NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Hydrogen Technologies & Systems Center

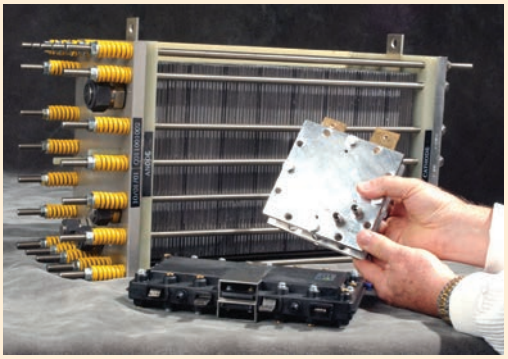
The National Renewable Energy Laboratory's Hydrogen Technologies and Systems Center is helping to facilitate the transition to a new energy future—a future built on diverse and abundant domestic renewable resources and integrated hydrogen systems.

The Hydrogen Technologies and Systems Center (HTSC) at the U.S. Department of Energy's (DOE) National Renewable Energy Laboratory (NREL) uses a systems engineering and integration approach to hydrogen research and development (R&D) to help the United States make the transition to a new energy future—a future built on diverse and abundant domestic renewable resources and integrated hydrogen systems. Research focuses on renewable hydrogen production, delivery, and storage; fuel cells and fuel cell manufacturing; technology validation; safety, codes, and standards; analysis; market transformation; and education.

Hydrogen can be used in fuel cells to power vehicles and to provide electricity and heat for homes and offices. This flexibility, combined with our increasing demand for energy, opens the door for hydrogen power systems. HTSC supports DOE and collaborates with other government agencies, industry, communities, universities, national laboratories, and other stakeholders to promote a clean and secure energy future.

Today, fuel cells are being developed to power passenger and specialty vehicles, transit buses, commercial buildings, homes, and even laptop computers. Fuel cell systems can provide 1 kW to hundreds of megawatts of power and can be extremely efficient. Some can achieve overall efficiencies of 80% or higher when heat production is combined with power generation. Fuel cell systems integrated with hydrogen production and storage can provide fuel for vehicles, energy for heating and cooling, and electricity to power our communities. These clean systems offer a unique opportunity for energy independence, highly reliable energy services, and economic benefits.

An understanding of the long-term benefits and near-term realities of hydrogen, fuel cell systems, and related infrastructure is an essential part of public and market acceptance.



A hydrogen fuel cell uses hydrogen and oxygen to generate electricity.

FAST FACTS

Fuel Cells

- Can use a variety of fuels to deliver clean, efficient, and reliable power for many applications.
- Reduce the environmental impact of transportation applications and energy generation.
- Cleanly and efficiently produce electricity.
- Emit only heat and water as byproducts when fueled by hydrogen.
- Provide continuous power as long as fuel is supplied.

Hydrogen Production, Delivery, and Storage

Researchers evaluate infrastructure-related barriers that might delay the widespread commercialization of hydrogen technologies. Multiple projects investigate a variety of pathways to sustainably produce hydrogen. They investigate ways to use chemical and biological means to produce hydrogen from renewable sources as well as hydrogen production from renewably generated electricity water electrolysis.

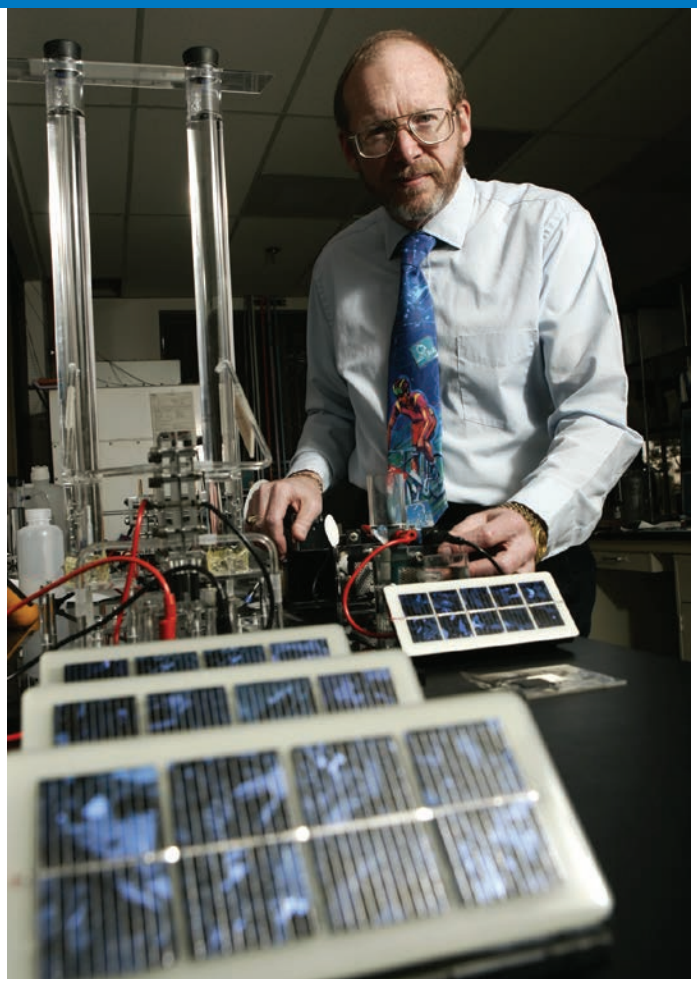
Fuel Cells and Fuel Cell Manufacturing

HTSC is improving fuel cell performance by developing extended surfaces for catalysts, enhancing catalyst support interactions, and using advanced supports based on tungsten oxide or heteropolyacids. Researchers are also investigating the effects of system contaminants on performance and durability. Manufacturing R&D focuses on developing quality control sensors for high-volume manufacturing of fuel cells.

Technology Validation

While examining the performance of fuel cell systems and the supporting hydrogen infrastructure, researchers focus on durability, efficiency, safety, and the value of fuel cells for passenger vehicles, transit buses, forklifts, hydrogen fueling stations, backup power, and primary power and combined heat and power systems.

HTSC supports DOE's Controlled Hydrogen Fleet and Infrastructure Demonstration Validation Project. This learning demonstration project is a consortium of automobile and fuel cell manufacturers and energy companies and evaluates field data from actual operating fuel cell electric vehicles and buses. Researchers also collect and analyze data on hydrogen production and dispensing systems.



Top image: Research fellow John Turner conducts hydrogen R&D in NREL's Hydrogen Laboratory.

Bottom image: This web line unit is used by NREL to evaluate quality control methods for fuel cell membrane manufacturing.

Fuel cells have the potential to replace the internal combustion engine in vehicles and provide power in stationary and portable power applications because they are energy efficient, clean, and fuel flexible.

Analysis

To provide direction, focus, and support for the development and introduction of fuel cells and other hydrogen technologies, researchers evaluate the technical, economic, environmental, and integration aspects of these systems and work to develop the information necessary to guide R&D. They work, in support of DOE program goals, to identify cost-effective pathways and develop analysis tools to help transform the fossil fuel market to a renewable energy market. Two notable examples of analysis tools are the H2A Production and the Fuel Cell Power Models. These can be used to assess the cost and performance of key pathways for hydrogen production by a variety of methods and power generation using fuel cells. Coordinating analysis work addressing hydrogen and fuel cell systems is essential to ensuring consistency and developing a stronger understanding of economically viable pathways to the hydrogen future.

Top image: This fuel cell electric vehicle runs on renewable hydrogen fuel produced at NREL's National Wind Technology Center.

Center image: Forklifts powered by hydrogen fuel cells are an early market application of this fuel cell technology.

Bottom image: This fuel cell power plant provides electricity for Verizon in Garden City, New York.

Market Transformation

Through market transformation efforts, NREL is accelerating the commercialization and the use of hydrogen and fuel cell systems. Activities focus on demonstrating and deploying hydrogen and fuel cell technologies in early market applications, improving the public/private process for transition to new technologies, tracking the progress of technology deployment, and increasing opportunities for market expansion. Fuel cells are entering the commercial market in a variety of applications, including transportation and stationary and portable power generation. The growing number of commercial products, along with available federal and state financial incentives, is instrumental in supporting fuel cells as a viable energy alternative.

Safety, Codes, and Standards

The safety, codes, and standards activity focuses on ensuring safe operation, handling, and use of hydrogen, fuel cells, and alternative fuels and systems through codes and standards development for buildings, components, systems, and vehicles. To support this development, researchers:

- Test components, systems, and sensors.
- Analyze fuel quality specifications data.
- Incorporate their technical knowledge into model codes and component and system standards.
- Coordinate DOE support for codes and standards development.
- Harmonize domestic and international codes and standards.

HTSC's Michael Ulsh demonstrates how solar energy can be used to create hydrogen.

FAST FACTS

Hydrogen

- The simplest element on Earth.
- Rarely found in its pure form, but is abundant in water, methane, and biomass.
- The lightest gas; it rises and disperses rapidly.
- Odorless, colorless, and nontoxic.
- When hydrogen burns in air, it does not produce smoke.
- 1 kilogram of hydrogen has the same energy content as 1 gallon (3.2 kilograms) of gasoline.
- Diverse domestic feedstocks can be used to produce hydrogen.

Education

To advance outreach and public education related to hydrogen, HTSC personnel on request visit local schools to educate students about hydrogen technologies and applications; provide information to stakeholders; and participate in community events. They also conduct and participate in workshops for code officials, policy makers, and other stakeholders. Web-based informational materials and a training course for code officials have been developed to provide easily accessible, accurate information to interested parties.

For More Information

HTSC directly supports the goals of the DOE Fuel Cell Technologies Program. To learn more, visit the NREL Hydrogen Web site at *www.nrel.gov/hydrogen/* and the EERE Fuel Cells Web site at *www.eere.energy.gov/hydrogenandfuelcells*. NREL also offers audit tools and capabilities to the U.S. Department of Defense (DOD) including assessments of energy efficiency, renewable energy, new construction, and net zero energy installations for military bases and campuses. DOE and DOD are partners in the Federal Energy Management Program (*www1.eere.energy.gov/femp/*).

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