HYDROGEN FOR REFINING

Prospects

EXCELLENT

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.

Refining demands must decline with time, but only hydrogen can clean up this process.

CONTEXT: Refineries take crude oil extracted from the ground and refine it into fuels that can be used in vehicles, aircraft, and other equipment. The process of transforming and separating out other molecules also results in a variety of products that can be burned on-site for energy or sold to the chemicals industry. These petrochemicals are a small share of overall refinery output but can be a significant part of their revenue and total petrochemical output.

Refineries are one of the top consumers of hydrogen today, using it to remove sulfur from crude oil and as part of other processes like breaking down complex hydrocarbons into refined fuels. A transition to electric vehicles, clean fuels, and clean feedstocks will eventually remove the need for oil refineries altogether (with these sectors covered in separate overviews). In the meantime, as long as refineries exist, their emissions can be reduced by switching from dirty natural gas-based hydrogen to clean electrolytic hydrogen—a shift that is already beginning.

INFRASTRUCTURE NEEDS: There are 131 operable refineries in the U.S. today. Reducing emissions in the refining sector while these facilities still exist relies on retrofitting existing plants (or merely swapping their hydrogen source) and reducing demand for their products.

Most hydrogen used in refineries comes from integrated steam methane reformation (SMR) facilities that make and use natural gas-based hydrogen on site (together with hydrogen produced as a byproduct from refinery processes). The remainder comes from merchant hydrogen producers that may have long-term natural gas offtake contracts upstream, hydrogen offtake contracts with refineries, and privately owned hydrogen pipelines. These dynamics make it difficult for electrolytic hydrogen to access the refining market on price alone (i.e., without regulatory intervention), as it may require stranding often-integrated assets, breaking contracts, or harming relationships with important oil and gas industry stakeholders.

Refineries also generally need a consistent hydrogen supply for their operations, which SMR has traditionally delivered. Moving these plants fully to electrolytic hydrogen is thus likely to require on-site storage or pipelines to smooth gaps in production, as electrolyzers should only run when clean energy is abundant and cheap (which are necessary conditions for lower-cost, zero-carbon hydrogen production).

SOCIAL IMPACTS: Refineries are extreme public health hazards, emitting various toxins and carcinogens. Hotspots of these facilities have led to "sacrifice zones that disproportionately harm frontline communities of color and low-income communities." A move toward clean hydrogen in refineries will reduce health risks associated with fossil fuel production and combustion. However, it will not directly mitigate risks associated with the actual refining

process. Doing so requires regulations targeting air pollution and, ultimately, reducing the need for refineries.

COMPETING TECHS: As hydrogen is a fundamental part of refining, there are no known alternatives to clean hydrogen for reducing emissions from this process. Instead, hydrogen's "competitors" for this market are **technologies that shrink the need for refined products**, such as electric vehicles, sustainable aviation fuels, clean fuels for marine shipping, and hydrogen-derived chemical feedstocks. However, these technologies must gain traction in parallel, as refineries are anticipating lower fuel demand (due to electrification) and are considering retrofits and process changes to emphasize chemicals production.

Electrolytic hydrogen will also arguably face greater competition from SMR hydrogen with carbon capture and sequestration (often called "**blue hydrogen**") in the refining sector. Blue hydrogen perpetuates reliance on fossil fuel extraction and transportation (along with associated leakage) and dependence on subsidies or carbon pricing for its financial viability (as adding and operating a carbon capture system to an existing hydrogen production process will always be more expensive than not adding or operating it). By contrast, electrolytic hydrogen does not depend on fossil fuels and can eventually become cheaper than SMR hydrogen even without subsidies with sufficiently low-cost electrolyzers and electricity. However, in the case of refining, blue hydrogen may hold an advantage in being relatively less disruptive—that is, in newer integrated systems, it may cost less to add carbon capture equipment, as it allows for the continued use of SMR facilities and does not require breaking or restructuring natural gas contracts. As electrolytic hydrogen declines in cost or refining demands wane, dependence on blue hydrogen (and its fossil fuel infrastructure) will also fall.

TAKEAWAY: Refining will be necessary to some degree until sectors reliant on its products fully switch to clean alternatives like electric vehicles, sustainable aviation fuels, and hydrogen- or biofuel-derived chemicals. During this transition, clean hydrogen can help reduce refineries' climate pollution. However, clean hydrogen is not a solution to refineries' total greenhouse gas emissions (including from fossil fuel extraction and the downstream use of refined products and chemicals), nor will it remedy refining processes' severe public health impacts. Ultimately, clean hydrogen is an important band-aid during the process of reducing oil refining—and ideally eliminating it altogether—and should be treated accordingly, rather than used as justification for an expansion or life extension of refineries.

FURTHER READING:

- International Energy Agency, "Global Hydrogen Review 2023," December 2023, https://www.iea.org/reports/global-hydrogen-review-2023, p.22-25
- U.S. Department of Energy, "Pathways to Commercial Liftoff: Decarbonizing Chemicals & Refining," September 2023, https://liftoff.energy.gov/wp-content/uploads/2023/09/20230921-Pathways-to-Commercial-Liftoff-Chemicals-Refining.pdf
- Element Energy, "REFHYNE: Clean Refinery Hydrogen for Europe – Lessons Learnt," September 2022, https://www.refhyne.eu/wp-content/uploads/2022/09/REFHYNE-Lessons-Learnt_Aug22_PU_FV.pdf
- **Featured story:** Adam Mahoney, "A community poisoned by oil: People living in Wilmington, California, experience higher levels of illness and ailing mental health," *High Country News*, June 22, 2022, https://www.hcn.org/issues/54-8/south-pollution-a-community-poisoned-by-oil/
- **Full report:** https://energyinnovation.org/publication/hydrogen-policys-narrow-path-delusions-and-solutions