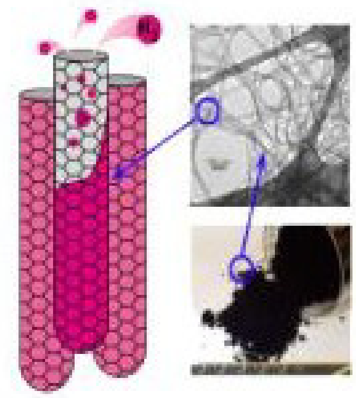
2.2.4 HYDROGEN STORAGE AND DISTRIBUTION

Technology Description

Unlike electricity, hydrogen can be stored for long periods of time and distributed over long distances without significant losses. Today, hydrogen is stored as a liquid or compressed gas, and distributed by truck, rail, and (to a limited extent) pipeline. In the future, it could be stored in chemical and metal hydrides and carbon nanostructure materials, and distributed via a vast network of pipelines. In the meantime, current technologies can be adapted to store and distribute hydrogen to the emerging transportation and stationary markets for hydrogen.


Carbon nanotube structure and micrographs.

System Concepts and Representative Technologies

- There are five hydrogen storage approaches under development at the present time: high-pressure composite tanks; low-temperature hydrogen storage; pressurized cryotanks; novel carbon structures as storage media; and reversible catalyst-assisted chemical and metal hydrides.
- Solid-state storage may offer increased safety for onboard storage of hydrogen, since tank punctures or ruptures would not result in large energy releases. These systems also require less volume than pressurized or liquid systems. Stationary applications also would benefit from the successful development of these systems.
- Distribution concepts include evaluation of existing natural gas pipelines for material compatibility, utilization of the existing delivery infrastructure to provide hydrogen to emerging markets, and improved auxiliary equipment (compressors, liquefaction equipment, valves, and gauges).


High-pressure, all-composite gaseous hydrogen storage cylinders encourage commercialization of hydrogen gas-powered vehicles.

Technology Status/Applications

- Hydrogen is stored as a liquid at 20 K in insulated dewars or as a compressed gas. Metal hydrides are used in limited stationary applications where weight is not a critical factor and where waste heat is available at the appropriate temperature for hydrogen release.
- Current R&D efforts are focused on improving such factors as weight, volume, cost, and safety.
- Particularly notable are recent advances in storage energy densities, primarily focused on mobile applications. The composite tank development is a prime example of a successful technology partnership among the national labs, DOE, and industry.
- Industrial investment in chemical hydride development has recently been initiated.
- Continued improvements are still required to meet perceived customer demands in vehicular applications, in particular with respect to convenience, safety, and cost.

Current Research, Development, and Demonstration

RD&D Goals

- By 2005: develop storage system with 4.5 wt%, 1,200 watt-hrs/liter energy density, at a cost of $6/kWh of stored energy.

- By 2010: demonstrate storage system with 6 wt%, 1,500 watt-hrs/liter energy density, a range >300 miles, at a cost of $4/kWh of stored energy.

RD&D Challenges

- Fundamental understanding of chemical and metal hydrides and carbon nanotubes as hydrogen storage media is needed to enable the efficient and timely development of storage systems that are inherently safe and more efficient and convenient than current systems.
- Onboard hydrogen storage for transportation applications requires increased storage density, so that the volume of storage on a vehicle can be reduced while providing range equal to that of a conventionally fueled vehicle, without compromising vehicle weight and performance.
- Development of improved low-permeability membrane liners for pressurized storage systems is needed to further improve storage volumes and reduce container weight.
- Research and development of advanced solid-state hydrogen storage systems – including chemical hydrides, metal hydrides such as alanates, and carbon materials – needs to be broadened, with deployment of the resultant systems in prototype vehicles and/or at user sites.
- Production processes for solid-state materials need to be developed and scaled up with industry.
- Compression energy requirements at high storage pressures are significant. Improved hydrogen compressors are needed.
- Improved liquefaction equipment that uses less energy to liquefy hydrogen compared to conventional processes (where 30%-35% of the energy contained in the hydrogen is required) could provide additional storage options for stationary applications.

RD&D Activities

- DOE's HFC&IT Program is carried out by national laboratories, universities, and the private sector, including CRADA collaborations between industry and the labs, and cost-shared industry-led efforts.
- The overall strategy of the HFC&IT Program is to conduct a comprehensive and balanced program that includes mid- and long-term research and development of hydrogen production, storage, and utilization technologies; integrated systems and technology validation with close industry collaboration that develops, demonstrates, and deploys critical technologies emerging from research and development; and an analysis element that helps to determine the performance and cost targets that technologies must meet to achieve the overall goals of the HFC&IT Program, as well as the specific project objectives determined by peer review.

Recent Progress

- High-pressure, composite storage tanks have been developed through the combined efforts of industry, national labs, and universities. These tanks have been tested and certified, and are being used in prototype hydrogen fuel cell vehicles.
- Hydride storage systems have been developed for use in mining vehicles, where the added weight of these storage systems is a benefit (improved traction).
- Sodium borohydride ($NaBH_4$) is being considered for use in fuel cell vehicles as a storage/delivery system for hydrogen.

Commercialization and Deployment Activities

- A novel thermal hydrogen compressor is being developed in an industry-led project. This compressor operates in conjunction with advanced hydrogen production technologies and improves the efficiency and economics of the compression and hydrogen utilization process. The thermal compressor is an absorption-based system that uses the properties of reversible metal hydride alloys to silently and cleanly compress hydrogen; hydrogen is absorbed into an alloy bed at ambient temperature; and, subsequently, is released at elevated pressure when the bed is heated with hot water. Compression energy can be supplied by waste heat or solar hot water.
- An industry-led project is developing metal-hydride storage containers for use on scooters, wheelchairs, and other personal mobility products.