Hydrogen Combustion in Power Plants

COSTS, RISKS, AND DRAWBACKS

Utilities in at least 18 states have built or are developing "hydrogen-ready" fossil-fuel power plants (source). These plants currently run on natural gas, but in the future they could combust a blend of hydrogen and natural gas. Because hydrogen does not produce carbon dioxide (CO_2) when combusted, these hydrogen power plants are being touted as a valuable decarbonization tool. The actual environmental benefits of hydrogen combustion are questionable.

Burning hydrogen is largely ineffective as a decarbonization tool and has potential adverse impacts to public health and energy affordability. The push for hydrogen combustion is motivated by the desire for short-term economic gains among utilities, power plant owners, and their shareholders. Regulated utilities, for example, are guaranteed a healthy rate of return for building new power plants, a cost that is footed by ratepayers. Similarly, the supposed emissions reductions from hydrogen blending in existing fossil-fuel power plants can extend the life of these assets, which may otherwise be retired to meet decarbonization goals. Given this push, it is important to fact-check the primary claims about the benefits of hydrogen combustion.

Hydrogen Combustion Does Not Reduce GHG Emissions—It May Increase Them

The argument for hydrogen as a decarbonization tool for power plants is based on the fact that hydrogen does not directly produce CO_2 when combusted. However, when life-cycle emissions and hydrogen's lower energy density are considered, the greenhouse gas (GHG) emissions reductions from hydrogen combustion are minimal at best. In some cases, the GHG emissions from hydrogen combustion may be worse than burning natural gas alone.

- Hydrogen has a lower energy density than natural gas, meaning that a **one-to-one replacement of hydrogen to natural gas will result in a lower energy output, unless the flow of hydrogen is increased**. This means that a 30 percent blend of hydrogen to natural gas, for example, would not result in a 30 percent decrease in CO_2 emissions (source). One hydrogen cofiring pilot found that a blend of 34 percent hydrogen to natural gas only resulted in a 14 percent decrease in CO_2 emissions (source).
- Depending on how it's produced, **hydrogen can also have significant upstream GHG emissions**. Almost all hydrogen produced in the world today is grey hydrogen, which is made from fossil fuels (source). Blue hydrogen is produced from fossil fuels paired with carbon capture and storage (CCS). It has significant upstream emissions due to the additional fuel needed to power the CCS technology, and CCS remains ineffective at capturing emissions. Because of this, blue hydrogen's **overall emissions are only 9 to 12 percent less than grey hydrogen produced from fossil fuels without carbon capture** (source). Green hydrogen is produced from water using renewable energy, through an energy-intensive process known as electrolysis. If not matched with hourly energy generation from nearby, newly built renewable energy sources, **green hydrogen can be three times as carbon intensive as grey hydrogen** (source). For more information on the lifecycle emissions of different hydrogen production processes, see Clean Energy Group's fact sheet on the colors of hydrogen.
- Regardless of how it's produced, **all hydrogen is an indirect greenhouse gas**. When leaked into the atmosphere, hydrogen extends the lifetime of methane, an extremely potent greenhouse gas. This effect is so powerful that in **the first 20 years of its atmospheric lifetime,**

— continued on page 3 —

Concerns about Hydrogen in the Power Sector

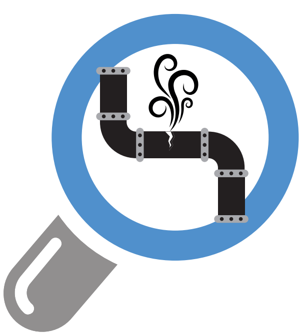
Despite the increasing hype surrounding hydrogen in the power sector, there are many reasons to be concerned about its use, including harmful air pollutants, increased costs, storage and transport issues, high water usage, and potentially emissions intensive production.

NO_x EMISSIONS

Combusting hydrogen or green hydrogen in a power plant can lead to nitrogen oxide (NO_x) emissions at six times the rate of methane. Even with effective pollution controls, NO_x emissions are about the same as those of a natural gas plant. Learn more here.

RATEPAYER IMPACTS

Green hydrogen is six times more expensive than hydrogen made from fossil fuels and blending it into the power system could almost double costs at power plants, which are then passed on to ratepayers. Learn more here.



STORAGE AND TRANSPORT

When steel pipelines are exposed to hydrogen at high temperatures or high pressure, hydrogen can crack the pipes, which could lead to leakage or explosions. Learn more here.

INDIRECT WARMING

All hydrogen is an indirect greenhouse gas which extends the lifetime of methane in the atmosphere. This effect is so powerful that in the first 20 years of its atmospheric lifetime, hydrogen produces 35x the climate warming impacts of CO_2. Learn more here.

WATER USE

Both blue and green hydrogen production facilities require significant amounts of water, up to nearly two million gallons per day. Much of this water cannot be recycled. Learn more here and here.

GHG-INTENSIVE PRODUCTION

Many types of “clean” hydrogen production can produce more greenhouse gas emissions than they reduce. If green hydrogen is not produced via electrolysis that is matched hourly with new, nearby renewable energy, it can have double the carbon intensity of hydrogen that is produced with fossil fuels. Learn more here.

hydrogen has a global warming potential 35 times greater than CO_2. Even a moderate amount of hydrogen leakage would completely offset any potential climate benefits (source). Unfortunately, it is nearly impossible to contain hydrogen leaks, due to its small molecular size. See Clean Energy Group's fact sheet on hydrogen's indirect global warming impact.

Hydrogen Combustion Significantly Worsens Local Air Pollution

The hype around hydrogen combustion also ignores its potential to significantly worsen local air pollution, which would be particularly harmful for communities located near power plants, who have already had to deal with a disproportionate air pollution burden for decades.

- While it does not produce CO_2, **hydrogen produces six times as many nitrogen oxides (NO_x) emissions as methane when combusted** (source). NO_x is a harmful pollutant that contributes to a range of respiratory and cardiovascular health conditions. NO_x formation is reliant on heat, and hydrogen burns hotter and faster than natural gas. While many power plants currently have some sort of NO_x emissions controls—such as using a catalytic reaction, diluting the fuel mix with water or steam, or using newer low-NO_x technology such as a dry low NO_x (DLN) combustion system—**these systems are not equipped to handle higher blends of hydrogen and natural gas** (source). Newer "hydrogen-ready" turbines, while better equipped to handle the NO_x emissions from hydrogen combustion, still produce about the same level of NO_x emissions as a newer natural gas plant (source).
- Hydrogen's high NOx emissions are particularly concerning because, due to the high cost of producing hydrogen as well as the high costs of operating hydrogen power plants, it's highly likely that hydrogen power plants will operate as peaker power plants, which start up and shut down frequently in response to peaks in energy demand. **During start up and shut down, emissions are unabated, meaning that nearby communities will be subjected to extremely dangerous amounts of NO_x during those periods.** Communities living near peaker plants already experience adverse respiratory and cardiac health outcomes due to overexposure to NO_x (source).

Hydrogen Combustion Increases Energy Costs

In addition to the expense of building new "hydrogen-ready" power plants or retrofitting existing ones, hydrogen combustion carries additional costs related to its production, transportation, and storage, which would be passed on to ratepayers.

- While new "hydrogen-ready" power plants capable of burning higher blends of hydrogen, and possibly 100 percent hydrogen, exist, they have limited market penetration and remain costly. **A new hydrogen-capable power plant is expected to cost at least 8.5 percent more than a conventional gas power plant** (source). The cost of building these more expensive power plants will be passed on to ratepayers, as will the costs of retrofitting existing plants. **Retrofitting an existing power plant to combust higher blends of hydrogen could cost as much as 20 percent of the original cost of the plant** (source).
- Additionally, **producing green hydrogen currently costs six times more than grey hydrogen** (source), and hydrogen requires additional costly infrastructure in order to be safely produced, transported, and stored. Hydrogen cannot be run through existing gas infrastructure without risking cracks and dangerous explosions in pipelines (source). Building dedicated hydrogen pipelines could cost upwards of $1 million per mile to construct (source). To learn more about the dangers of blending hydrogen into existing gas pipelines, see Clean Energy Group's fact sheet.
- These cost issues are not reduced by combusting hydrogen blends. **A 30 percent blend of hydrogen into the natural gas system could almost double the cost of energy produced by power plants** (source).

While there may be some uses for zero-carbon green hydrogen in a decarbonized economy, hydrogen combustion is unlikely to be one of them. Burning hydrogen in a power plant, either alone or blended with natural gas, risks increasing greenhouse gas emissions, local air pollution, and costs for ratepayers. Decarbonization and cost savings for ratepayers would be better achieved through investments in proven clean energy technologies.

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To learn more about other harms associated with hydrogen's production and use, visit www.cleanegroup.org/initiatives/hydrogen.