A national laboratory of the U.S. Department of Energy
Office of Energy Efficiency & Renewable Energy

NREL National Renewable Energy Laboratory

Innovation for Our Energy Future

Center for Electric & Hydrogen Technologies & Systems—Energy Systems Group
Hydrogen Technologies and Systems Team

Facilitating the Transition to a Hydrogen Economy

All energy resources, from fossil fuels to renewables, can be used to produce hydrogen. Hydrogen can be used in fuel cells, engines, and turbines to power our vehicles and provide electricity and heat for our homes and offices. This flexibility, combined with our nation's ever-increasing demand for energy, opens the door for hydrogen power systems and the associated societal benefits. But there are several key barriers to hydrogen becoming America's clean and secure energy option. Hydrogen technology must be flexible, affordable, safe, and available to all sectors of the economy and all regions of the country. And to truly be sustainable it must be produced from domestic renewable resources.

The Hydrogen Technologies and Systems Team is working to meet these challenges to facilitate the transition to a hydrogen economy.

Team Mission

The Hydrogen Technologies and Systems Team works toward the integration of hydrogen systems to ensure successful deployment of technologies and to deliver multiple products and services from renewable resources by developing advanced technologies and systems. The team partners with other programs at NREL, DOE and other government agencies, industry, communities, universities, and other national labs to implement the National Hydrogen Energy Vision for America's clean and secure energy future.

The team takes a systems engineering and integration approach to match hydrogen research and development (R&D) needs and opportunities with NREL's expertise in renewable hydrogen. The group provides strategic support to DOE's Hydrogen, Fuel Cells & Infrastructure Technologies Program to coordinate research priorities across multiple NREL research centers, and advise DOE on innovation pathways.

Research in Hydrogen Production and Utilization

Hydrogen from Renewable Resources — Currently, grid stability and intermittency issues are major limitations to significant penetration of renewables like wind and solar into the electricity market. By combining these generation technologies with hydrogen production and storage, intermittent renewables could potentially capture a larger share of the power-production market without major upgrades to the existing grid. The hydrogen produced using renewables can also help expand electricity applications for hydrogen as a transportation fuel.

Photoelectrochemical Water Splitting — This is a one-step process for producing hydrogen using solar irradiation of semiconductor devices. Team researchers test new materials and structures that have the proper characteristics to collect the required energy and are stable in the reaction environment. The Hydrogen Technologies and Systems Team holds the world record for efficiency in direct water splitting.

Photoelectrochemical water splitting: Using a photovoltaic cell/electrolyzer submerged in an alkaline aqueous solution to produce hydrogen.
(Photographer: Richard Peterson)

Advanced Fuel Cell R&D — Manufacturing challenges are one of the major obstacles to the implementation of fuel cell technology. Component material properties, manufacturability, and overall fuel cell operation are thus key research areas. Currently, research is conducted to understand and control the corrosion mechanisms in bipolar plates and to evaluate new materials for use in a solid electrolyte system that can operate in an intermediate temperature range. The team is also working with other technology centers at NREL to integrate fuel cell systems with renewable energy conversion technologies and advanced thermally activated building technologies.

Systems Engineering and Analysis

Process and Systems Analysis — Process analysis provides direction, focus, and support to the development and commercialization of hydrogen technologies.

- Technoeconomic analyses (TEA) are performed to determine the potential economic viability of a specific process, to direct research toward areas in which improvements will result in the largest cost reductions, and to design and optimize integrated systems.
- Analytical models have also been developed to determine the most economical hydrogen delivery option for a given scenario, and geographical information systems mapping of energy resources is used to identify opportunities for hydrogen production throughout the United States.

Life cycle assessments are performed to identify and evaluate the environmental impacts associated with a specific process. In these assessments, emissions, resource depletion, and energy consumption of all steps in the process are quantified, from the initial extraction of raw materials, through transportation and production, to the final disposal of products and by-products.

Hydrogen Analysis Working Group (H2A) — Coordination of analysis work being conducted on hydrogen and fuel cell systems is essential to ensure consistent analysis methodologies and a stronger understanding of the pathways to the hydrogen future. The Hydrogen Technologies and Systems Team is working with DOE to enable this collaboration between analysis experts through the H2A.

Hybrid power plants can use renewable energy to produce and store hydrogen on site. The hydrogen can then be used for transportation or by fuel cells to generate electricity when the wind isn't blowing. Such systems overcome the intermittency of solar and wind resources.

Technology Validation

To realize a future hydrogen economy, fuel cell vehicles and a new hydrogen-based production, storage, and delivery infrastructure must be developed and demonstrated in optimized system solutions. The Hydrogen Technologies and Systems Team is working to integrate innovative R&D programs with creative deployment projects. The team is supporting DOE's Controlled Hydrogen Fleet and Infrastructure Demonstration Validation Project. This learning demonstration project is a collaboration of auto and fuel cell manufacturers and energy companies focused on developing fuel cell vehicles and the requisite hydrogen infrastructure simultaneously. Testing R&D advances in real-world operating conditions can help remove barriers to commercialization and identify future research needs.

Safety, Codes, and Standards

The development and acceptance of codes and standards are essential if hydrogen is to become a significant energy carrier and fuel. This step is critical to establishing a market-receptive environment for commercializing hydrogen-based products and systems. The team coordinates standards development organizations, code developers, and regulatory agencies under a national program sponsored by DOE.

Partnerships and Collaboration

Education — Understanding the long-term benefits and near-term realities of hydrogen, fuel cell systems, and related infrastructure are essential to transition to a hydrogen economy. The team draws on NREL capabilities to provide information to target audiences about fuel cell and hydrogen systems in order to facilitate commercialization and market acceptance.

International Collaboration — Because all countries possess some form of sustainable primary energy sources, hydrogen energy technologies offer an important potential alternative to fossil-fuel energy supplies — in many instances, to imported fuels. The Hydrogen Technologies and Systems Team works with experts from around the world to address many of the technical challenges and long-term research needs that face the hydrogen community under the auspices of the International Partnership for the Hydrogen Economy, International Energy Agency, International Gas Union, and related forums.

For More Information

The work of the Hydrogen Technologies and Systems Team directly supports the goals of the Department of Energy's Hydrogen, Fuel Cells & Infrastructure Technologies Program R&D activities. To learn more about this work, visit http://www.eere.energy.gov/hydrogenandfuelcells.

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