

## Facts on

# Heating with Hydrogen

Hydrogen is used in industrial processes and can play an important role in decarbonizing parts of our economy. It can be used effectively for:

- Energy storage when solar and wind produce excess electricity.
- Long distance transportation for container ships and trucks.
- High heat manufacturing such as making aluminum and steel.

However, hydrogen is not a viable solution for heating our buildings. It's not an efficient, affordable, equitable, safe, healthy, or climate-friendly source of energy.

## What is hydrogen?

Hydrogen is the most common element.

- As a highly reactive element, it can be used as a source of energy
- Hydrogen doesn't exist by itself. If we want to use hydrogen, we have to make it.
- Hydrogen can be generated from fossil fuels by steam methane reforming or from water using electric energy from solar and wind.

## How hydrogen is made.

Hydrogen does not exist in nature and must be extracted from other substances.

While hydrogen can be made from coal, oil, or plastic waste, almost all hydrogen is made from fossil ("natural") gas.

From methane:

- In the US, 95% of hydrogen is made from fossil gas and fresh water through a process called steam methane reformation.
- Making hydrogen requires 35% more fossil gas to provide the same amount of energy as if that gas were used directly.

- Hydrogen from methane or coal and water results in substantial carbon dioxide emissions.<sup>1</sup>
- This form of hydrogen is fossil gas by another name.

From electricity:

- Hydrogen can be made from electricity and fresh water, using a machine called an electrolyzer to separate the hydrogen from the oxygen.
- Generating hydrogen through electrolysis loses 30% of the energy originally in the electricity.<sup>2</sup> In other words, making 1 billion kWh of hydrogen uses 1.43 billion kWh of electricity.
- To make all the green hydrogen Massachusetts would need for a ten percent blend, we'd need 1,430 onshore wind turbines—1 every 7 square miles—or 715 offshore turbines.

There is currently no commercial production of hydrogen from electricity.

## Hydrogen is more expensive than natural gas or electricity.

Heating with hydrogen is not efficient.

Heating with electricity can be as much as six times more efficient than with hydrogen.

Using 100 kWh of electricity:

- To run an air-source heat pump results in **270 kWh** of heating.
- To run an electric space heater results in **95 kWh** of heating.
- To make hydrogen and power a hydrogen boiler results in just **46 kWh** of heating.

Electric heat pumps:

- Will be at least 50% less expensive to operate than hydrogen furnaces, even with conservative fuel cost projections.<sup>3</sup>
- Also provide air conditioning, already a necessary safety feature for most homes.

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<sup>1</sup> See [Hydrogen does not lower emissions](#).

<sup>2</sup> Electrolysis of Water, Wikipedia, [https://en.wikipedia.org/wiki/Electrolysis\\_of\\_water](https://en.wikipedia.org/wiki/Electrolysis_of_water)

<sup>3</sup> Baldino, Chelsea, et al. "Hydrogen for Heating? Decarbonization Options for Households in the European Union in 2050." *International Council on Clean Transportation*, 2021. "In a sensitivity analysis, we find that even if natural gas costs were 50% lower or renewable electricity prices were 50% higher in 2050 compared to our central assumptions, heat pumps would still be more cost-effective than hydrogen boilers or fuel cells."

## Making hydrogen requires producing more gas.

Close to 99% of all hydrogen made today is made from fossil fuels—mainly from natural gas, but also from coal and oil.<sup>4</sup> Because hydrogen production is 65% efficient at best, more gas must be fracked and piped to the plant than if the gas were used directly.

Making hydrogen:

- Burns 35% more fossil gas at the hydrogen plant.
- Uses water in large volumes. Millions of gallons of fresh water are also used during fracking.
- Emits 9-11 tons of greenhouse gas for every ton of hydrogen.

## Hydrogen requires replacing infrastructure.

Gas utilities are planning to replace the fossil gas that's piped to our homes with hydrogen. Over time, they plan to increase fuel blending from 1% to 20%.

Hydrogen embrittles or corrodes metal pipes. To heat with hydrogen, companies must replace most gas distribution infrastructure and gas appliances.

- Hydrogen is less energy dense than fossil gas, with only one-third the energy content. That means that all compressors—the machines that pressurize and move gas—need to be three times more powerful.
- Metal pipes, the most common material in many distribution systems, break down—or “embrittle”—and leak in the presence of hydrogen. These need to be replaced with fiber-reinforced, medium-density plastic.
- Hydrogen is lighter than fossil gas and naturally separates. Blending mechanisms are needed to keep the gases mixed.
- Appliances, furnaces, and boilers made in the United States are not certified to burn hydrogen and should be replaced for safety.

All of these costs will be passed along to customers.

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<sup>4</sup>Dale Allen Pfeiffer, the myth of the hydrogen economy, <https://www.resilience.org/stories/2006-01-03/myth-hydrogen-economy/>

## Heating with hydrogen will penalize those least able to afford it.

Hydrogen will always cost more than methane.

In Massachusetts, we pay about \$0.75–\$0.95/per therm for gas. Estimates of hydrogen fuel costs are:

- Grey hydrogen made from methane: \$0.88–1.58/therm
- Blue hydrogen made from methane with carbon capture: \$1.23–2.11/therm
- Green hydrogen made from electricity: \$2.20–5.98/therm

These costs cover only the fuel itself. They do not include the delivery/therm cost, which is currently 1.5 times the fuel cost.

In addition, customers will pay a hydrogen surcharge to cover the cost of:

- Additional fracked gas necessary to make hydrogen.
- Energy wasted in fracking, transmission, and leakage
- Water and the cost to purify it
- Infrastructure replacement and leak repair
- Compression and transportation costs for hydrogen
- Home systems and appliances that are safe to use with hydrogen
- Public health costs

Customers who can afford air source heat pumps will pay a lower lifetime cost than those who heat with hydrogen. The cost of hydrogen will fall on those least able to pay for it.

## Hydrogen does not lower emissions.

Making hydrogen from coal, oil, or natural gas contributes to the climate crisis.

- The process of extracting and transporting fossil fuels to a hydrogen power plant emits methane, a potent greenhouse gas.
- Making hydrogen requires more gas, emits carbon dioxide, and leaks methane, which leaks more easily than fossil gas through tiny pores.
- Hydrogen is an indirect greenhouse gas, causing 200 times the damage of CO<sub>2</sub> at the time of release by “recycling” methane.<sup>5</sup>

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<sup>5</sup> Nicholaus J. Kurmayer, Euractiv, Scientists warn against global warming effect of hydrogen leaks, 10/14/2021, [https://www.euractiv.com/section/climate-environment/news/scientists-warn-against-global-warming-effect-of-hydrogen-leaks/?utm\\_source=piano&utm\\_medium=email&utm\\_campaign=9722&pnespid=v711BXleJK8dxPrDpm6kFo2l4QKxWoztl\\_Ht0.Vw.gRmkE\\_Ok3q5Nf9V3ZZTbOXKXt6HEf.X](https://www.euractiv.com/section/climate-environment/news/scientists-warn-against-global-warming-effect-of-hydrogen-leaks/?utm_source=piano&utm_medium=email&utm_campaign=9722&pnespid=v711BXleJK8dxPrDpm6kFo2l4QKxWoztl_Ht0.Vw.gRmkE_Ok3q5Nf9V3ZZTbOXKXt6HEf.X)

- When the blend of hydrogen with gas reaches 70% or above, nitrous oxide—a greenhouse gas 300 times as damaging as carbon dioxide—is released.

## Carbon Capture

Gas companies developed carbon capture methods to help extract more petroleum. Now they talk about using the same technology to capture and store carbon dioxide from hydrogen production.

Carbon capture and storage (CCS):

- Has not been proven to keep carbon in the ground.
- Requires burning fossil gas to run the process, emitting more than if there were no CCS.<sup>6</sup>
- Is prohibitively expensive and requires a carbon tax in order to be affordable.
- Doesn't address other greenhouse gas emissions such as leaks and intentional venting.

Carbon capture from hydrogen production will always be partial. For example, the Shell Quest plant in Alberta, Canada captured 5 million tonnes of carbon over a five-year period, but it also emitted 7.5 million tonnes of climate pollution during the same time period.

## Hydrogen is not safe.

Hydrogen is more explosive than natural gas,<sup>7</sup> has no smell, and burns with a pale blue flame that is hard to see in daylight or bright light. A person could unknowingly walk into a hydrogen fire that has formed on the street or in a kitchen.

- Hydrogen is highly flammable and ignites more explosively than natural gas, with enough force to cause shock waves.
- Hydrogen explodes in concentrations between 17% and 56%,<sup>8</sup> compared to methane, which explodes in a range from 4% to 15%.<sup>9</sup>

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<sup>6</sup> Bob Howarth, Mark Jacobson, How green is blue hydrogen? Energy Science and Engineering, Wiley Online Library, August 12, 2021, <https://onlinelibrary.wiley.com/doi/full/10.1002/ese3.956>

<sup>7</sup> James Purtill, What is green hydrogen, how is it made and will it be the fuel of the future?, <https://www.abc.net.au/news/science/2021-01-23/green-hydrogen-renewable-energy-climate-emissions-explainer/13081872>

<sup>8</sup> <https://environmentalchemistry.com/yogi/periodic/H.html>

<sup>9</sup> Engineering ToolBox, (2003). *Gases - Explosion and Flammability Concentration Limits*. [online] Available at: [https://www.engineeringtoolbox.com/explosive-concentration-limits-d\\_423.html](https://www.engineeringtoolbox.com/explosive-concentration-limits-d_423.html) [Accessed 8/11/2021].

- Hydrogen is flammable in concentrations between 4% and 75%.<sup>10</sup>
- Hydrogen fires have low radiant heat, so a person can't sense the presence of a flame until you are very close to it.
- Hydrogen is piped at higher pressures than fossil gas, creating more conditions for fires.

## Hydrogen combustion fumes are not healthy.

Like natural gas, hydrogen produces nitrogen oxide (NO<sub>2</sub>) when it burns. Nitrogen oxide is a lung irritant and a cause of respiratory ailments such as asthma.

- Burning natural gas in cooking stoves without ventilation has already been shown to exceed EPA limits for nitrogen oxides.
- Two studies show that burning hydrogen-enriched natural gas can lead to nitrogen oxide emissions up to six times that of methane alone.<sup>11</sup>

Burning hydrogen makes indoor air pollution worse. Appliances that burn hydrogen make more indoor air pollution than appliances that burn natural gas, unless they are fitted with expensive add-ons that clean the exhaust.

## What is green hydrogen?

Less than one percent of hydrogen is made from electricity generated by solar, wind, or other renewable energy sources.

If the electricity used to make hydrogen comes from the grid, that hydrogen is also called green.

- The electric grid doesn't distinguish between renewables or fossil-based energy.
- Most of the electricity on the grid is made from fossil fuels, so grid hydrogen is most likely fossil hydrogen.
- Currently, there is no certification or assurance that hydrogen is truly green, sourced from solar or wind.

Electric companies need all the green electricity they have for their customers and have no

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<sup>10</sup> Flammable refers to, specifically, a substance that easily ignites at or below room temperature, i.e. 73° F (~23° C). Explosive detonates, as in it burns at a rate in excess of the speed of sound, per Andee Krasner, MPH.

<sup>11</sup> Lew Milford, Seth Mullendore, and Abbe Ramanan, Clean Energy Group | Projects: Resilient Power Project, Energy Storage and Health, Phase Out Peakers, Hydrogen Hype in the Air, <https://www.cleangroup.org/hydrogen-hype-in-the-air/>

incentive to sell it to gas companies.

Utilities say they will use green hydrogen, but since there is no reliable source of green hydrogen, they will likely use fossil hydrogen.

It's easier and cheaper for gas companies to use fossil fuels to make hydrogen because the infrastructure is in place.<sup>12</sup>

Diverting electricity from renewable sources such as solar and wind to make hydrogen requires more energy overall than using that electricity directly.

The best use for green electricity is to store it in batteries to support the electric grid.

## **Piping hydrogen to heat buildings is not a viable solution.**

Heating with hydrogen is not affordable, not equitable, not clean, not safe, not healthy, and doesn't lower emissions.

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<sup>12</sup> Given the costs and prior relationships with gas suppliers, the business model that makes sense is for gas companies to pipe fossil hydrogen.  
<https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/for-gas-grid-operators-hydrogen-holds-plenty-of-promise-lots-of-challenges-62852865>.