



The Hydrogen Fuel Cell Power System, being tested in the Energy Systems Integration Lab in the ESIF before it is moved into the High Performance Computing Data Center. *Photo by Dennis Schroeder, NREL 48948.*

Hydrogen—An Alternative to Fossil Fuels for Stationary and Transportation Power

Hydrogen is an effective carrier for power production and energy storage. We are working to produce more hydrogen more rapidly and at lower costs, and developing high-performance fuel cells to convert hydrogen to power.

Hydrogen Research Offers Pathways to Renewable Power

Hydrogen is one of the most abundant elements in our environment, typically stored in compounds such as water, hydrocarbons, and organic matter. Researchers at the National Renewable Energy Laboratory (NREL) are developing and advancing several pathways to renewable and economic hydrogen production for use as an alternative fuel.

NREL researchers explore various options for efficient water splitting, a process in which an electric current separates the hydrogen and oxygen in water molecules. A popular water splitting method using electrolysis can be integrated with other renewable energy sources, such as wind turbines or photovoltaic arrays, to produce the electric current for a zero-carbon energy option. Although commercial electrolysis systems exist, NREL is working to optimize these systems using proton exchange membrane technology to offer higher power densities.

Hydrogen Production Initiatives

ARIES Platform

>1MW hydrogen production (electrolyzer) and fuel cell capability at its Flatirons Campus near Boulder.

BioH2 Consortium

This multi-lab consortium evaluates dark fermentation of biomass and integrated microbial electrolysis cell systems to improve hydrogen molar yield and reduce fermentation of waste products.

HydroGEN Advanced Water Splitting Materials Consortium

NREL serves as the lead national laboratory for this project, which focuses specifically on advanced water splitting pathways, including:

- photoelectrochemical
- solar thermochemical
- low-temperature electrolysis
- high-temperature electrolysis.

In addition to electrolysis, NREL is developing new methods to split water, such as photoelectrochemical methods and anion exchange membrane electrolysis. Several biological processes can also produce hydrogen using naturally occurring organisms. One method NREL scientists are using is fermentation to produce hydrogen from lignocellulosic biomass. Another method is catalytic reforming of biomass pyrolysis products, essentially converting waste to hydrogen.

From Hydrogen to Electricity

Hydrogen can provide power to a wide range of applications using fuel cells to create a flow of electricity. Researchers are evaluating a variety of fuel cell types—polymer electrolyte membrane and alkaline membrane—to improve their cost, performance, and durability.

NREL also performs extensive analysis to provide direction, insight, and support for emerging hydrogen technologies. Researchers at NREL have developed a suite of hydrogen tools to accelerate industry adoption of fuel cell electric vehicles.

New Avenues for Energy Storage

To evaluate hydrogen storage opportunities, NREL co-leads the Hydrogen Materials Advanced Research Consortium (HyMARC). This collaboration is developing solid-state hydrogen storage materials, hybrid materials systems, and carriers for energy storage. Large scale energy storage facilities using hydrogen can balance seasonal demand for renewable energy from wind and solar sources.

Partner with Us

The **Hydrogen Infrastructure Testing and Research Facility** within NREL is available to industry to research hydrogen storage, compression, and dispensing for fuel cell vehicle fueling and component testing.

In addition, the **National Fuel Cell Technology Evaluation Center** allows for an independent, third-party analysis of existing hydrogen fuel cell technologies.

We partner with:

- Federal agencies—U.S. Department of Energy and U.S. Department of Defense
- Vehicle manufacturers— General Motors, Ford, Daimler Toyota, Hyundai, Honda
- Transit agencies—AC Transit, SunLine, and CTTRANSIT
- Hydrogen suppliers—Air Products, Linde, Nel Hydrogen, Air Liquide, Chemours, Giner
- Fuel cell developers—Plug Power, Nuvera, General Motors, Ford, 3M
- Organizations—Fuel Cell and Hydrogen Energy Association, the California Fuel Cell Partnership, California Hydrogen Business Council, Colorado Hydrogen Network



Researchers working on a grid integration of electrolyzers project inspect an electrolyzer at the Energy Systems Integration Laboratory. Photo by Dennis Schroeder, NREL 40206.

A Few Hydrogen Tools

H2FAST: Hydrogen Financial Analysis Scenario Tool

Available as an interactive online tool or a downloadable Excel spreadsheet, this modeling tool provides a quick and convenient in-depth financial analysis for hydrogen fueling stations.

SERA: Scenario Evaluation and Regionalization Analysis Model

SERA provides insights that can guide infrastructure development and transportation investment decisions and accelerate the adoption of electric vehicles.

H2Fills: Hydrogen Filling Simulation

H2Fills helps safely design and operate a hydrogen fueling stations by tracking the transient change in hydrogen temperature, pressure, and mass flow when filling a fuel cell electric vehicle.

H2A: Hydrogen Analysis Production Model

H2A models provide transparent reporting of process design assumptions and cost analysis methodology for hydrogen production.

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