III.0 Hydrogen Delivery Sub-Program Overview

Introduction

Hydrogen must be transported from the production site to a fuelling station or stationary power site or produced on-site. It also must be compressed, stored and dispensed at refueling stations or stationary power facilities. Due to its relatively low volumetric energy density, transportation, storage and final delivery entail significant costs and inefficiencies for hydrogen as an energy carrier. The Hydrogen Delivery activity is focused on developing technology to reduce the cost and increase the energy efficiency of hydrogen delivery for the transition to and long-term use of hydrogen as a major energy carrier.

There are three potential delivery pathways: gaseous hydrogen delivery, liquid hydrogen delivery, and novel solid or liquid hydrogen carriers. A carrier is a material that carries hydrogen in a form other than free H_2 molecules. Examples of potential hydrogen carriers include metal or chemical hydrides, nanostructures, and liquid hydrocarbons that can be easily and simply dehydrogenated and re-hydrogenated.

The DOE Hydrogen Delivery Program element is relatively new. FY 2005 was the first year of any significant funding in this area. In FY 2006, the increase in planned funding had to be curtailed as Congressional appropriations for discretionary spending was less than requested. FY 2007 was the first year that Hydrogen Delivery received sufficient funding to begin significant research efforts. However, the funding was not obtained for use until the second half of the fiscal year. None the less, considerable progress on delivery research and analysis was achieved. Currently funded research efforts are focused on delivery infrastructure analysis, lower-cost pipelines, and lower-cost off-board storage at refueling stations. In addition, research on improved compression technology is being funded through two DOE Small Business Innovative Research projects.

Goal

Develop hydrogen delivery technologies that enable the introduction and long-term viability of hydrogen as an energy carrier for transportation and stationary power.

Objectives

- By 2007, define criteria for a cost-effective and energy-efficient hydrogen delivery infrastructure for the transition to and long-term use of hydrogen for transportation and stationary power.
- By 2012, reduce the cost of hydrogen transport from central and semi-central production facilities to the gate of refueling stations and other end users to <$0.90/gasoline gallon equivalent (gge) of hydrogen. By 2017, reduce this cost to <$0.60/gge.
- By 2010, reduce the cost of compression, storage and dispensing at refueling stations and stationary power facilities to <$0.80/gge of hydrogen (independent of transport). By 2015, reduce this cost to <$0.40/gge.
- By 2017, reduce the cost of hydrogen delivery from the point of production to the point of use in vehicles or stationary power units to <$1.00/gge of hydrogen in total.

FY 2007 Technology Status

Current costs for the transport of hydrogen, with the exception of that transported through the very limited amount of hydrogen pipelines, is $4-$9/gge of hydrogen. This is based on transport by gaseous tube trailers or cryogenic liquid trucks and is very dependent on amounts and distances. Pipeline transport costs are significantly lower but are also very dependent on transport distance and amounts. These transport costs do not include the delivery costs associated with compression, storage and dispensing at fueling sites. These additional costs could be as high as $2-3/gge of hydrogen.

In order for hydrogen to become a major energy carrier, the total delivery cost must be substantially reduced. The long-term goal for delivery is $1/gge of hydrogen.

In order to achieve this long-term goal for the cost of hydrogen delivery, and to have commercially viable costs during the transition period, significant technology development is needed. This includes:

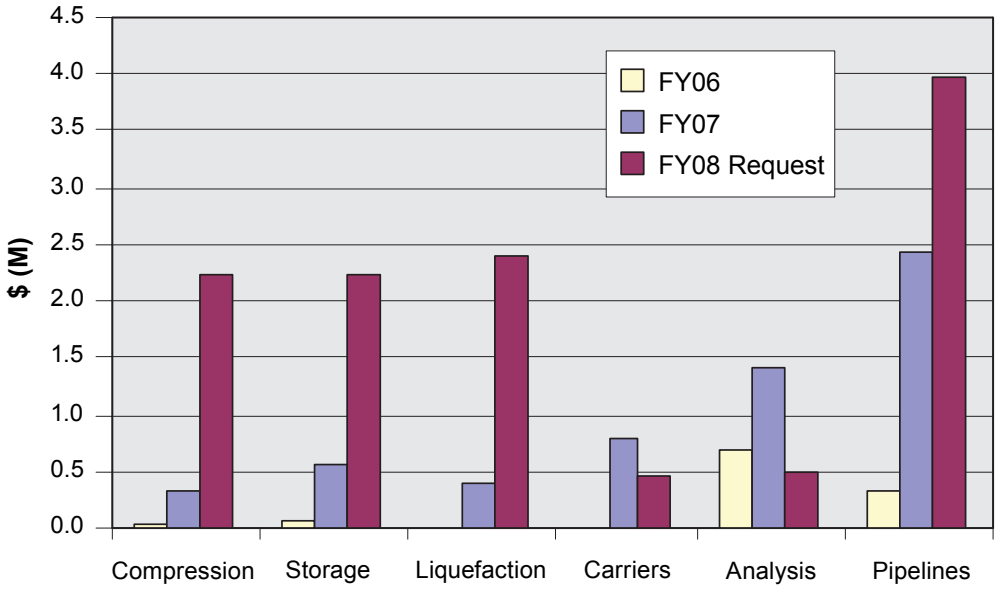
- Comprehensive analysis of the options and trade-offs of hydrogen delivery approaches for the near-term and long-term.
- Pipelines: Resolve hydrogen embrittlement concerns with steel pipelines, reduce capital costs by developing new steel compositions and/or welding and installation techniques, and/or develop viable composite pipeline technology with reduced capital costs.
- Compression: Develop more reliable and lower cost hydrogen compression technology for pipeline transmission and refueling station applications.
- Storage: Develop lower capital cost off-board storage technology; confirm the technical feasibility and adequate availability of hydrogen geologic storage.
- Liquefaction: Dramatically reduce the capital cost and increase the energy efficiency of hydrogen liquefaction.
- Carriers: Leverage the National Hydrogen Storage Project on-board storage program element to determine if a novel solid or liquid carrier might be suitable for hydrogen transport or off-board storage and result in the targeted delivery cost and energy efficiency.

FY 2007 Accomplishments

- Expanded and improved the analysis of the current costs of hydrogen delivery using pipelines, liquid trucks and gaseous trucks. This included a comprehensive analysis of hydrogen hourly, daily, and seasonal demand and supply variations and optimized off-board storage infrastructure to handle these variations, variable sized refueling sites (50-6,000 kg/day), and improved cost estimates for pipelines, liquefaction, compression, and storage. The use of novel carriers is also being analyzed to determine which approaches might be useful for hydrogen delivery. Updated versions of the H2A Delivery Models and a report summarizing the results of these and prior hydrogen delivery infrastructure analyses should be completed and posted (www.hydrogen.energy.gov/Systems_Analysis) for public use by the end of 2007. This will mark the completion of the first Hydrogen Delivery Objective (see above).
- Progress continues to be made on developing a mechanistic understanding of hydrogen pipeline embrittlement. This includes developing a finite element code for the study of transient stress-driven hydrogen transport coupled with large strain material elastoplastic deformation.
- Hydrogen permeation testing equipment has been set up and verified. Data is being obtained on both steel and composite materials in efforts to develop improved and lower cost hydrogen pipelines as well as for use in the hydrogen embrittlement modeling effort.
- Appropriate state-of-the-art equipment and test procedures have been established for mechanical testing of steels and composite materials for use with hydrogen to aid in the development of improved and lower cost pipeline and storage technology.
- Progress was made on a combination of cold gas (-30 to -100°C), pressure (5,000-8,000 psi) and the use of composite material structures that has the potential to significantly reduce the cost of hydrogen stationary storage at refueling stations and for other stationary storage needs. This approach could also be used to reduce the cost of delivery for hydrogen in tube trailers. A glass fiber through strut structure with a metal skin containerized in a conventional rectangular steel trailer has been modeled using finite element analysis and shows promise. Research for appropriate glass fiber materials and initial structure prototyping is planned for FY 2008.
- Progress was made on a novel liquid hydrocarbon carrier system. Research was conducted on defining the best reactor design for hydrogen release at the refueling station or on-board a vehicle. This research demonstrated that a monolithic or micro-channel reactor could overcome the limitations of conventional trickle bed reactors in this system.

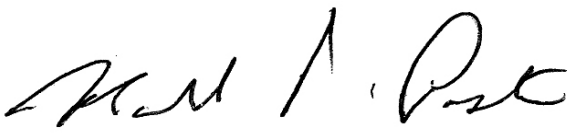
Budget

The budget profile for the Hydrogen Delivery Program element is shown below. Plans are to substantially further increase funding in FY 2008 compared with FY 2007 appropriations. The FY 2007 appropriation for the Hydrogen Delivery Program element was $5.9 million; the FY 2008 budget request is for $11.7 million. In particular, research on compression, off-board storage, liquefaction, and pipelines will be markedly increased.



2008 Plans

- Continue hydrogen delivery infrastructure analysis to complete carrier technology approaches and expand to more comprehensive regional and other geographic specific aspects.
- Significantly expand R&D on compression, liquefactions and stationary storage for technology readiness by 2015. Two solicitations were issued in FY 2007 on these topics, both by the Hydrogen, Fuel Cells and Infrastructure Technologies program and by the Small Business Innovative Research program.
- Maintain funding for pipelines R&D as the long-term lowest cost delivery option. As the use of hydrogen as an energy carrier expands, production focus will likely shift from distributed to central facilities in order to take advantage of economies of scale.



Mark Paster
Hydrogen Delivery Team Lead
Department of Energy
Hydrogen, Fuel Cells & Infrastructure Technologies, EE-2H 1000
Independence Ave., SW, Washington, D.C. 20585-0121
Office: (202) 586-2821
E-mail: Mark.Paster@ee.doe.gov