# Project #A099
# Conceptual Analysis of Cryogenic Hydrogen Distribution at Airports

Lead investigator: Jacob Leachman, Washington State University
Project manager: Bahman Habibzadeh, FAA

October 15th, 2025

## Summary

Airport infrastructure must be adapted for liquid hydrogen ($LH_2$) fueling of aircraft. This work investigates the implementation of $LH_2$ considering dispensing costs, distribution pathways, boil-off losses, fueling technology needs, storage facility sizing, and safety.

## Motivation and Objectives

$LH_2$ is a promising energy carrier for aviation due to its high specific energy. NREL previously investigated $GH_2$ usage at four west-coast airports. In partnership with WSU, the investigation explores $LH_2$ at those airports with six objectives:

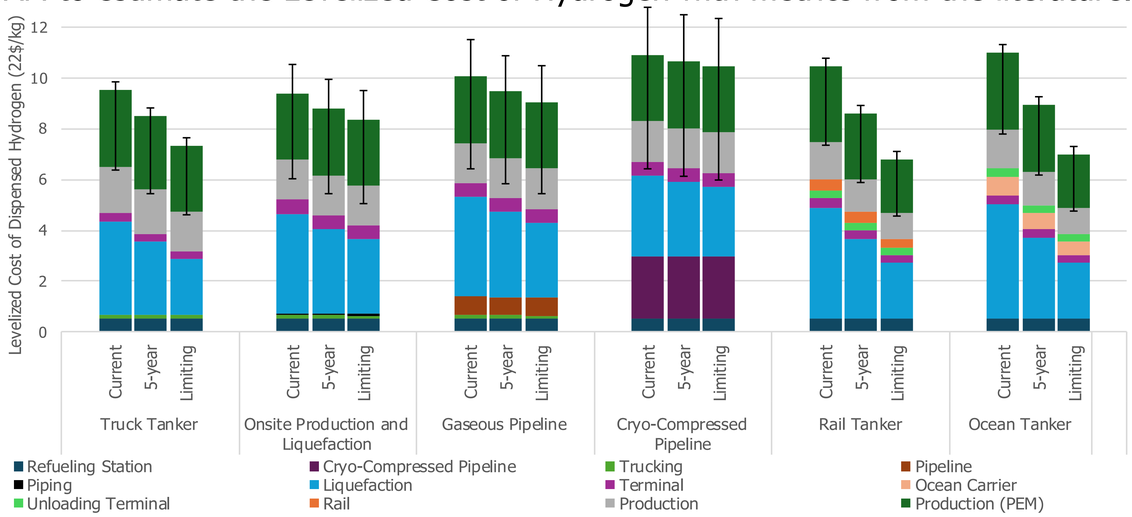
1. Contribute to the state of the technology analysis considering current efficiencies, realistic 5-year efficiencies, and ideal/limiting efficiencies.
2. $LH_2$ delivery analysis supporting site selection, aligning with the NREL study.
3. Cryogenic hydrogen effects on demand modeling.
4. Cryogenic hydrogen fueling analysis including needs for technology development.
5. Sizing estimates for cryogenic hydrogen infrastructure.
6. Safety analysis for cryogenic hydrogen infrastructure.

## Objectives 1 and 2

1. For the state of the technology analysis, literature review explored potential $LH_2$ delivery pathways for airports, including current, 5-year, and limiting efficiencies.

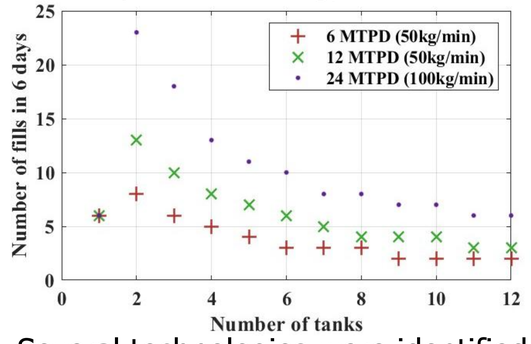
| | Truck | Rail | Marine | Onsite Liquefier | $CCH_2$ pipeline |
|---|---|---|---|---|---|
| **Current Losses [%]** | 3.0 | 1.0 | 1.0 | - | - |
| **5-year Losses [%]** | 0.3 | 0.3 | 0.3 | - | - |
| **Limiting Losses [%]** | 0 | 0 | 0 | - | - |
| **Current SEC [kWh/kg$LH_2$]** | - | - | - | 12.3 | 6.42 |
| **5-year SEC [kWh/kg$LH_2$]** | - | - | - | 6.7 | 5.62 |
| **Limiting SEC [kWh/kg$LH_2$]** | - | - | - | 2.98 | - |

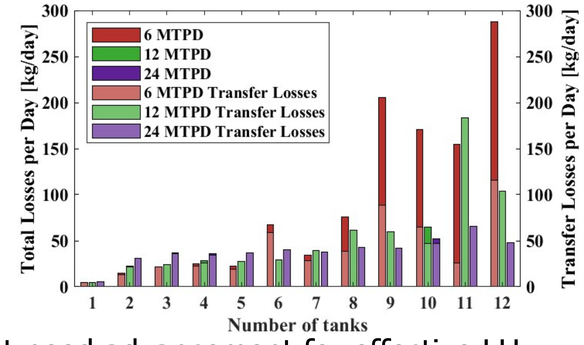
2. Assumptions for new delivery pathways enabled the use of Argonne National Lab's HDSAM to estimate the Levelized Cost of Hydrogen with metrics from the literature.




## Objectives 3-6

3. A numerical model for $LH_2$ tanks is used to predict boil-off losses during $LH_2$ storage with a single spherical tank or 2-12, 18000-gallon cylindrical tanks oriented horizontally or vertically. Over a six-day simulation, boil-off losses due to transfers and steady-state venting, and the number of fills over six days were predicted.

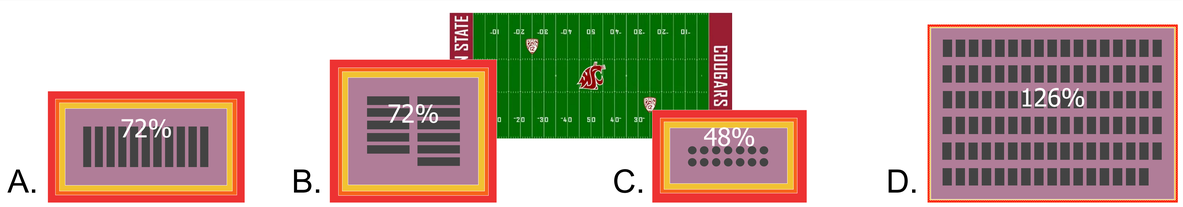



4. Several technologies were identified that need advancement for effective $LH_2$ implementation at airports:
   - High efficiency electrolyzers
   - High efficiency coolers
   - Boil-off management systems
   - $LH_2$ hydrants and pumps
   - Mobile refuelers
   - Mobile refueler safety devices
   - Standardized refueling procedures

5. Theoretical layouts compare spatial requirements for $LH_2$ storage facilities considering multiple capacities and using NFPA-2 codes with vertical or horizontal 18000-gallon cylindrical tanks.

| Refueling Capacity | One Horizontal $LH_2$ Row | Two Horizontal $LH_2$ Rows | Vertical $LH_2$ | $GH_2$ Tube Array |
|---|---|---|---|---|
| **6 MTPD** | 2017 $m^2$ | 2567 $m^2$ | 1459 $m^2$ | 2380 $m^2$ |
| **12 MTPD** | 2710 $m^2$ | 2896 $m^2$ | 1646 $m^2$ | 4369 $m^2$ |
| **24 MTPD** | A. 3861 $m^2$ | B. 3877 $m^2$ | C. 2433 $m^2$ | D. 6750 $m^2$ |




6. Safety codes and standards are adapted from the previous report specifically for cryogenic hydrogen infrastructure.

## Conclusions and Next Steps

Implementation of $LH_2$ at airports is furthered through new delivery pathway analysis, prediction of tank losses using a real-world validated tank model, estimation of spatial requirements for multiple tank configurations, and updates of technology, citing, and safety requirements. These results will be documented in a report in collaboration with NREL.

This research was funded by the U.S. Federal Aviation Administration Office of Environment and Energy through ASCENT, the FAA Center of Excellence for Alternative Jet Fuels and the Environment, project A099 through FAA Award Number AWD006507 under the supervision of Bahman Habibzadeh.
Any opinions, findings, conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the FAA.