FIVE REASONS TO BE CONCERNED ABOUT

Green Hydrogen

Green hydrogen has generated a lot of interest as a zero-carbon or low-carbon fuel. Its ability to be injected into existing natural gas infrastructure has led to several large oil and gas companies promoting its use to preserve their existing pipeline assets while lowering emissions (source). However, despite all the hype surrounding green hydrogen, Clean Energy Group has found that there are several reasons to be concerned about its use, particularly in power plants. While hydrogen might have a valid role to play in deep decarbonization of the heavy transport or industrial sectors, runaway plans to use it extensively in the power sector have the potential to jeopardize the health of environmental justice communities, not to mention renewable energy goals.

1. NOx Emissions

- When hydrogen gas (H2) is combusted, as in a power plant, it is **not emissions free**. While H2 does not generate carbon dioxide (CO_2) when combusted, it does emit nitrogen oxide (NOx). However, a fuel cell can use the chemical energy of hydrogen or another fuel to cleanly and efficiently produce electricity. If hydrogen is the fuel for a fuel cell, then electricity, water, and heat are the only byproducts (source).
- Burning H2 can lead to NOx emissions up to ***six times that of methane*** (source 1, source 2).
- NO_x does significant damage to the respiratory system over time. In areas affected by smog, symptoms including coughing, increased rates of asthma, and comorbidities with other respiratory illness develop (source). This impact is already apparent in many frontline communities dealing with heavy NOx emissions discharged by nearby highly polluting peaker power plants. These communities have developed historical health disparities and vulnerabilities as a result of constant NOx exposure.
- To comply with *Clean Air Act* regulations, most power plants limit their NOx emissions either through a catalytic reaction, dilution of the fuel mix with water or steam, or using newer low-NOx technology such as a dry low NOx (DLN) combustion system. Due to the fundamental differences between hydrogen and methane, existing NOx reduction methods are only effective at controlling NOx at a blend of 30% H2 or less.
- Blending hydrogen at safe levels also does not lead to a significant decrease in CO_2 emissions. Because of the lower energy density of H2 (it burns hotter than methane, and is less dense), a blend of 30% H2 and 70% methane by volume would result in a 13% decrease in CO_2 (source).
- The world's first dry low NOx, 100% H2 power generation system was developed in July 2020. However, even with dry low NOx technology, this pilot project still produces NOx levels similar to that of a newer natural gas plant (source).
- The bottom line: the slew of proposals for the use of H2 in new and existing natural gas plants will create new sources of NOx emissions for decades to come, with frontline communities bearing the brunt.

2. Costs and Safety

- If steel is exposed to H2 at high temperatures, hydrogen will diffuse into the alloy and combine with carbon to form tiny pockets of methane. This methane does not diffuse out of the metal and cracks the steel. This process, called "Hydrogen embrittlement," means that H2 cannot simply be stored and transported with existing infrastructure (source).

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Concerns about Hydrogen in the Power Sector

Despite the increasing hype surrounding green hydrogen in the power sector, there are many reasons to be concerned about its use, including harmful emissions, poor efficiency, storage and transport issues, high water usage, and the potential for explosions.

NOx EMISSIONS

Burning hydrogen in a power plant can lead to nitrogen oxide (NOx) emissions at six times the rate of methane. Effective pollution controls for high hydrogen blends and pure H2 in gas turbines do not yet exist.

DIVERSION OF RENEWABLE ENERGY

When green hydrogen is burned in a power plant, 70% of the initial renewable energy is wasted due to inefficiencies. This diversion of renewables reduces the amount of fossil fuels that could be directly replaced, along with corresponding reductions in CO_2 emissions.

PUBLIC HEALTH

Burning H2 would create new sources of local NOx emissions, harming the health of families in frontline communities for decades to come.

HIGH WATER USAGE

Electrolysis to create green hydrogen requires up to 9 tons of water per ton of H2 produced. If the water needs to be purified, the amount of water needed could double to 18 tons of water per one ton of hydrogen.

STORAGE AND TRANSPORT

When steel pipelines are exposed to H2 at high temperatures or high pressure, it can crack the pipes, which could lead to leakage or explosions.

DANGERS OF EXPLOSION

Using H2 in homes for heating and cooking would lead to four times as many domestic explosions, resulting in increased injuries and loss.

- Steel makes up more than a quarter-million miles in natural gas transmission systems in the U.S. Because of the embrittlement issue, any plans to use existing natural gas assets with H2 would require replacement of these pipelines.
- Pipeline replacement is not cheap. Plans currently underway in the City of Chicago to replace all its natural gas pipelines will cost each utility customer $750 per year by 2040 (source).
- In addition to pipeline replacement, if natural gas was to be replaced with hydrogen, *all end-user appliances would have to be replaced as well.* Appliances currently built to run on natural gas, such as stoves, would not be able to run on H2 (source).
- Using H2 in the home instead of natural gas would lead to ***four times*** as many domestic explosions and subsequent injuries (source).

3. Poor Efficiency

- With current electrolyzers, green hydrogen's efficiency—from production back to energy through combustion—is around 30%, which means 70% of the renewable energy put into producing green hydrogen is lost across the full cycle of production and use (source).
- Next generation electrolyzers could have an efficiency cycle of 80%—which will only bring green hydrogen's total efficiency to around 45% (source).
- To replace all current industrial consumption of grey hydrogen—produced by fossil-fuels without carbon capture—with green hydrogen would require 3,500 TWh of renewable energy, the amount of renewable energy currently produced by the entire European Union (source).
- Because of the massive inefficiency of electrolysis, green hydrogen production has the potential to divert renewable energy away from directly offsetting fossil fuel emissions.

4. Water

- Electrolysis requires up to 9 tons of water per ton of H2 produced (source).
- Because electrolysis breaks down water into constituent elements, this water needs to be purified. Most industrial water purification processes require, at minimum, a ratio of 2:1 wastewater to pure water, effectively doubling the amount of water required. This means each ton of green hydrogen produced requires 18 tons of water total (source).
- This analysis excludes the additional water used as a cooling fluid in most power plants. Most combined cycle natural gas plants currently use up to 300 gallons of water per megawatt-hour of electricity produced (source).

5. Storage

- As stated earlier, when steel is exposed to hydrogen at high temperatures, H2 will diffuse into the steel and cause tiny cracks. These tiny cracks can lead to leaks and an increased likelihood of explosion (source).
- This makes storage a major concern for H2. While other methods such as using salt caverns have been proposed, these do not make sense in dense urban areas (source).
- Hydrogen's competitiveness and value in a renewable energy future resides in its ability to be stored and readily available to deploy at any given time. However, the storage infrastructure needed for a hydrogen revolution does not yet exist.

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For more information about hydrogen use in the power sector, visit Clean Energy Group's website at www.cleanegroup.org/ceg-projects/hydrogen.