NREL FACTS

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NREL Research

Hydrogen Research

Developing sustainable technologies for the 21st Century

The vision is staggering: a society powered almost entirely by hy drogen, the most abundant element in the universe. In this vision, renewable resources such as biomass, wind, and solar energy are used to extract hydrogen from water. When the hydrogen is used as an energy source, it generates no emissions other than water, which is recycled to make more hydrogen. Making this vision a reality in the 21st Century is the goal of researchers at the National Renewable Energy Laboratory.

Hydrogen and Its Uses

Hydrogen is a colorless, odorless gas that accounts for 75 percent of the universe's mass. Hydrogen is found on Earth only in combination with other elements such as oxygen, carbon and nitrogen. To use hydrogen, it must be separated from these other elements.

Today, hydrogen is used primarily in ammonia manufacturing, petroleum refining and synthesis of methanol. It's also used in NASA's space program as fuel for the space shuttles, and in fuel cells that provide heat, electricity and drinking water for astronauts. Fuel cells are devices that directly convert hydrogen into electricity. In the future, hydrogen could be used to fuel vehicles and aircraft, and provide power for our homes and offices.

NREL's Hydrogen Research

As part of the U.S. Department of Energy's (DOE) Hydrogen Program, NREL conducts research on advanced technologies to produce, store and safely use hydrogen made from renewable resources. The goal is to help industry develop technologies to produce, store, transport and use hydrogen in quantities large enough, and at costs cheap enough, to compete with traditional energy sources such as coal, oil and natural gas.

Production Research

NREL researchers are exploring using renewable resources such as sunlight, biomass and biological organisms to produce hydrogen economically.

Photoconversion production—Researchers use either biological organisms (bacteria or algae) or semiconductors to absorb sunlight, split water and produce hydrogen. Through their normal metabolic function, some biological organisms naturally produce hydrogen; semiconductors produce hydrogen by generating an electric current that splits water.

NREL researchers have developed a device that splits water into hydrogen and oxygen with greater efficiency than most other methods using sunlight. Current systems link photovoltaic cells that generate electricity with an electrolyser to break down water. The NREL all-in-one device is an advanced alternative to these less efficient photovoltaic/electrolyser systems. The new NREL device converts about 12 percent of available sunlight into hydrogen, compared to 4 to 6 percent for the photovoltaic/eletrolyser system. While not currently economical, the device has a potential for lower cost hydrogen and represents a breakthrough in hydrogen research.

Thermochemical production—This approach uses heat to produce hydrogen from biomass and solid waste. An NREL-developed pyrolysis technology uses heat to liquefy biomass. Steam is then used to make hydrogen from the resulting bio-oil in a process known as steam reforming.

Storage Research

Hydrogen is currently stored as a compressed gas or a cryogenic liquid in physical storage systems. NREL is developing a solid-state storage system that is safer than physical storage systems, and could potentially store more hydrogen per unit volume. Solid-state systems chemically or physically bind hydrogen to a solid material.

NREL's solid-state storage system uses microscopic carbon tubes to adsorb hydrogen. The technology can store high volumes of hydrogen at higher temperatures than other technologies, and at near ambient pressure levels. The hydrogen attaches to the surface of the carbon and is released by changing temperature and pressure levels.

Hydrogen Sensors

Since hydrogen can neither be seen nor smelled, as an added safety precaution for hydrogen-fueled vehicles, NREL researchers are developing a hydrogen leak detector. To detect hydrogen, a very thin sensor that reacts to hydrogen by changing colors is applied to the end of a fiber optic cable. The sensors can be placed throughout the vehicle to relay information on leak detection to a central control panel.

Industry Interaction

NREL scientists interact with researchers from other national laboratories and industry to exchange technical information and receive industry input on the direction of NREL's research program. This helps NREL understand industry's needs, and helps industry understand the technologies NREL is developing.

Benefits of Hydrogen

Hydrogen made from renewable energy resources is a virtually inexhaustible, environmentally benign energy source that could meet most of our future energy needs. It's more versatile and has more uses than electricity. These uses include providing energy for businesses, factories, electric utilities, homes, vehicles and airplanes. Hydrogen is also a domestically produced energy source that could help reduce our reliance on foreign oil.

Challenges

Researchers must overcome several obstacles if hydrogen is to become a major energy resource. Hydrogen is currently more expensive than traditional energy sources; the production efficiency (the amount of energy or feedstock used to produce hydrogen) must improve; and an infrastructure to efficiently transport and distribute hydrogen must be developed. NREL's research is directed towards resolving these issues.

Potential

The first widespread use of hydrogen as an energy source is likely to be in the transportation sector, where it will help reduce pollution. Internal combustion engines can be fueled with pure hydrogen, or hydrogen blended with natural gas. Vehicles can also be powered with hydrogen fuel cells, which are three times more efficient than a gasoline powered engine. Fuel cells can also supply heat and electricity for homes and buildings.

The overall goal of DOE's Hydrogen Program is to replace 2 to 4 quads of conventional energy with hydrogen by the year 2010, and replace 10 quads per year by 2030. A quad is the amount of energy consumed by 1 million households.