II.0 Production and Delivery Sub-Program Overview

Introduction

The Production and Delivery activity is focused on developing hydrogen fuel production and delivery technologies that enable the introduction and long-term viability of hydrogen as an energy carrier for transportation and stationary power. A variety of feedstocks, processes, and pathways are being pursued to meet the objective of producing hydrogen that is pure enough for use in proton exchange membrane fuel cells and cost-competitive with gasoline.

Several workshops were held by the Hydrogen Production and Delivery team in the past year to outline the opportunities and challenges associated with potential production routes.

- The Workshop on Electrolysis Production of Hydrogen from Wind and Hydropower was held on September 9-10, 2003. Over 50 participants from wind turbine and electrolyzer manufacturers, power producers, research organizations and labs, and trade and public interest associations came together with DOE representatives to explore the potential for cost-effective electrolysis production of hydrogen from wind and/or hydropower.
- On June 9, 2004, about 40 technical experts from across industry, universities, national laboratories, and other organizations met to (1) discuss the assumptions and findings of a Neoterics/NREL study and its implications for fermentation R&D targets; (2) identify technical barriers and challenges that must be overcome to achieve cost effective production of hydrogen via direct fermentation; and (3) explore ideas for breakthrough technologies and research and development that could overcome these technical barriers and challenges, including synergies with other technologies in photobiology and photoelectrochemistry.
- During the Hydrogen Separations and Purification Technologies Workshop on September 8-9, 2004, the DOE gathered input from industry and the research community on options and needs for developing PEM-grade hydrogen separations and purification technologies that could contribute to achieving the 2010-2015 DOE cost goals for delivered hydrogen. The three specific technology areas considered were ion (proton) transport separation systems, atomic transport/dense metallic separation systems, and molecular transport/microporous separation systems.
- On September 22-23, 2004, representatives from the utility and electrolysis industries participated in a two-day roadmapping workshop to discuss electrolysis advances, electric integration activities, and future-state transmission and distribution scenarios.

To further advance hydrogen production and delivery technologies toward the technical targets, DOE solicited Applications for research in the following ten topic areas: Hydrogen from Biomass; Photolytic Processes; Distributed Production Technologies; Separation and Purification Technologies; Advanced Electrolysis Systems; Hydrogen Production Using High Temperature Thermochemical Water Splitting Cycles; Hydrogen Production Infrastructure Analysis; Hydrogen Delivery; Crosscutting Projects; and University Projects. Thirty-six projects totaling over $75 million (approximately $100 million when industry cost shares are included) were selected and awarded to move the hydrogen production and delivery technologies toward goals needed to enable an industry commercialization decision by 2015 and toward the long-term goal of a hydrogen-based economy.

Hydrogen Production and Delivery activities were refocused in 2004 to address the recommendations of the National Research Council. Acknowledging that progress in hydrogen production and delivery technologies is currently inhibited by the limited funding available after distribution of congressionally earmarked funds to projects that do not contribute significantly to the goals of the Program, the committee

offered several recommendations for reprioritization to improve the effectiveness of the research. The following areas of research are now emphasized:

- Innovative technologies for distributed reforming, including autothermal, partial oxidation and steam methane reforming reactor development.
- Wind and other renewable-based electrolysis.
- Fundamental research in hydrogen compression and hydrogen gas separation/purification technologies.
- Fundamental research in photobiological and photoelectrochemical processes.
- Technical and economic analyses and planning for hydrogen infrastructure development.

Technology Status

The Production and Delivery Sub-Program is approaching its 2005 distributed hydrogen production target of <$3.00 per kg H_2 at the pump using steam reforming of natural gas. Other production and delivery technologies are in various stages of development. For each production and delivery technology area, the ultimate target is for the hydrogen fuel to be competitive with gasoline. However, because some technologies are more mature than others, the timeline for meeting the ultimate target varies by feedstock and process option.

Techno-economic analyses are currently being conducted to determine the commercialization potential of each of the technologies being researched. The analyses will provide a consistent basis by which to compare technologies and assess the status of each.

FY 2004 Accomplishments

Cooperative R&D:

- FreedomCAR and Fuel Partnership Production Tech Team initiated; first roadmap containing reforming and electrolysis technology development plans expected by year end
- An industry/government techno-economic analysis model (H_2A) has been developed to enable harmonizing basic financial and technical assumptions

Distributed Production from Natural Gas:

- Air Products and Chemicals is approaching the 2005 cost target of $3.00/kg hydrogen cost at dispenser (690 kg/day, 11% capital factor, >100 units annually, $4/MMBTU(HHV) natural gas, 90% utilization) and exceeded 2005 efficiency target
- Air Products and Chemicals developed pressure swing absorption (PSA) system to deliver 99.999% pure hydrogen from a steam methane reformer stream at 120 psig for 2-4 times reduction in cost, smaller footprint, and efficiency exceeding 2005 target

Delivery:

- H2A Delivery analysis has set a benchmark for measuring research progress in compression, liquefaction, pipeline, and carrier technologies
- Ergenics: Hydride-based compression and purification demonstrated
- FreedomCAR and Fuel Partnership Delivery Tech Team initiated, draft roadmap expected by year end

Biomass Gasification/Pyrolysis:

- National Renewable Energy Laboratory (NREL) demonstrated improved reforming catalyst reducing attrition and coking

Electrolysis:

- Conducted analysis of wind technologies for hydrogen production (NREL)
- Held industry meeting on hydrogen production from wind and hydropower
- Developing baselines using H2A analysis on forecourt and central electrolysis

HT Thermochemical Cycles:

- UNLV Consortium: Completing database and ranking of cycles and solar concentrators

Photobiological:

- Reduced chlorophyll antenna size of green algae by 58% to increase utilization efficiency of absorbed sunlight energy to ~15%
- Achieved six months continuous hydrogen photoproduction

Photoelectrochemical:

- Developed a new material, gallium phosphide nitride (GaPN), that is expected to achieve the 2005 goal of 7% efficiency and 1000 hours lifetime
- Identified cost-effective zinc based mixed metal oxides with 4 times solar-to-hydrogen production efficiency improvement
- Began developing models that will assist in the identification of materials that will meet the DOE targets for photoelectrochemical hydrogen production

FY 2005 Plans

A significant number of new cooperative agreements will be initiated in 2005 to develop hydrogen production and delivery technologies that have potential to achieve the 2010 R&D targets. Analysis activities will better determine the current status and the commercialization potential of each technology area under consideration for meeting the objective of providing hydrogen fuel to the pump at a price that is competitive with gasoline, with adequate pressure and purity to meet the demands of polymer-based fuel cells in transportation and stationary applications.

Compared to the FY 2004 appropriation of $10.1 million for Hydrogen Production and Delivery (in addition to $12 million in congressionally directed projects), the FY 2005 request is $25.2 million. The budget request for 2005 reflects the recommendations of the National Research Council to increase funding for distributed hydrogen production, electrolysis, and hydrogen delivery. Funding for exploratory research on photolytic technologies is also being increased in response to the committee's recommendation. Future efforts will also involve greater integration with the Office of Fossil Energy and the Office of Nuclear Energy on the research and development of hydrogen production technologies.