline integrity, material compatibility, gas blending, metering and measurement technologies, leak detection and quantification, customer appliance performance, and other end use applications. These studies, along with numerous other scientific studies conducted and published by other entities around the world, have given us insight into how hydrogen will behave in our networks and how we can implement hydrogen in a way that is safe for our customers, employees, and equipment. Specific hydrogen safety topics are explored in the next section of this document.

- We are working with the U.S. Department of Energy and four of their national laboratories on the Pipeline Blending CRADA – a HyBlend Project, which seeks to address technical barriers to blending hydrogen in natural gas pipelines.
- We are working with the New York State Energy and Research Development Authority (NYSERDA) and Stony Brook University to understand how hydrogen will perform in our existing gas infrastructure.
- We are introducing one of the first and largest clean hydrogen blending projects in the country in the town of Hempstead, Long Island, which will heat 800 homes and fuel a fleet of city vehicles.
- We are partnering with the Standard Hydrogen Corporation (SHC) to build and operate SHC's Energy Transfer System, the nation's first multi-use, renewable hydrogen-based energy storage and delivery system, in New York. This project has been approved by New York's Public Service Commission and will have the

[1] National Grid, "Our clean energy vision," 2022. Accessed online: https://www.nationalgrid.com/document/146251/download

ability to provide clean energy services to National Grid and its customers, including renewably charging electric vehicles, refueling long-range fuel cell electric vehicles, providing long-duration backup power, and blending hydrogen into the gas network – all from one piece of infrastructure.

- In the UK, we are launching a research facility to test how Britain's gas transmission network can be used for transporting hydrogen, in partnership with Northern Gas Networks, a gas distribution company. With financial support from the UK regulator Ofgem, blends of hydrogen up to 100% will be tested at the pressures found in the existing network, to assess how the gas behaves and interacts with various parts of the system, such as pipes, valves, and gas meters.

4. How is hydrogen being distributed and used in the U.S. today?

While clean hydrogen is not widely used currently, hydrogen has a long track record of safe transportation, storage, and use in the United States and around the world. Blends of hydrogen and other gases were first used as a residential heating fuel more than 150 years ago, and today Hawaii Gas Company continues to safely deliver residential gas containing up to 15% hydrogen to customers around the Hawaiian Islands.[2] Hydrogen has also long been used in fertilizer production, steelmaking, electric transmission cooling, and other industries. To serve these industries, more than 1,600 miles of pipelines carrying pure hydrogen exist in the U.S. today,[3] including three miles of pipeline in upstate New York.[4] These hydrogen pipelines have been operating safely for decades and are very similar to other gas-carrying pipelines. Hydrogen is also transported via truck as a gas or liquid in cylindrical tanks, or via barge or tanker as a liquid. Additionally, in recent years, hydrogen has seen a growing interest as a transportation fuel, with about 35,000 hydrogen forklifts[5] and over 13,500 hydrogen vehicles[6] operating in the U.S. today.

Worldwide, more than 90 million tons of hydrogen are produced each year.[7]

Hydrogen Safety

5. Is hydrogen safe?

Like any other fuel, hydrogen has unique properties that are managed via the use of appropriate safety measures. Hydrogen is used safely in a wide array of settings across the U.S. and globally, including in gas networks, and is safely transported and stored in both compressed gas and liquid forms (see Q4: "How is hydrogen being distributed and used in the U.S. today?"). This demonstrates that hydrogen is safe when it is implemented properly – a conclusion further supported by many studies, conducted by National Grid and others, that examine specific behaviors of hydrogen and its use in various applications (see Q3: "What has National Grid done to ensure that hydrogen is safe?"). As a member of the Center for Hydrogen Safety and a sponsor of relevant research through numerous academic and industry organizations, we are committed to looking beyond today's research to exhaustively evaluate the safety of hydrogen, exploring and addressing risk.

Safety is National Grid's number one priority, and we will ensure the safety of any hydrogen introduced into our infrastructure and our customers' equipment.

6. Is hydrogen safer or more dangerous than natural gas?

Hydrogen behaves differently from natural gas, but it is not inherently more or less safe. As with introducing any change to our system, we are ensuring that hydrogen is implemented in a way that is safe for our communities, customers, and employees. We have conducted rigorous scientific studies on how hydrogen behaves, which have shown that blends of up to 20% hydrogen in natural gas are safe in our system. In specific segments

[2] Hawaii Gas, "Decarbonization and Energy Innovation." Accessed online: https://www.hawaiigas.com/clean-energy/decarbonization

[3] U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy, "Hydrogen Pipelines." Accessed online: https://www.energy.gov/eere/fuelcells/hydrogen-pipelines#

[4] U.S. Department of Transportation PHMSA Portal. Accessed online: https://portal.phmsa.dot.gov/analytics/saw.dll?Go

[5] AP News, "Hydrogen-powered vehicles: A realistic path to clean energy?" August 13, 2021. Accessed online: https://apnews.com/article/technology-joe-biden-business-environment-and-nature-climate-change-5913fff50378b5706769463a2b02dfca

[6] California Fuel Cell Partnership, "FCEV Sales, FCEB & Hydrogen Station Data." Accessed online on May 27, 2022: https://cafcp.org/by_the_numbers

[7] International Energy Agency, "Global Hydrogen Review 2022." Accessed online: https://www.iea.org/reports/global-hydrogen-review-2022

of our network where we and the local community agree that transitioning to 100% hydrogen is the best solution, we will only proceed after careful planning about how to introduce hydrogen and with the implementation of new safety features as appropriate. Some of the differences between hydrogen and natural gas are described in the questions that follow.

7. Is hydrogen more flammable than natural gas?

Studies have shown that natural gas blended with up to 25% or 30% hydrogen behaves similarly to pure natural gas,[8] and the blends of hydrogen and natural gas that we intend to deliver to the vast majority of our customers will fall within this range.

When delivered as pure hydrogen (relevant only for specific segments of our network), hydrogen behaves differently from natural gas. For example, while hydrogen is flammable under a wider range of conditions than natural gas, it also disperses more quickly than natural gas, so when released into air it quickly becomes diluted to a level that is no longer flammable.[9] Despite hydrogen's different behaviors, in cases where we deliver pure hydrogen, we will implement appropriate safety features to ensure that hydrogen is as safe or safer than natural gas.

8. Does hydrogen leak more than natural gas?

Hydrogen molecules are smaller than natural gas molecules, and they have the ability to escape through small openings like cracks and gaps more quickly than natural gas molecules might. However, this can be mitigated by using modern plastic piping that reduces the potential for cracks and gaps to form. A recent study found that a main that doesn't leak when it carries natural gas will not leak when it carries hydrogen.[10] In other words, the leak prevention we are doing for natural gas can prevent leaks of hydrogen and hydrogen blends as well.

Over the last five years, we've invested more than $3 billion upgrading our older infrastructure to superior plastic piping, and we continue to do so. Reviews to-date of the plastic pipe that utilities like National Grid are installing show that these materials are compatible with hydrogen.

In every case, before injecting hydrogen into our network, we will confirm the suitability of the piping and all piping components in that section of the network for carrying hydrogen. As described in Q5 ("Is hydrogen safe?") and Q6 ("Is hydrogen safer or more dangerous than natural gas?"), hydrogen is a safe fuel when implemented correctly, and we will ensure that it does not increase safety risks to our communities, customers, and employees.

9. You can smell a natural gas leak and usually know if there's a problem, but hydrogen has no smell. How will you know if there's a leak?

Natural gas has a smell because we add an odorant to the gas to make leaks easier to detect. Research to-date indicates that adding odorants to hydrogen blends or pure hydrogen is feasible for ordinary home uses.[11] The result will be that hydrogen provided to customers will have a similar smell to natural gas for the foreseeable future. Leak detection sensors for hydrogen are also being developed to provide an additional layer of leak protection.

[8] Stony Brook University et al., "Hydrogen Blending in Gas Pipeline Networks—A Review," Energies, volume 15, issue 10, 2022, page 3582. Accessed online: https://www.mdpi.com/1996-1073/15/10/3582/htm

[9] College of the Desert, "Hydrogen Properties," Hydrogen Fuel Cell Engines and Related Technologies, 2001. Accessed online: https://www1.eere.energy.gov/hydrogenandfuelcells/tech_validation/pdfs/fcm01r0.pdf

[10] Harwood, T. et al., "H21 Phase 1 Technical Summary Report," H21 Program, 2021. Accessed online: https://h21.green/app/uploads/2018/11/H21-Phase-1-Technical-Summary-Report_v6.pdf

[11] SGN, "Project Closure Report: Hydrogen Odorant and Leak Detection Part 1, Hydrogen Odorant," Hy4Heat Program, 2020. Accessed online: https://sgn.co.uk/sites/default/files/media-entities/documents/2020-11/00%20Hydrogen%20Odorant%20Final%20Report%20v10.pdf

Beyond home uses, further research is needed to determine whether added odorants would need to be removed (via purification) from hydrogen that will be used in a particular type of device called a proton exchange membrane (PEM) fuel cell. PEM fuel cells convert hydrogen to electricity and are commonly used in fuel cell vehicles. This will not affect ordinary home uses of hydrogen or hydrogen blends.

10. Are emergency responders available and trained for handling hydrogen?

Training programs for hydrogen safety are already being used by emergency personnel,[12] and the industry is well-experienced in disseminating safety training to commercial operations, emergency responders, and the public. Hydrogen is already in use across the U.S. (see Q4: "How is hydrogen being distributed and used today in the U.S.?"), and in the Northeast specifically, there are a number of existing hydrogen vehicle fueling stations and other types of hydrogen facilities. First responders for these facilities have already received hydrogen safety training. National Grid will ensure that all first responders for our hydrogen facilities receive appropriate training, and we have already engaged local fire departments to establish best practices.

Hydrogen and Infrastructure

11. Many gas pipelines in the U.S. are steel, which can experience hydrogen embrittlement, resulting in the potential for cracks to form more easily in pipes when exposed to hydrogen. Are current pipelines in the U.S. unsafe for transporting hydrogen?

Hydrogen embrittlement effects in piping have been studied since the 1970s and continue to be the subject of many research studies. Hydrogen embrittlement is primarily a concern when severe structural defects exist in the pipeline and the pressure is high or fluctuating. At the low pressures used in gas distribution networks like ours, studies have shown that the types of steel typically used in distribution networks are unlikely to experience cracking from hydrogen embrittlement within the lifetime of the mains.[13,14,15] Furthermore, much of our upgraded gas network uses piping made from polyethylene plastic, which has been shown to be compatible with hydrogen (see Q8). In every case, before we inject hydrogen into a section of our distribution network, either as a blend or as pure hydrogen, we will confirm the suitability of the infrastructure in that section of the network for carrying hydrogen.

12. Do my appliances need to be modified to be able to use a hydrogen-natural gas blend? Do I need to buy new appliances?

No, most home appliances will not need to be modified or replaced to accept hydrogen blends up to 20%, the amount we intend to blend across most of our distribution network by 2040. Several studies have tested individual appliances and found that they are compatible with hydrogen blends up to 20%.[16,17,18] Further, a recent project in Staffordshire, England confirmed these findings by introducing a 20% hydrogen blend city-wide, observing that appliances performed well and seeing no increase in appliance failures.[19] National Grid has the capability to evaluate how specific appliances common in our service territory will perform when

[12] H2 Tools (a program of Pacific Northwest National Laboratory), "Hydrogen Safety Training Materials." Accessed online: https://h2tools.org/training-materials

[13] NREL, "Blending Hydrogen into Natural Gas Pipeline Networks: A Review of Key Issues," 2013. Accessed online: https://www.nrel.gov/docs/fy13osti/51995.pdf

[14] University of Illinois at Urbana-Champaign et al. "Assessment of resistance to fatigue crack growth of natural gas line pipe steels carrying gas mixed with hydrogen," International Journal of Hydrogen Energy, volume 44, issue 21, 2019, page 10808.

[15] CEA, "Non-combustion related impact of hydrogen admixture – material compatibility," Testing Hydrogen admixture for Gas Applications (THyGA) Project, 2020. Accessed online: https://thyga-project.eu/wp-content/uploads/20200703-D2.4-Non-combustion-related-impact-of-hydrogen-admixture-material-compatibility.pdf

[16] Gas Technology Institute, "Impact of Hydrogen/Natural Gas Blends on Partially Premixed Combustion Equipment: NOx Emission and Operational Performance," Energies, volume 15, issue 5, 2022, page 1706. Accessed online: https://www.mdpi.com/1996-1073/15/5/1706

[17] Canadian Standards Association, "Appliance and Equipment Performance with Hydrogen-Enriched Natural Gases," 2021. Accessed online: https://www.csagroup.org/article/research/appliance-and-equipment-performance-with-hydrogen-enriched-natural-gases/

[18] Enertek International, "Final Report: Assessment of Hydrogen Enriched Natural Gas," Air Conditioning, Heating, and Refrigeration Institute, 2021. Accessed online: https://ahrinet.org/App_Content/ahri/files/RESEARCH/Technical%20Results/AHRI-8024_Final%20Report.pdf

[19] Keele University, Cadent, and Northern Gas Networks, "HyDeploy: Demonstrating non-disruptive carbon savings through hydrogen blending," HyDeploy Project, 2021. Accessed online: https://hydeploy.co.uk/app/uploads/2018/02/21063_HyDeploy_Carbon_Savings_Report1_DIGITAL.pdf

receiving different fuel compositions, using a predictive tool called RANGE™ Plus.[20] We expect that some very old appliances may need to be replaced to accept a hydrogen blend, however these appliances would likely be replaced within the next few years anyway, before hydrogen is introduced to the gas network. National Grid will only blend hydrogen when and where it is safe for customers' appliances.

For specific segments of our network where we and the local community agree that transitioning to 100% hydrogen is the best solution, we will partner with our customers and communities to identify hydrogen-compatible appliances and facilitate the change.

13. Hydrogen burns with a nearly invisible flame. How will I know that my appliances are lit?

The flames of the hydrogen-natural gas blends that National Grid intends to deliver to customers are blue and visible, much like natural gas flames.[21] For very high rates of hydrogen blending or pure hydrogen service, colorants can be added to hydrogen to illuminate the flame.[22] It's also important to know that home heating appliances like furnaces, boilers, and water heaters use electrical flame sensors or thermocouples to confirm that the appliance is lit, rather than detecting the flame visually. These sensors will continue to function normally with a hydrogen blend or pure hydrogen flame.

Environmental Impacts of Hydrogen

14. Most of the hydrogen today is produced from natural gas. Does this mean hydrogen actually increases, rather than reduces emissions?

Hydrogen can be produced in multiple ways. For many years, hydrogen for use in industries like fertilizer manufacturing and refining has been produced from natural gas through a process called steam methane reforming, which is energy-intensive and emits carbon dioxide. Today, it is possible to produce hydrogen with very limited emissions or even zero emissions, which is called clean hydrogen.

One of those processes is called electrolysis, which uses electricity to split water into hydrogen and oxygen. When electrolysis is powered by electricity from renewables like solar, hydro power, or wind, the hydrogen produced has zero emissions. This zero-emissions hydrogen (sometimes called "green hydrogen") is the type of hydrogen that National Grid intends to supply to customers in our gas network. In addition to being an emissions-free fuel, this type of hydrogen can be generated using electricity that would have otherwise been wasted – for example, at moments when there is more wind power available than the electric grid can accept – thereby allowing us to get more value out of the clean electricity sources we already have.

It is also possible to produce clean hydrogen from natural gas. Unlike conventional steam methane reforming, these processes produce no carbon dioxide or use carbon capture technologies (trapping the carbon dioxide at its source and transporting it to a storage location – usually deep underground – to isolate it). This prevents carbon dioxide from being released to the atmosphere.

15. Is hydrogen a greenhouse gas?

Hydrogen itself is not a greenhouse gas, but leaking hydrogen could interact with greenhouse gases to a very small degree, which is continuing to decline as leak rates are driven down. The climate benefits of transitioning from fossil fuels to clean hydrogen far outweigh hydrogen's global warming impacts.[23]

[20] https://www.nysearch.org/apps/gix

[21] Gas Technology Institute, "Impact of Hydrogen/Natural Gas Blends on Partially Premixed Combustion Equipment: NOx Emission and Operational Performance," Energies, volume 15, issue 5, 2022, page 1706. Accessed online: https://www.mdpi.com/1996-1073/15/5/1706

[22] DNVGL, "Work Package 2: Colourant," Hy4Heat Program, 2019. Accessed online: https://static1.squarespace.com/static/5b8eae345cfd799896a803f4/t/60991d8ad18def12bb3dc90a/1620647310480/WP2+Colourant+Report+final+10+May+2021.pdf

[23] Rocky Mountain Institute, "Hydrogen Reality Check #1: Hydrogen Is Not a Significant Warming Risk," May 9, 2022. Accessed online: https://rmi.org/hydrogen-reality-check-1-hydrogen-is-not-a-significant-warming-risk/

16. What will National Grid do to maximize the climate benefits of hydrogen?

To maximize the climate benefits of hydrogen, it will be important to minimize the potential for leaks across the entire hydrogen supply chain, as is our responsibility with any fuel flowing through our pipes. National Grid's role in this is three-fold:

1. Preventing leaks in our own network. We are taking precautions to strategically blend hydrogen into the sections of our network with modern, corrosion-resistant infrastructure. Every year, we are upgrading additional gas mains to increase the robustness of our network and will continue to invest in this.
2. Ensuring the integrity of gas lines during the regular safety inspections we conduct on our systems and in our customers' homes.
3. Holding our hydrogen suppliers to high standards regarding leak prevention in their operations.

One analysis concluded that even with very high rates of hydrogen leakage – which are avoidable with careful controls – using hydrogen in place of natural gas would result in a global warming impact that is one-fifth to one-seventh that of natural gas when comparing units of energy. With lower, more realistic leakage rates, the impact of hydrogen is 95% lower than that of natural gas.[24]

17. Does hydrogen emit CO_2?

No, hydrogen doesn't contain carbon, which means that it doesn't emit carbon monoxide or carbon dioxide, a greenhouse gas. When hydrogen is used as an energy source, it emits water vapor.

18. What are nitrogen oxides (NOx)? Do I need to worry about NOx emissions in home use?

Nitrogen oxides (NOx) are molecules that, when emitted into the atmosphere in high amounts, can lead to the formation of smog, a type of local air pollution that can cause negative health effects. NOx forms when nitrogen from the air is exposed to flames or high temperatures. Any flame (even a candle or a campfire) can result in NOx emissions, and home boilers, furnaces, and water heaters release a small amount of NOx through chimneys or vents outside of the home.

Some groups have expressed concern that burning hydrogen may produce more NOx than burning natural gas because hydrogen flames tend to be hotter than gas flames. However, early research findings are that North American home appliances using blends of hydrogen and natural gas similar to the blends National Grid intends to use don't produce more NOx, and in fact often produce less NOx than they produce when using only natural gas.[25,26] This is because when a hydrogen blend heats an appliance, the fuel mixes with more air, cooling the temperature of the flame. There are also known and proven ways to reduce NOx emissions that can be adopted for appliances receiving pure hydrogen. Early evidence shows that this reduces their NOx emissions below the level of gas appliances.[27]

19. What about NOx formation from other uses of hydrogen, like transportation or power generation?

NOx emissions can be controlled or even eliminated entirely in these applications. In fact, the U.S. Environmental Protection Agency (EPA) enforces strict standards on NOx emissions in transportation and power generation, and hydrogen fuels will need to meet these same strict limits.

Hydrogen transportation applications like automobiles and heavy-duty trucking use fuel cells to extract energy from hydrogen. Fuel cells are devices that convert hydrogen to electricity without a flame. Fuel cells produce no NOx. Because of this, hydrogen as a transportation fuel is completely emissions-free of harmful byproducts.

[24] Rocky Mountain Institute, "Hydrogen Reality Check #1: Hydrogen Is Not a Significant Warming Risk," May 9, 2022. Accessed online: https://rmi.org/hydrogen-reality-check-1-hydrogen-is-not-a-significant-warming-risk/

[25] Gas Technology Institute, "Impact of Hydrogen/Natural Gas Blends on Partially Premixed Combustion Equipment: NOx Emission and Operational Performance," Energies, volume 15, issue 5, 2022, page 1706. Accessed online: https://www.mdpi.com/1996-1073/15/5/1706

[26] Canadian Standards Association, "Appliance and Equipment Performance with Hydrogen-Enriched Natural Gases," 2021. Accessed online: https://www.csagroup.org/article/research/appliance-and-equipment-performance-with-hydrogen-enriched-natural-gases/

[27] ERM, "Understanding Commercial Appliances for UK Hydrogen for Heat Demonstration," Hy4Heat Program, 2020. Accessed online: https://static1.squarespace.com/static/5b8eae345cfd799896a803f4/t/600b21507e57ed248ed0358b/1611342168875/ERM+FINAL+2020.pdf

Power generation can also use emissions-free fuel cells at a small scale. More commonly, we use gas turbines, which are a different type of device for converting fuels to electricity. There are multiple, established techniques for keeping NOx emissions low when using gas turbines. Right now, turbine manufacturers are designing the world's first gas turbines that use only hydrogen fuel, which they expect will be ready for use by 2030.[28,29] These zero-carbon turbines will emit only very low levels of NOx that are compliant with EPA regulations.

20. How would clean hydrogen be transported from renewable sources like offshore wind? Would this be through trucking and if so, wouldn't that create more emissions?

One of the benefits of clean hydrogen is that in many cases it can be produced close to where it is consumed, reducing the need for transportation. Where transportation is required, we expect that clean hydrogen will ultimately be transported via pipelines, just as gas is transported today. Early on, however, it will be necessary to transport hydrogen by truck or barge until there is enough hydrogen demand to fill a pipeline. The transportation industry is increasingly adopting new technologies to reduce emissions, and during this transitional period, trucks and barges powered by hydrogen or electricity can be used in place of diesel trucks and barges, making transportation pollution-free. Regardless, the climate benefits of replacing fossil fuels with clean hydrogen outweigh any emissions that come from hydrogen transportation (see Q15: "Is hydrogen a greenhouse gas?").

Community Impacts of Hydrogen

21. Many existing and proposed hydrogen projects are located near oil, gas, and chemical facilities, which are disproportionately sited in communities of color and low-income communities. In your planning for the hydrogen hub, is this a consideration of yours? Is this putting communities of color and low-income communities at greater risk from an environmental and safety perspective?

Environmental justice is of critical consideration in our hydrogen plans. With input from our communities and other local stakeholders, we aim to site our projects so that they benefit communities of color and low-income communities, which have historically experienced a disproportionate environmental burden for energy projects.

Hydrogen blending will provide safe, clean hydrogen heating fuel alongside natural gas through the existing networks that feed our customers' homes, in a way that's compatible with their homes' existing appliances. Customers will be able to access clean heat without making costly investments in new electric appliances and upgrading the electrical systems of their homes, which would be required if the future relied on all electric heat. This is especially important for renters who would not be able to upgrade existing appliances.

Hydrogen blending will not pose a safety risk (see Q5: "Is hydrogen safe?") and in addition to reducing carbon dioxide emissions that contribute to climate change, can also reduce NOx emissions that contribute to smog (see Q18: "What are nitrogen oxides (NOx)? Do I need to worry about NOx emissions in home use?"). Additionally, the equipment used to produce and blend hydrogen is compact and clean and will not create air pollution.

[28] Patel, S., "Siemens' roadmap to 100% hydrogen gas turbines," Power Magazine, July 1, 2020. Accessed online: https://www.powermag.com/siemens-roadmap-to-100-hydrogen-gas-turbines/

[29] Simon, F., "GE eyes 100% hydrogen-fuelled power plants by 2030," Euractiv, May 12, 2021. Accessed online: https://www.euractiv.com/section/energy/news/ge-eyes-100-hydrogen-fuelled-power-plants-by-2030/