Control Center facility and IESS Research Facility

Expanding NREL's Advanced Research on Integrated Energy Systems (ARIES) Capabilities

NREL's Integrated Energy Pathways vision represents a transformed, future integrated energy system that is more affordable, clean, secure, and resilient than today. Key to this vision is the unique Advanced Research on Integrated Energy Systems (ARIES) research platform. With a focus on advancing modern grid infrastructure, making investments in energy efficiency building technology research, and innovating battery storage and much more, the unique ARIES research platform can be used to accelerate the integration of new technologies into a modern grid.

Our national electrical grid infrastructure has evolved from large centralized power generation and control to a hybrid system that incorporates a variety of distributed resources near the load. Trends such as new energy storage, building smart loads, and electrification of transportation and industrial sectors also necessitate greater integration. The power grid is also becoming increasingly interdependent with other infrastructures like natural gas, transportation, water, and telecommunications. We must address three fundamental challenges of integrated energy systems at scale:

- Variability in the physical size of new energy technologies
- Securely controlling large numbers (millions to tens of millions) of interconnected devices
- Integrating multiple diverse technologies that have not previously worked together.

All three of these challenges introduce complexity and variability on an energy system that is not able to flex and adapt sufficiently. A transformation is required for the future energy system.

The Opportunity

Addressing changes to the energy system requires an investment in a new national capability—an ability to conduct integrated research at the interface between distribution and bulk power systems, complemented with the development of new technologies and control techniques, advanced sensing and data analytics, and more sophisticated models and validation techniques. There is currently no research platform anywhere in the world that incorporates analysis, modeling, and hardware that can support research at the scale and versatility necessary. This lack of scale in experimentation severely limits the ability to integrate new technologies into either distribution or bulk power systems.

NREL's Advanced Research on Integrated Energy Systems (ARIES) initiative is an environment to address the integrated energy systems at-scale challenges in the areas of energy storage, power electronics, hybrid energy systems, future energy infrastructure, and cybersecurity—five research areas of critical importance for the future transformed energy system.

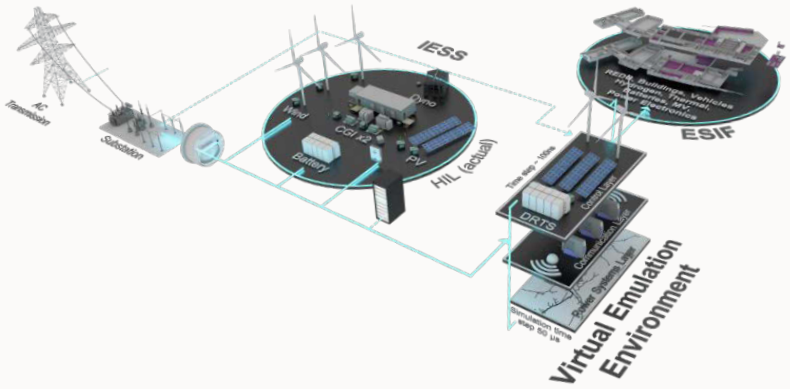
Unique NREL Capabilities

Because the electric grid is the central enabler for most real-world integrated energy systems, ARIES is built around an integrated electric grid research environment. Infrastructure required for the ARIES capability also supports NREL's vision for a Circular Economy for Energy Materials and for Electrons to Molecules. For instance, low-cost renewable electricity can be used to produce hydrogen and provide the energy source to convert waste CO_2 streams, end-of-life materials, and bio-based carbon resources to new low-carbon chemicals, materials, and fuels.

ARIES leverages existing capabilities at the Energy Systems Integration Facility (ESIF) and the Integrated Energy Systems at Scale (IESS) capabilities at NREL's Flatirons Campus and furthers these capabilities with a virtual emulation environment that uses advanced computing and digital real-time simulators (DRTS). This allows hardware-in-the-loop (HIL) control and integration of any combination of hardware components, including hybrid systems.

Research at ESIF goes up to 2 MW, which covers customer-level and distribution-size experiments while IESS allows for research at the 20-MW scale and beyond. This level represents the interface between the distribution and bulk power levels. The virtual emulation allows for even larger scale. Using a state-of- the-art, high-speed network as its backbone, this new capability will create solutions that optimize the integration of renewables, buildings, energy storage, and transportation. Control algorithms for various power electronics can be analyzed virtually by launching real-world cyberattacks.

ARIES is able to connect with multiple types of generation, storage, conversion devices, or a hybrid combination of technologies. The platform was specifically designed to answer the most important challenges that face the Department of Energy and industry. ARIES is a research space that unites capabilities across technology areas and explores operations on realistic, integrated systems. Only through evaluations and understanding of the interdependencies among these areas is it possible to fully optimize integrated energy systems and de-risk future technologies and infrastructure.



Layout of ARIES interconnecting the ESIF, IESS, and the Virtual Emulation Environment

Required Infrastructure

Fundamentally, the ARIES research mission is multi-technology, multi-disciplinary, highly complex, and has extremely high requirements for equipment interconnectivity/flexibility and data handling. To fully succeed in the ARIES mission, cutting-edge research equipment, facilities, and site research infrastructure are needed.

Although ongoing investments provide much of the required research hardware, there is significant need for the following facilities and site infrastructure:

- IESS Research Facility
- Automation and Optimization Research Facility
- Multimodal Research Network.

IESS Research Facility

NREL's new Integrated Energy Systems at Scale Research Facility will provide laboratory, research, assembly, and office space for NREL researchers, managers, support personnel and external research partners. It also provides sufficient space for meetings, group collaboration, data analysis, pre-experiment staging and preparation, and post-mortem evaluation of components and hardware.

The proposed IESS Research Facility will surround the already planned Control Center Facility and provide the laboratory, office, and meeting space to make the combined facilities the central nervous system for research at the Flatirons Campus. The IESS Research Facility is critical to enabling the multi-office, multi-technology research that is at the core of ARIES. The 133,000-square-foot structure will be a four-story building with space for research, engineering, analysis, education, and conferencing, as well as management and administrative support.

Automation and Optimization Research Facility

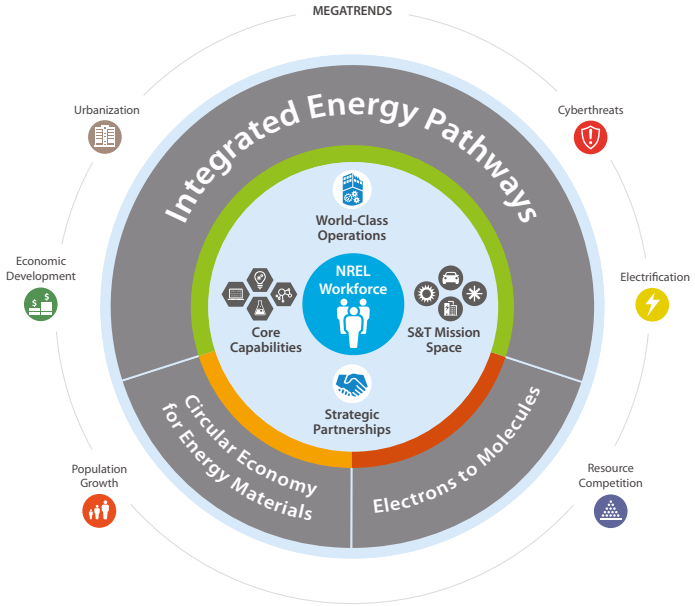
The existing NREL Composites Manufacturing Education and Technology (CoMET) building is not long or high enough to accommodate offshore wind blades and the latest marine and hydrokinetic devices. Current capabilities are limited to 13 meters while length up to 130 meters is needed. The required 30- and 40-foot high bays exceed existing and proposed IESS Research Facility capacities.

The large-scale research and prototyping facility enables research and full-scale prototyping needed to accelerate industry adoption of cutting-edge material systems and manufacturing processes. This proposed facility also enables innovation in automation, robotics, and process optimization for large-scale composite manufacturing. Workforce development, helping to establish the next generation of U.S. workers in the composite industry, would also be a key focus.

Multimodal Research Network

Power and water utilities, telecommunications, and full digital interconnectivity are critical to successful and safe ARIES activities across the Flatirons Campus. ARIES site research infrastructure needs include various power requirements (load banks, transformers, various distribution feeders), data acquisition and handling systems, communications trunks, water lines, waste systems, and safety systems. ARIES outside field research and laboratories will need total digital communications for controlling and monitoring individual and system-level experiments. This system-level interconnectivity is critical to the unique controllable grid interface and DRTS assets in the ARIES virtual emulation environment.

Contact NREL Associate Laboratory Director Johney Green at johney.green@nrel.gov to learn more.



NREL's 10-Year Plan: A Vision for the Future

NREL Transforming ENERGY

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