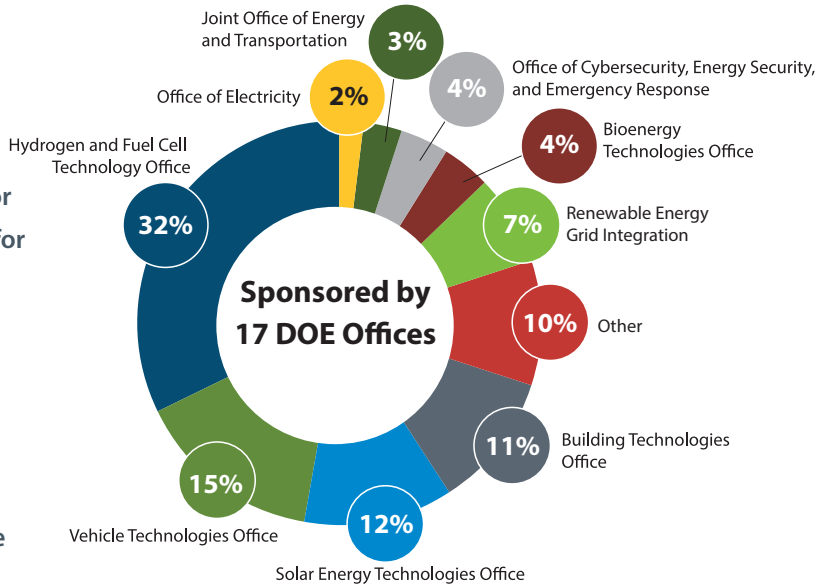
Photo by Gregory Cooper, NREL 96069

Energy Systems Integration Facility Stewardship Summary: Fiscal Year 2024

In 2024, the National Renewable Energy Laboratory's (NREL's) Energy Systems Integration Facility (ESIF) and NREL's larger research platform for Advanced Research on Integrated Energy Systems (ARIES) delivered timely research and innovation. We expanded our capabilities for energy security and resilience as we built a new test bed for power electronics and completed a 1-megawatt platform for validating standards for grid-forming inverters. Researchers collaborated with utilities, manufacturers, and communities on grid modernization solutions, such as a control architecture that heralds a new direction for distributed energy management systems. With support from the U.S Department of Energy (DOE), the work in the ESIF laboratories continues to advance national goals for resilient and affordable energy.



Facility Performance Metrics

170 multidisciplinary research projects

706 high-performance computer users

85 partners from industry, academia, research, and federal agencies

Partnerships and Engagement

As a DOE user facility, the ESIF offers a unique space for collaboration. Here are a few examples from 2024:

The Critical Energy Cybersecurity Accelerator focused on emerging technologies that monitor energy systems for cyber threats.

Best practices and standards for inverter integration can now be validated on ESIF's 1-MW platform developed with the Universal Interoperability for Grid-Forming Inverters (UNIFI) Consortium.

NREL was appointed to lead a Roll-to-Roll Consortium to advance manufacturing techniques for fuel cells and electrolyzers.

Four utility companies were selected from competitive proposals to use the Advanced Distribution Management System Test Bed to address the challenges of managing distribution power systems.

Infrastructure Upgrades

NREL is constantly modernizing and scaling the ESIF's state-of-the-art capabilities to address the complexities of integrated energy systems and validate emerging technologies. These are a few upgrades completed in Fiscal Year 2024:

With five times the computing power of the previous system, NREL's new supercomputer, Kestrel, can make 44 million-billion calculations per second.

The Energy Security and Resilience Laboratory opened, providing a space to virtualize, emulate, and visualize energy systems under disruption scenarios and threats.

A commercial distributed energy management system was connected to the ESIF's assets.

NREL developed a test bed for medium-voltage power electronics to help grid operators make the most of higher voltages and power coming from renewables.

Environmental chambers allow researchers to test electric vehicles and heat pumps under nearly any condition.

Computer-generated visualizations display transmission and distribution infrastructure and potential grid effects over the same geospatial map.

ESIF-Powered Inventions: Among the patents earned by researchers in 2024 is a technology for photovoltaic windows, materials for stabilizing semiconductors, an improvement for heating buildings efficiently, and an unconventional method of making a perovskite that addresses a problem with the efficiency of solar cells.

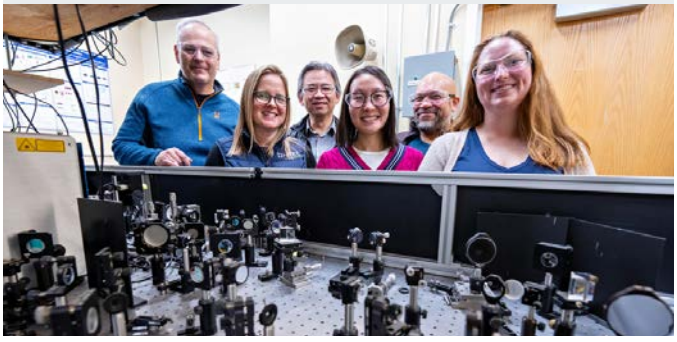


Photo by Werner Slocum, NREL 83897

Visit the ESIF Stewardship Summary webpage for more stories on the facility's capabilities and research.

Facility R&D Impact

These R&D achievements from FY 2024 were powered by the ESIF's laboratories, capabilities, and expertise.

Experiments Reveal the Effect of Iridium on Electrolyzer Performance

Researchers analyzed iridium degradation in PEM electrolyzers using long-duration cell testing and microscopy, enhancing cost-effective clean hydrogen production.

Sponsor: DOE Hydrogen and Fuel Cell Technologies Office

Feeder-Level Controls Can Simplify Utility Operations and Reserve Power for Emergencies

A hardware controller for decentralized systems coordinates grid-forming solar PV inverters to be a source of resilience.

Sponsor: DOE Solar Energy Technologies Office

NREL and Southern Company Show Advantages of New Control Architecture

A demonstration with Southern Company will validate a scalable solution for managing uncertain supply and demand and aggregating distributed resources.

Sponsors: DOE Grid Modernization Laboratory Consortium and DOE Building Technologies Office

Prize Winners Optimize Affordable Building Electrification Technologies

Two teams competing for a DOE prize validated their quick-to-install and equitable building retrofits at the ESIF with researchers who specialize in home energy efficiency.

Sponsor: DOE Building Technologies Office

Cyber Experts Unite to Defend Energy Infrastructure

NREL researchers modeled power networks in the ARIES Cyber Range and tested them against cyberattacks to share insights with DOE's Energy Threat Analysis Center.

Sponsor: DOE Office of Cybersecurity, Energy Security, and Emergency Response

Scientists Convert Carbon Dioxide to Valuable Industrial Chemical, Formic Acid

Researchers produced formic acid from CO_2 with high energy efficiency and low cost while using renewable electricity.

Sponsor: DOE Bioenergy Technologies Office

NREL Transforming ENERGY

National Renewable Energy Laboratory
15013 Denver West Parkway, Golden, CO 80401
303-275-3000 • www.nrel.gov

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