III.1 Hydrogen Delivery Sub-Program Overview

Introduction

Hydrogen must be transported from the point of production to the point of use. It also must be compressed (gaseous), stored and dispensed at refueling stations or stationary power facilities. Due to its relatively low volumetric energy density, transportation, storage and final delivery to the point of use can carry with it significant cost as well as the energy inefficiencies associated with using 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 planned increase in funding had to be curtailed as Congressional Appropriations for discretionary spending was less than requested. Nonetheless considerable progress on delivery research and analysis was achieved. Current 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 SBIR 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 and long-term use of hydrogen for transportation and stationary power.
- 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 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/gge of hydrogen.
- 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 2006 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 the point of use. 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. If hydrogen was a major energy carrier transported in large volumes and there was a pipeline infrastructure of the nature of the current natural gas infrastructure, the total cost of hydrogen delivery

could be on the order of $2/gge with existing technology. 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:

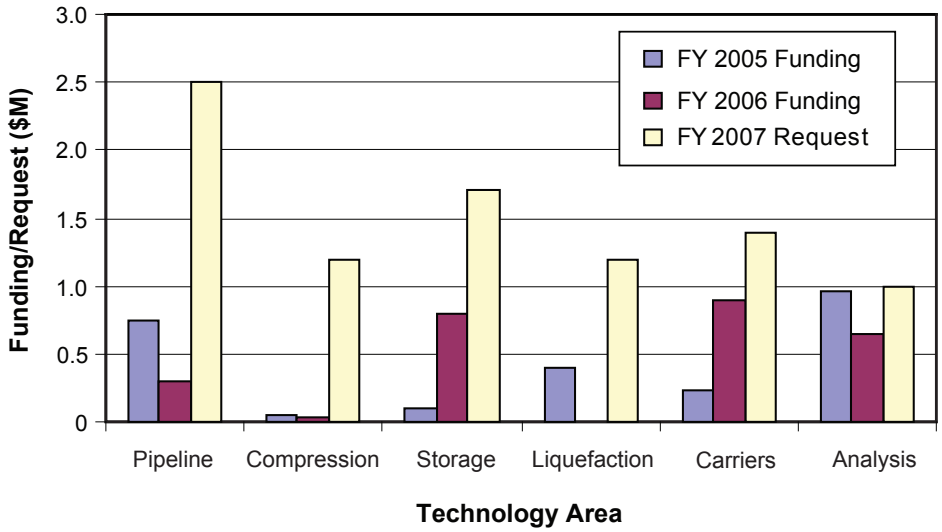
- Comprehensive analysis of the options and trade-offs of hydrogen delivery approaches for the near-term and long-term.
- Pipelines: Resolve hydrogen embrittlement concerns with steel pipelines, reduce capital costs by developing new steel compositions and/or welding and installation techniques, and/or develop composite pipelines 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 vessel 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 Hydrogen 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 2006 Accomplishments

- Completed an analysis of the current costs of hydrogen delivery using pipelines, liquid trucks and gaseous trucks. This included the development of the H2A Delivery Component and Scenario Models tools that were posted for public use along with comprehensive Users Guides (www.hydrogen.energy.gov/Systems_Analysis).
- Made significant progress on developing a mechanistic understanding of hydrogen pipeline embrittlement. This included developing a finite element code for the study of transient stress-driven hydrogen transport coupled with large strain material elastoplastic deformation.
- Progress was made on setting up testing equipment and initiating mechanical testing and hydrogen permeation rate measurements in steels and other materials in support of developing improved and lower cost materials for hydrogen pipelines and vessels.
- Defined a feasible design for a hydrogen pipeline centrifugal compressor through the use of air foil bearings and seals. This effort will move to research and development efforts in FY 2007. Current centrifugal compression technology is not applicable for hydrogen. Centrifugal compression is more reliable and lower cost than other compression technologies for this application.
- Defined 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 for hydrogen tube trailers and could make tube trailers an attractive option for hydrogen delivery. Research for appropriate composite materials and structures is planned for FY 2007.

Budget

The budget profile for the Hydrogen Delivery program element is shown in the following graph. Plans are to significantly increase funding in FY2007 and beyond compared with FY2005 and 2006 appropriations. In particular, additional projects for compression, liquefaction, and off-board storage will be initiated through future solicitations. The FY 2006 appropriation for the Hydrogen Delivery program element was $2.7 million; the FY 2007 budget request is for $9 million.



2007 Plans

- Complete hydrogen delivery infrastructure analysis to include carrier technology approaches and more comprehensive regional and other geographic specific aspects.
- Initiate additional research focused on compression, liquefaction, stationary storage, and the potential for higher capacity tube trailers through a new solicitation.
- Fully fund previously selected projects to make significant progress in the research areas of pipelines, and carriers.

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