



We evaluate technologies that are making homes and buildings smarter

The newest generation of connected appliances, home energy management systems (HEMS), photovoltaic inverters, and energy storage solutions offers enormous potential for energy optimization and smart control.

To help advance these systems and enable effective integration with the electric grid, the National Renewable Energy Laboratory (NREL) has developed a controllable, flexible, and fully integrated lab space dedicated to residential smart energy technologies research.

The Systems Performance Laboratory in NREL's Energy Systems Integration Facility (ESIF) is a one-of-a-kind RD&D space that connects appliances, a home, or even a community to an end-to-end energy ecosystem. By incorporating power generation, energy storage, and end loads into the Systems Performance Lab, researchers can simulate real-world conditions in a controlled laboratory environment.

This means that an appliance manufacturer can validate not only the features of its new smart washing machine, but also how it performs in a brownout scenario or in a neighborhood with high concentrations of rooftop solar power. An HVAC company can replicate typical environmental conditions in Phoenix or Boston to evaluate a new grid-connected communications system. And a plug-in electric vehicle (PEV) maker can measure how battery charging interacts with a home's components—and with the electric grid.

Research at the ESIF's Systems Performance Lab gives manufacturers, utilities, and service providers a more complete picture of a device or system, leading to improvements in efficiency, safety, and design.

What we can do

The Systems Performance Lab lends itself to endless configurations and can adapt to the needs of even the most complex projects. Here are just a few of the things the Systems Performance Lab can do:

- Explore how intelligent building systems and the dynamic grid of the future can work together.
- Validate the features, effectiveness, and energy savings of HEMS, nonintrusive load-monitoring systems, advanced sensors, and smart appliances.
- Isolate and evaluate any portion of a home's energy ecosystem, including end loads, transformers, thermal and electrical energy storage, and photovoltaic inverters.
- Explore different communication protocols, functionality, interoperability, and cybersecurity questions related to Internet of Things technologies prior to deployment in the field.



The Systems Performance Lab contains the infrastructure for three homes, including major appliances, air conditioning, lighting, plug loads, electric vehicle charging stations, and residential photovoltaic systems.

Illustration by Josh Bauer, NREL

ENERGY SYSTEMS INTEGRATION



ESI optimizes the design and performance of electrical, thermal, fuel, and water pathways at all scales.



See what's happening in the Systems Performance Lab at https://youtu.be/Hzf_zsCyFvw.



The Systems Performance Lab gives PEV manufacturers greater insight into how battery charging interacts with homes and with the electric grid. *NREL 32483*

- Evaluate how a device or system performs under varying energy supply situations such as grid fluctuations or high concentrations of renewable energy.
- Interactively tie products and supercomputer simulations together using hardware-in-the-loop technology.
- Optimize controls for backup power and energy storage solutions—including batteries, generators, and fuel cells—to improve a home's resiliency.
- Evaluate advanced algorithms for energy savings and new techniques for fault detection and diagnostics for buildings and systems.
- Characterize individual loads with highly granular power consumption measurements on every circuit.
- Analyze an individual home with simulated occupancy or tie three homes together to evaluate them as a neighborhood.
- Connect experiments across the ESIF via AC and DC electrical or thermal distribution buses.

Partner with us

We believe that with the right tools and the right team, great things can happen. The ESIF offers utilities, industry, manufacturers, universities, and other government laboratories access to an award-winning, state-of-the-art lab space and a team of specialized scientists and engineers to help move new technologies forward. Bring us your biggest energy system challenges, and let's solve them together.

Contact the ESIF User Program at 303-275-3027 or userprogram.esif@nrel.gov to discuss opportunities.

Learn more about the ESIF and see a list of current partners at <http://www.nrel.gov/esi/partnerships.html>.

For complete details on the ESIF's capabilities, tools, research focus areas, and user facility opportunities, please visit www.nrel.gov/esi.

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Researchers are able to characterize individual loads with highly granular power consumption measurements on every circuit. *NREL 32480*