Hydrogen's Water Problem

The Department of Energy (DOE) is rolling out a national plan to bolster hydrogen production, with $8 billion worth of funding up for grabs. Despite the rhetoric about hydrogen being the next clean energy innovation, community and environmental leaders are raising concerns about what this could mean for clean air and water.[1] While the only products of hydrogen consumed in fuel cells are electricity, water, and heat, hydrogen burned for electricity generation can produce six times more nitrous oxides — harmful pollutants that can cause respiratory illness and contribute to the formation of smog — than natural gas.[2] In addition, hydrogen production can entrench fossil fuel use and infrastructure, since it will likely contribute a small fraction of total energy demand, even by 2050.[3]

Alarmingly, hydrogen is also extremely water intensive, which poses significant hurdles for scaling up production.[4] The DOE's call for 50 million metric tonnes (MMT) of hydrogen production each year by 2050 could require up to a trillion gallons of freshwater annually, including in areas struggling with historic drought.[5]

Hydrogen and Its Water Needs

Hydrogen is a simple element that is not often found on its own in nature and can store, transport, and deliver energy produced from other sources.[6] Currently, by far the most common use for hydrogen is industrial processing such as oil refining and fertilizer production; other uses include electricity production through fuel cells, burning hydrogen for electricity generation, and as an alternative fuel for vehicles.[7] Hydrogen production requires energy, with most production still relying on fossil fuels.[8] The resulting hydrogen is labeled by different colors, based on the energy source used during production (see below).[9]

The amount of water needed to produce hydrogen varies with the method of production; the chemical reaction alone requires 1.2 to 2.4 gallons of water per kilogram (kg) of hydrogen produced. The process also requires vast quantities of water for cooling, raw water treatment, and water disposal.[10] Finally, upstream energy production itself uses water, with fossil fuels using substantially more water compared to renewables like wind and solar.[11] Seawater is sometimes used as a water source in hydrogen production to reduce stress on nearby freshwater sources.

This requires desalination, which greatly increases the amount of water and electricity required, which poses a threat to some projects' feasibility.[12] Further, the disposal of wastewater and brine produced during the desalination process can have harmful impacts on waterways and ecosystems.[13]

FIG. 1: Water Footprint by Hydrogen Type
IN GALLONS OF WATER USED PER KILOGRAM OF HYDROGEN PRODUCED

HYDROGEN SOURCE	PRODUCTION METHOD	FRESHWATER USE	SEAWATER USE
Black/brown hydrogen	coal	up to 18 gallons	up to 92 gallons
Gray hydrogen	oil or natural gas	up to 11 gallons	up to 26 gallons
Blue hydrogen	brown or gray hydrogen produced along with carbon capture and sequestration, or CCS	up to 12 gallons	up to 29 gallons
Green hydrogen	renewable energy	up to 25 gallons	up to 126 gallons

Source: Energy Information Administration and Retha et al. (2020)

The water intensity numbers above only include water used in the hydrogen production process, and *do not* include the water needed to produce the energy source used to produce hydrogen.[14] The upstream water consumption for hydrogen produced from natural gas is over one and a half times more water intensive than that produced with solar energy and 31 times more water intensive than that produced with wind power. Hydrogen sourced from fracked natural gas is 6 times more water intensive than that sourced from solar power and 120 times more than wind.[15] In addition, all of these water usage estimates assume evaporative cooling systems as part of the hydrogen production process. Air cooling can decrease water intensity; however, air cooling costs more, requires more power, and is not viable in many locations due to climate.[16]

The DOE's Hydrogen Hype

Announced in 2022, the DOE National Clean Hydrogen Strategy and Roadmap plans to fund between six and ten hubs to produce "clean" hydrogen from natural gas, coal, renewable energy, nuclear energy, and biomass. End uses for the hydrogen include industrial feedstocks, transportation, power generation and storage, hydrogen blending in natural gas for industry and building heating applications, and at ammonia plants for fertilizer production.[17] Long term DOE plans also promote hydrogen exports from the U.S. to the world.[18] At least two hubs will be located in regions with substantial natural gas resources, highlighting the connection between this "clean" energy solution and dirty fossil fuels.[19] Currently, dozens of private fossil fuel companies and public utilities are partnering to secure federal funds for future hydrogen

production. Many of these proposals are in areas struggling with historic drought and water scarcity. [20]

The marketing of hydrogen as a clean energy breakthrough is at odds with reality. As of 2020, the U.S. produces 10 MMT of hydrogen annually, with 95 percent produced using natural gas (gray hydrogen), 4 percent produced using coal (black hydrogen), and only 1 percent using renewable energy (green hydrogen).[21] Projections for 2050 hydrogen production optimistically estimate that two-thirds of the hydrogen will come from renewable sources, with the other third coming from natural gas.[22] With this mix, Food & Water Watch (FWW) estimates that the DOE's goal of 50 MMT of hydrogen production annually in 2050 would require up to one trillion gallons of freshwater (or 4.6 trillion gallons of seawater), which is equivalent to over 34 million Americans' annual home water use.[23] These figures only include water needed to produce hydrogen with existing energy; they do not account for the upstream water needs for natural gas production, which is an already very water intensive process.[24]

Hydrogen Projects in Drought-Stricken Areas

Many of the proposed hydrogen projects vying for federal funds are in areas currently experiencing historic drought compounded by climate change, specifically California and the American West.[25] The Los Angeles Department of Water and Power (LADWP) plans to make Los Angeles a "Hydrogen Hub," despite the fact that the city and the surrounding area are in the midst of historic drought.[26] The LADWP's plan involves retrofitting four archaic natural gas electrical generation plants with the capacity to burn hydrogen for power generation.[27] Based on the proposed hydrogen production at two of the plants, as well as for all four plants combined (see Fig. 2), FWW estimates that by 2045, the LADWP's proposal would require 1.7 billion gallons of freshwater (or 8.5 billion gallons of seawater) each year.

The LADWP's plan comes at the same time as the city has announced strict water conservation measures to address the severe drought.[28] The city would be better off investing in renewable energy generation, which would significantly reduce this water footprint. FWW calculates that Los Angeles could produce the same amount of energy from wind or solar photovoltaic (PV) sources in 2045 while using just 214,348 or 8.5 million gallons of freshwater, respectively. This equals the annual indoor freshwater consumption of between 14 and 559 Californians, respectively. The amount of freshwater needed to produce the same energy with hydrogen would be 1.7 billion gallons of freshwater, equal to 111,033 Californians' annual usage.[29]

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FIG. 2: Annual Water Needs for the LADWP Hydrogen Project

PLANT	YEAR	HYDROGEN PRODUCED IN TONNES	FRESHWATER USED IN MILLIONS OF GALLONS	SEAWATER USED IN MILLIONS OF GALLONS
Haynes Generation Station	2035	820	21	103
	2040	4,451	112	559
	2045	29,347	737	3,683
Scattergood Generation Station	2035	1,022	26	128
	2040	1,824	46	229
	2045	4,879	122	612
All four plants combined	**2035**	**5,765**	**145**	**723**
	2040	**16,814**	**422**	**2,110**
	2045	**67,817**	**1,702**	**8,511**

Source: Food & Water Watch analysis of Los Angeles Department of Water and Power and Retha et al. (2020)

This is just one example of proposed hydrogen projects in California that will be competing for federal funds as well as valuable water resources.[30] Other utility and energy companies are looking to entrench their outdated fossil fuel infrastructure through hydrogen retrofits, including Pacific Gas and Electric Co. (PG&E) and Siemens Energy, which plan to construct a Northern California Hydrogen Hub based in Lodi.[31] Further, the proposed California Hydrogen Hub, which includes partners like Shell and Southern California Gas Company, plans to roll out hydrogen in many sectors of California's economy while leveraging existing factory farm gas and other dirty biogas infrastructure.[32]

New Mexico is another state that is currently experiencing historic drought while also touting hydrogen hubs proposals.[33] The Albuquerque based BayoTech is partnering with New Mexico Gas Company to seek federal funding from the DOE to increase hydrogen production in the already water stressed state.[34] BayoTech, which has its sights set on large scale hydrogen projects across the country, plans to first deploy smaller hydrogen hubs that produce between one and five tonnes of hydrogen per day.[35] Once these hubs are at their full production capacity, they will use 21 to 46 million gallons of freshwater annually, depending on their energy feedstock.[36] Meanwhile, New Mexico farmers are selling off their livestock as irrigation canals are beginning to run dry for the first time in centuries.[37]

Looking Ahead

As private energy companies and public utilities scramble to secure federal funds for hydrogen projects, climate change continues to accelerate drought and other natural disasters across the country.[38] Hydrogen, when sourced from fossil fuels, entrenches natural gas and other fossil fuel infrastructure while competing for scarce water resources. Moreover, leaks are a climate threat: Hydrogen has over 33 times the global warming potential of carbon dioxide over a 20-year period.[39] And at the local level, many communities already struggling with environmental justice problems may face increasing health issues with a transition to hydrogen, including increased nitrous oxide emissions from natural gas plants retrofitted to burn hydrogen. Additionally, piping hydrogen into people's homes could also exacerbate respiratory illness, because of hydrogen's nitrous oxides levels.[40]

For these reasons, it is important to understand that a shift to hydrogen energy that entrenches fossil fuel infrastructure would come at the cost of a renewable energy future that has a small water and carbon footprint. The hydrogen economy sold by natural gas companies to keep their obsolete operations running is not the clean energy future we want and need.

Food & Water Watch recommends that policymakers:

- Support efforts to build out clean renewable energy and electrification of the transportation and building sectors;
- Prohibit the use and production of hydrogen from any sources other than electrolysis and renewable energy; and
- Further study the cumulative effects and lifecycle of hydrogen on water access, public health, and the environment before permitting or subsidizing any new hydrogen production and infrastructure.

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