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Hydrogen Gas Does Not Belong in Your Home: Hydrogen Faces a Diminishing Future as a Heating and Cooking Fuel

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Key Findings

Energy utilities' plans to blend hydrogen with methane—or convert entirely to hydrogen—for home heating and cooking, are out of touch with the limitations of hydrogen and the risks posed by home use.

Burning hydrogen in homes for heat and cooking purposes poses health and safety risks for residents, and is an inefficient way to cut carbon dioxide emissions.

Both heat pumps and energy efficiency are positioned to present robust market competition to hydrogen, and hydrogen availability is likely to be limited.

Taxpayer-subsidized hydrogen hubs and private hydrogen production developments should not be designed to rely on home heating and cooking as a target market.

Executive Summary

Energy utilities' plans to blend hydrogen with methane—or convert entirely to hydrogen—for home heating and cooking purposes, are out of touch with the real limitations of hydrogen and the risks posed by home use. Similarly, hydrogen production planners who are relying on home heating utilities as a market for their hydrogen gas should think again. A realistic assessment of the unfavorable market forces for hydrogen should lead utilities away from such poor investments and toward enterprises such as wind, solar power and battery storage that have brighter and more competitive futures.

IEEFA finds the following:

- Burning hydrogen in homes poses health and safety risks for residents, especially at blends higher than 50%. Also, hydrogen blending at any level is likely to delay electrification transition, resulting in the prolonged combustion of gases in the home, which poses health risks.
- Burning hydrogen for heat and cooking is an inefficient way to cut carbon dioxide (CO_2) emissions. Also, hydrogen transport requires greater gas compression than natural gas—and compression consumes energy.
- Burning hydrogen is not a clean process, even when the hydrogen is "green." It produces nitrogen oxides (NO_x) pollution when it interacts with the air. Also, hydrogen leaks faster than methane, and blending hydrogen with methane may increase methane leakage.
- Hydrogen use in the home faces substantial market competition and upstream challenges. Both heat pumps and energy efficiency pose robust competition to hydrogen, and hydrogen availability is likely to be limited.

Plans that rely on hydrogen use in the home are more wishful thinking than real planning. Taxpayer-subsidized hydrogen hubs and private hydrogen production developments should not be designed to rely on home heating and cooking as a target market. The costs and burdens are not justified by the limited impact that hydrogen use is likely to have, especially in blended form, on carbon dioxide emissions.

Background

The National Renewable Energy Laboratory (NREL) produced an analysis in 2020 of the technical and economic potential for boosting hydrogen's role in the energy economy. It reported that if one did not consider economics at all, hydrogen could achieve a consumption rate of 106 million metric tons per annum (mmtpa)—about 11 times larger than the 2020 market. But the NREL warned, "Most

of that potential demand would be for applications that are currently served by energy sources other than hydrogen."[1] Taking into account economic factors, the NREL estimated hydrogen's market potential to be 22 mmtpa to 41 mmtpa in the contiguous United States, which would be only about two to four times larger than the current market.[2] Heavy hydrogen hype made much more aggressive claims, but the NREL's early caution appears to be justified.

One of the targets for hydrogen gas marketing that is most likely to fall away is home heating.

The U.S. Department of Energy (DOE) lists hydrogen blending among the approaches it includes as options for decarbonizing buildings,[3] but it has not proven to be a popular option. A few examples of blending projects for home heating and cooking do exist. For example, Dominion Energy Utah launched a modest 5% hydrogen blending project in Delta, Utah, in 2023 for about 1,800 homes.[4] Dominion Energy now has a 5% hydrogen pilot project in Hudson, Ohio.[5] A Minnesota utility, Center Point Energy, began a similarly modest blending project in downtown Minneapolis in 2022.[6] National Grid launched an 800-home project in Hempstead, New York in 2021.[7] NW Natural, providing services in Oregon, has stated, "We envision providing a 5% hydrogen blend (by volume) and long term, see a potential for hydrogen blends approaching 20%,"[8] although reportedly it is only blending at a 0.2% rate.[9] Such projects are limited in scale and in level of blending.

The future for hydrogen blending with natural gas for home heating and cooking is not bright, as the purported benefits are far from impressive and fail to stack up against the risks.

Burning Hydrogen in Homes Poses Health and Safety Risks for Residents

Hydrogen presents management and safety issues, particularly at the local service level. The New York State Department of Environmental Conservation (NYSDEC) in 2021 denied a permit for a natural gas peaker plant (to be used to meet high demand during extreme temperatures) in Newburgh, New York, whose sponsor had claimed it planned to reduce carbon emissions by blending hydrogen with the natural gas. The agency explained:

[1] NREL. The Technical and economic Potential of the H2@Scale Concept Within the United States. October 2020, p. 110.
[2] *Ibid*.
[3] DOE. Decarbonizing the U.S. economy by 2050: A national blueprint for the buildings sector. April 2024, p. 52.
[4] Dominion Energy. Dominion Energy Utah starts hydrogen blending. PRNewswire, April 3, 2023.
[5] Spectrum News 1. Dominion Energy tests blending of hydrogen into natural gas on appliances. January 22, 2024.
[6] Canary Media. This utility is blending hydrogen into fossil gas. Can it scale? January 31, 2023.
[7] National Grid. One of the US' first green hydrogen blending projects launches on Long Island. December 15, 2021.
[8] NW Natural. Emerging opportunities for hydrogen and carbon capture. Accessed December 10, 2024.
[9] KGW8 News. Yes, NW Natural has started blending hydrogen into gas sent to some Portland customers. September 13, 2024.

> When compared to natural gas, hydrogen has a higher explosive potential, a higher leak potential, a lower volumetric heating value, and a higher flame temperature.[10]

The DOE reports that hydrogen flames are "virtually invisible in daylight."[11]

The NREL, which in 2013 examined the issues of blending hydrogen into natural gas pipeline networks, cautioned:

> Because hydrogen has a broader range of conditions under which it will ignite, a main concern is the potential for increased probability of ignition and resulting damage compared to the risk posed by natural gas without a hydrogen blend component.[12]

The risk is more problematic for local service lines. Such lines operate at lower pressure than distribution lines, which can reduce leakage risk,[13] but their location can present accumulation hazards. Although the NREL report on hydrogen-methane blending concluded that higher concentrations of hydrogen in distribution mains, up to 50%, present a "minor" increase in overall risk, the report cautioned:

> Risks associated with service lines are different because service lines are often found in confined spaces where leaked gas would be more likely to accumulate. If hydrogen concentrations exceed 20% in service lines, the increase in overall risk is more significant than for distribution mains. For both distribution mains and service lines, proper risk management practices, such as the installation of monitoring devices, reduces overall risk. However, adding more than 50% hydrogen to either distribution mains or service lines results in a significant increase in overall risk. Again, these risk results are associated with introducing hydrogen blends into the existing U.S. natural gas pipeline system and do not apply to new, dedicated hydrogen pipelines carrying pure hydrogen, which would be designed and managed differently than the existing natural gas pipeline system.[14]

Higher blends of hydrogen, although promoted as a carbon reduction measure, pose an elevated safety risk. The NREL 2013 technical report warned:

> Compared with explosions of pure natural gas in confined areas, the relative increase in the severity of confined vented explosions was modest for blends with less than 20% hydrogen. A more significant increase in overpressure, and therefore risk or damage, was observed for blends with more than 50% hydrogen. Vapor cloud explosion overpressure can be

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[10] NYS Department of Environmental Conservation (NYSDEC). Notice of Denial of Title V Air Permit ID No. 3-3346-00011/00017 (Danskammer project). October 27, 2021.
[11] DOE. Factsheet: Hydrogen Data. Accessed January 13, 2025.
[12] NREL. Blending hydrogen into natural gas pipeline networks: A review of key issues. Technical Report NREL/TP-5600-51995. March 2023 (hereafter, NREL 2013 Report), p. vii.
[13] *Ibid.*, p. 21.
[14] *Ibid.*, p. viii.

> significantly reduced for higher hydrogen concentrations if ventilation is used or if the structural congestion causing confinement is reduced (Florisson 2010; Lowesmith 2009).[15]

A study issued by the California Public Utilities Commission in 2022 came to similar conclusions about hydrogen blending, concluding hydrogen blends above 5% could require modifications of appliances to avoid leaks and equipment malfunction, while blends of more than 20% hydrogen present a higher risk of hydrogen permeating plastic pipes and a higher risk of gas ignition outside the pipeline.[16]

Even an Energy Futures Initiative report that makes recommendations to increase production and use of hydrogen nevertheless cites the need for new regulations to guard against safety risks for safe production, transport and distribution of hydrogen, asserting "Protocols and safety systems will have to be developed to protect pipeline workers as well as the communities that hydrogen pipelines traverse."[17]

Managing safety risks generally entails higher maintenance costs. NREL's 2013 report highlighted the issue of maintenance, stating:

> The level of hydrogen that is acceptable for transmission pipelines may need to be reassessed for distribution systems in terms of the frequency and severity of fire or explosion in a highly populated area. In addition, the hazards arising from gas leakage in a distribution system may be more severe than in transmission pipelines, especially in a confined service area. The integrity management for distribution systems under hydrogen services may require a leak detector or a monitoring device or sensor. The maintenance costs for distribution systems under hydrogen service likely will increase because these systems will need to be inspected more frequently and likely will require additional leak detection systems.[18]

NREL cited a study (Florisson 2010) estimating that modifications to existing integrity management practices may incur an additional 10% cost increase due to hydrogen blends.[19]

Graham Bennette, vice president of business development for GNV GL's UK and West Africa regions, and Andrew Williams, senior principal consultant at DNV GL – Oil & Gas in Loughborough, UK, expressed optimism that hydrogen has a role in a low-carbon future, but warned that "extensive work will be needed to prove that the introduction of H2 will not compromise the safety and integrity of gas networks and that there is no increase in risk to the public, either directly or indirectly."[20] For

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[15] *Ibid.*, p. 16.
[16] California Public Utilities Commission. Hydrogen Blending Impacts. R.13-02-008 ALJ/JSJ/jnf (University of California, Riverside). July 18, 2022.
[17] Energy Futures Initiative. The U.S. Hydrogen Demand Action Plan. February 9, 2023, p. 83.
[18] NREL 2013 Report, p. ix.
[19] *Ibid*., p. ES-ix.
[20] Gas Processing News. Gas and the energy transition—repurposing the system with hydrogen. 2019.

example, equipment used during maintenance must be suitable for atmospheres where hydrogen may be present, given the difference between its ignition and flow properties and those of natural gas.[21]

To the extent that blending hydrogen with natural gas prolongs the use of natural gas in home heating and cooking, delaying transition to electrification, it poses a health concern. A 2023 study of home cooking stoves found that natural gas burners set on high and ovens set at 350◦F emitted detectable levels of benzene, a cancer-causing chemical, and in some homes raised indoor benzene concentrations above well-established health benchmarks. Disturbingly, the study also found that benzene produced by the gas-fired stoves migrated throughout homes, in some instances elevating bedroom benzene concentrations above chronic health benchmarks for hours after the stove was turned off.[22]

Such exposure is of particular concern with regard to potential effects on children. It is well-established that exposure to cancer-causing chemicals during gestation and in childhood and adolescence can lead to cancer later in life. An individual's risk also depends on the exposure magnitude and duration and the individual's genetic susceptibility. Medical experts note the most vulnerable ages are the fetal and perinatal periods and the first years of life.[23]

The home cooking stove study did not evaluate a hydrogen-methane blended fuel, but most blends that are actually being implemented, as noted above, are very low in hydrogen. Prolonging the health risk of cooking fuels, particularly for children, is hard to justify—especially given that the hydrogen blending tactic that would prolong the risk, as explained below, is an inadequate method for reducing greenhouse gas emissions.

Hydrogen Burning to Produce Energy Is Inefficient for Cutting Greenhouse Gas Emissions

Hydrogen Gas Produces Comparatively Little Energy by Volume

Hydrogen starts out with a disadvantage as an energy producer from the standpoint of reduction of carbon emissions because the gas produces very little energy per unit of volume. National Grid acknowledges in its proposed 20 Year Plan for its New York gas distribution services that if hydrogen

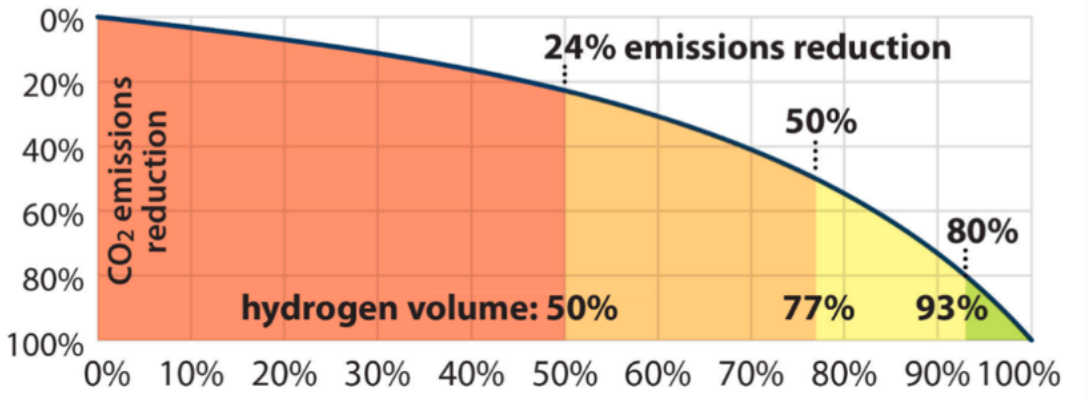
[21] *Ibid*.
[22] Y.S. Kashtan, *et al.* Gas and propane combustion from stoves emits benzene and increases indoor air pollution. Environmental Science & Technology 57(26):9653-9663. June 115, 2023. Also see: E. Lebel, *et al.* Methane and NO_x emissions from natural gas stoves, cooktops, and ovens in residential homes. Environ. Sci. Technol. January 27, 2022.
[23] D. Carpenter, M.D., and S. Bushkin-Bedient, M.D. Exposure to chemicals and radiation during childhood and risk for cancer later in life. Journal of Adolescent Health. 52(5, Supplement):S21-S29. May 2013.

gas is blended with natural gas (methane) at a level of 20% by volume, the hydrogen would substitute for only 7% of the energy provided by a 100% methane blend.[24]

At a DOE webinar in October 2023, Argonne National Laboratory scientists explained that because of hydrogen's lower energy density, pipeline operators must replace each standard cubic foot of gas with three standard cubic feet of hydrogen to deliver the same amount of energy for end users. As a result, they concluded, even a blend of 30% hydrogen likely would only net a 6% reduction in CO_2-e emissions in a lifecycle analysis.[25]

A 100% hydrogen substitution for natural gas would provide only 35% of the energy that had previously been provided by the natural gas. This means an enormous volume of hydrogen would be required to substitute for natural gas.

Figure 1: It takes a lot of hydrogen to cut CO_2 emissions



Source: SS & A Power Consultancy GmBH

National Grid, in its proposed 20 Year Plan for its gas supply services in New York State, advocates for hydrogen but notes certain challenges that entail costs. Although National Grid asserts its leaking pipeline replacement program (LPP) is currently upgrading pipeline segments to accommodate hydrogen-blended gas, its proposed Plan puts the New York State Public Service Commission on notice that a hydrogen strategy would require substantial additional investments. This includes

[24] National Grid. Revised Gas System Long-Term Plan. See In the Matter of a Review of the Long-Term Gas System Plans of The Brooklyn Union Gas Company d/b/a National Grid NY, KeySpan Gas East Corporation d/b/a National Grid, and Niagara Mohawk Power Corporation d/b/a National Grid, Case No. 24-G-0248. October 23, 2024 (hereafter, National Grid Draft 20 Year Plan), p. 57. The final plan is due in March 2025.
[25] Argonne National Laboratory. LCA of NG/H2 blend for various end use applications. DOE H2/Q/Hour—HyBlend Initiative webinar presentation. October 26, 2023, pp. 5 and 38-39.

investments for work "confirming the blended hydrogen in the network will not result in any long-term reliability concerns due to the lower Btu value per cubic foot of hydrogen blended gas."[26]

Hydrogen Pipeline Transport Requires Greater Gas Compression—Which Consumes Energy and Heightens the Risk of Leakage

The Argonne National Laboratory scientists at the 2023 DOE webinar explained a blend of 30% hydrogen would require the pipeline operator to increase pipeline flow rate by about 30% and pressure by 70%—heightening the risk of leakage, while consuming more energy to double the amount of compression power.[27]

A recent study by Switchbox, commissioned by the Environmental Defense Fund, finds blending 20% hydrogen by volume into the gas pipeline system to heat homes would consume nearly eight times more electricity than heating the same number of homes with heat pumps, and would reduce emissions from gas-heated buildings by only 7%. Using heat pumps instead would nearly eliminate building sector emissions, consuming 87.2% less electricity.[28]

Hydrogen Burning Is Not Clean, Even When the Hydrogen Is "Green"

Burning Hydrogen in Air Produces Nitrogen Oxides (NO_x) Pollution.

By volume, the atmosphere is 78% nitrogen (N_2) and 21% oxygen (O_2).[29] As long as hydrogen is burned in air, it will produce NO_x emissions, including the third most significant greenhouse gas—nitrous oxide (N_20). NO_x emissions can have local and regional air pollution effects, as a result of direct emissions and due to interaction with volatile organic compounds in the atmosphere to form tropospheric ozone pollution (a component of smog).[30]

[26] National Grid Draft 20 Year Plan, p. 58.
[27] Argonne National Laboratory, *op. cit.*, pp. 5 and 38-39.
[28] Switchbox. Blending Hydrogen and Natural Gas: A road to nowhere for New Yorkers. Commissioned by the Environmental Defense Fund. September 12, 2024.
[29] Engineering Toolbox. Air – Composition and molecular weight. Accessed August 22, 2024. The remaining 1% is comprised of water, argon, carbon dioxide, and trace gases.
[30] U.S. Environmental Protection Agency. Basic information about NO2. Last updated July 16, 2024.

N_2O is of even greater concern. The third most significant greenhouse gas after CO_2 and methane,[31] N_2O is also currently the dominant depleting substance of stratospheric ozone (in the wake of the Montreal Protocol, which reduced emissions of chlorofluorocarbons, or CFCs). The chemical persists in the air, with an atmospheric lifetime of more than 100 years.[32]

In the typical process of hydrogen combustion, the hydrogen gas (H_2) reacts with air to produce water (H_2O) and nitrogen. The chemical equation is $2H_2 + (O_2 + 3.7N_2) = 2H_2O + 3.7N_2$. But various intermediate reactions and subsequent reactions can occur, especially given the high temperature of hydrogen combustion, resulting in emissions of N_2O and other oxides of nitrogen.[33]

The properties of hydrogen, as an energy source, exacerbate the emissions problem. A study of hydrogen blends in a constant-volume chamber found higher percentage blends of hydrogen reduce hydrocarbons and CO_2 emissions but increase NO_x emissions.[34] The NYSDEC, in denying a permit for the peak power plant noted above, rejected the argument that a possible blending or switch to hydrogen would allay the agency's concerns. Noting hydrogen's lower volumetric heating value (energy density) compared to natural gas, the NYSDEC stated:

> A lower volumetric heating value means that more fuel needs to be fired to achieve the same output. The additional volume of fuel fired, combined with the higher flame temperature when firing hydrogen, is expected to cause higher emissions of Oxides of Nitrogen (NO_x) without the installation of additional NO_x controls.[35]

A 2017 study documented that combined combustion of higher-percentage blends of hydrogen with natural gas in a constant-volume chamber reduced hydrocarbons and CO_2 emissions but increased emissions of NO_x.[36]

[31] World Meteorological Organization. State of the Global Climate 2023. WMO-No. 1347. 2024, p. 2.
[32] H. Tian, *et al.* Global nitrous oxide budget (1980-2020). Earth Systems Sci. Data. 16:2543-2604. June 11, 2024.
[33] L. Jung, *et al.* Numerical investigation and simulation of hydrogen blending into natural gas combustion. Energies 17(15):3819. August 2, 2024, p. 3.
[34] S. Lee, *et al.* Combustion and emission characteristics of HCNG in a constant volume chamber. Journal of Mechanical Science & Technology 25:489-494, March 19, 2011.
[35] NYS Department of Environmental Conservation, *op. cit.*
[36] S. Lee, *et al.* Combustion and emission characteristics of HCNG in a constant volume chamber. Journal of Mechanical Science & Technology 25:489-494, March 19, 2011.

Hydrogen Leaks Faster and More Readily Than Methane, and Blending Hydrogen with Methane May Increase Methane Leakage

Hydrogen leaks faster than methane. The NREL's 2013 technical report explains, "Hydrogen is more mobile than methane in many polymer materials, including the plastic pipes and elastomeric seals used in natural gas distribution systems."[37] It concludes:

> Permeation rates for hydrogen are about 4 to 5 times faster than for methane in typical polymer pipes used in the U.S. natural gas distribution system.[38]

The report cited evidence that the hydrogen permeation coefficient in U.S.-grade plastic distribution pipes is five or six times higher than that of methane, and adding 20% hydrogen to natural gas in plastic pipes doubles the total gas loss.[39]

Hydrogen leakage is of concern from a climate perspective because hydrogen molecules in the atmosphere lead to a decrease in hydroxyl radicals (OH). Hydroxyl radicals react with, and reduce, methane molecules in the troposphere.[40]

The Argonne National Laboratory scientists, in their DOE webinar presentation in October 2023, determined that the mechanism of moving hydrogen in a hydrogen-methane blend through pipelines leads to more leakage of both hydrogen and methane.[41]

Methane-Based Hydrogen, Called "Blue Hydrogen," Is Dirty

Methane-based hydrogen, sometimes called "blue" hydrogen, is neither clean nor low-carbon. A 2023 IEEFA report examined the assumptions of the GREET model (Greenhouse gases, Regulated Emissions and Energy use in Transportation) that the DOE uses to evaluate CO_2-equivalent (CO_2-e) emissions from methane-based hydrogen. The report found the model significantly understates the likely emissions associated with blue hydrogen production because it:

- Assumes an upstream methane fugitive emission rate of only 1%—far less than the level identified in recent peer-reviewed scientific analyses and by airplane and satellite surveys.
- Uses a 100-year global warming potential (GWP), which understates methane's impact in the short term, since its 20-year GWP is more than 80 times that of CO_2.

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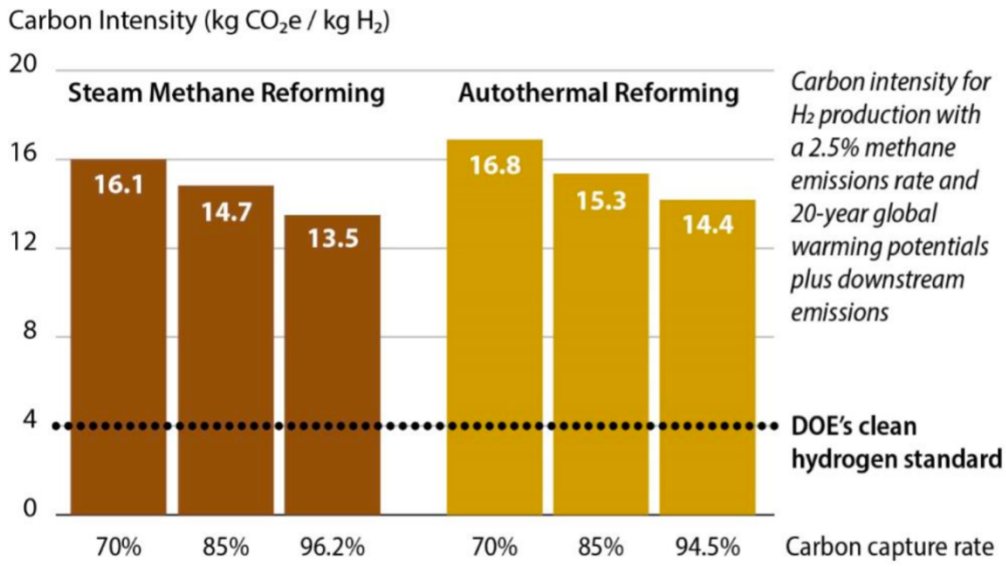
[37] M. W. Melaina, *et al.* Blending hydrogen into natural gas pipeline networks: A review of key issues. NREL Technical Report NREL/TP-5600-51995. March 2013 (hereafter, NREL 2013 Report), p. ES-x.
[38] NREL 2013 Report, p. ES-x.
[39] NREL 2013 Report, p. 21.
[40] Argonne National Laboratory, *op. cit.*, p. 44.
[41] Argonne National Laboratory, *op. cit.*, pp. 38-39. Also see: Hydrogen Central. Hydrogen blending in gas pipelines faces limits due to leakage – US DOE lab – SPGlobal. October 27, 2023.

- Fails to consider the global warming impact of hydrogen, which has a 20-year GWP more than 30 times that of CO_2 because of its impact on methane in the atmosphere.
- Does not consider downstream emissions from the produced hydrogen or the electricity generation needed to compress, store and transport the hydrogen to end users.
- Makes overly optimistic assumptions about the effectiveness of carbon capture processes.[42]

IEEFA determined that just using methane's 20-year GWP and a more realistic 2.5% methane fugitive emission rate raises blue hydrogen's carbon intensity significantly, making it two to three times higher than the clean hydrogen production standard of 4.0 kg CO_2-e per kilogram of hydrogen, set by Congress and the DOE.[43]

Figure 2: The carbon intensity of blue hydrogen using 20-year GWPs and more reasonable ranges of assumptions for methane emissions and hydrogen leakage, related downstream emissions and carbon capture rates



Source: DOE GREET model, IEEFA analysis

Hydrogen Use in the Home Faces Substantial Market Competition and Upstream Challenges

Not surprisingly, hydrogen is already behind the curve in home heating. Electrification of home heating and cooking systems is moving quickly to capture market share. This does not leave an

[42] IEEFA. Blue Hydrogen: Not clean, not low carbon, not a solution. September 12, 2023, p. 5.
[43] *Ibid.*, p. 6.

obvious need for new uses of natural gas or blue hydrogen in the home and building sector. Hydrogen blending cannot reasonably be put forth as a justification to expand natural gas infrastructure and services to more homes and buildings for heating or cooking.

Heat Pumps Are Grabbing Market Share in Home Heating

Air source heat pumps have been gaining ground in the home heating market. Global Market Insights's recent analysis of the U.S. Heat Pump Market, which was valued at USD 11.2 billion in 2024, estimates that the market will grow at a compound annual growth rate (CAGR) of 8.4% from 2025 to 2034, with the residential sector's use of heat pumps growing a little faster at 9% CAGR.[44]

The DOE observes, "An air-source heat pump can deliver up to two to four times more heat energy to a home than the electrical energy it consumes," because a heat pump transfers heat rather than producing it through combustion of a fuel.[45]

Sales may expand more readily now in areas that experience severe cold, as the technology for cold climate heat pumps (CCHP) has advanced substantially. The DOE announced on October 23, 2024, that all eight manufacturers in its Residential Cold Climate Heat Pump Challenge had completed field testing to demonstrate efficiency and performance in very cold weather.[46] Utilities in cold climate states, as well as other states, were involved in the project. The cold climate states included Alaska, Maine, Michigan and Wisconsin.[47] DOE reported new cold climate heat pumps developed through its project will provide heat with little assistance from auxiliary elements even during the coldest winter months.[48]

Energy Efficiency Is Playing an Increasingly Strong Role in Home and Business Heat Energy Demand

Energy efficiency and demand response systems are playing an increasingly greater role in planning for home heating and cooking energy needs. Bloomberg NEF projects improved building efficiency in new construction and renovations would provide an additional 10% reduction in emissions by 2050.[49] When peak demand management methods are deployed, this also shaves more energy use

[44] Global Market Insights. U.S. Heat Pump Market Size - By Product, By Application, Analysis, Share, Growth Forecast, 2025 – 2034. December 2024.
[45] DOE. Air source heat pumps. Accessed January 13, 2025.
[46] Pacific Northwest National Laboratory, Guidehouse and U.S. Department of Energy. Rising Up to the Challenge: Cold climate heat pumps in the field. October 2024, p. 15.
[47] *Ibid.*, p. 5.
[48] DOE. DOE efforts send new and improved cold-climate heat pumps to the market. October 23, 2024. Also see: S&P Global Commodity Insights. Cold climate heat pumps head to market after completing DOE challenge. October 23, 2024.
[49] Bloomberg NEF. New Energy Outlook 2021. July 2021, p. 8.

from the scenario, since utilities plan their needs based on peak demand days, which occur only a few days out of the year.[50]

Hydrogen Availability Is Likely to Be Limited

The United States currently only produces about 10 million tons of hydrogen annually, nearly all of which is used in the petrochemical and fertilizer industries. In a recent report, IEEFA described how hydrogen supply-related issues have made it difficult even to conduct blending tests in natural gas turbines, while some sponsors of so-called hydrogen-capable gas-fired power plants have made it clear that they will not use any hydrogen for years, if ever.[51]

After years of what might be termed "hydrogen hype," reality is beginning to set in. The International Energy Agency's (IEA) *Renewables 2023* report tamped down expectations for the role of hydrogen in the energy transition, stating, "Current hydrogen plans and implementation don't match."[52]

Of the announced hydrogen projects at the time of the IEA report, totaling 360 gigawatts (GW) of potential power, the report stated, "only 3% (12 GW) of them had reached financial close or started construction, a smaller amount than expected in our *Renewables 2022* forecast."[53]

The IEA explained:

> While almost all regions are still expected to increase the amount of renewable energy capacity dedicated to hydrogen production by 2028, the pace of growth is now less optimistic than in *Renewables 2022*. In fact, this year's forecast is 35% lower than in 2022 due to downwards revisions for all regions except China. The main reason is the slow pace of bringing planned projects to financial close due to a lack of off-takers and the impact of inflation on production costs. Overall, the amount of renewable energy capacity for hydrogen production growth represents only an estimated 7% of announced project capacity.[54]

In addition to production incentives, the IEA states:

> More effort will be required to ensure that adequate infrastructure to store and transport hydrogen is in place, to clarify regulatory uncertainty, and to boost investment in R&D to improve technologies for new and existing uses.[55]

Green hydrogen supply, in particular, is likely to be extremely limited.

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[50] See IEEFA. Proposed NESE Pipeline in New York: A bad bargain for ratepayers and taxpayers. April 17, 2020.
[51] IEEFA. Hydrogen: Not a solution for gas-fired turbines. August 2024, pp. 7-12.
[52] IEA. Renewables 2023: Analysis and forecasts to 2028. January 2024, p. 11.
[53] *Ibid.*, p. 90.
[54] *Ibid*.
[55] *Ibid.*, p. 93.

Pipeline Transport of Hydrogen Presents a Challenge

National Grid's proposed 20 Year Plan states it assumed that "hydrogen would be stored underground and delivered into the region."[56] The infrastructure to transport hydrogen or blended hydrogen as contemplated in the plan, however, does not yet exist. The United States only has about 1,600 miles of hydrogen-dedicated pipelines, nearly all of which are concentrated in Texas and Louisiana.[57] An unstated amount of new pipeline construction would likely be needed.

The plan asserts that a 20% blend can be run through existing gas networks "without significant upgrades to infrastructure or equipment.[58] The premise, however, is open to debate.

A 2022 National Renewable Energy Laboratory (NREL) technological assessment of hydrogen observed: "Gaseous hydrogen has a considerable effect on fatigue and fracture resistance of steels, including line pipe steels and any other steel components operating at pressure within a pipeline."[59] The NREL identified several concerns regarding hydrogen blending into natural gas pipeline infrastructure, which include but are not limited to the following:

- Enhanced fatigue crack growth in pipeline steel
- Reduced fracture resistance in pipeline steel
- Reduced energy transmission capacity
- Increased pressure drop when meeting energy demand
- Increased gas velocities
- Increased required compression power
- Increased centrifugal compressor rotational speed
- Increased NO_x emissions for end users
- Excessive combustion dynamics, flame lift-off and flashback
- Valve leakage and durability
- Hydrogen leakage in polymer piping[60]

The NREL reported on a range of studies regarding the issues of hydrogen blending in gas pipeline infrastructure, but ultimately concluded:

> The current state of literature indicates that substantial research remains before widespread hydrogen blending implementation can occur. There exists a need for additional testing on both steel and plastic pipeline materials implemented in the U.S. natural gas pipeline system to identify and confirm relationships between hydrogen presence and fatigue, crack growth,

[56] National Grid Draft 20 Year Plan, p. 57.
[57] Congressional Research Service. Pipeline Transportation of Hydrogen: Regulation, Research and Policy. March 2, 2021, p. 5.
[58] National Grid Draft 20 Year Plan, p. 56.
[59] K. Topolski, *et al.* Hydrogen blending into natural gas pipeline infrastructure: Review of the state of technology. NREL Technical Report. October 10, 2022, p. 8.
[60] *Ibid.*, p. 10.

and failure rates. Additional research can also explore the impacts of hydrogen on previously installed valves, meters, and pressure regulators to clarify short-and long-term functionality over a wider range of conditions.[61]

[61] *Ibid.*, p. 43.

Conclusion

Hydrogen is the most ubiquitous chemical on earth, and the main technology proposed for its use—combustion—is not new. But the chemical is hard to manage. It requires enormous infrastructure development and significantly expanded monitoring. Hydrogen has not become a leading energy source because the barriers to its use are substantial and the benefits are limited. Because of the environmental and safety risks, hydrogen is particularly ill-suited for use in the home.

Hydrogen as an energy source is not ready for prime time, and efforts to use it in the home will likely be eclipsed by electrification with heat pumps, buttressed by energy efficiency. Taxpayer-subsidized hydrogen hubs and private hydrogen production developments should not be designed to rely on home heating and cooking as a target market.

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About the Author

Suzanne Mattei

Suzanne Mattei, an attorney (Yale Law School) and policy consultant with Lookout Hill Public Policy Associates, has over 30 years' experience in environmental and government policy. As Regional Director for the NYS Department of Environmental Conservation for four years, she led permitting and enforcement in New York City. Her widely cited report on a proposed fracked gas pipeline in New York challenged proponents' arguments about need and helped support rejection of the project in favor of non-pipeline alternatives. In her tenure with the NYC Comptroller's Office and Public Advocate's Office, her analysis of costly waste incineration projects and an ill-advised plan to sell the NYC drinking water supply led to rejection of those proposals. In her work for the Sierra Club, she exposed federal mismanagement of the 9/11 response, and her testimony to Congress helped lead to passage of legislation funding healthcare to Ground Zero workers.

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