Hydrogen Program

Technology Overview

Use of hydrogen today faces four primary challenges: 1) the ability to deliver to the consumer at prices competitive with other fuels 2) to increase production efficiency, 3) the need to develop better methods for storing hydrogen, and 4) the need to lower the cost of fuel cells and electrolyzers.

Most of the hydrogen now produced in the United States is on an industrial scale using the process of steam reforming, or as a byproduct of petroleum refining and chemicals production. Other ways to produce hydrogen include electrolysis, steam electrolysis, thermochemical water splitting processes, and photoelectrochemical processes.

Motor vehicles can be converted to use hydrogen as a fuel. One near-term approach to expand the role of hydrogen is to use it for transportation by mixing it with natural gas in internal combustion engines; this would increase engine performance and decrease pollution. Hydrogen is being blended with other alternative fuels and used in fleets of buses in a number of cities. Automobile manufacturers have developed hydrogen-powered cars.

Fuel cells are a type of technology that use hydrogen to produce useful energy. In fuel cells, hydrogen and air are combined through an electrochemical process, which produces electricity, heat, and water.

The U.S. space program has used fuel cells to power spacecraft for decades. Fuel cells capable of powering automobiles and buses have been and are being developed. Several companies are vigorously developing fuel cells for stationary power generation, perceiving huge market demand for such clean, quiet, modular technology.

In order to use hydrogen on a large scale, safe, practical storage systems must be developed, especially for automobiles. Although hydrogen can be stored as a liquid, it is an energy-intensive process because the hydrogen must be cooled to -423° Fahrenheit (-253° Celsius). Hydrogen may also be stored as a gas, which uses less energy than making liquid hydrogen. Because hydrogen is a gas, it must be pressurized to 5,000 psi to store any appreciable amount. For large-scale use, storage in low-pressure metal hydride and carbon-based tanks offer even greater volumetric efficiency and safe operation. The hydrogen gas could then be piped into refueling stations and stationary generation applications in the same way as natural gas.

Photo courtesy of Sunline Transit Agency

Commercialization for the 21st Century, a project managed by Sunline Transit Agency in Thousand Palms, California, integrates hydrogen production using natural gas reformers, wind, and solar resources to produce electricity that runs electrolyzers. They also validate the safety of compressed and stored hydrogen technology systems, and fueling appliances in their "rolling labs" (i.e., buses and other vehicles).

U.S. Department of Energy Program

The mission of the Hydrogen Program is to enhance and support the development of cost-competitive hydrogen technologies and systems that will reduce the environmental impacts of energy use and enable the penetration of renewable energy into the U.S. energy mix.

The Hydrogen Program develops and validates critical technologies for hydrogen systems and supports a vision of a sustainable energy future.

The Program supports the following activities: (1) developing and integrating the technology base for producing hydrogen using fossil and renewable sources; (2) developing advanced materials and delivery systems for storage and transport options; (3) evaluating safety and reliability issues associated with utilization technologies; (4) performing technical and economic analysis on component technologies and processes; and (5) demonstrating hydrogen technologies within integrated energy systems, with strong industry collaboration.

The hydrogen program has four strategies: (1) expand the use of hydrogen in the near-term by working with industry, including hydrogen producers, to improve efficiency, lower emissions, and lower the cost of technologies that produce hydrogen from natural gas for distributed filling stations; (2) work with fuel cell manufacturers to develop hydrogen-based electricity storage and generation systems that will enhance the introduction and penetration of distributed, renewables-based utility systems; (3) coordinate with DOE's Office of Transportation Technologies and the U. S. Department of Transportation to demonstrate safe and cost-effective fueling systems for hydrogen vehicles in urban non-attainment areas and to provide onboard hydrogen storage systems; and (4) work with the national laboratories to lower the cost of technologies that produce hydrogen directly from sunlight and water.

Hydrogen Program

Quantum Technologies, Inc.

DOE, Lawrence Livermore National Laboratory, and Quantum Technologies, Inc. have successfully developed and demonstrated the lightest compressed hydrogen storage tank in the world, and that achieved a mass performance record of 11.3 percent hydrogen storage by weight. This achievement has gained the attention of fuel cell vehicle developers and automobile manufacturers, since it represents increased vehicle range and easier packaging onboard the vehicle. Initial applications for these storage systems include fuel cell automobiles, trucks, and buses.

Photo courtesy of Quantum Technology Inc.

Quantum Technologies, Inc. storage tank with patented in-tank regulator.

Market Potential

The vision for the future includes a society where hydrogen, the most abundant element in the universe, and electricity are the preeminent energy carriers.

In this vision, ultimately, renewable resources such as biomass, wind, geothermal and solar energy are used to extract hydrogen from water. In the interim, hydrogen is extracted from fossil fuels, such as coal or natural gas, with carbon sequestration. When hydrogen is used in energy systems, it generates no emissions other than water, which is recycled to make more hydrogen.

In the next twenty years, concerns about global climate change and energy security will create the platform for the penetration of hydrogen into several niche markets. Ultimately, hydrogen and electricity will come from sustainable renewable energy resources, but fossil fuels will be a significant transitional resource during this period. The growth of fuel cell technology will provide a base for the establishment of the hydrogen option into both transportation and electricity supply markets.

Two conversion technologies – fuel cells and internal combustion engines – can make use of hydrogen fuel in the near term. In the electric utility market, hydrogen-fueled technologies are likely to be used in distributed generation applications, the fastest-growing segment of the generation market. Significant market penetration of hydrogen-fueled generation would have a positive impact on national air emissions.

The first widespread use of hydrogen as an energy carrier is likely to be in the electricity generation sector, where fuel cells can supply heat and electricity for homes and buildings. Internal combustion engines can be fueled with pure hydrogen, or hydrogen blended with natural gas. Subsequently, vehicles will likely be powered with hydrogen fuel cells, which are three times more efficient than current gasoline powered engines.

The overall goal of DOE's Hydrogen Program is: (1) to realize the meaningful introduction of fuel cells for distributed energy generation by 2005, (2) to be able to make an informed fuel decision on fuel cells in vehicles by 2010, and (3) to replace 0.04 quads of conventional energy (1999 total U.S. energy use was nearly 97 quads) with hydrogen by the year 2010, and replace tens of quads per year by 2030. A quad is roughly the amount of energy consumed by 1 million households.

For More Information:

Hydrogen Information Network Web site
of the DOE Hydrogen Program
Tel: (202) 586-5517
Web: www.eren.doe.gov/hydrogen

Los Alamos National Laboratory
Hydrogen Education Site
Web: http://education.lanl.gov/RESOURCES/h2

National Hydrogen Association
Tel: (202) 223-5547
Fax: (202) 223-5537
Web: www.hydrogenus.com

American Hydrogen Association
Tel: (480) 827-7915
Fax: (480) 967-6601
Web: www.clean-air.org

Glossary from HyWeb – Hydrogen and Fuel Cell information System
Web: www.HyWeb.de/index-e.html

Glossary of fuel-cell technical terms presented by the U.S. Fuel Cell Council
Web: www.usfcc.com/Glossary2.pdf

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