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Fleet Hydrogen Basics

Hydrogen is one transportation fuel option public and private heavy-duty vehicle fleets can consider. Heavy-duty hydrogen fuel cell electric vehicles provide the performance benefits of electric drivetrains (e.g., high instantaneous torque for heavy loads and performance improvements at high altitudes and on steep grades) and can contribute to air quality improvements in high-traffic areas. For some regions and duty cycles, hydrogen could be a better fit for heavy-duty fleets than current battery-electric options because of the increased range and faster fueling times.

Fueling Experience

Hydrogen fueling offers a fueling experience comparable to gasoline or diesel stations. Drivers use a similar dispenser interface, connect the nozzle in a familiar manner, and complete the process within minutes. This enables a quick vehicle turnaround and maintains operational efficiency for fleet applications. Commercial hydrogen fueling stations primarily dispense gaseous hydrogen in two pressure classes: H35 (350 bar/35 MPa/5,000 psi) or H70 (700 bar/70 MPa/10,000 psi) utilizing specialized fueling equipment designed to safely handle extreme pressure and temperatures. Currently, H70 is most widely used for light-duty vehicles and Class 8 semi-trucks, and H35 is predominantly used for transit buses and material handling equipment. The lower pressure class of H35 reduces the complexity of infrastructure and results in lower station and operating costs.[1] Several international demonstration projects are exploring direct liquid hydrogen (LH2). Direct LH2 fueling is not expected to reach commercial applications until after 2030.

Fuel Availability

Hydrogen fuel is currently available at private fleet stations and publicly available retail stations (nearly all retail stations in the United States are in California).[2] These public stations are predominantly used by light-duty consumer vehicles (transferring less than 10 kg of hydrogen in 5 minutes) and are mostly co-located with existing gasoline or diesel stations. These public stations are not designed for the high throughput fueling, mass transfer (more than 10 kg and up to 100 kg), and space needed for heavy-duty vehicles with larger onboard hydrogen tanks or long wheelbases. Fleets considering hydrogen will need to evaluate available fuel supply options and might need to develop dedicated, on-site fueling infrastructure and hydrogen procurement strategies.

350/700 Bar Hydrogen Station and Dispenser. *Photo by Keith Wipke, National Laboratory of the Rockies (NLR) 17316*

[1] https://teem.ornl.gov/hop-model.shtml
[2] Hydrogen Fuel Cell Partnership Stations Map: https://h2fcp.org/stationmap

Production and Distribution

Stations traditionally receive their supply of hydrogen by freight delivery in gaseous (tube trailer) or liquid (tanker/Dewar) form. On-site generation and pipeline delivery are less common. On-site production is typically by steam-methane reformation from natural gas or electrolysis using electrolyzers. Pipelines that deliver fuel directly to a station are rare, although one exists in the Los Angeles area. Fleets choosing to produce their own fuel on site is uncommon due to the additional capital investment, operating costs, and general complexity. The appropriate hydrogen delivery method will depend on the selected on-site storage approach. See the Alternative Fuels Data Center for more details on hydrogen production and distribution.[3]

Storage and Dispensing

Choosing liquid versus gaseous storage should account for fleet size, location, fuel demand profiles, operations and maintenance requirements, and anticipated future expansion. For gaseous storage and dispensing, hydrogen needs to be compressed to improve volumetric density (i.e., higher pressures enable more hydrogen to be stored in the same amount of space). However, compression systems add cost and complexity. Smaller fleets that don't use very much fuel might be able to use gaseous storage in high-pressure tube trailers, with skid-mounted infrastructure or infrastructure on temporary trailers. Large amounts of gaseous storage can require a significant footprint and might require more frequent and costly refills.

Liquid hydrogen offers greater volumetric density than gaseous but presents challenges for long-duration storage (maintaining cryogenic temperatures [20 K, -253 °C]) and requires large-scale vaporizers and heat exchangers to gasify the liquid for dispensing. Liquid hydrogen is also a more efficient and cost-effective approach for moving bulk molecules because it requires fewer deliveries and smaller storage vessels than the equivalent amount of gaseous hydrogen.[4] Fleets that require high throughput and more volume per fill might want to consider bulk liquid hydrogen storage, which provides a smaller station footprint and higher storage density.

Liquid hydrogen storage systems are prone to boil-off, where liquid becomes gas and is vented out of the storage tank and into the atmosphere. If station throughput is insufficient (the hydrogen isn't used fast enough) boil-off can result in significant hydrogen losses over time. Fleets should carefully examine their potential usage profiles to understand whether investing in liquid-based bulk storage is economically viable. New technologies are being developed to mitigate and capture the boil-off, but this is still an emerging area. Fleet operators should consult with fueling and infrastructure providers when creating a plan and consider losses from boil-off.

Planning

Integrating hydrogen vehicles into fleet operations requires comprehensive planning. The upfront cost can be a barrier to adoption, especially for fleets that are starting with only a handful of vehicles, but well-planned infrastructure that considers all aspects of adopting hydrogen can scale with fleet growth. Key considerations include fleet demand and fueling requirements, hydrogen supply and delivery, on-site storage, site layout, footprint, safety, codes, regulatory compliance, maintenance, and long-term technology evolution. Safety considerations such as ventilation, gas detection, blast walls, bollards, and modified access routes could necessitate changes to the fueling site and existing vehicle maintenance facilities. Maintenance and operation costs of hydrogen equipment should also be evaluated early. Routine inspections, leak detection, and staff training are essential for maintaining safe and reliable operations. Early engagement with vehicle suppliers, hydrogen equipment manufacturers, and the authority having jurisdiction helps ensure regulatory compliance, mitigate installation challenges, and support a smooth fleet transition to hydrogen.

Additional Resources

- **Hydrogen Tools—Best Practices:** h2tools.org/bestpractices/best-practices-overview
- **Hydrogen Tools—Hydrogen and Fuel Cells Codes and Standards Database:** h2tools.org/fuel-cell-codes-and-standards
- **California Governor's Offices of Business and Economic Development—Hydrogen Station Permitting Guidebook:** business.ca.gov/wp-content/uploads/2019/12/GO-Biz_Hydrogen-Station-Permitting-Guidebook_Sept-2020.pdf

[3] https://afdc.energy.gov/fuels/hydrogen-production
[4] https://www.sciencedirect.com/science/article/pii/S2352484723012143

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