III.0 Hydrogen Storage Sub-Program Overview

Introduction

Hydrogen storage is a key enabling technology for the advancement of hydrogen and fuel cell power technologies in transportation, stationary, and portable power applications. The Hydrogen Storage activity focuses primarily on the research and development of on-board vehicular hydrogen storage systems that will allow for a driving range of greater than 300 miles while meeting packaging, cost, and performance requirements.

In 2004, the awards from the Hydrogen Storage "Grand Challenge" solicitation were announced with projects at 30 universities, 10 companies and 10 federal laboratories. The selections included focused collaborative R&D on metal hydrides, chemical hydrogen storage, and carbon-based materials, with multiple university, industry and national laboratory partners. Independent awards to universities and industry were also announced on systems analyses, new concepts, and off-board storage. In addition, interaction with the DOE Office of Basic Energy Sciences is ongoing to define and to coordinate the basic research activities for hydrogen storage materials. The Hydrogen Storage activity has responded positively to recommendations from the National Research Council to increase longer-term, multidisciplinary applied research for breakthrough approaches to overcome the hydrogen storage technical barrier to a hydrogen economy.

Technology Status

On-board hydrogen storage approaches under investigation include compressed hydrogen gas tanks, cryogenic hydrogen tanks, metal hydrides, carbon-based materials and high surface area sorbents, and chemical hydrogen storage. Tanks, metal hydrides, high surface area sorbents and carbon-based materials constitute on-board reversible hydrogen storage systems because hydrogen regeneration or hydrogen uptake can take place on-board the vehicle. For chemical hydrogen storage approaches, hydrogen regeneration is not possible on-board the vehicle; thus, these systems must be regenerated off-board.

The current status values, as shown below, are estimates provided by developers and the R&D community and will be updated continuously. Because it is often difficult to estimate system-level weights and volumes when research is still at the stage of materials development, the current status data will be revisited periodically. However, it is clear that none of the current systems meets the combined gravimetric, volumetric, and system cost targets for either 2010 or 2015. Also note that although recent accomplishments show materials-based capacities of over 5 wt.%, the targets of 6 wt.% by 2010 and 9 wt.% by 2015 are system-level capacities which include the material, tank and all balance-of-plant components of the storage system.

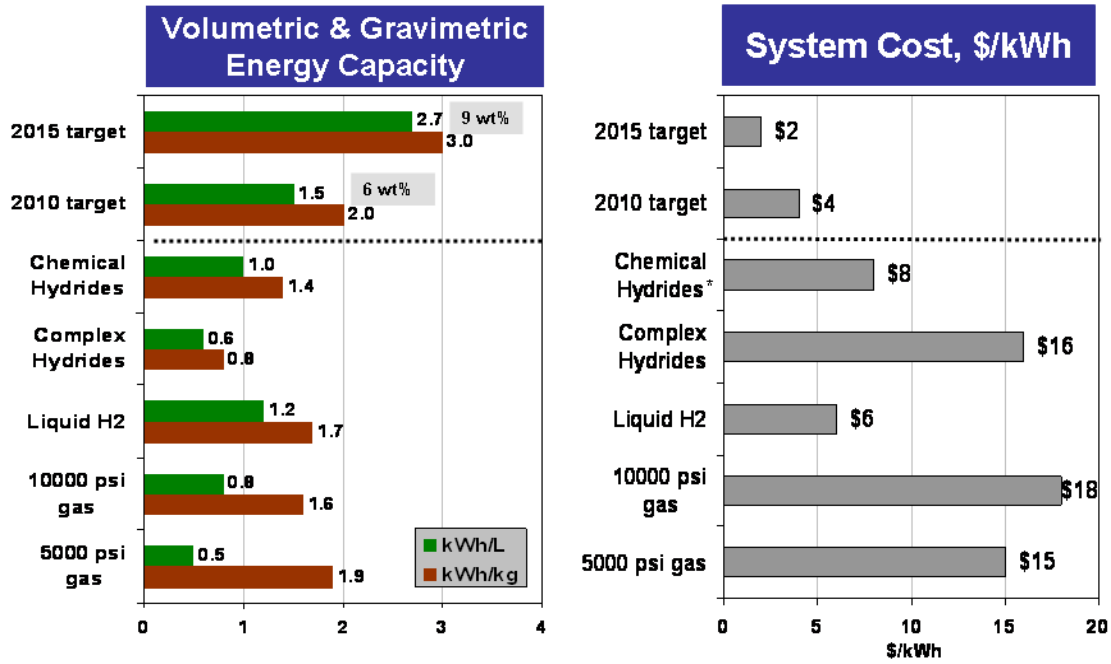
FY 2004 Accomplishments

Compressed and Cryogenic Tanks:

- First-generation, lower cost 10,000-psi tank designed, fabricated, and tested (Quantum).

Metal Hydrides:

- Demonstrated 5 wt.% (materials-based capacity) reversible hydrogen storage in a Mg-modified Li-amide material (Sandia National Laboratory).
- Completed a first-generation prototype of a 1-kg H_2 alanate-based hydrogen storage system (United Technologies Research Center).



Chemical Hydrogen:

- Identified liquid materials that store greater than 5.5 wt.% (materials-based capacity) H_2 and greater than 50 g H_2/L, and operate at temperatures less than 200°C (Air Products and Chemicals).

Carbon:

- Conducted external peer review of hydrogen capacity measurements, verifying measurement methodology [National Renewable Energy Laboratory (NREL)].
- Measured 3 wt.% (materials-based capacity) hydrogen storage in metal atom-doped single-walled carbon nanotubes at room temperature (NREL).

FY 2005 Plans

Subject to Congressional appropriations and direction, the FY 2005 plans are to launch Centers of Excellence on Metal Hydrides, Carbon-based Materials and Chemical Hydrogen Storage that include multiple university, industry and federal laboratory partners. In addition, 15 independent industry and university projects will include new concepts, off-board storage and systems analyses.

The current hydrogen storage activities, together with the outcome of the Grand Challenge, constitute the framework of the "National Hydrogen Storage Project", with $150 million over five years (subject to congressional appropriations). The result of this R&D investment will be the development of hydrogen storage systems capable of meeting the 2010 targets and with potential to meet the 2015 targets.

The R&D planned on Metal Hydrides will focus on the development of advanced metal hydride materials, including light element advanced complex hydrides, destabilized binary hydrides, intermetallic hydrides, modified lithium amides and other on-board reversible hydrides. The R&D planned on Chemical Hydrogen Storage focuses on three "tiers" of R&D for chemical hydrogen storage: borohydride-water, novel boron chemistry, and innovation beyond boron. In the area of Carbon-Based Materials, the planned R&D will focus on breakthrough concepts for storing hydrogen in high surface area sorbents such as hybrid carbon nanotubes, aerogels, and nanofibers, as well as metal-organic frameworks and conducting polymers.

The National Hydrogen Storage Project also involves independent projects that explore promising new hydrogen storage materials and concepts, off-board hydrogen storage needed for a hydrogen delivery infrastructure, standardized testing of hydrogen storage capacities, and analyses of life-cycle cost, energy efficiency, and environmental impact for hydrogen storage systems. Some of the new materials/concepts being studied are nanostructured materials, amine borane complexes, metal perhydrides, clathrates, lithium nitride and irradiation activation of materials.

The funding for hydrogen storage activities in FY 2004 was $13.2 million. There was also approximately $15 million in congressionally directed projects within the Storage Sub-Program. As we look forward to the FY 2005 request of $30 million, there is increased emphasis on new materials and concepts as well as on systems analyses. There is also a shift away from development of near-commercial compressed tank technology. The future effort in compressed/liquid tanks is on R&D for cost reduction and advanced concepts, including tanks for solid-state or chemical hydrogen storage, and off-board storage.

The Hydrogen Storage activity is consistent with the National Research Council's recommendation that "there should be a shift in the hydrogen program away from some development areas and toward exploratory work- as has been done in the area of hydrogen storage." The continued shift in hydrogen storage activity, as evident by the increased number of university grants, will focus on innovative chemistries and novel materials approaches in collaboration with the DOE Office of Science - through university, industry and national laboratory R&D. Additional awards by the Office of Science through their 2004 solicitation on basic reasearch for hydrogen storage are anticipated to be made in FY 2005.