Suppliers currently transport hydrogen by pipeline or over the road using tube trailers and cryogenic liquid hydrogen tankers. For special purposes, liquefied hydrogen is transported by barge. Hydrogen can also be moved using chemical carriers - substances composed of substantial amounts of hydrogen, as well as other elements.

Fuel Cell Technologies Program: Delivery

Hydrogen Distribution and Delivery Infrastructure

Most of the hydrogen used in the U.S. is produced at or near where it is used — typically at large industrial sites. As a result, an efficient means of delivering large quantities of hydrogen fuel over long distances and at low cost does not yet exist. Before hydrogen can become a mainstream energy carrier, we must first develop and build the infrastructure (e.g. the miles of transmission and distribution pipelines, bulk storage vessels, and refueling stations) that will support its consumer use.

How Is Hydrogen Delivered Today?

Suppliers currently transport hydrogen by pipeline or over roadways using tube trailers or cryogenic liquid hydrogen tankers. In special cases, liquefied hydrogen is transported by barge. Hydrogen can also be moved using chemical carriers — substances composed of substantial amounts of hydrogen as well as other elements; for example, ethanol (C_2H_5OH) and ammonia (NH_3).

Transmission by pipeline is the least expensive way to deliver large amounts of hydrogen and several lines have been built in the U.S., specifically near large petroleum refineries and chemical plants in Illinois, California, and along the Gulf Coast. However in comparison with the more-than-one million miles of natural gas pipelines, the current hydrogen pipeline infrastructure in the U.S. is very small, less than 1,200 miles in length.

Hydrogen gas can also be compressed and transported over the road in high-pressure tube trailers. This option is used primarily to move modest amounts of hydrogen over relatively short distances. It tends to become cost prohibitive when these distances are greater than approximately 200 miles from the point of production. By comparison, for a given volume, liquefied hydrogen (hydrogen that has been cooled to -253°C) is more dense and contains greater energy content than gaseous hydrogen. In the absence of an existing pipeline, this option is the preferred method of delivering hydrogen over long distances. However, liquefaction is costly because the process

A pipeline is currently one method used to transport hydrogen.

requires a substantial amount of energy. Nonetheless, due to the limited amount of pipeline available, hydrogen is often transported as a liquid in super-insulated, cryogenic tank trucks and later vaporized for use at the customer site.

What Are the Challenges?

For a given volume, hydrogen contains a smaller amount of useable energy than other fuels such as natural gas and gasoline. Because of its low volumetric energy density, hydrogen is comparatively more costly to transport and store. As mentioned, the primary means of reducing the as-delivered cost of hydrogen, via pipeline transmission, is currently lacking. Principally, this is because of the large initial capital investment required to construct a new pipeline infrastructure. However, there are also a number of technical concerns with pipeline transmission of hydrogen over long distances, including: the potential for hydrogen embrittlement in the base steel and in the welds used for pipeline construction, the need for lower cost/higher reliability hydrogen compression technology, and the desire to prevent hydrogen permeation and leakage from pipeline and other containment materials.

The method by which hydrogen is produced also affects the cost and method of delivery. Distributed production at the point of use, such as directly at refueling stations or at stationary power sites, eliminates the transportation costs for hydrogen delivery. Conversely, production in large central plants requires long-distance transport that increases delivery costs. However the latter approach also results in lower production costs due to greater economies of scale; i.e., the cost of production and delivery must be analyzed together.

Research Directions

Researchers are working to better understand the options and trade-offs for hydrogen delivery from central, semi-central, and distributed production sites under various transmission and transportation scenarios. Research is also focused on developing:

- Lower-cost, more reliable hydrogen compression technology
- More cost-effective bulk hydrogen storage technology
- New materials for lower-cost hydrogen pipelines
- More energy-efficient and lower-cost hydrogen liquefaction processes
- Integrated production, delivery, and end-use technologies

Building a national hydrogen delivery infrastructure is a significant challenge. It will take time to develop and will likely include various combinations of technologies. Infrastructure needs and resources will vary by region and by type of market; e.g., urban, interstate, or rural, and infrastructure options (or the delivery mix) will continue to evolve as the demand for hydrogen grows and as delivery technologies develop and mature.

For More Information

More information on the Fuel Cell Technologies Program is available at *http://www.hydrogenandfuelcells.energy.gov*.

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