HYDROGEN FOR DAY-TO-DAY POWER GENERATION

Prospects

TERRIBLE

This fact sheet is part of an Energy Innovation paper assessing clean hydrogen's value for cutting climate pollution from 12 end uses. The full report includes context, analysis, policy recommendations, and citations—see QR code or link at bottom.

Hydrogen can't compete with direct clean energy use or batteries for daily power needs.

NOTE: *This should be compared with the "Seasonal Electricity Storage" overview.*

CONTEXT: Electric utilities and independent power producers (IPPs) in at least 18 U.S. states have proposed "hydrogen-ready" power plants, aiming to co-fire natural gas and hydrogen to gradually reduce these facilities' carbon intensity. The U.S. Environmental Protection Agency (EPA) also issued rules in April 2024 addressing climate pollution from existing coal- and new natural gas-fired power plants, with hydrogen co-firing being one potential compliance tool.

INFRASTRUCTURE NEEDS: Hydrogen is not a "drop-in" fuel replacement for natural gas; however, it is possible to design or retrofit natural gas power plants to handle some share of—and up to 100 percent—hydrogen while keeping the same "basic configuration" of the turbine. Hydrogen can also be electrolyzed and stored on site; however, salt dome caverns may be the only cost-effective bulk storage option and are geographically limited. Hydrogen sourced via pipeline would likely need to come from new or repurposed lines, as nearly all existing U.S. natural gas transmission pipelines are subject to embrittlement from hydrogen.

A core challenge with hydrogen for power generation is controlling emissions of nitrogen oxide (NOx)—a pollutant that harms the respiratory system. Standard "diffusion" combustion systems can be modified or built to use 100 percent hydrogen, but doing so could worsen NOx emissions due to hydrogen's higher flame temperature. Newer "lean premix" combustion systems can mitigate NOx emissions by keeping temperatures low, but these systems struggle to manage natural gas's and hydrogen's disparate characteristics. Today's cutting-edge premix systems are limited to approximately 50 percent hydrogen co-firing by volume—a rate that would only cut climate pollution by 22 percent at most (i.e., with zero-carbon hydrogen and no hydrogen leakage) due to hydrogen's lower volumetric energy density. Separately, post-combustion emissions control technologies can further reduce (but not eliminate) NOx.

SOCIAL IMPACTS: Burning hydrogen to help meet day-to-day electricity demands carries risks related to greenwashing, public health, and consumer costs. Electric utilities and IPPs often plan to test low levels of hydrogen co-firing, then gradually raise this amount over time. Such proposals can imply two benefits, neither of which tell the full story. First, the climate impact of such claims appears as if it would be the share of hydrogen being co-fired (e.g., 30 percent co-fire by volume equating to a 30 percent greenhouse gas emissions reduction), but the reality is much lower (approximately 12 percent in this example) due to hydrogen's lower volumetric energy density. Second, this strategy suggests such facilities will eventually burn exclusively clean hydrogen; this may be the intent, but as discussed below, this is very unlikely for intermediate and baseload power generation. Ultimately, such plans may only prolong fossil fuel power plants (and their pollution in surrounding communities) with few real benefits.

Co-firing hydrogen with natural gas can worsen NOx emissions, particularly if using diffusion combustion systems. This may even be allowed under current EPA rules, as emissions limits for natural gas currently do not apply equally to hydrogen. While measures can be taken to reduce NOx emissions, these facilities are often in communities that have long borne the brunt of harmful air pollution, and the residual levels may still be unacceptable.

Lastly, hydrogen co-firing costs can be extreme even with federal subsidies and particularly when predicated on frequent operations. The costs of fuel, facility upgrades, and stranded assets (i.e., facilities closing early because they are no longer competitive or able to comply with federal regulations) can all be passed through to customers with regulatory approval.

COMPETING TECHS: The key consideration for hydrogen in power generation is *when* the hydrogen is being used. This end-use overview looks at replacing natural gas with hydrogen for most of its current use, which is to help serve day-to-day electricity demands.

On an average day, it is cheapest to meet demand with low to zero marginal cost **clean energy resources** like wind, solar, geothermal, hydro, and nuclear power. **Lithium-ion batteries** are complementary to these clean generation resources—they can charge from excess clean energy in some parts of the day (e.g., afternoon) and discharge in other parts of the day (e.g., evening). Batteries have no emissions, can provide power instantaneously, and have round-trip efficiencies of 85 to 90 percent. By contrast, electrolytic hydrogen combustion has a round-trip efficiency on the order of 24 to 35 percent (at best approaching 65 percent with technological improvements) while having operational limits and NOx emissions impacts. Clean energy and batteries can collectively serve the vast majority of demand. Thus, hydrogen has no role to play in day-to-day power generation, as its use at higher frequencies would imply electrolyzing hydrogen in many of the same hours when it's being burned for power.

TAKEAWAY: Regulators should dismiss proposals to co-fire hydrogen with natural gas at existing power plants or to build new "hydrogen-ready" power plants for the purpose of serving day-to-day power generation needs. Other technologies are available today that can provide these services at lower cost (largely due to their efficiency advantages) and without adverse public health risks. These proposals risk giving electric utilities an excuse to continue operating or building fossil fuel power plants with no actionable plan for cost-effectively cleaning up their portfolio, thereby delaying the transition to a decarbonized electricity generation mix.

FURTHER READING:

- Ghassan Wakim and Kasparas Spokas, "Hydrogen in the Power Sector: Limited Prospects in a Decarbonized Electric Grid," Clean Air Task Force, June 2024, https://www.catf.us/resource/hydrogen-power-sector/
- Dennis Wamsted, "Hydrogen: Not a solution for gas-fired turbines," Institute for Energy Economics and Financial Analysis, August 1, 2024, https://ieefa.org/resources/hydrogen-not-solution-gas-fired-turbines
- New York State Department of Environmental Conservation, "Notice of Denial of Title V Air Permit, DEC ID: 3-3346-00011/00017," October 27, 2021, https://extapps.dec.ny.gov/docs/administration_pdf/danskammer10272021.pdf
- **Featured story:** Jeff St. John, "The problem with making green hydrogen to fuel power plants," Canary Media, October 11, 2023, https://www.canarymedia.com/articles/hydrogen/the-problem-with-making-green-hydrogen-to-fuel-power-plants
- **Full report:** https://energyinnovation.org/publication/hydrogen-policys-narrow-path-delusions-and-solutions