Fueling the Future: Integrating Liquid Hydrogen Infrastructure into Modern Airports

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AVM6412 – Airfield Operations and Management

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August 28, 2026

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The author reports no conflicts of interest.

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Figure 1.

Conceptual representation of liquid hydrogen (LH_2) airport infrastructure, illustrating cryogsenic fuel storage, specialized aircraft refueling systems, safety considerations, and the transition from conventional Jet A infrastructure to hydrogen-powered aviation.

Can liquid hydrogen be delivered to aircraft using existing airport fuel infrastructure?

Liquid hydrogen cannot simply be delivered to aircraft through existing airport Jet A/Jet A-1 fuel infrastructure, but portions of the present airport fuel-distribution architecture could be adapted as the foundation for a new hydrogen system. Conventional aviation fuel is stored near ambient temperature and transported through ordinary tanks, pumps, underground hydrant piping, and refueling trucks, whereas liquid hydrogen (LH_2) must be maintained near 20 K (−253°C). At that temperature, conventional fuel-system materials, seals, valves, piping, and storage tanks are unsuitable without substantial redesign because hydrogen introduces cryogenic contraction, embrittlement, leakage, boil-off, and ignition-control concerns. Hoelzen, Flohr, Silberhorn, Mangold, Bensmann, and Hanke-Rauschenbach (2022) concluded that airports could retain the basic logistical concepts of centralized storage, mobile refueling vehicles, and ultimately hydrant distribution, but the equipment carrying the hydrogen would have to be purpose-built for LH_2. Therefore, existing infrastructure can be leveraged geographically and operationally, but in most cases it cannot be reused physically for hydrogen service.

The concept is not new. Hydrogen-powered aviation research dates to at least the 1950s, with major aerospace studies expanding during the 1970s and later through projects such as the European Cryoplane program. Early researchers recognized both hydrogen's extraordinary specific energy and its principal disadvantage for aircraft: very low volumetric density, making cryogenic storage necessary for practical transport-aircraft ranges. Degirmenci, Uludag, Ekici, and Karakoc (2023) reviewed hydrogen aviation research conducted between 1955 and 2022 and found that airport storage and supply infrastructure has repeatedly emerged as one of the principal barriers to operational adoption. Earlier studies even projected very large LH_2 requirements at major airports such as Chicago O'Hare and San Francisco, demonstrating that researchers were already considering centralized storage and high-capacity distribution decades before current decarbonization efforts. What has changed is that modern research now addresses hydrogen infrastructure as an integrated airport system rather than merely as a fuel-transfer problem.

Current engineering studies indicate that aircraft refueling itself is technically feasible without imposing unacceptable turnaround penalties. Mangold, Silberhorn, Moebs, Dzikus, Hoelzen, Zill, and Strohmayer (2022) modeled LH_2 aircraft refueling through both tanker-truck and pipeline-dispenser configurations and found that flow rates near 20 kg/s are achievable with appropriately sized cryogenic equipment. Their work also showed that procedures such as connection, purging, chill-down, refueling, and disconnection can be incorporated into normal aircraft turnaround operations and, under some conditions, may require no more time than conventional Jet A-1 fueling. The important distinction is that these systems use vacuum-insulated or otherwise cryogenically protected lines, specialized couplings, hydrogen-compatible components, leak detection, and explosion-protection procedures. Thus, a fuel truck can still drive to an aircraft and a hydrant dispenser can still service an aircraft at the gate, but neither would be the same truck, hose, hydrant, or underground pipe presently used for kerosene.

Practical implementation is now moving beyond conceptual analysis. The European GOLIAT program, launched in 2024, is demonstrating high-flow liquid-hydrogen handling and aircraft ground-refueling technologies at three European airports, representing an important transition from laboratory research toward routine airport operations. At the same time, recent airport-system research shows why initial deployment will probably occur through modular storage and mobile bowsers rather than immediate replacement of entire airport hydrant networks. Semchukova, Topolski, and Abdin (2026) found that airport hydrogen deployment is constrained by storage volume, fuel logistics, cryogenic safety, permitting, leakage management, and the need to coordinate aircraft fueling with other hydrogen uses such as ground support equipment and stationary power. Their analysis suggests that early hydrogen airports will likely develop dedicated hydrogen zones and mobile delivery systems first, followed by permanent distribution infrastructure only when aircraft demand becomes large enough to justify it.

DARPA has been involved with liquid hydrogen technology, although I found no evidence that DARPA currently operates a program specifically devoted to converting commercial airport Jet A infrastructure to LH_2 aircraft refaueling. DARPA's Experimental Spaceplane/XS-1 work incorporated advanced lightweight composite cryogenic tanks designed for liquid oxygen and liquid hydrogen, demonstrating that the agency has directly pursued technologies relevant to aerospace LH_2 storage and rapid-turnaround operations. However, the current civilian airport-refueling effort appears to be led primarily by NASA, European research programs, airports, hydrogen suppliers, and aircraft manufacturers rather than DARPA. This distinction is important because DARPA's work contributes to the broader technology base—especially cryogenic tanks, materials, and high-tempo aerospace operations—while airport implementation requires an additional layer of civil certification, fire protection, land-use planning, fuel logistics, and standardized ground-handling procedures that extend well beyond the aircraft itself (Defense Advanced Research Projects Agency [DARPA], 2017).

Looking toward 2035–2050, the most likely infrastructure evolution is a staged transition rather than wholesale replacement of airport fueling systems. Smaller hydrogen operations can be supported by tanker delivery, dedicated LH_2 tanks, and mobile refuelers, while major hubs with substantial hydrogen traffic may eventually require dedicated cryogenic pipelines and hydrant networks. Krog, Jooss, Fyhn, Nekså, and Hjorth (2025) modeled a large-scale LH_2 pipeline system for airports and showed that such systems are technically possible, but continuous circulation and careful thermal management are necessary to keep the hydrogen subcooled and limit vaporization. Their work also suggests an intriguing systems-level benefit: hydrogen vapor generated during airport distribution could potentially be recovered and used by hydrogen-powered ground-support equipment rather than simply vented. The answer to the original question is therefore qualified but clear: airports can reuse existing rights-of-way, ramp-service concepts, fuel-farm locations, logistics networks, and operational procedures, but liquid hydrogen requires a parallel cryogenic fuel infrastructure specifically engineered for hydrogen. If hydrogen-powered commercial aircraft achieve significant fleet penetration, today's Jet A hydrant network may provide the conceptual blueprint for tomorrow's LH_2 network, but it will not simply be filled with a different fuel.

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