Rethinking Hydrogen Fueling: Insights from Delivery Modeling

Marianne Mintz *and* ***Amgad Elgowainy****, Argonne National Laboratory, and* ***Monterey Gardiner****, U.S. Department of Energy*

Overview

Gasoline fueling has evolved from a variety of informal, diverse methods to a standardized, highly automated system that exploits the fuel's benefits and mitigates its hazards. Any effort to transition to another fuel with different properties must make similar adjustments.

The Hydrogen Delivery Scenario Analysis Model (HDSAM) is used to calculate the levelized cost of delivering hydrogen from a central production facility to a vehicle using currently available technologies and a profile of vehicle utilization and fueling demand. Results are shown for a status quo or "Gasoline-Centric" case in which demand reflects the current gasoline-based fueling system and supply responds accordingly and a "Hydrogen-Centric" case that alters some of those patterns. The comparison highlights fueling requirements that are particularly problematic for hydrogen and suggests alternative business models to reduce delivered hydrogen cost.

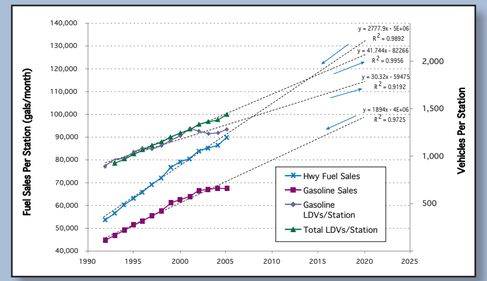
Gasoline vs. Hydrogen

Why look at gasoline fueling?

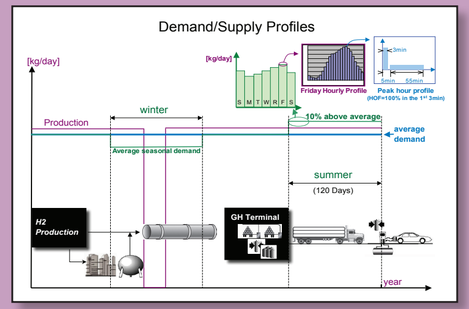
- The transition to an alternative transportation fuel requires detailed technical and economic analyses of all aspects of the supporting infrastructure.
- Cost models suggest fueling will account for a large portion of delivered hydrogen cost.
- Hydrogen stations are assumed to serve much the same function as today's gasoline stations (dispense fuel, sell convenience items and fast food, provide ATMs) with similar market reach, demand profile, and footprint.

What gasoline stations tell us about hydrogen

- Gasoline fueling has evolved to increase efficiency and satisfy consumer needs. ***So, too, might hydrogen.***
- The properties of gasoline, delivery logistics, and consumer preferences heavily influence current station design. ***Might the properties of hydrogen change station design?***
- Station productivity and capital intensity have climbed 60% in the past decade as large, new stations replaced smaller stations and fast food and ATM offerings rose. However, gross margins remain slim. ***Hydrogen will be hard-pressed to match these levels.***



Application of HDSAM



HDSAM considers market demand and supply infrastructure to calculate delivery cost

Part of DOE's Hydrogen Analysis (H2A) project, HDSAM

- Characterizes potential pathways for delivering hydrogen from central production facilities to hydrogen-fueled vehicles
- Estimates the contribution of each major step in the pathway to the levelized cost of the fuel.

Components are sized to

- Meet average market demand
- Account for losses and other inefficiencies in the pathway
- Accommodate supply outages and demand fluctuations

Except for a single planned outage (off-peak season) for annual maintenance, production is assumed to be constant throughout the year.

- Supply is assumed to come from bulk storage built up from a slip stream of either liquefied product stored in cryogenic tanks or gaseous product stored in geologic formations.
- Steady-state production and the requisite delivery infrastructure satisfy average daily demand and the buildup of stored product.
- Fuel stations are modeled to permit optimization of storage and compression requirements and allocate costs.

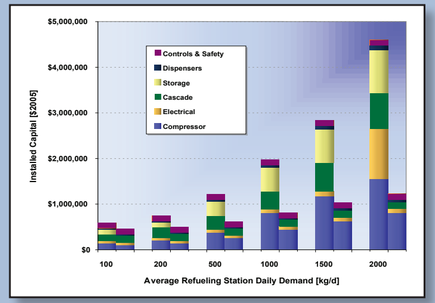
Equipment modeled at the fuel station includes

- Compressors
- Site storage
- A cascade charging system
- Dispensers
- Controls and safety equipment
- Electrical upgrades

Estimated Cost of Hydrogen Fueling

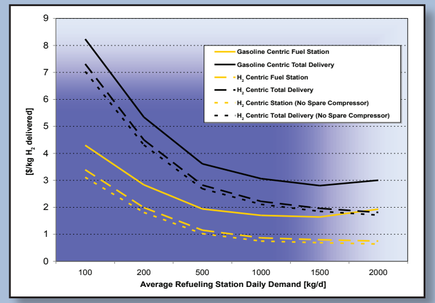
Cost and Demand: Hydrogen vs. Gasoline

- In the default, gasoline-centric case, demand follows daily and hourly profiles shown. Depending on average daily demand, hydrogen fuel stations cost $600–4600K, with compression, cascade systems, and site storage accounting for the bulk of initial capital cost.
- With a flat demand profile, hydrogen stations cost 30–280% less, depending on daily demand. While compression accounts for a larger share of initial capital cost, the cost itself is halved and site storage is virtually eliminated.



Factors Influencing Hydrogen Delivery Cost

- If hydrogen demand were flattened to a constant average daily level (H_2 Centric Case), site storage, electrical upgrades, and some compression could be avoided, thereby reducing levelized delivery cost by $0.90 to $1.18/kg, depending on station size.
- If backup compression were also eliminated (No Spare Compressor Case), investment cost would drop appreciably, but overall station and delivery costs would change little.



Use these links to learn more about this work:
http://www.hydrogen.energy.gov/h2a_delivery.html
http://www.hydrogen.energy.gov/pdfs/review08/pd_16_mintz.pdf

Multiple Business Models

- ***Easy Access***

  In the United States, 80% of all fuel is dispensed at stations containing convenience stores. Model responds to consumer desires for quick, convenient access to food and ATMs – the main sources of profit.

- ***One-Stop Shopping: The "Hypermarket" Model***

  Between 1997 and 2002, hypermarkets associated with big box retailers grew from supplying 0.3% to nearly 6% of the U.S. motor fuels market. The model is much more prevalent overseas.

- ***No Place Like Home***

  Home-based businesses, home shopping, home theaters, and home gyms are proliferating. Why not home fueling?

- ***Concierge Services***

  Hydrogen stations could offer a range of business and personal goods and services appealing to hydrogen and fuel cell early adopters and other enthusiasts.

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