



Thank you for joining.

**The ARIES Industry Workshop
will begin shortly.**



Please note:

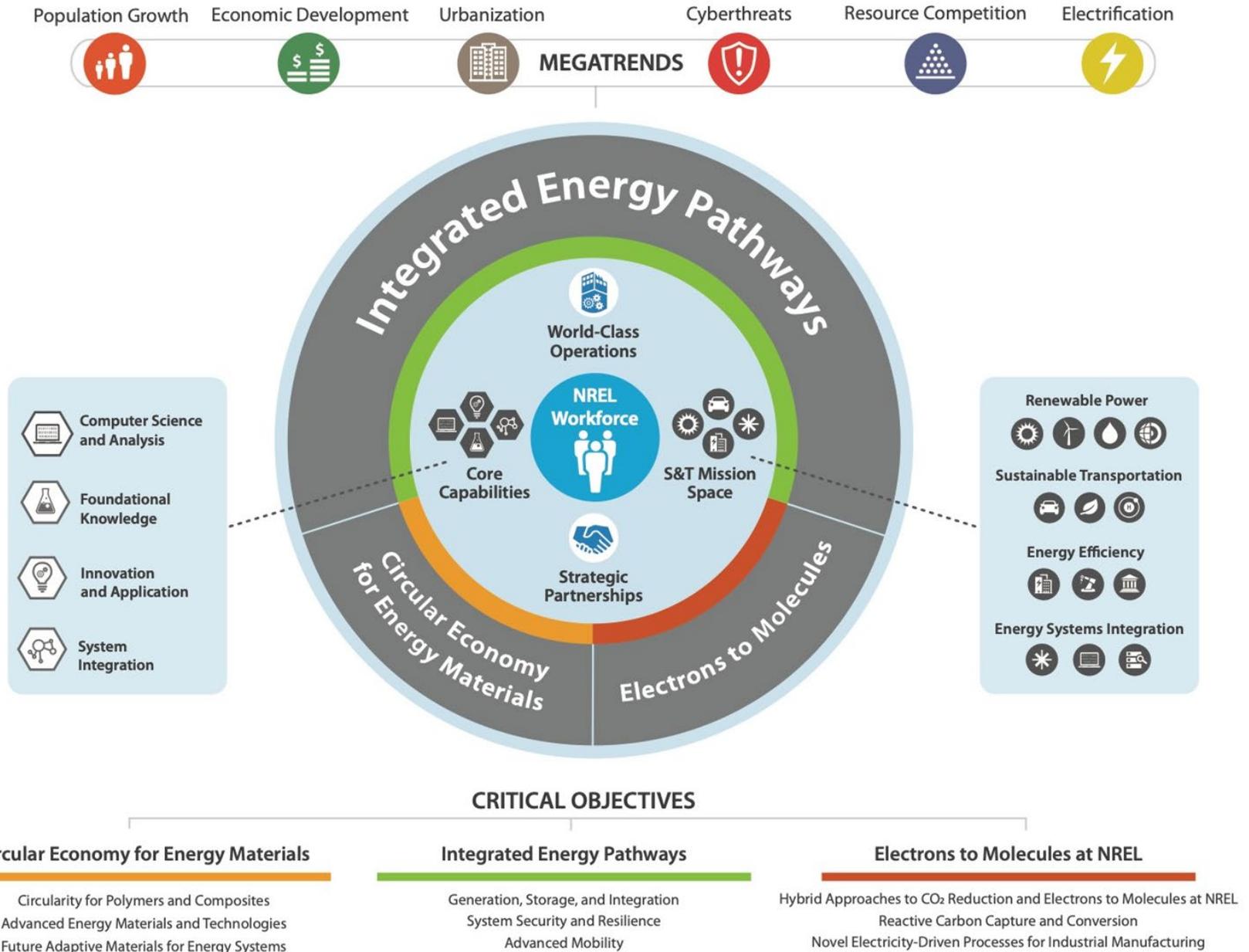
Your microphone will be muted throughout the meeting. If you wish to contact the host or panelists, please use the Chat or Q&A features.

ARIES Industry Workshop

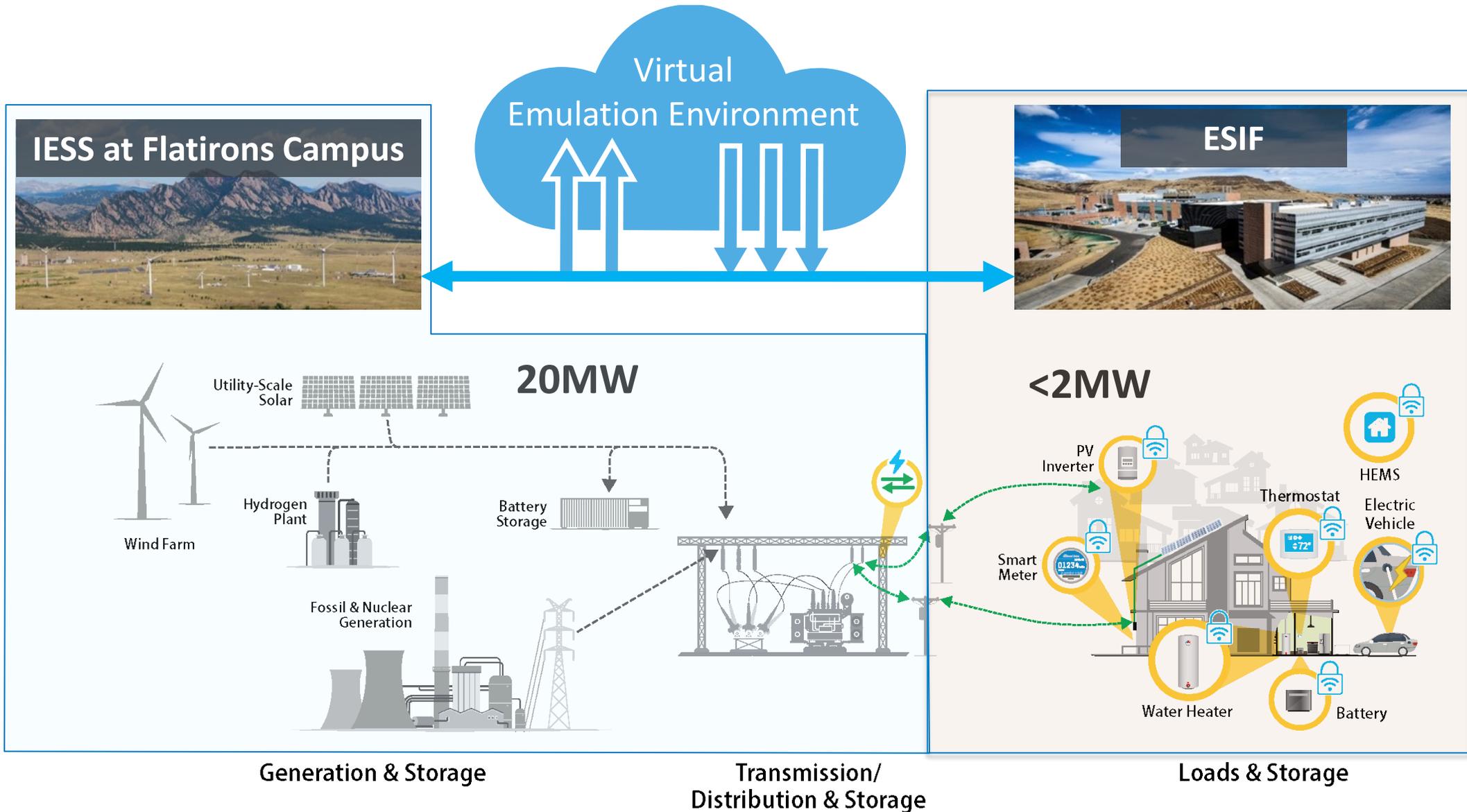
12:00 p.m.	Welcome and Agenda <i>Juan Torres (NREL), Bill Farris (NREL), and Martha Symko-Davies (NREL)</i>
12:05 p.m.	Energy Vision <i>Peter Green (NREL), Kevin Lynn (DOE, EERE), and Gary Smyth (Advisor)</i>
12:20 p.m.	About ARIES <i>Jen Kurtz (NREL)</i>
12:40 p.m.	Introduction to ARIES Capabilities <i>Martha Symko-Davies and Rob Hovsopian (NREL)</i>
1:00 p.m.	Illustrative ARIES Research <i>Matt Futch (NREL)</i>
1:15 p.m.	How to be a part of the Vision <i>Keith Ropchock (NREL)</i>
1:20 p.m.	Feedback and Q&A from Participants
1:50 p.m.	Concluding Remarks <i>Gary Smyth, Kevin Lynn and Johney Green (NREL)</i>

Working Toward Our Vision

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



ARIES Research Platform – At-Scale



The New Normal: Rapid Innovation – Disruption – Exponential Growth

“Nikola wants to be the Tesla of Trucking”

Barron's - June 2020

“Elon Musk teases building new Tesla GigaFactory in Texas”

ABC News - Feb 2020

“I believe that the automotive industry will change more in the next 5 to 10 years than it has in the last 50”

Mary Barra - CEO General Motors - 2018

“Welcome Salesforce stock to the Dow Jones”

Cloud based software company founded 20 years ago

MSN Money - August 2020

“Amazon to acquire autonomous driving startup Zoox”

TechCrunch - June 2020

Trends Driving Change in Energy



Increasing Interdependencies



Energy Diversification



Vehicle Electrification



Grid-Connected Smart Buildings



Big Data, Artificial Intelligence,
and Machine Learning



Cybersecurity



Resilience



Millions of Devices at the Grid Edge



About ARIES



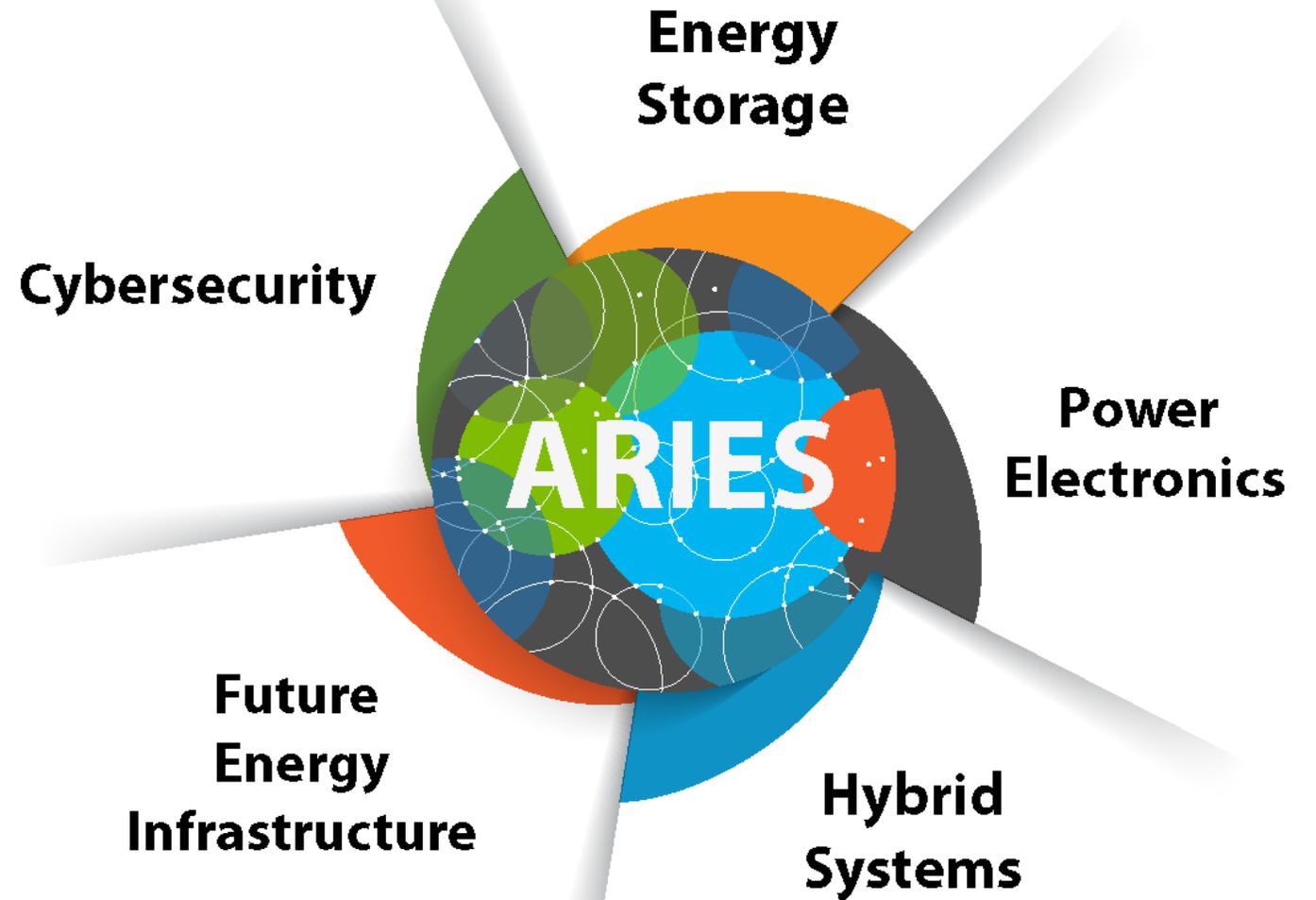
ARIES

Advanced Research on Integrated Energy Systems

ARIES is a research platform designed to de-risk, optimize, and secure current energy systems and to provide insight into the design and operation of future energy systems. It will address the fundamental challenges of:

- Variability in the **physical size** of new energy technologies being added to energy system
- Controlling **large numbers** (millions to tens of millions) of interconnected devices
- Integrating **multiple diverse technologies** that have not previously worked together

ARIES Integrated Research



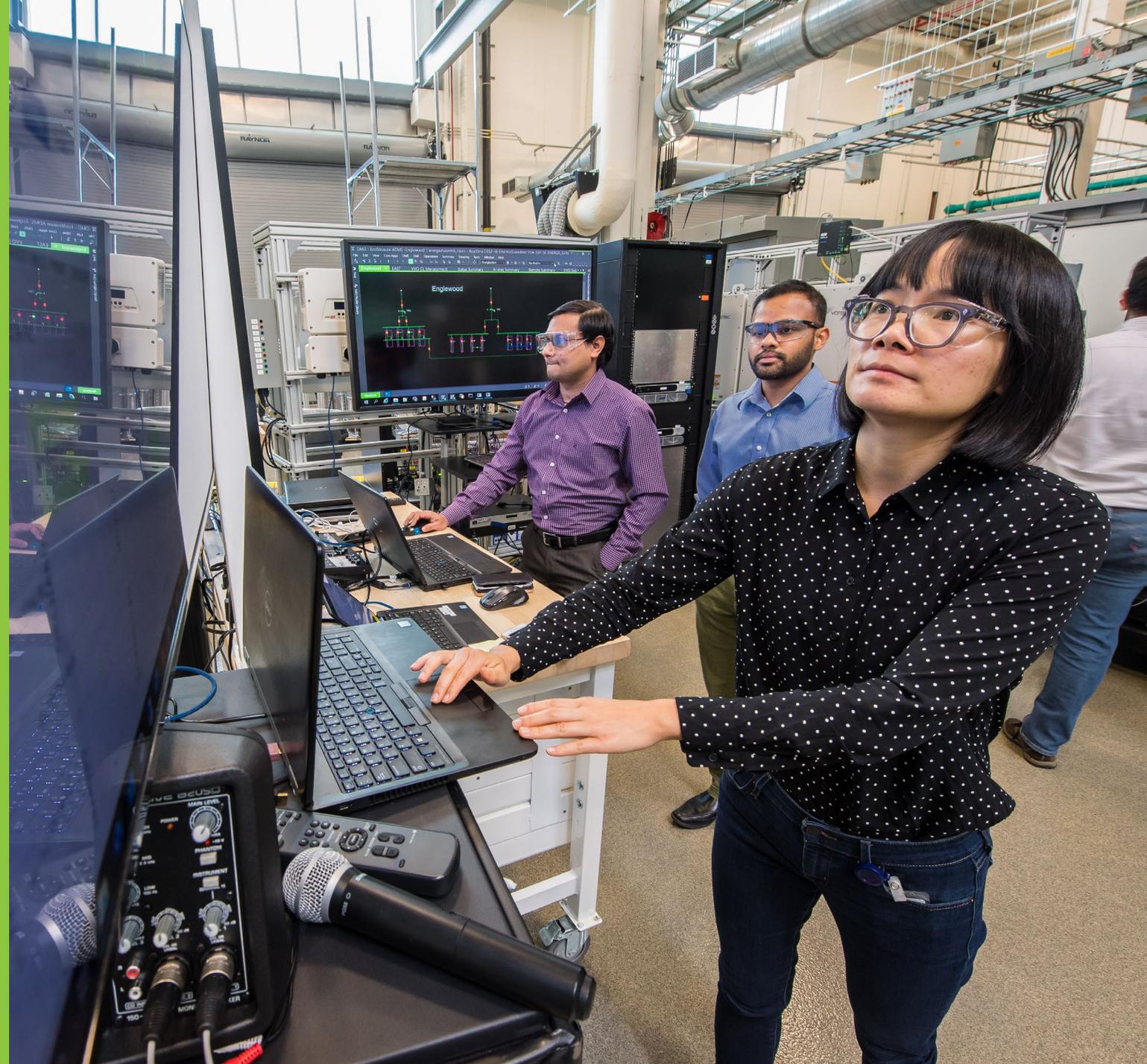
A Focus on Energy Storage Challenges

- Purpose driven integration and controls for flexibility and security
- Accelerating diverse technologies (e.g., electrochemical, molecular, thermal, and mechanical storage)
- Balancing for various size and timescales



A Focus on Advancing Power Electronics

- Grid operation at high-levels of power electronic interfaced generation and load
- Real-world proving grounds
- Develop and validate new power electronic technologies



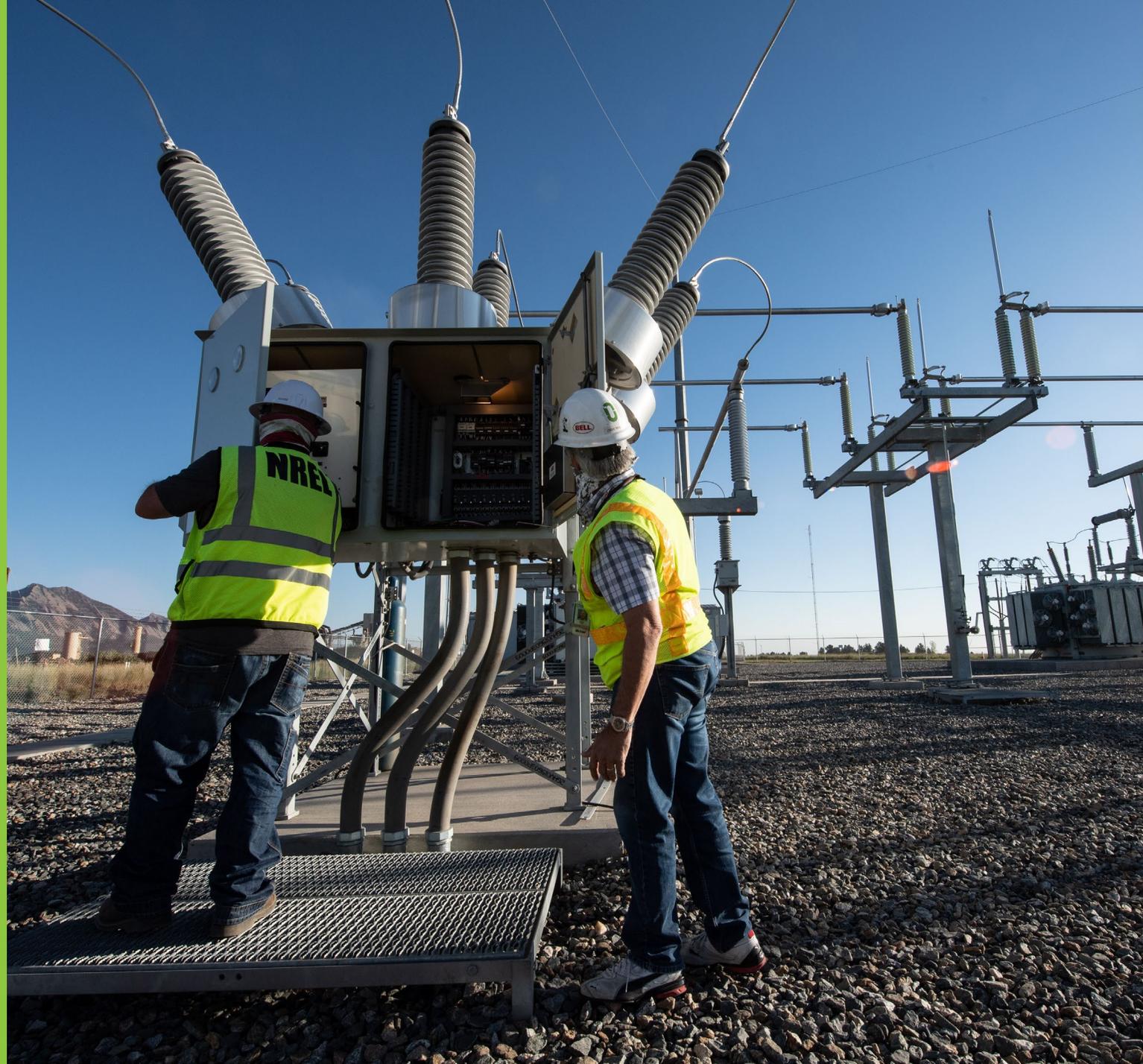
A Focus on Hybridization Opportunities

- Optimizing dynamic controls of diverse technologies
- Understanding the interdependencies and effects
- Quantifying hybridization benefits



A Focus on Future Energy Infrastructure Needs

- Protection for highly connected systems
- Advanced system-level operations
- Controls for operational efficiency and stability



A Focus on Cybersecurity

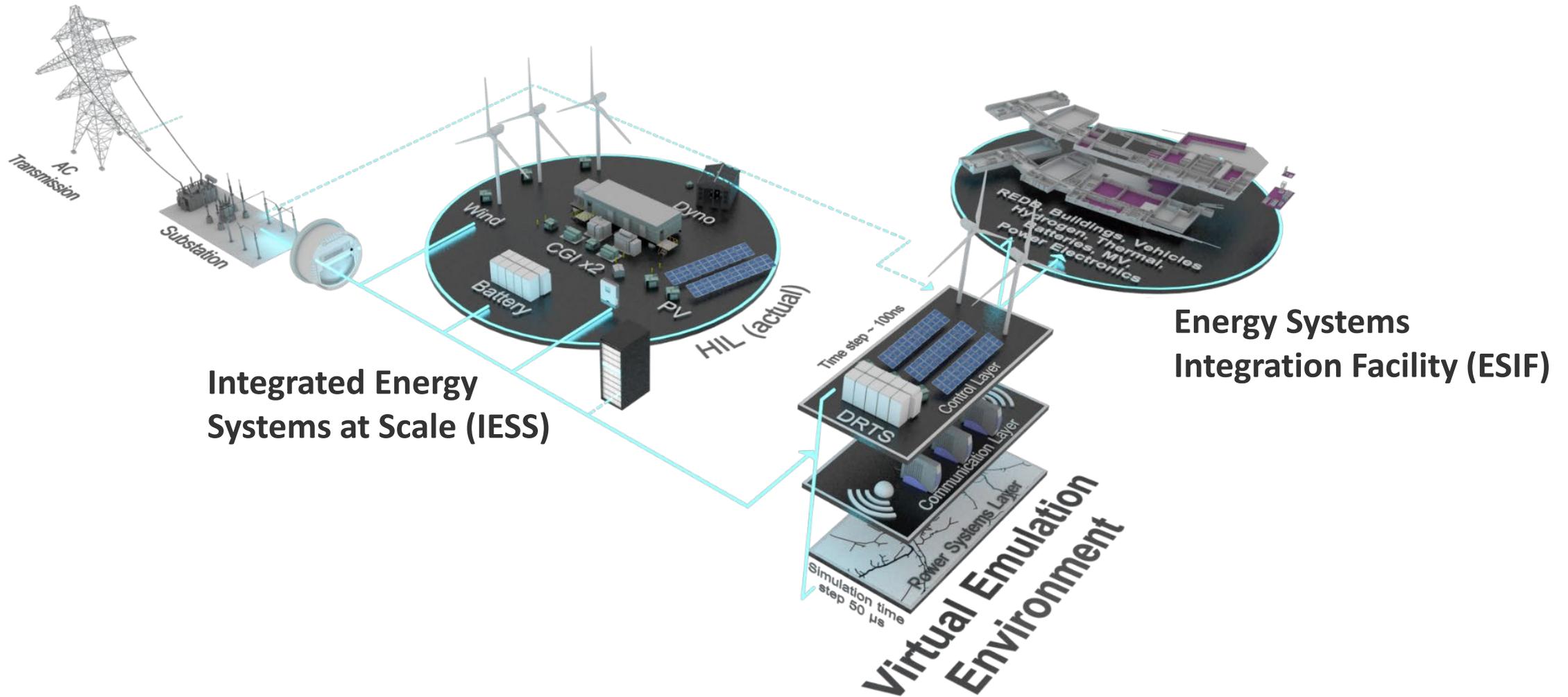
- Proactive defense and automated response
- Improved situational awareness
- Secure communication innovation



ARIES Research Capabilities



ARIES Research Platform





High-level View of the ESIF at NREL's Main Campus

Facility Attributes

- Designated Technology User Facility
- **8 Petaflop HPC, data center, and visualization room**
- **Hydrogen system and chemistry labs**
 - production, compression, storage, dispensing
- **Integrated Labs**
 - REDB, Thermal, Modeling/RTS, Outdoor Test Areas, Fixed Equipment, Future ESR/AMP/NWTC 2.0

Key Research Enablers

- Hardware and controls experimentation
- Power Hardware in the Loop (PHIL) and Controller Hardware in the Loop (CHIL)
- Fundamental science for energy materials
- Modeling and simulation
- Data analytics and visualization
- Education and training

Integrated research capabilities advancing diverse technologies for buildings, vehicles, and fast charging





High-level View IESS at NREL's Flatirons Campus

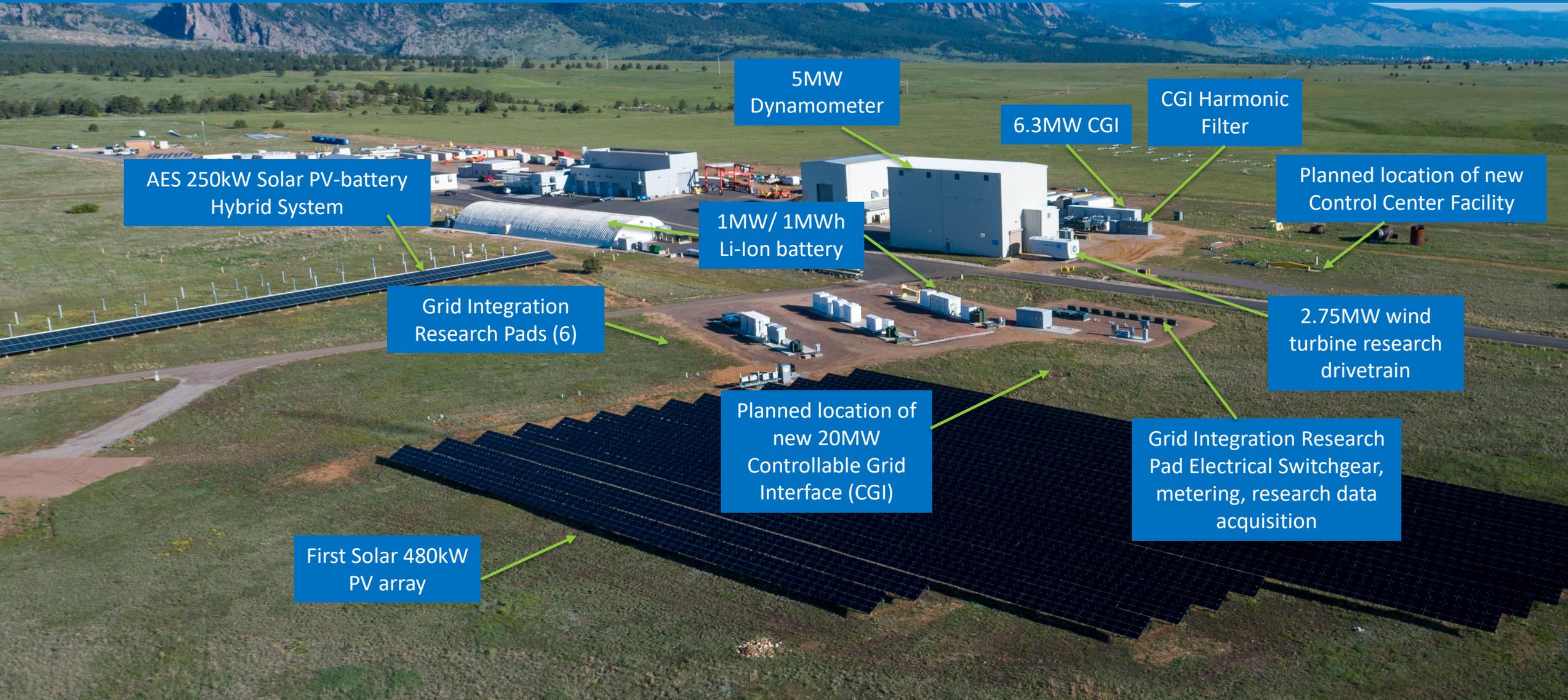
Facility Attributes:

- At-scale evaluation of resiliency reliability and flexibility services
- Flexible configuration of hybrid energy experiments
- Grid integration research pads
- Science of nonlinear scaling
- Advanced controls and optimization
- Electrons-to-molecules-to-electrons
- Integration with national-scale research and robust validation platform

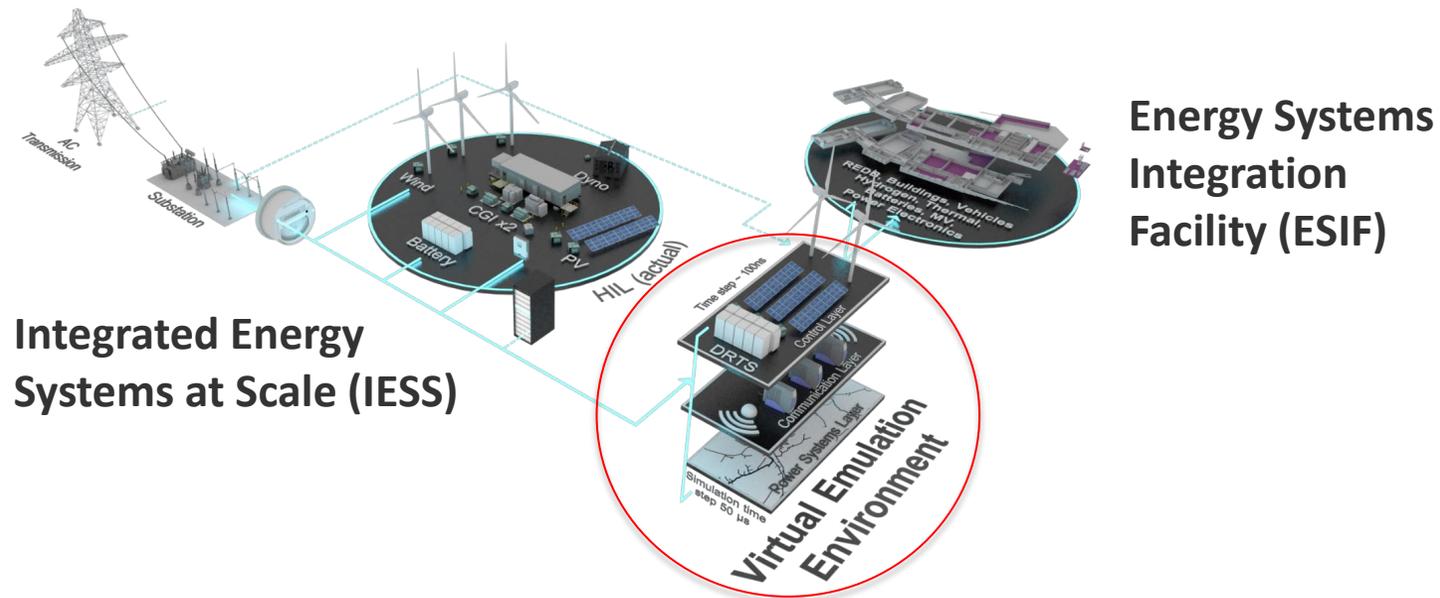
Key Research Enablers

- Total of 7+ MW variable renewable generation (Wind and Solar)
- 20MVA (7MVA + 13MVA) Controllable Grid Interface (CGI)
- Multi-MW energy storage research facility
- 2.5MW and 5MW dynamometers
- Distribution network at 13.2 kV MV grid upgradable to 34.5 kV
- At scale power and controller HIL up to 20MW
- Digital Real Time Simulation (DRTS)
- High Speed ESnet Connectivity, with Internet2 links at 10 Gb/sec
- Electrical interconnections to all plausible configurations of grid integration research assets (e.g. loads, generators, storage) on utility grid or isolated research grids

ARIES At-Scale Infrastructure at Flatirons Campus



Highly integrated capabilities to understand the science of scaling



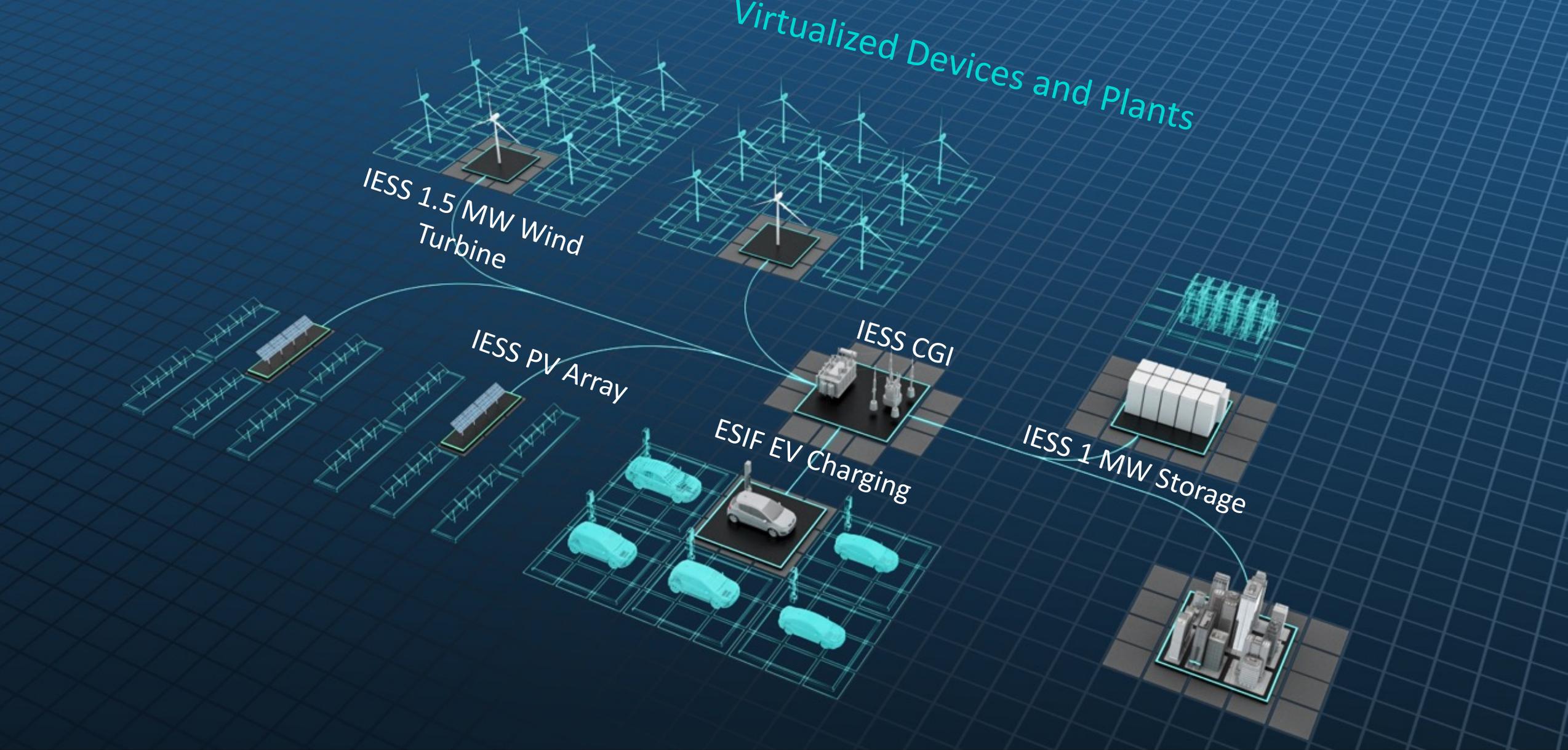
High-level View of the Virtual Emulation Capability

Facility Attributes

- Ability to integrate 10K+ devices as HIL, CHIL to emulate real world environment
- Establish Digital Twin (DT) of Electrical, Mechanical and Thermal systems to evaluate dynamic interactions of those devices and systems
- Provide communication layer to emulate cyber physical network of systems
- Emulation capability for millions of devices with DRTS and HPC
- At-scale research of complex interaction of devices at multiple timescales
- Verification and validation environment using device characterization at HIL

Key Research Enablers

- Large cluster of **Digital Real Time Simulators** for Rapid Prototyping and Digital Twin development
- **Communication Emulation** - Configurable high-speed field-programmable gate arrays development environment
- Power Electronics Grid Interface (**PEGI**) - Power Electronics CHIL platform
- Hybrid Energy Real Time Hub (**HERTH**) - A platform for Real Time electrical, mechanical, thermal and communication integration and evaluation
- Integrated DRTS with **HPC** for 1 million device emulation



Virtual Emulation Environment

Emulating complex virtual systems using digital multiplier

Virtual Emulation Environment (MW to GW Scale) + (Millions of devices)

Integrated Energy Systems at Scale
(IESS) at NREL's Flatirons Campus

(20MW)
(10,000s of devices)

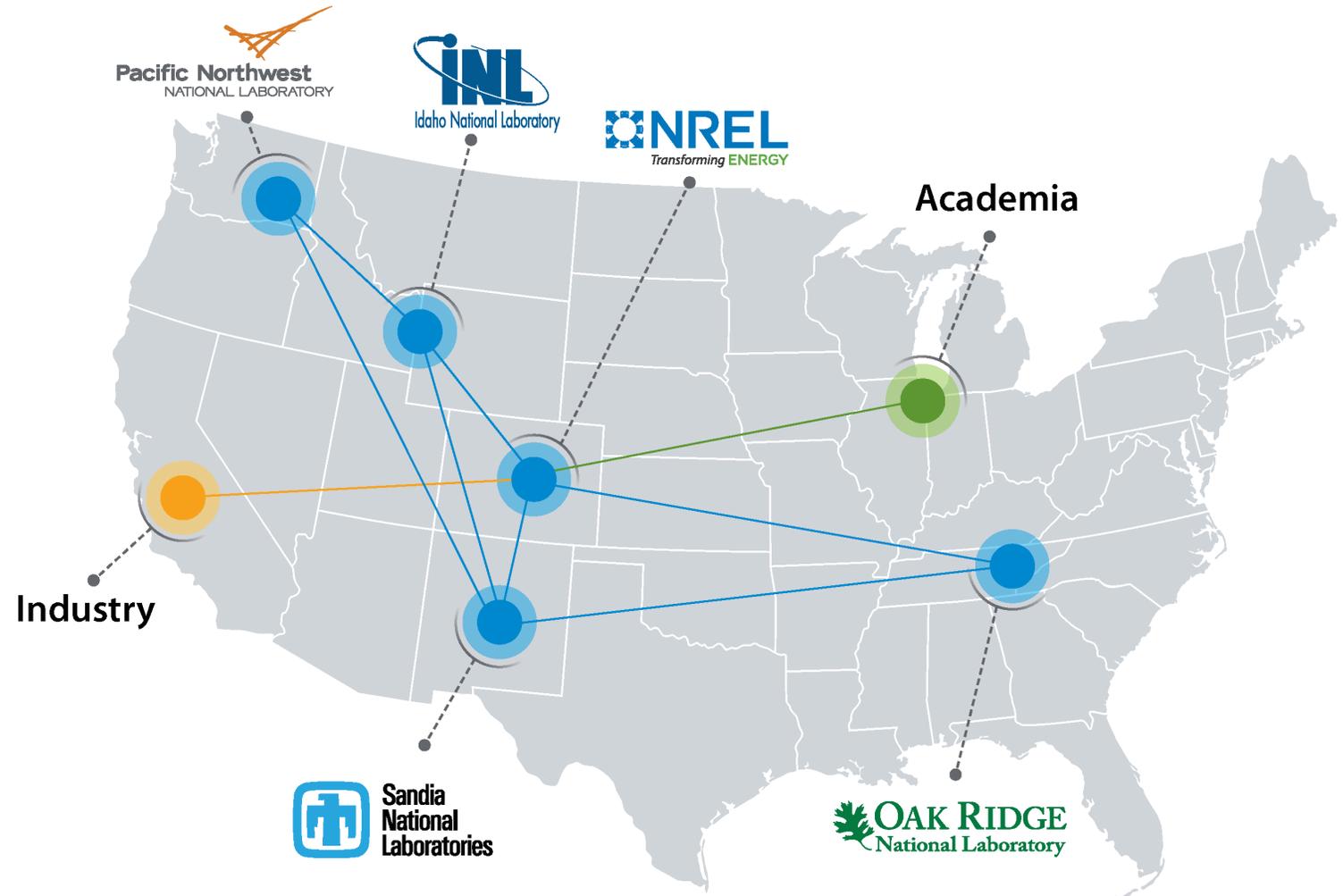
Energy Systems Integration Facility
(ESIF) at NREL's Main Campus

(Up to 2MW)
(100s of devices)

For regional and national level energy systems R&D

ARIES Strategic Partnerships Increase Impact

The interconnected nature of the ARIES platform enables significant opportunities to coordinate its research capabilities across industry, academia, and other national labs.



Illustrative ARIES Research Past and Future



Case Study | Preparing the Grid for More Plug-In Hybrid Electric Vehicles

CHALLENGE:

How will more plug-in, hybrid electric vehicles (PHEV) affect power quality on the grid?

Partner: Toyota



SOLUTION

Strategies to monitor, control distribution, and understand the effect of PHEVs on the grid.

OUTCOME

Managing the additional load will ensure grid stability and reliability.

Case Study | Energy Storage with Power-to-Gas Technology

CHALLENGE:

Over production of renewable energy during off peak hours leads to curtailment

Partners:
Southern California Gas Company
and Electrochaea



SOLUTION

Optimize water electrolysis and bioreactor technologies to convert water + waste CO₂ into cost competitive bio-methane.

OUTCOME

Maximize value of curtailed electrons leveraging existing utility gas and electric infrastructure for seasonal storage capability.

Case Study | Validation of DC coupled hybrid PV/BESS peaker plant

CHALLENGE:

De-risk system integration and control logic i.e. charging and dispatching of combined solar and storage system prior to installation in Kauai.

Partner: AES



SOLUTION

Leveraged NRELs Controllable Grid Interface and RTDS in combination with AES 500kWh BESS and 240kW PV array to validate charging dispatch performance of system.

OUTCOME

Validated system performance and capabilities prior to installation de-risking the deployment of a new Hybrid Peaker Plant serving Kauai's 65,000 customers.

Case Study |

Validate large-scale storage hardware and advanced controls for high-renewable resilient microgrids

CHALLENGE:

Variable conditions challenge economics of energy storage for US DOD installations.

Partners: Cummins, Environmental Security Technology Certification Program (ESTCP), DOD



SOLUTION

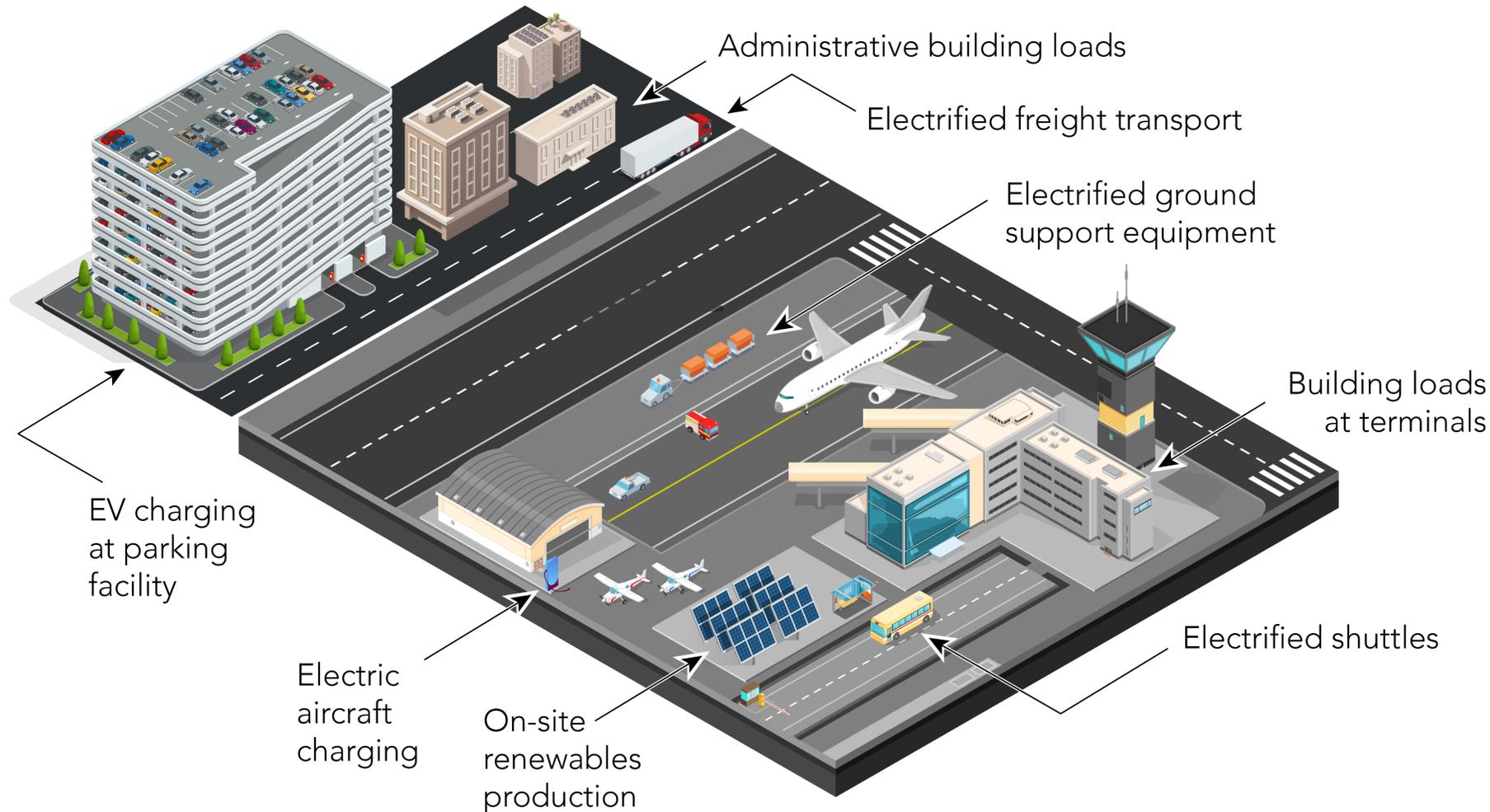
Prove proposed power system designs for DOD installations in different climates, markets, and renewable generation.

OUTCOME

Transforms future military based microgrids to optimally exploit on-site renewable energy.

Future Use Case

Airport Infrastructure | System Optimization



Key Research Challenge:
How to optimize MW scale building loads, charging loads, energy storage, and renewables production?

ARIES is the only research platform in the country able to address large scale energy integration challenges this scale

How to be Part of the Vision



Partnering With Business for Competitive Advantage

Nearly **900** active partnerships with industry, academia, and government

In **2019** NREL had:

299

new
**partnership
agreements**

\$74M
value

of new
**partnership
agreements**

255

**unique
new partners**

587

**unique
active partners**



The NREL Difference

Industry invests in short-term R&D when they are confident about a return on investment. NREL

- Assumes a longer, broader view
- Takes on early-stage, high-risk R&D
- Conducts research that makes it possible for industry to bring important new solutions to the market.

“It is often too risky for the private sector to be on that bleeding edge of research where profits are years and years away.”

Venkatesh Narayanamurti, Harvard Kennedy School professor of science and technology policy, told *The Washington Post*



Innovation



Honored with **65 R&D 100 awards**, known as the “Oscars of Innovation,” to date.

571
patents to date
40%
licensed

43,438
publications
to date

How to Partner with NREL

Talk to us about the research challenges in your space



We'll match your interests with our technical team and research capabilities, and guide you through the entire process



There are options for agreement types to meet your goals



NREL can team/partner with you on any lab-eligible opportunity through a CRADA

DOE Cost-Share Funding Opportunities

Recent Opportunity that will use ARIES Capabilities

DOE Fuel Cell Technologies Office H2@Scale 2020 CRADA Call

Up to \$24 million in DOE funding will be awarded for collaborative projects at national laboratories in two priority areas of R&D:

- Hydrogen fueling technologies for medium- and heavy-duty fuel cell vehicles
 - Technical barriers to hydrogen blending in natural gas pipelines
-

Upcoming Opportunity!

DOE Solar Energy Technologies Office Power Electronics Opportunity

- 50/50 cost share for \$3.6M in projects starting in late 2021, focused on grid stability related power electronics research
- **Virtual workshop with full details will take place October 13, 2020, from 9 a.m.-3 p.m. MST**

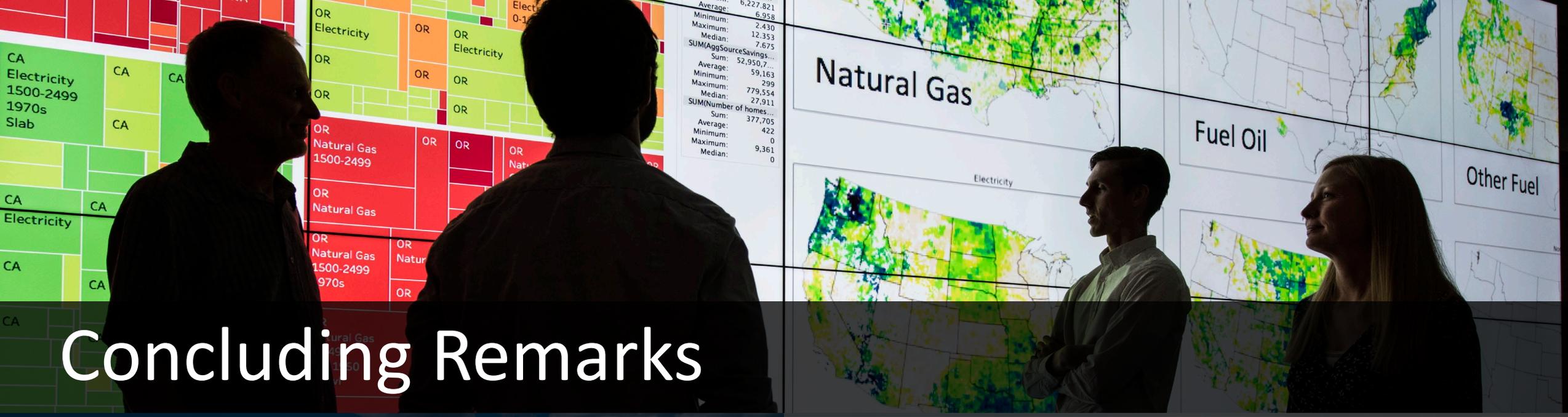
ARIES Poll Questions

Please take a few minutes to complete the poll questions currently displayed in the right-hand panel on your screen.

Feedback and Q&A

Please use the Q&A feature to type in feedback or questions to the panelists.

- If you do not immediately see the Q&A option hover over the  additional options icon and select the Q&A button.



Concluding Remarks



Contact

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Web: nrel.gov/aries



Thank you!

www.nrel.gov

