# NREL: Transforming Energy Through Innovation

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## 1. Introduction

At the United State Department of Energy's (DOE) National Renewable Energy Laboratory, advanced scientific research drives innovation. NREL's mission is to advance the science and engineering of energy efficiency, sustainable transportation, and renewable power technologies and provide the knowledge to integrate and optimize energy systems. Our approximately 2900 researchers and staff are transforming energy by developing cutting-edge renewable power, sustainable transportation, energy efficiency, and energy systems integration technologies.

## 2. R&D activities related to clean energy technology

Three critical objectives—Integrated Energy Pathways, Electrons to Molecules, and Circular Economy for Energy Materials—drive most of NREL's research. Our Integrated Energy Pathways research is developing foundational knowledge and technologies to optimize the integration of renewables, buildings, energy storage, and transportation, modernizing our energy systems, and ensuring a secure and resilient grid. The Electrons to Molecules research underway at NREL is focused on the conversion of electricity and small waste gasses (e.g., CO2, H2O, N2) into chemical bonds for the purposes of chemical, material, or fuel synthesis and/or energy storage. NREL scientists engaged in Circular Economy for Energy Materials research are establishing the foundational knowledge/technology for design, recycle, reuse, remanufacture, and reliability for energy-relevant materials and processes.

## 3. Specific research activities in next generation energy management systems with batteries, renewable energy, hydrogen, CCUS, and related technologies

At NREL's state-of-the-art Energy Systems Integration Facility, areas of energy management research underway include:

- Renewable electricity to grid integration
- Vehicle-to-grid integration
- Renewable fuels-to-grid integration
- Energy-water nexus
- High-performance computing, analytics, and visualization
- Large-scale numerical simulation
- Cybersecurity and resilience
- Smart home and building systems
- Microgrids
- Battery and thermal energy storage

For example, because scientists and engineers at NREL recognize that the way the world uses electricity is changing, our energy management systems research focuses on developing future energy systems that will be fully integrated and more complex, distributed, and interdependent.

In addition, NREL researchers are working to design energy management systems that are efficient, resilient, and affordable.

NREL researchers also understand that power electronics-based technologies will be deployed in the future more than ever for the management of energy grids. For this reason, NREL engineers are conducting autonomous energy systems research on utilizing power electronics for electricity generation and storage and for building load management and mobility.

Three key goals drive most of NREL's energy storage research: higher energy density, longer life, and enabling greater adoption. Our energy storage research includes basic and applied research, lifetime and deployment models, grid integration, systems design, and contract research with partners in industry.

Advanced scientific research in renewable power is the lifeblood of NREL. For example, due largely to the leadership of NREL, the U.S. solar industry is growing rapidly, and solar energy is becoming more affordable and accessible than ever. Areas of solar research at NREL include: photovoltaics, concentrating solar power, grid integration, and market analysis. Together, these areas will enable reliable, low-cost solar energy at scale—on the grid and beyond the grid.

The NREL Flatirons Campus is home to some of the largest wind turbines in the world (3 MW). Wind energy research at NREL is enabling low-cost and grid-supporting wind energy by joining forces with DOE, industry, and interagency and state partners to advance scientific knowledge and technological innovation.

NREL has a broad portfolio of hydrogen production, storage, delivery, and utilization research. Our scientists and engineers actively conduct research that contributes to the DOE H2@Scale Initiative. This research advances affordable hydrogen production, transport, storage, and utilization to increase opportunities in multiple energy sectors—including and beyond transportation.

NREL has decades of experience in polymer electrolyte membrane (PEM) fuel cell science and technology including electrocatalysis, membranes, durability, and stack testing. Researchers at NREL are now applying these capabilities to the electrolytic production of hydrogen from water splitting.

As previously mentioned, NREL's Electrons to Molecules research is developing innovative science and technology for using electricity and electrochemical processes to convert low-energy molecules—such as water, carbon dioxide (CO2), and nitrogen (N2)—to higher-value molecules. These molecules can be used as fuels, chemicals, material products, or as chemical energy storage carriers.

**4. International collaboration**

Currently, NREL is engaged in 80 international collaborations in more than 66 countries and has over 900 active partnerships with industry, academia, and government.

- International joint research with institutes taking part in RD20.
- International joint research with any countries.

## 5. Future perspectives

Looking to the future, NREL recently launched Advanced Research in Integrated Energy Systems (ARIES), a unique research platform designed to provide insights into the design and operation of future energy systems. ARIES will address fundamental challenges of variability in the physical size of new energy technologies being added to energy systems, the control of tens of millions of interconnected devices, and the integration of multiple diverse technologies that have not previously worked together.