

2023

## Message From External Advisory Board Member

“As a member of the external advisory board for ARIES for the last two years, I’ve been able to see this remarkable research platform evolve from concept to research and deployment. ARIES allows NREL, its stakeholders, industry, and communities the chance to begin to fully understand what an equitable energy transition looks like. With this year’s launch of the U.S. Department of Energy’s Clean Energy to Communities (C2C) program, ARIES is helping to serve communities that are making the transition to renewable energy. Teams of researchers are understanding the impact to these communities as well, helping them to answer some of their most pressing challenges, such as how can we do this equitably, without negatively impacting energy costs for families. The ARIES platform will help us achieve our clean and equitable energy goals that we’ve set as a nation.”

**Paula Glover**, President, Alliance to Save Energy



## Message From U.S. Department of Energy Steering Committee Member

“At a time when our world needs the best and brightest minds working together to create an integrated grid, NREL’s ARIES research platform brings together the national lab complex to help DOE accelerate the implementation of clean energy technologies with our fellow partners from government, industry, and communities. By validating a broad range of future energy systems and grid scenarios, ARIES helps meet our country’s 2035 and 2050 decarbonization goals.

With the investments and growth of the research capabilities at NREL this past year, and increased collaboration across the national lab complex, the ARIES team has greatly expanded the platform’s impact. I’m proud to be a part of this exciting team fostering clean energy progress at NREL and across our national labs and looking forward to seeing the successes next year brings.”

**Alejandro Moreno**, Associate Principal Deputy Assistant Secretary for the Office of Energy Efficiency and Renewable Energy at the U.S. Department of Energy



MESSAGE FROM EXTERNAL ADVISORY BOARD MEMBER.....	2
MESSAGE FROM U.S. DEPARTMENT OF ENERGY STEERING COMMITTEE MEMBER.....	2
ARIES VISION.....	4
ARIES FRAMEWORK.....	5
2023 NUMBERS AT A GLANCE.....	6
RESEARCH IMPACTS.....	8
<b>INTEGRATED ENERGY SYSTEMS FOR REAL-WORLD SCENARIOS</b> .....	8
FAIRBANKS, ALASKA, TARGETS TRANSITION AWAY FROM COAL WITH HELP FROM AWARD-WINNING ARIES RESEARCH...8	
ARIES PROVES HOW HYBRID POWER PLANTS CAN OPERATE IN ENERGY MARKETS.....	9
ARIES DIGITAL TWIN LEADS TO RESILIENT MICROGRID DEPLOYMENT IN ALASKA.....	9
<b>SOLUTIONS FOR GRID STABILITY</b> .....	10
UNIFI CONSORTIUM ADVANCES INVERTER TECHNOLOGIES TO SUPPORT 100% RENEWABLE ENERGY.....	10
UTILITIES IMPLEMENT CLEAN ENERGY TECHNOLOGIES USING EXPANDED ADVANCED DISTRIBUTION MANAGEMENT SYSTEM RESEARCH PLATFORM.....	10
DANGEROUS ELECTRICAL OSCILLATIONS ARE IDENTIFIED AND AVOIDED WITH ARIES SCAN TOOL.....	10
ARIES-SCALE DEMONSTRATION SHOWS GOVERNMENT OFFICES WHAT’S AT STAKE IN CYBERSECURITY.....	11
DISRUPTIVE SOLID-STATE CONVERTER TECHNOLOGIES PROTOTYPED WITH ARIES.....	11
<b>TRANSFORMATION WITH FUTURE ENERGY INFRASTRUCTURE</b> .....	12
NATION-SPANNING DATA NETWORK LEVERAGES ARIES FOR REMOTE AND REAL-TIME SUPERLAB.....	12
ELECTRIC VEHICLE GROWTH CHARGES AHEAD WITH ARIES INFRASTRUCTURE.....	12
ARIES PROVIDES DIGITAL TWIN EMULATION FOR CYBER DEFENSE OF BUILDINGS.....	13
<b>LAB CAPABILITIES AND BUILDOUTS</b> .....	14
ARIES CONNECTS DISTANT U.S. DEPARTMENT OF ENERGY CAPABILITIES USING ESNET FOR CONTINENT-SPANNING RESEARCH.....	14
NEW TECHNOLOGIES IN THE POWER ELECTRONICS GRID INTERFACE HELP PARTNERS DESIGN STABLE POWER SYSTEMS.....	15
FLATIRONS CAMPUS BUILDOUT ADDS NEW STRENGTHS IN HYDROGEN AND LARGE-SYSTEM EMULATION.....	15
CYBERSECURITY BECOMES ONE OF ARIES’ FULLY INTEGRATED CAPABILITIES.....	15
ARIES ADDS INTERFACE WITH QUANTUM COMPUTERS.....	16
SUPERCOMPUTER KESTREL TAKES FLIGHT WITH SUBSTANTIAL INCREASE IN COMPUTING POWER.....	16
<b>ENGAGEMENT AND OUTREACH</b> .....	18
<b>LOOKING AHEAD</b> .....	20
<b>ADVISORY COMMITTEES</b> .....	21
ARIES EXTERNAL ADVISORY BOARD.....	21
ARIES STEERING COMMITTEE.....	22

# ARIES VISION

The Advanced Research on Integrated Energy Systems (ARIES) vision is to validate a broad range of future energy systems and loads for various grid and industrial decarbonization scenarios, helping stakeholders accelerate the implementation of energy technologies needed to meet the U.S. goal of a carbon pollution-free power sector by 2035 and a net-zero emissions economy by 2050.

## Addressing an Urgent National Need

ARIES accelerates the ability to research and validate innovative solutions for large-scale integrated renewable generation, storage, and increasing demand-side loads—essential technologies to realize our national energy goals.

## Developing an At-Scale Research Platform

ARIES is DOE's advanced research platform for energy systems integration research, validation, and demonstration at a scale that reflects the challenges faced by industry.

## De-Risking Energy Systems

ARIES can replicate real-world scenarios of broad clean energy deployment, allowing users to safely demonstrate their best pathways to reaching local and national decarbonization goals.

## Distinguishing National Asset

ARIES crosses multiple energy sectors, scales, and technologies. It joins together physical and virtual energy assets and enables national labs to combine their expertise and capabilities to address complex energy systems integration challenges.

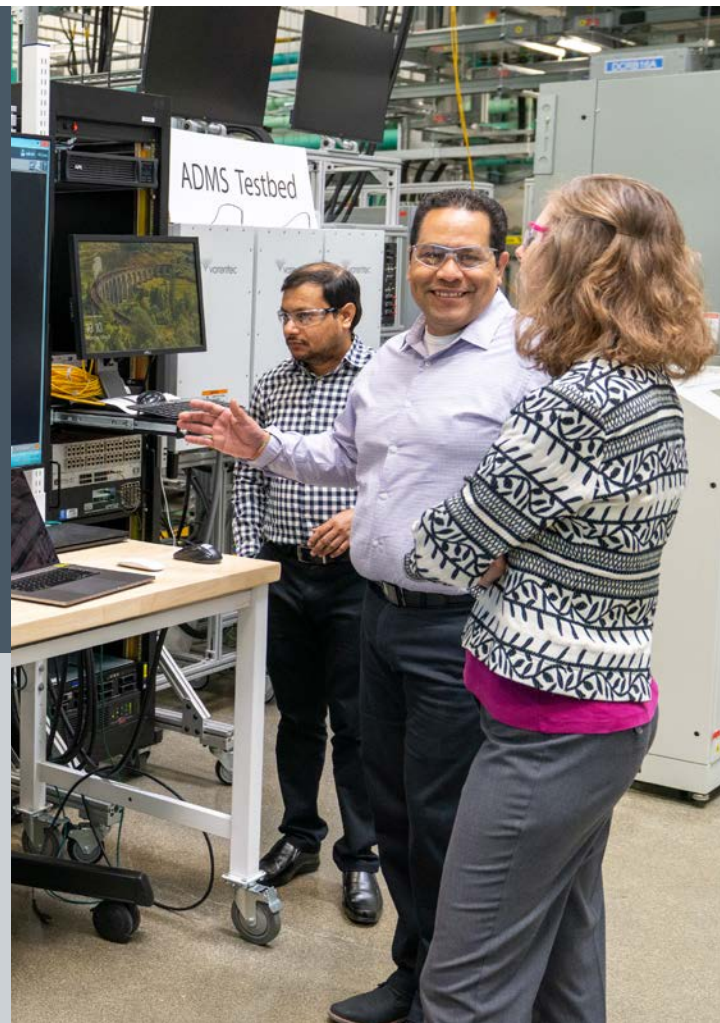
# ARIES FRAMEWORK

Systems-level challenges drive the need for a research platform that could support integrated research, development, and demonstration at scale. ARIES focuses on solving three key challenges by addressing them through our strategic research areas: energy storage, future energy infrastructure, power electronics, cybersecurity, hybrid energy systems, and an emerging research area for Fiscal Year 2024, industrial decarbonization.



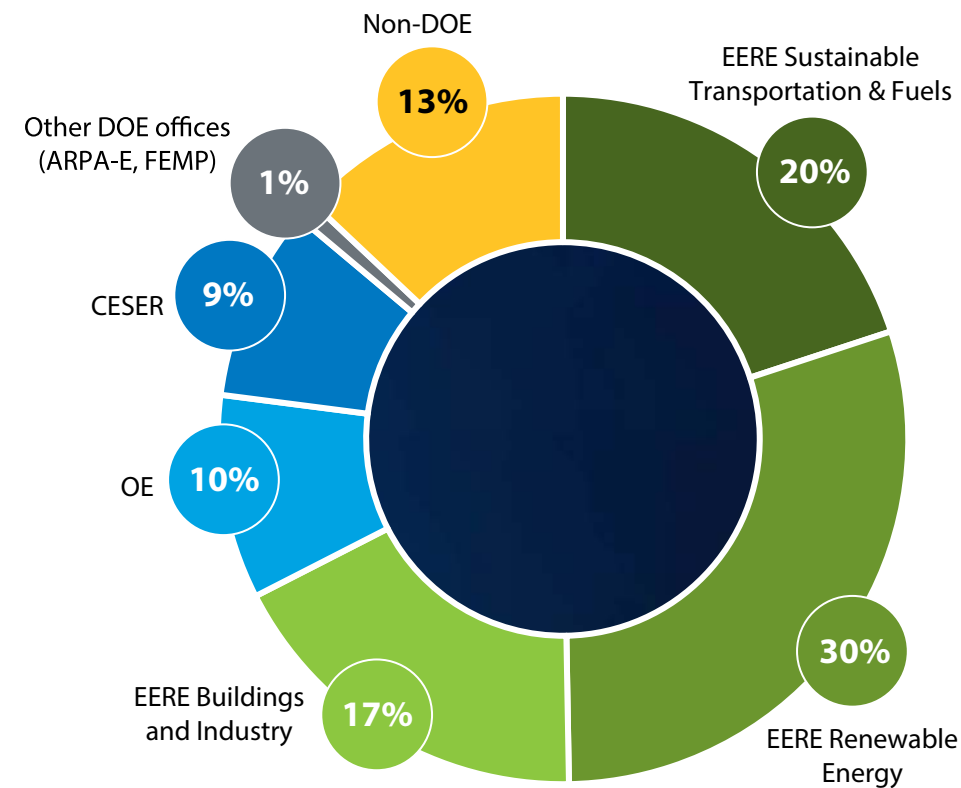
# 2023 NUMBERS AT A GLANCE

**158** multidisciplinary research projects  
**\$40.4 million** in FY 2023-funded research  
**14** DOE offices engaged from EERE, OE, CESER, FEMP, and ARPA-E  
**30** non-DOE partners. Key partners include government agencies and organizations at the federal, state, and local levels; utilities; industry and commercial organizations; and nonprofit and academia.



Learn more about the NREL facilities that make ARIES research possible:

- [Advanced Computing](#)
- [Energy Systems Integration Facility Stewardship Summary](#)



This chart represents the funding percentages from DOE offices and partners.

## ASSET TECHNOLOGY ICON LEGEND:

Look for these icons throughout the next section:

### Technologies

- Buildings
- Hydrogen
- Grid
- Hydro
- Microgrid
- Wind
- Solar
- Vehicles

### Research Areas

- Hybrid Energy Systems
- Energy Storage
- Cybersecurity
- Future Energy Infrastructure
- Power Electronics
- Industrial Decarbonization (coming FY 2024)

## List of Acronyms

- AMMTO** Advanced Materials and Manufacturing Technologies Office
- ARPA-E** Advanced Research Projects Agency-Energy
- BTO** Building Technologies Office
- CESER** Office of Cybersecurity, Energy Security, and Emergency Response
- DOE** U.S. Department of Energy
- EERE** Office of Energy Efficiency and Renewable Energy
- FECM** Office of Fossil Energy and Carbon Management
- FEMP** Federal Energy Management Program
- GMI** Grid Modernization Initiative
- GMLC** Grid Modernization Laboratory Consortium
- HFTO** Hydrogen and Fuel Cell Technologies Office
- NE** Office of Nuclear Energy
- NREL** National Renewable Energy Laboratory
- OE** Office of Electricity
- OTT** Office of Technology Transitions
- REGI** Renewable Energy Grid Integration
- SC** Office of Science
- SETO** Solar Energy Technologies Office
- VTO** Vehicle Technologies Office
- WETO** Wind Energy Technologies Office
- WPTO** Water Power Technologies Office

# RESEARCH IMPACTS

## INTEGRATED ENERGY SYSTEMS FOR REAL-WORLD SCENARIOS

### Fairbanks, Alaska, Targets Transition Away From Coal With Help From Award-Winning ARIES Research

Sponsor: **REGI**



DOE launched the Clean Energy to Communities (C2C) program in 2023 to assist U.S. communities with their diverse clean energy goals and challenges. This support has been crucial for Fairbanks, Alaska, where electrical reliability issues are affecting residents with outages, emissions, and varying energy costs. Fairbanks received tailored technical guidance from NREL, including virtual system emulation with ARIES.

Using the ARIES software Simulation and Emulation for Advanced Systems (SEAS), NREL showed how large-scale wind power and a new battery energy storage system could be added to Fairbanks's grid to improve reliability and facilitate Fairbanks's retirement of its 50-MW coal plant and 20-year-old nickel-cadmium battery. SEAS allowed researchers to comprehensively model Fairbanks's proposed grid upgrades, including the possibility of an improved transmission line from areas with renewable generation. For this work, the SEAS software was awarded a coveted R&D 100 Award in 2023, and SEAS is poised to continue helping C2C cohorts by providing a clean energy sandbox to evaluate community energy plans.

[Learn more about the award-winning SEAS software.](#)



### ARIES Proves How Hybrid Power Plants Can Operate in Energy Markets

Sponsors: **GMLC project funded by WETO, HFTO, WPTO, and OE**



FlexPower is a GMLC effort that combines the strengths of several DOE laboratories and funding offices to demonstrate hybrid plants using a full range of energy types, including pumped storage hydropower, ultracapacitors, nuclear, methane, hydrogen, kinetic storage, and more. The project team used ARIES to build physical hybrid plants with multiple energy types, design a controller for managing the resources, and deploy the hybrid plants against standard grid scenarios. Besides delivering unparalleled data around how hybrid systems can be integrated into current power systems, the team showed the value of hybrid plants to reduce the variability of renewable energy and increase their capacity factor.

A complementary study within FlexPower identified regions throughout the United States where such hybrid plants would be feasible. The final project work will connect all the lab results to show the benefits of hybrid plants in U.S. bulk grid applications for reducing emissions and providing reliable electricity.

### ARIES Digital Twin Leads to Resilient Microgrid Deployment in Alaska

Sponsors: **GMLC project funded by OE and WPTO**



The city of Cordova, Alaska, has modernized its microgrid resilience thanks to unparalleled capabilities within ARIES and funding support through the GMLC **RADIANCE project**. Cordova's new microgrid uses state-of-the-art metering and controls to optimally manage its hydropower generation, battery energy storage system, and unique electrical demand of the city's dominant fishing industry. DOE officials and project participants gathered in Cordova to celebrate and discuss the research breakthroughs, which include real-time data sharing from Cordova's microgrid to ARIES assets for risk-free system experimentation in a digital twin environment. This environment allowed Cordova and researchers to compare and review resilient operational strategies, and it has become part of the ARIES arsenal for remote system validation.

[Learn more about the impacts of this microgrid project.](#)





## SOLUTIONS FOR GRID STABILITY



### UNIFI Consortium Advances Inverter Technologies to Support 100% Renewable Energy

Sponsors: **SETO, WETO**



As some systems approach 100% renewable energy, their stability hinges on the underlying technologies, especially the power inverters that interconnect many forms of renewable generation to the grid. The Universal Interoperability for Grid-Forming Inverters (UNIFI) consortium is a vast mixture of institutions that are combining efforts to advance grid-forming inverters—a necessary technological ingredient to operating renewable energy systems. UNIFI partners are preparing for multimegawatt ARIES demonstrations with participation from grid-forming inverter vendors. The demonstrations will evaluate systems ranging from 50%–100% renewable energy and will validate specification documents drafted by the consortium. From the demonstrations, industry will have a clearer and more unified understanding of how to design future clean energy systems.

### Utilities Implement Clean Energy Technologies Using Expanded Advanced Distribution Management System Research Platform

Sponsor: **OE**



The Advanced Distribution Management System (ADMS) Test Bed allows utilities and companies to validate their grid solutions in emulated environments and, beginning this year, using all ARIES assets. Two ADMS projects launched this year with industry and utility partners: one studying the impact of virtual power plants on operations and another evaluating the use of advanced sensors

for locating faults. The test bed was also used in DOE projects to demonstrate innovative grid controls, and it was the focus of a well-attended workshop with key partners. Following the 2023 user call, selected partners will use the test bed for vehicle-to-grid integration projects that will feature demonstrations on ARIES assets.

Read more about the ADMS 2023 R&D 100 Award nominee.



### Dangerous Electrical Oscillations Are Identified and Avoided With ARIES Scan Tool

Sponsor: **WETO**



The Grid Impedance Scan Tool (GIST) can detect destabilizing interactions that arise in renewable power systems, and utilities and device manufacturers around the world are recognizing the importance of this ARIES-originated tool. Multimillion-dollar outages in Australia and the United Kingdom have been linked to electrical oscillations caused by wind and solar power plants, which also threaten to derail clean energy progress in many other locations targeting high levels of renewables. One such area, the island of Kauai, has relied on GIST to overcome emerging stability issues. As Kauai connected to ARIES using its authentic battery model, the GIST team injected a spectrum of electrical frequencies into the battery to scan its response, assuring the Kauai Island Utility Cooperative that their deployment could safely continue. GIST was a finalist for an R&D 100 Award in 2023 and continues to amass geographically broad interest from industry partners because of its uniqueness—there is no other tool with its full range of capabilities—and its technical importance to clean energy systems.

[Learn more about NREL's GIST software and grid stability capabilities.](#)

### ARIES-Scale Demonstration Shows Government Offices What's at Stake in Cybersecurity

Sponsor: **NREL**



During an NREL-hosted cyber-resilience symposium for federal agencies, ARIES researchers, in coordination with eight other DOE national labs, performed a first-of-its-kind demonstration of potential impacts to grid reliability due to cyberattacks. The researchers showed a plausible multistage attack scenario on a virtual regional power system. The system included bulk power generation—including a wind power plant with a full-scale ARIES wind turbine as hardware-in-the-loop as well as other transmission, distribution, and grid-edge components. The symposium audience viewed the full attack sequence, moderated by the research team, and witnessed a live feed of the turbine blades slowing to a stop. The ARIES Cyber Range real-time visualization and simulation capabilities allowed the cyberattack demonstration to occur and helped federal agency and office members grasp the importance of cyber resilience technologies in reducing cyber risk to future energy systems.

### Disruptive Solid-State Converter Technologies Prototyped With ARIES

Sponsor: **AMMTO**



The electric grid could be transformed by an emerging power electronics technology—medium-voltage, silicon carbide, back-to-back converters—that enables two-way power flow and high-precision control of distribution grid architectures. To prepare solid-state converters for the field, NREL and partner institutions prototyped two separate halves of a 330-kW device with ARIES power-hardware-in-the-loop. Researchers will next integrate the two halves into a single system for prototyping at full power and with realistic operations to verify the device's anticipated features. Such converters could allow grids to interconnect more distributed energy resources with less storage and to operate more adaptively during emergencies—playing a pivotal role in improving the reliability and security of our nation's electric grid.

## TRANSFORMATION WITH FUTURE ENERGY INFRASTRUCTURE



### Nation-Spanning Data Network Leverages ARIES for Remote and Real-Time SuperLab

Sponsors: **OE, NE, SC, HFTO**



Somewhere between Golden, Colorado, and Idaho Falls, Idaho—and between reality and virtuality—an unlikely power plant that combined hydrogen, solar, battery, and nuclear resources operated for an hour. The unique power plant was the latest example of what can be accomplished with a DOE SuperLab, in which national laboratories connect their assets using the expansive Energy Sciences Network (ESnet) of data hubs. This demonstration was notable for being the first-ever proof of megawatt power experiments over ESnet. In doing so, the research team overcame technical challenges of latency despite extremely fast timescale communications. It was also an exceptionally unique power plant that could inspire future hybrid renewable energy options. With this achievement behind them, researchers now hope to build a super lab of 10,000 devices interacting across ARIES with other laboratories. This capability will allow users to address large energy integration challenges with the full force and scale of all DOE labs.

[Learn more about the SuperLab demonstration.](#)

### Electric Vehicle Growth Charges Ahead With ARIES Infrastructure

Sponsor: **VTO**



ARIES is supporting DOE's Electric Vehicles at Scale Lab Consortium (EVs@Scale) with research and development platforms to address challenges and barriers for high-power electric charging infrastructure that enables greater safety, grid operation reliability, and consumer confidence. Alongside five national laboratories and key stakeholders, NREL's world-class ARIES facilities are a crucial resource for the multiyear collaboration's design and validation activities. ARIES capabilities enabled consortium researchers to characterize and quantify the charging profiles of high-power charging systems to improve control modeling and performance, develop a kilowatt-scale direct current (DC) charging hub platform that can integrate various DC-DC converters with a common DC distribution system, and develop 30 million daily travel itineraries that help identify energy needs and charging opportunities by outlining daily distances traveled, driving times, and dwell periods. The consortium's work ultimately accelerates the transition to electric fleets.



### ARIES Provides Digital Twin Emulation for Cyber Defense of Buildings

Sponsors: **BTO, CESER**



An effort to implement cybersecurity into building control systems is using a recently updated ARIES capability to emulate cyberattacks and develop advanced defenses. The project, named Building Intelligence with Layered Defense Using Security-Constrained Optimization and Security Risk Detection (BUILD-SOS), offers a solution that protects smart buildings from cyber intrusions. It leverages buildings' network and physical data to identify attacks, and this year it was demonstrated on the ARIES Cyber Range using the building emulation tool Alfalfa and remote hardware-in-the-loop. The researchers used their findings to publish a first-ever data set documenting impacts from cyberattacks on buildings and distinguishing between attacks and mechanical faults. The ARIES building emulation capability will be central to a follow-on project, Emulation-Based Cyber Risk Assessment and Mitigation for Disadvantaged Communities.

NREL was recognized as a codeveloper for the R&D 100 Award-winning software/services project from Los Alamos National Laboratory, PowerModelsONM: Optimizing Operations of Networked Microgrids for Resilience. This software leverages ARIES simulation validation and hardware-in-the-loop capabilities and optimizes networked microgrids for power restoration during blackouts and other extreme events. Other codevelopers on the project include Sandia National Laboratories and the National Rural Electric Cooperative Association.

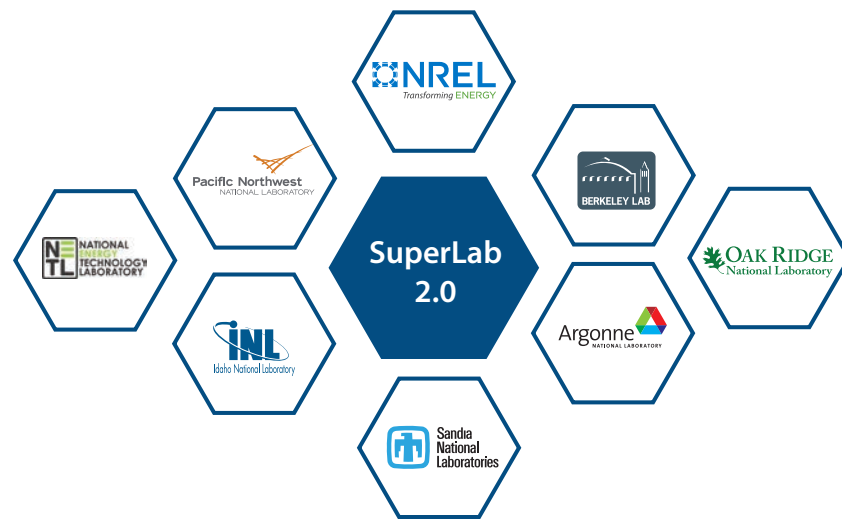
# LAB CAPABILITIES AND BUILDOUTS

## ARIES Connects Distant U.S. Department of Energy Capabilities Using ESnet for Continent-Spanning Research

Developed in collaboration with EERE, FECM, NE, OE, and SC

The ESnet data network blurs the boundaries of ARIES by connecting it with other labs across the United States. ESnet now has exceedingly low latency, higher data capacity, and the architecture to virtually emulate power systems while concurrently using the very best U.S. research capabilities.

“Bringing together the complementary expertise of the national labs is what we do best—everyone brings their best game, and we all work together,” said Eli Dart, Science Engagement Group lead at ESnet.



## New Technologies in the Power Electronics Grid Interface Help Partners Design Stable Power Systems

Developed in collaboration with SETO and WETO

The Power Electronics Grid Interface (PEGI) is a plug-and-play space for partners to experiment with power technologies. PEGI provides controllability and measurement at very fast timescales of milliseconds, allowing researchers to study electrical interactions that are consequential for the safety of renewable power systems. Partners visited PEGI for a 2023 workshop, which stoked their interest in high-priority applications, such as analyzing the power stability of 100% renewable systems, made possible through the continued development of GIST.

[Read more about the PEGI collaborative workshop.](#)

## Flatirons Campus Buildout Adds New Strengths in Hydrogen and Large-System Emulation

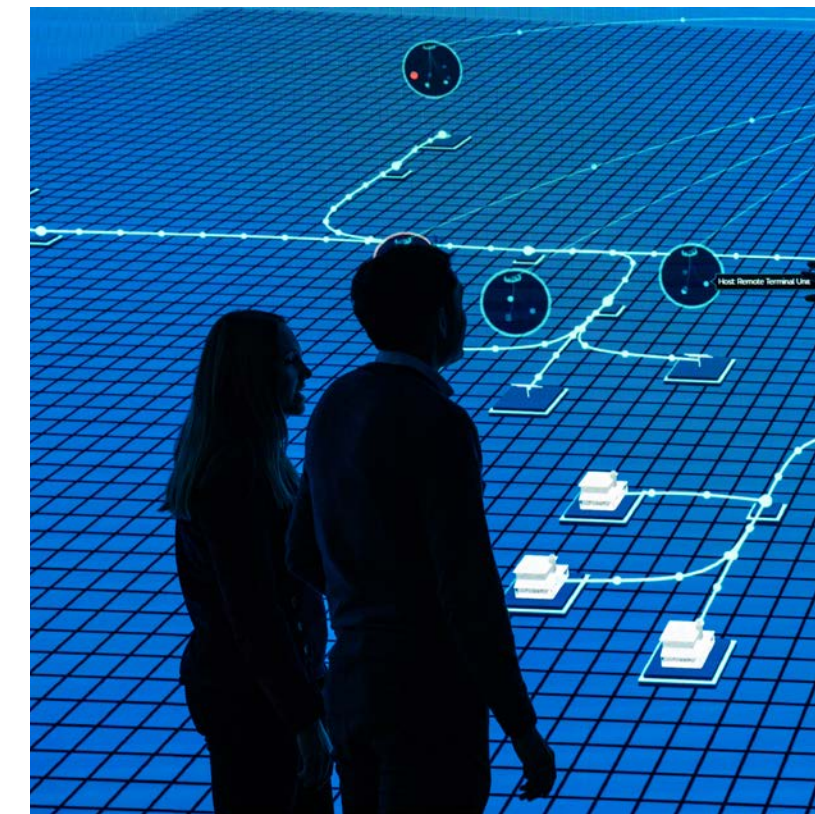
Developed in collaboration with EERE

The Flatirons Campus hosts an impressive field of ARIES renewable energy infrastructure, and that infrastructure will soon be more versatile with the buildout of important hardware for clean energy solutions. Already underway, additions to the Flatirons Campus include a new [Controllable Grid Interface \(CGI\)](#), a system control facility, and visionary hydrogen system. The CGI-2's 20-MW capacity more than doubles the power of its predecessor, enabling larger and more complex grid emulations, while the control center provides a much-needed facility for collaboration and campus operations. The hydrogen infrastructure will allow research on all aspects of utility-scale hydrogen deployment, including production, compression, distribution, and underground storage.

## Cybersecurity Becomes One of ARIES' Fully Integrated Capabilities

Developed in collaboration with CESER and EERE

The ARIES Cyber Range capabilities have expanded in scope, scale, and fidelity to unlock cyber and physical research. Coupled with the wide range of hardware assets at ARIES, the cyber range provides a platform to study cyberattacks, cyber resilience, and telecommunications as part of the transforming clean energy system. NREL's investment in expanding the capabilities of the ARIES Cyber Range will continue through FY 2024 and beyond.







DOE's Ann Dunkin (left) gets an overview of Kestrel from NREL's Ray Grout during a visit to NREL.

## ARIES Adds Interface With Quantum Computers

Developed with support from EERE, OTT, Atom Computing, and RTDS Technologies, Inc.

ARIES researchers designed an interface for quantum computers to communicate with power devices in-the-loop, allowing experiments with an early-stage technology in a potentially disruptive application.

"Consider some of the most challenging problems in energy systems today: making decisions based on large sensor networks, optimizing system recovery during fault conditions, securing communications between network devices. There are core applications that quantum computers may excel at, so we're accelerating their adoption in power systems with this interface," said Rob Hovsapan, an ARIES senior researcher at NREL.

*Read more about this exciting capability.*

## Supercomputer Kestrel Takes Flight With Substantial Increase in Computing Power

Developed in collaboration with Hewlett Packard Enterprise and EERE

*Kestrel* was installed this summer and began operations on time for the start of the new fiscal year in October. At five times the computing power of its predecessor, *Kestrel* is a central asset for complex grid simulations in ARIES.

"*Kestrel* represents a new capability for us to do better science faster. There's an awful lot of research problems that just need more GPU power to make progress," said Aaron Andersen, *Kestrel* engineering lead at NREL.

Researchers raised the bar in FY 2023 with yet another high-flow-rate, heavy-duty hydrogen filling milestone—82.5 kg hydrogen fueling in 6 minutes. The previous record was 78.7 kg in FY 2022.



# ENGAGEMENT AND OUTREACH

NREL hosted more than 10,000 visitors from communities, industry, government, and academia to tour ARIES capabilities at the Energy Systems Integration Facility (ESIF) and Flatirons Campus in FY 2023. Engagement and outreach highlights include:

- Hosting and introducing ARIES capabilities to U.S. government leaders and dignitaries from around the world, including U.S. Secretary of Energy Jennifer Granholm and other DOE executive leadership, Colorado Governor Jared Polis and other state staff, a Colorado senator, congressional staff, executive leadership from other federal agencies, industry leaders, international ministers, and local officials
- Meeting and consulting with the external advisory board, comprising 13 members with utility, industry, academic, and governmental perspectives
- Presenting ARIES capabilities at various energy conferences and regional/community events, including NREL's seventh annual Partner Forum, where Robert Horton from Dallas Fort Worth International (DFW) Airport spoke about the airport's experience in planning its energy transition using ARIES assets
- Collaborating with national labs:
  - Hosting national lab executive leadership and technical researchers
  - Connecting research capabilities and assets with other national laboratories.
- Engaging with communities to support their energy transition strategies
- Convening industry leaders and NREL experts in three NREL-hosted workshops focused on the ADMS Test Bed, PEGI, and autonomous energy systems
- Gathering representatives from DOE, NREL, the National Rural Electric Cooperative Association, and other DOE laboratories in Cordova, Alaska, to celebrate the success and witness the real results of their effort on **RADIANCE**
- Celebrating 10 years of the ESIF—a key facility that makes ARIES research possible
- Engaging with the media with news stories that potentially reached more than 108 million and were covered in outlets like *Forbes*, *Axios*, *Popular Mechanics*, and *Scientific American*.



DOE's Jeff Marootian (center) tours NREL's Flatirons Campus with Roderick Jackson (right) and Daniel Laird (left) atop a wind turbine.

## Research Outcomes

- 19 peer-reviewed journal articles
- 2 high-impact publications
- 34 conference papers
- 5 technical reports
- 11 software records
- 8 records of invention
- 6 patents
- 2 R&D 100 Awards

The ARIES non-DOE partner portfolio grew 10% from FY 2022.



U.S. Secretary of Energy Jennifer Granholm (front) and NREL Director Martin Keller (right) during a visit to NREL.

# LOOKING AHEAD

A 100% renewable energy future is possible, and resilience is an urgent necessity, but the particulars of how we'll get there are still being filled in by enterprising groups confronting uncertainties head-on. ARIES is their vehicle to comprehensively design and validate their desired energy systems—from fully decarbonized industrial plants to entirely electrified campuses. The future impact of ARIES is certain: wider collaboration, in-depth assistance to burdened communities, and technological innovation to reach new levels of renewable energy.

## Local Support

ARIES has unique assets for community-scale transitions, and upcoming projects will put those assets to work in service of underrepresented communities. Research environments for networked microgrids—a [2023 R&D 100 Award winner](#)—and digital twins for system planning are some tools that ARIES will provide to small U.S. communities as part of the next cohort in the [DOE C2C program](#). Through C2C and other DOE programs, local communities will lead their own energy investments using ARIES for impartial evaluations along the way.

## Wide-Impact Collaborations

ARIES offers common ground for industries, cities, or stakeholders to work together and standardize their solutions. This is what drives major collaborations, such as [transit hubs](#) mobilizing around DFW Airport's energy transition to learn and apply similar ARIES findings to their own efforts. Even deeper collaboration is on the way with the construction of the [Global Energy Park \(or GLO Park\)](#), an energy innovation business complex adjacent to NREL, and the launch of [DOE's Energy Threat Analysis Center](#), a nationwide partnership to share threat information and strategies for securing the nation's critical energy infrastructure. ARIES will be in the middle of these alliances and more.

## Technological Leadership

The diverse validation environments of ARIES make technological innovation possible across many domains. Planned expansions to hydrogen, vehicle, communications, and grid capabilities, among others, will enable demonstrations of next-generation energy technology breakthroughs. Long-duration energy storage projects sponsored by the DOE Office of Clean Energy Demonstrations indicate where ARIES could be especially useful in the near term, while newly slated projects in the GMI show the importance of ARIES for developing grid solutions of top national priority.

ARIES is also influential in designing solutions for hard-to-decarbonize industrial systems. NREL has led analysis on the technological feasibility of carbon-free operations, and now partners are putting solutions to the test at sites like remote mines and chemical processing plants. These same partners, among others, are now looking to ARIES for its unique scale and technological diversity to solve large decarbonization challenges.

Looking ahead, a research ecosystem is building around ARIES, and partners are realizing how far this new platform can take them toward finding innovative energy solutions at scale. Enabled by upcoming expansions, ARIES is emerging as the transformational tool that can unite and unlock our clean energy aspirations.

U.S. Secretary of Energy Jennifer Granholm (right) tours the ESIF with NREL's Jennifer Kurtz (left) while visiting NREL.



# ADVISORY COMMITTEES

## ARIES External Advisory Board

The ARIES external advisory board provides external perspectives from industry, academia, and other government agencies/programs to NREL, DOE, and EERE on the research direction; the research, development, and demonstration gaps that ARIES should address; and the development and deployment of the ARIES research platform.

### External Advisory Board Members

**Chair: Gary Smyth**

Executive Director, Global R&D Laboratories  
General Motors (retired)

**Jeffrey Baumgartner**

Senior Advisor  
Berkshire Hathaway Energy

**Colton Ching**

Senior Vice President, Planning & Technology  
Hawaiian Electric Company

**Lauren Faber O'Connor**

Operating Partner,  
Lowercarbon Capital

**Paula R. Glover**

President  
Alliance to Save Energy

**Christopher Herbst**

Vice President, Strategic Partnerships and  
Innovation  
Eaton

**Robert Horton**

Vice President,  
Environmental Affairs  
DFW Airport

**Alice K. Jackson**

Senior Vice President, System Strategy and  
Chief Planning Officer  
Xcel Energy

**Danielle W. Merfeld**

Chief Technology Officer  
QCells

**Teresa R. Pohlman**

Executive Director, Sustainability and  
Environmental Programs  
U.S. Department of Homeland Security

**Ronald M. Segal**

Representative  
U.S. Department of Defense

**Timothy D. Unruh**

Executive Director  
National Association of Energy Service  
Companies

**Evan Wolff**

Partner  
Crowell and Moring LLP

## ARIES Steering Committee

The ARIES steering committee comprises DOE EERE and NREL executive leadership. This committee meets biannually and has oversight of and responsibility for ARIES research and development management, research impact, and financial and business practices.

### Steering Committee Members

#### U.S. Department of Energy

- **Alejandro Moreno**, Associate Principal Deputy Assistant Secretary for Energy Efficiency and Renewable Energy
- **Michael Berube**, Deputy Assistant Secretary for Sustainable Transportation and Fuels
- **Carolyn Snyder**, Deputy Assistant Secretary for Buildings and Industry
- **Becca Jones-Albertus**, Acting Deputy Assistant Secretary for Renewable Energy
- **Christy Cooper**, Deputy Assistant Secretary for Operations
- **Kevin Lynn**, ARIES Lead and Director of Grid Modernization
- **Derek Passarelli**, Golden Field Office Director

#### NREL ARIES Team

- **Peter Green**, Deputy Laboratory Director, Science and Technology
- **Johney Green**, Associate Laboratory Director
- **Juan Torres**, Associate Laboratory Director
- **Jennifer Kurtz**, ARIES Research Director and Center Director
- **Jerry Davis**, ESIF and ARIES Laboratory Program Manager
- **Jennifer Palmer**, ARIES Research Advisor and Technical Coordinator
- **Rob Hovsopian**, Senior ARIES Research Advisor

Daniel Laird, Matt Keyser, Barry Mather, Dane Christensen, Matt Thornton, and Steve Hammond.

Laboratory program managers, operations team, communications leads, executive assistants, project managers, partnerships development team, finance leads, and subject matter experts.

DOE's Gene Rodrigues (right) tours the Flatirons Campus while visiting NREL.



**NREL works with organizations—large and small—to expand the clean energy economy. You can partner with ARIES to accelerate renewable energy and energy-efficient solutions into practical applications. Watch for opportunities to work with us on the [ARIES webpage](#) or email us at [ARIES@nrel.gov](mailto:ARIES@nrel.gov) to discuss your project.**

Robert Horton, Dallas Fort Worth International Airport (left) and NREL's Johney Green (right) speak at NREL's Partner Forum.



Cover (front), illustration by Anthony Castellano; page 2, illustration by Anthony Castellano, photo courtesy of Paula Glover, photo courtesy of Alejandro Moreno, DOE, page 4-5, photo from iStock,1090668730; page 6-7, photo from Gettyimages, 1178228880, photo by Werner Slocum, NREL, 78808; page 8-9, photo from iStock, 664134998, photo from Gettyimages, 501766632, photo from Gettyimages,1332019013; page 10-11, photo from iStock, 664134998, photo by Bryan Bechtold, NREL 82072; page 12-13, photo from Gettyimages, 1319989199 photo by Joe DelNero, NREL 78860, photo by Werner Slocum, NREL 76090; page 14-15, photo by Photo by Bryan Bechtold, NREL 82080, illustration by Anthony Castellano, photo by Werner Slocum, NREL 74769; page 16-17, photo by Werner Slocum, NREL 77629, photo by Joe DelNero, NREL 77534; page 18-19, photo from Gettyimages, 1403425623, photo by Werner Slocum, NREL 78984, photo by Werner Slocum, NREL 79588; page 20, illustration by Anthony Castellano, photo by Joe DelNero, NREL 79069; page 22-23, photo by Werner Slocum, NREL 78588, photo by Bryan Bechtold, NREL 82430; Cover (back), photo by Josh Bauer/Bryan Bechtold, NREL 82080



National Renewable Energy Laboratory  
15013 Denver West Parkway, Golden, CO 80401  
303-275-3000 • [www.nrel.gov](http://www.nrel.gov)

*NREL prints on paper that contains recycled content.*

NREL is a national laboratory of the U.S. Department of Energy  
Office of Energy Efficiency and Renewable Energy  
Operated by the Alliance for Sustainable Energy, LLC

NREL/BR-6A42-88370 • January 2024