Technical and Economic Analysis of Hydrogen Refueling Stations

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Presentation Overview

- Refueling Station Configuration Options
- Station Storage Requirements
- Design and Cost Assumptions
- Optimization
- Results
- Summary and Conclusions
Gaseous Refueling Station Configuration Options

Dispensing
Cascade Charging System
Compression
Pipeline Supply
Storage

Dispensing
Cascade Charging System
Compression
Tube-Trailer
Liquid Refueling Station Configuration for Liquid H2 Delivery by Trucks
Station MINIMUM Storage Requirement

- Refueling station storage requires a **minimum** of 1/3 of the station daily demand

![Friday Demand Profile Graph]

- Average: ~30% of Daily Demand
- Tube-trailer delivery
- Liquid truck delivery
- Low pressure vessels pipeline delivery

At refueling station
STATION DESIGN AND COST ASSUMPTIONS
Cascade Charging System (NOT Effective for Storage)

- ASTM SA372, Grade J, Class 70 low alloy steel
- Vessels are 16 inches diameter, 30 feet long
  - 6500 psia vessel holds 67 kg
  - $926/kg of hydrogen (uninstalled)

- Recommended inputs to H2A model
  - $1204/kg of hydrogen, including shipping, auxiliaries, and installation
  - No economies of scale
Low Pressure Gaseous Storage

- Gas storage vessel design
  - SA516, Grade 70; 2,500 psia; 2.5 in. wall thickness
  - 4.1 ft. diameter, 24.9 ft. long, 91 kg hydrogen capacity
  - $2.30/lb of steel; $900/kg of hydrogen (uninstalled)

- Recommended inputs to H2A model
  - $1170/kg of hydrogen, including shipping, auxiliaries, and installation
  - No economies of scale
Compressor Cost

\[ y = 4.2058x + 18.975 \]

- **Reciprocating**

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<th>Capacity (kg/hr)</th>
<th>Total Uninstalled Cost ($K)</th>
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Refueling Station Optimization: Balance between Cascade & Compressor Capacities

**Optimum:**
Compressor Capacity / Ave. Station Hourly Demand Rate ~ 2.0
Cascade Capacity / Ave. Station Daily Demand ~ 0.15

![Graph showing hourly percent of daily demand with data points for 4.16%, 3.64%, and 7.8% at specific hours.]
Validation: Independent Models Produced Same Result Despite Small Variations in Assumptions

Station Average Daily Capacity [kg/day]

C = Compressor capacity
AHD = Average Hourly Demand
CASCAP = Cascade capacity
ADD = Average Daily Demand
RESULTS
GH2 Refueling Station Cost Analysis

- Refueling station cost is a major contributor to the total delivery cost
GH2 Refueling Station Cost Analysis

- Installed capital cost represents the majority of the refueling station cost

![Breakdown of Total Refueling Station Cost](image)

- Total Installed Capital: 75%
- Other Capital: 17%
- Total O&M: 8%
GH2 Refueling Station Cost Analysis

- Compressors, Cascade System, and GH2 storage are the major component contributing to the total capital cost.
GH2 Refueling Station Cost Analysis

- Compressors, Cascade System, and GH2 storage are the major components contributing to total capital cost

% Cost Contribution of Refueling Station Components to Total Installed Capital
[500 kg/day Station]

- Compressor(s): 31%
- Cascade: 26%
- Storage: 26%
- Dispensers: 2%
- Electrical: 5%
- Controls and Safety: 10%

Note: Compressor cost include one backup compressor
Summary and Conclusions

- A methodology was developed to design and optimize gaseous and liquid hydrogen refueling stations.

- Refueling station compressors and cascade system were sized to minimize total station cost.

- Refueling station storage requires a minimum of 1/3 of the station daily demand.

- Compressors, cascade system, and GH2 storage are the major components contributing to the total capital cost of hydrogen delivery.

- The total cost of the refueling station is a major contributor to the total delivery infrastructure cost.
Version 2.0 of the H2A Delivery Models will be Published SOON!

Thanks to other members of H2A/Nexant project team, USDOE Delivery Tech Team and OFCHIT

Questions??

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