HYDROGEN FOR HEAVY-DUTY VEHICLES

Prospects

POOR

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.

Electric trucks are cheaper than fuel cell options, with the performance gap narrowing.

NOTE: *This should be compared with the "Light-Duty Vehicles" overview.*

CONTEXT: While light-duty vehicles (LDVs) are well on their way to an electric future, hydrogen is often talked about as still having a sizable market in cleaning up heavy-duty trucks (HDTs)—and particularly long-haul tractor-trailers—due to perceived limitations with battery electric trucks (BETs). For example, six of seven federally funded hydrogen hubs have plans to build out hydrogen refueling station networks, with at least five explicitly pointing to serving HDTs.

INFRASTRUCTURE NEEDS: Supporting hydrogen HDTs would not require as expansive of a network of refueling stations and pipelines as for hydrogen LDVs, as this infrastructure could be limited to major highways and industrial centers. However, hydrogen HDT refueling stations "require significantly more hardware and, in turn, have higher construction costs" than comparable electric HDT recharging stations. Both electric and hydrogen HDTs would need substantial investments in transmission lines or pipelines, respectively, to supply their stations; however, electric HDTs' greater efficiencies would make co-located electricity generation and storage lower cost for recharging stations than co-located hydrogen electrolysis and storage.

The key infrastructure challenge for hydrogen HDTs is justifying the cost of pipelines and stations for serving a limited and contested slice of the HDT market. Nearly 90 percent of all domestic freight tonnage is moved less than 250 miles—a use case that clearly favors electric HDTs. Medium-duty vehicles like buses and delivery vehicles are also well suited to go electric, even in cold weather. The question then becomes whether (or to what extent) it's lower-cost to build hydrogen infrastructure to support the remaining, more challenging HDT use cases relative to fostering continually improving electric HDTs and charging solutions.

SOCIAL IMPACTS: Fuel cell electric trucks (FCETs) are generally a net benefit for reducing local pollution, as internal combustion engine trucks (ICETs) are responsible for health-harming smog while fuel cells emit only water vapor. However, if electrolytic hydrogen production is dirty, this benefit risks coming at the cost of communities near fossil fuel power plants that will run more often to supply the power. Unlike with BETs, dirty electrolytic hydrogen can wipe out or reverse FCETs' climate benefits—an impact that can be worsened by the high rates of hydrogen leakage at refueling pumps, given that hydrogen has roughly a 12 times greater warming impact than CO_2 over a 100-year period.

COMPETING TECHS: Even with long-haul tractor-trailers, **battery electric trucks** are likely to be cheaper than FCETs, limiting the latter's growth and longevity. BETs are much more efficient, requiring two to three times less clean electricity than FCETs using electrolytic hydrogen. Studies find long-haul tractor-trailer BETs will be less expensive than diesel ICETs

on a total cost of ownership basis by 2030 (holding true even at "very high daily mileages" and when factoring in battery size limits and electric infrastructure costs) and on sticker price by 2040. These BETs will also be less expensive than hydrogen FCETs, which will "struggle" to reach parity with ICETs. Other studies also show BETs' cost advantage over ICETs and FCETs.

The argument in favor of hydrogen HDTs is that they are more capable of meeting companies' strict timetables due to their longer range, faster refueling, and greater cargo capacity. However, this performance gap is quickly closing due to innovations in batteries and charging.

First, batteries are rapidly improving on cost and energy density. Battery prices and energy densities have fallen 19 percent and risen 7 percent (respectively) on average with every doubling in deployment, with no signs of slowing. As this trend continues, batteries will enter new markets like buses and vans, driving more deployment that fuels this virtuous cycle and expands charging infrastructure. In fact, real-world tests show "big improvements in [battery] trucks and chargers" and that "truck depots can operate battery electric vehicles in large numbers in a variety of use cases," which makes weight limits much less of an issue.

Second, charging innovations are boosting BETs' on-road time. New ultra-fast chargers can add 150-250 miles in just 30 minutes; paired with higher ranges, mandatory breaks and driving time limits, and charging opportunities during loading and unloading, battery tractor-trailers will soon be capable of handling most jobs. Electric rate design reforms can help charging become "substantially cheaper than diesel" by setting time-varying rates and avoiding the highest-price hours. Innovations in how trucks charge may further propel battery HDTs' advantage. For example, 50 percent of electric trucks sold in China in 2022 were battery-swap capable, able to pull into stations to exchange depleted batteries for full ones in minutes.

TAKEAWAY: Hydrogen HDTs may have a niche market for especially difficult jobs, such as those requiring around-the-clock operations, extremely high payloads, or operations far from the grid. However, battery HDTs are increasingly capable of handling the vast majority of tasks, including in long-haul, heavy-duty trucking. Battery HDTs' fundamental efficiency advantage, favorable cost prospects, and domination of other transportation markets may leave hydrogen HDTs little room to grow and suggest policymakers should prioritize battery HDTs' success.

FURTHER READING:

- Amol Phadke et al., "2035 The Report – Transportation: Plummeting Costs and Dramatic Improvements in Batteries Can Accelerate Our Clean Transportation Future," University of California, Berkeley, April 2021, https://www.2035report.com/transportation/wp-content/uploads/2020/05/2035Report2.0-1.pdf
- Hussein Basma et al., "Total Cost of Ownership of Alternative Powertrain Technologies for Class 8 Long-Haul Trucks in the United States," International Council on Clean Transportation, April 2023, https://theicct.org/wp-content/uploads/2023/04/tco-alt-powertrain-long-haul-trucks-us-apr23.pdf
- Sam Wilson, "Hydrogen-Powered Heavy-Duty Trucks: A review of the environmental and economic implications of hydrogen fuel for on-road freight," Union of Concerned Scientists, November 2023, https://www.ucsusa.org/sites/default/files/2024-04/hydrogen-powered-heavy-duty-trucks.pdf
- **Featured story:** Jack Ewing, "Truck Makers Face a Tech Dilemma: Batteries or Hydrogen?" *New York Times*, April 11, 2022, https://www.nytimes.com/2022/04/11/business/electric-hydrogen-trucks.html
- **Full report:** https://energyinnovation.org/publication/hydrogen-policys-narrow-path-delusions-and-solutions