



NREL's Grid Integration Hardware Capabilities

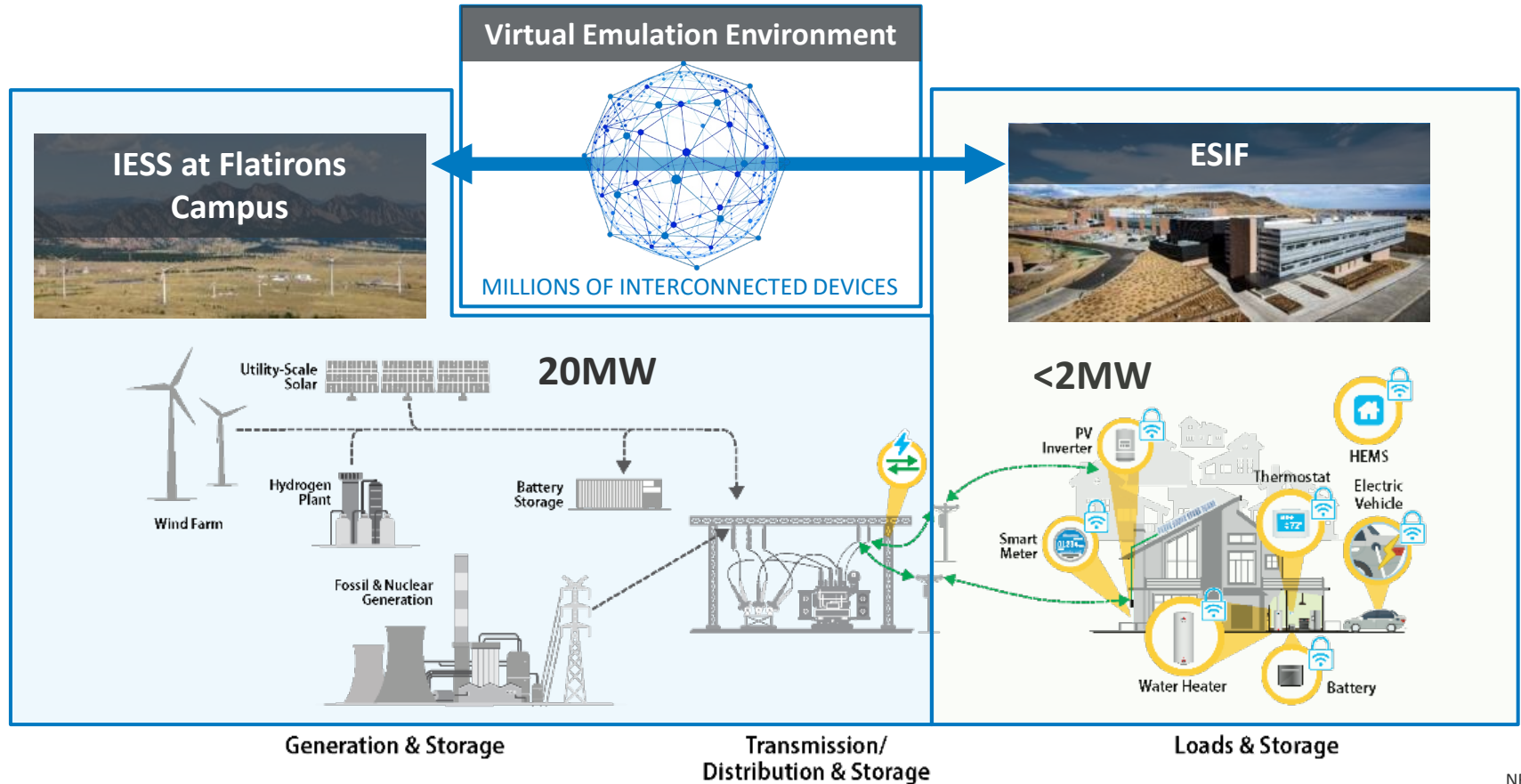
Murali Baggu, Laboratory
Program Manager – Grid Integration, NREL

Advanced Research on Integrated Energy Systems (ARIES) is a research platform that can match the complexity of the modern energy system and conduct integrated research to support the development of groundbreaking new energy technologies.

ARIES



ARIES research platform pillars



ARIES Addresses Three Energy System Technical Challenges

1

Variability in the **physical size** of new energy technologies being added to energy system

2

Securely controlling **large numbers** (millions to tens of millions) of interconnected devices

3

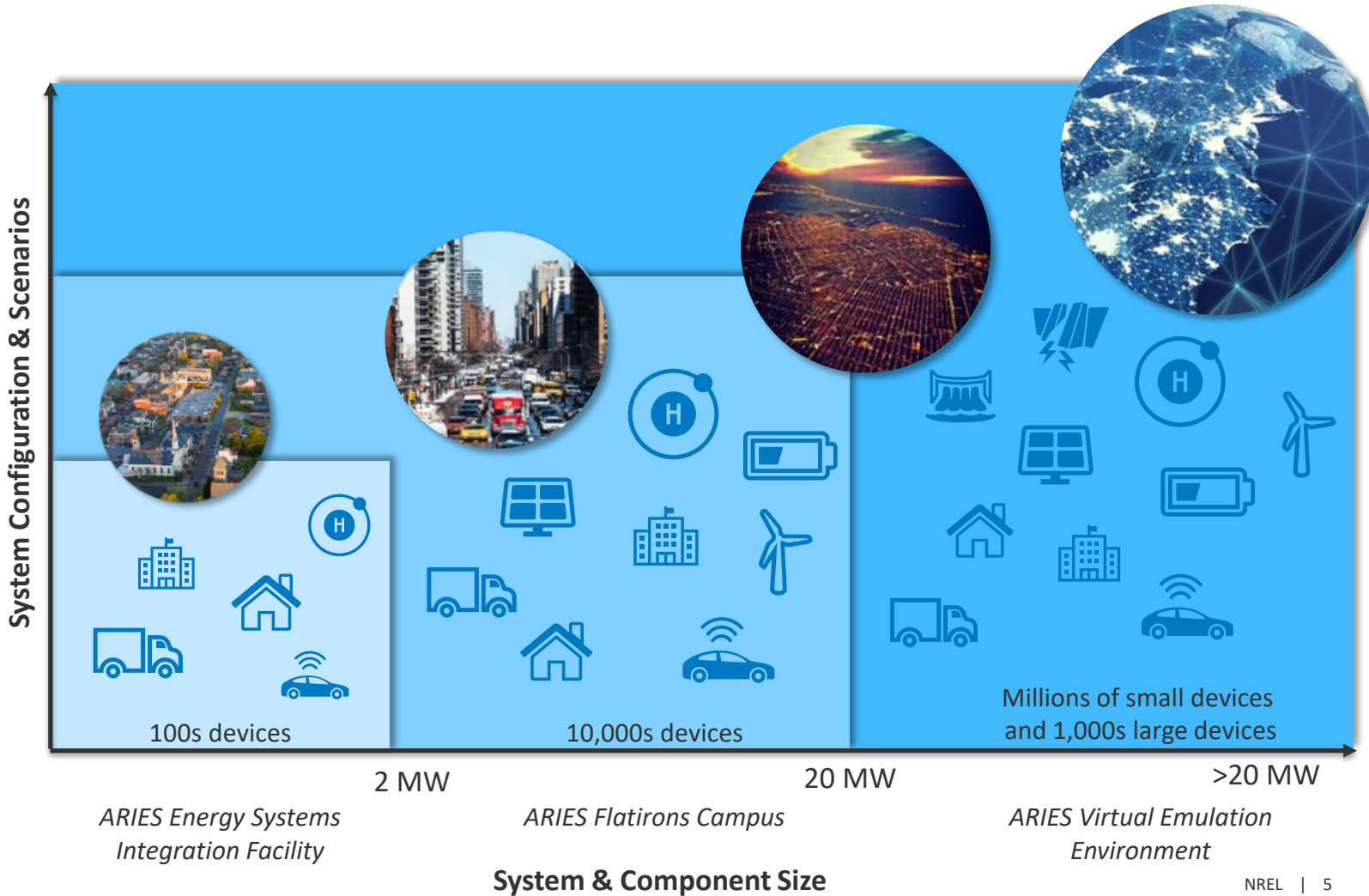
Integrating **multiple diverse technologies** that have not previously worked together



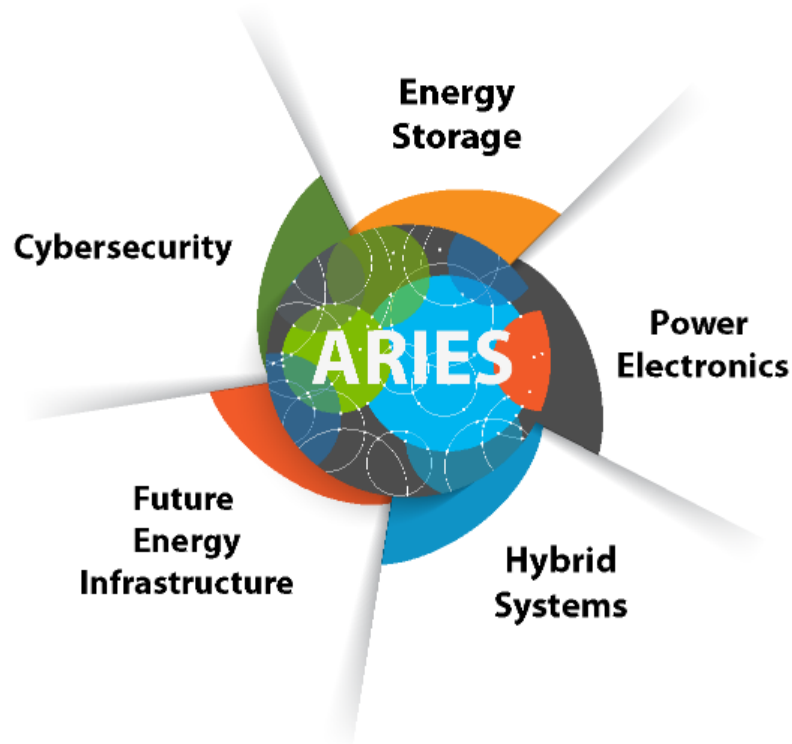
Supporting the transition to a decarbonized energy system:

a safe environment to prove things out, to avoid introducing significant risk, vulnerability, and expense to the providers, customers, and other stakeholders.

ARIES Scale



Five ARIES Research Areas for Solutions



Energy storage to balance variable renewable generation and demand



Power electronics to control and integrate rapidly increasing electronics-based technologies



Hybridization to achieve enhanced coordinated capabilities beyond isolated technologies



Infrastructure to adapt existing energy infrastructure for safety, monitoring, and controls

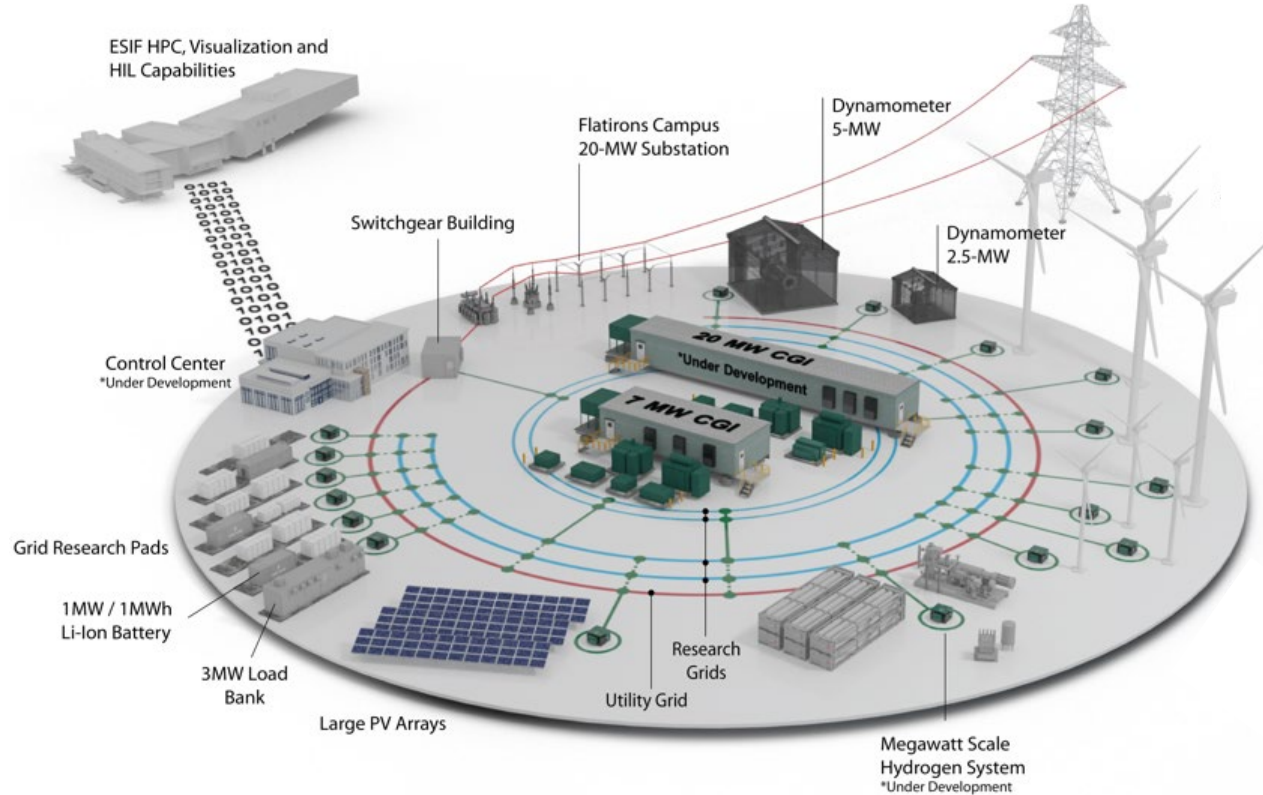


Cybersecurity to secure operations to prevent disruption, damage, and loss of functionality.

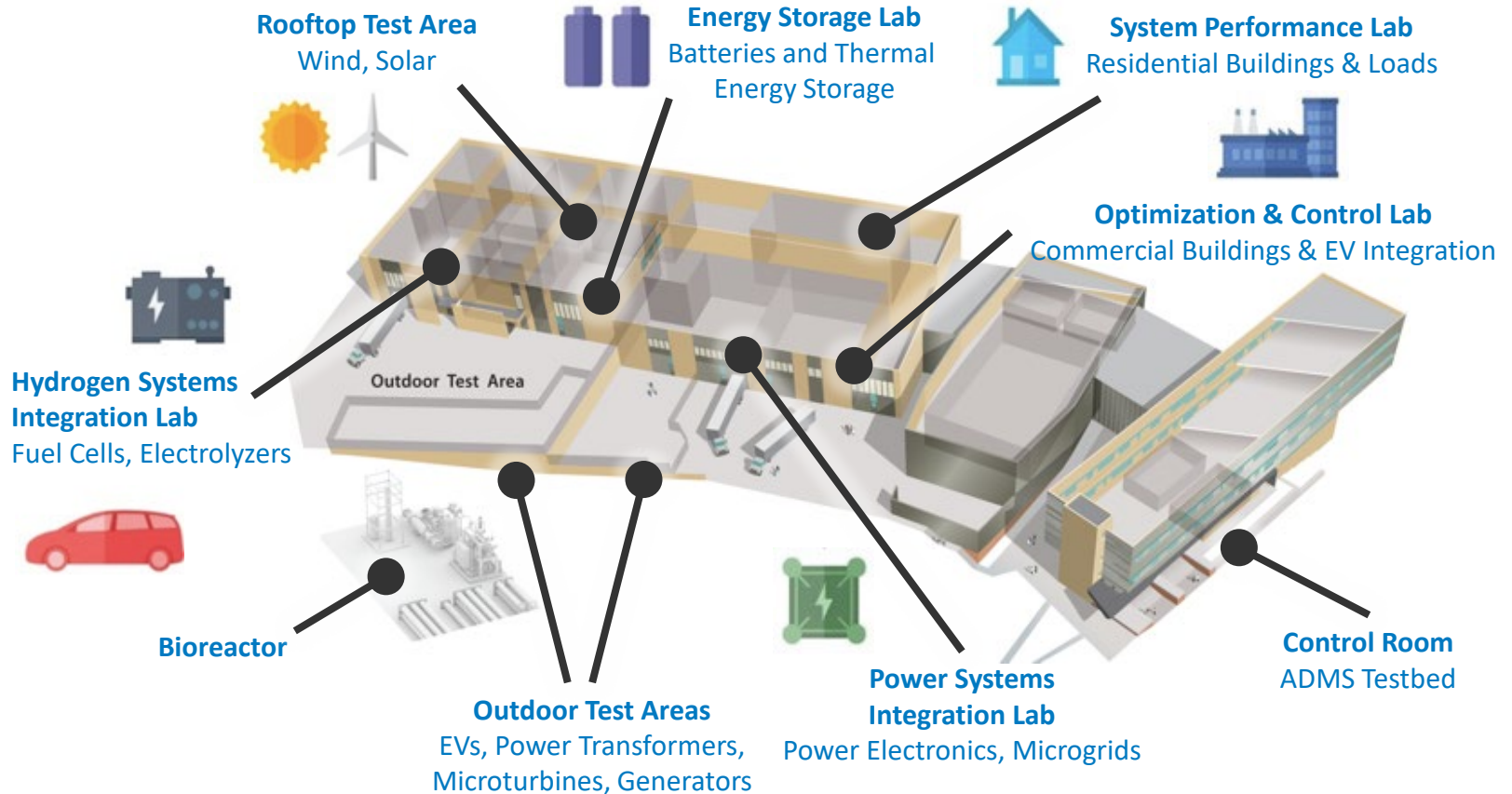
ARIES



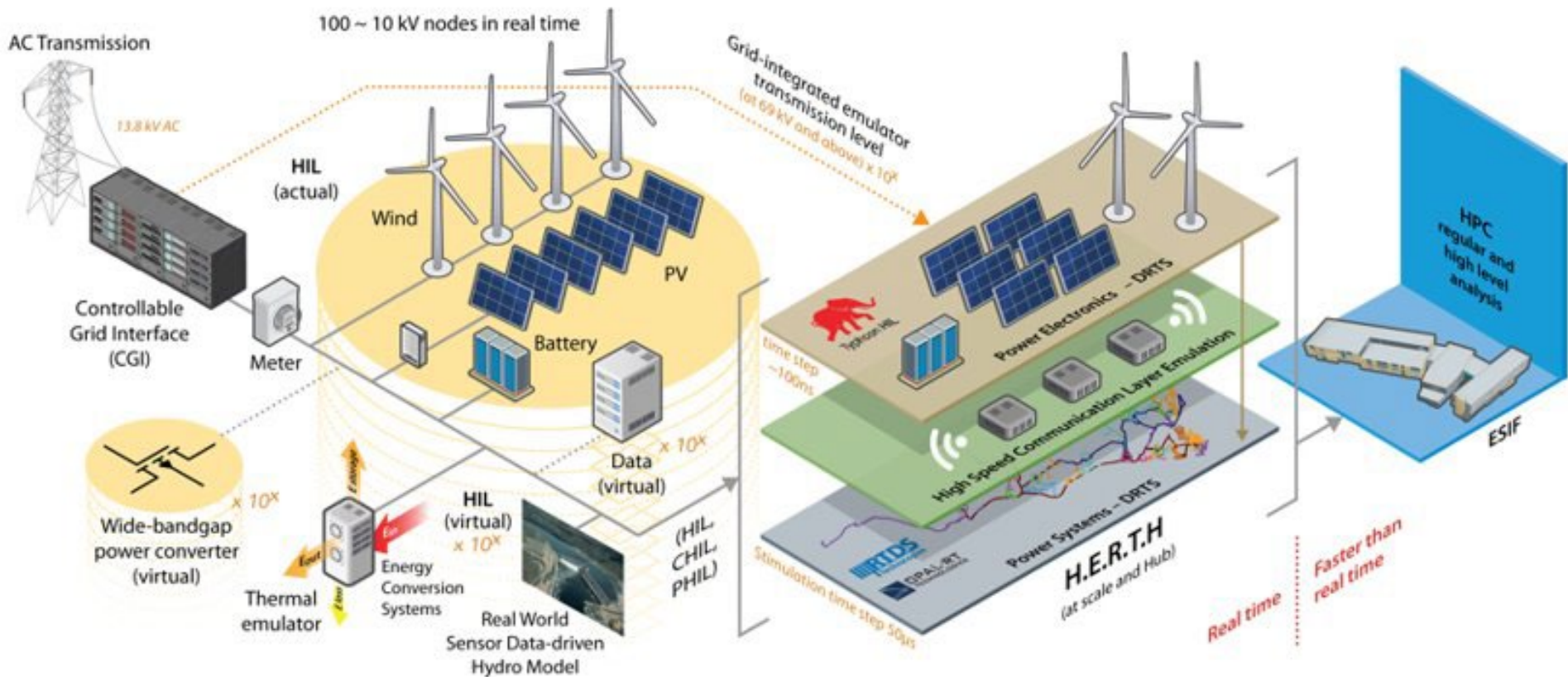
Flatirons Campus Connections



Energy System Integration Facility

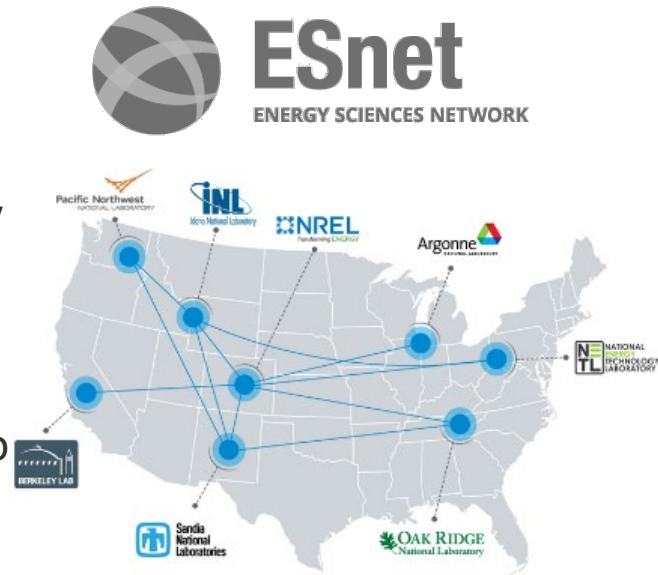


Virtual Emulation



Lab-to-Lab Demonstration

- In FY22, for the first time, ESnet-OSCARS was used to integrate energy systems across geographies (PNNL & NREL).
- **INL/NREL Jan 31 demo** integrates nuclear assets at INL and renewable assets at NREL into one experiment. Will explore the complementary interactions between energy storage, nuclear, and various renewable energy technologies.
- Low latency data exchange accelerates grid research by allowing geographically separated assets and scientists to work like they are side-by-side.
- Goal is "SuperLab 2.0." with 7 connected national laboratories.
 - NETL, ORNL, LBNL (2023)
 - Sandia (TBD)



ARIES is an enabler to support a “Connected Energy” future

Mission:

1

Increasing variability in the physical size of new energy technologies

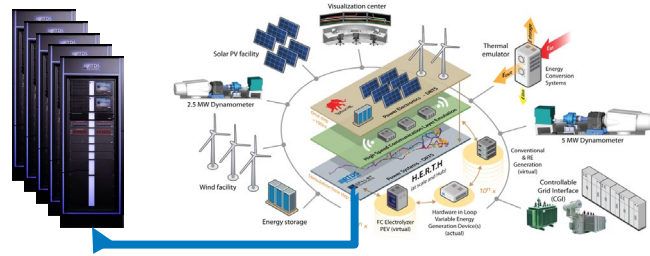
2

Controlling large numbers of interconnected devices

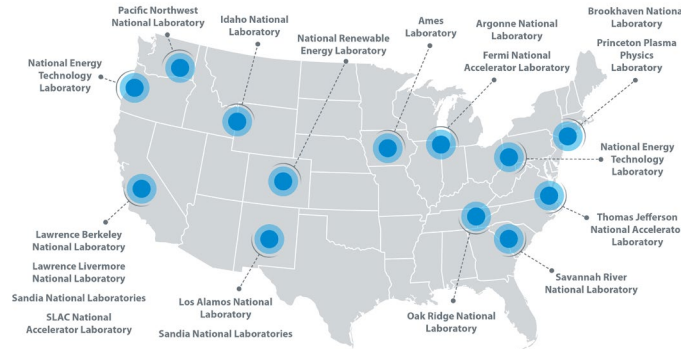
3

Integrating diverse technologies that have not previously worked together

NREL- ARIES Integrated Grid Assets



Enhanced
Collaboration
to innovate
faster

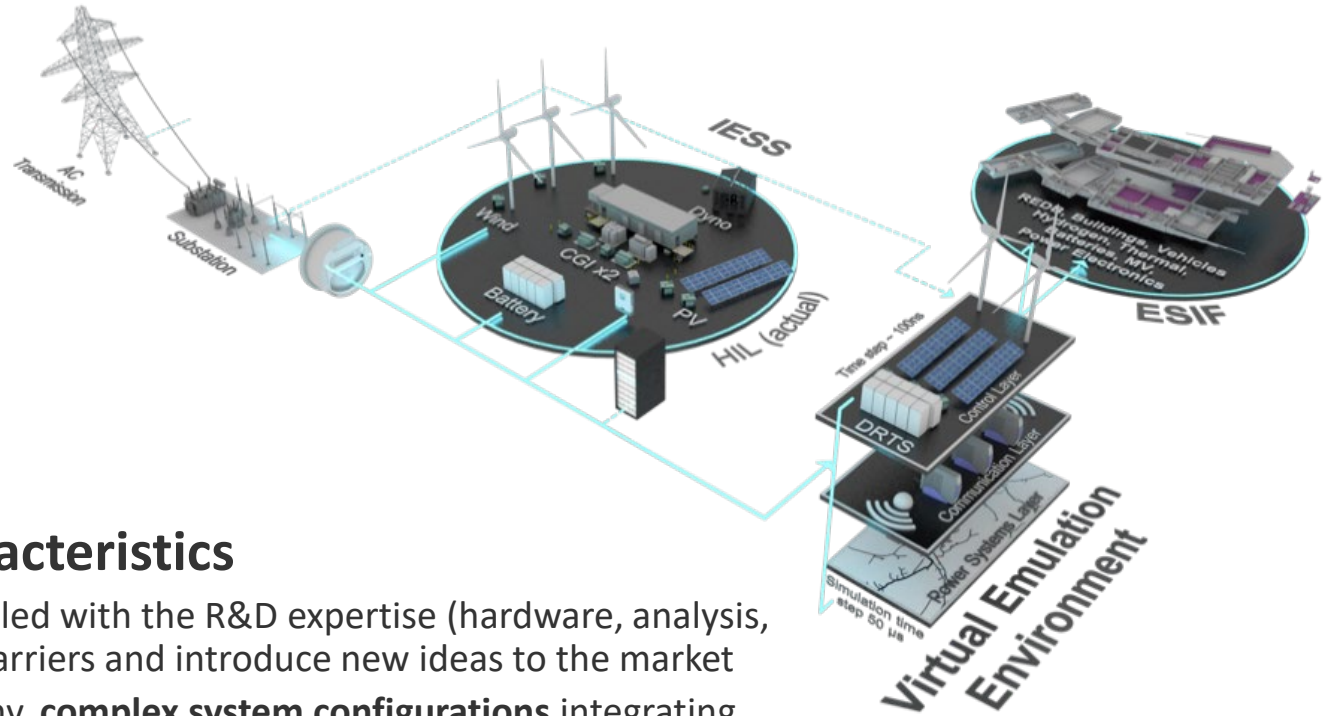


+ Assets across all
DOE National
Labs

ARIES

Differentiating Characteristics

- **Infrastructure at scale**, coupled with the R&D expertise (hardware, analysis, and modeling), to remove barriers and introduce new ideas to the market
- **Flexibility** to investigate many, **complex system configurations** integrating real devices and protocols
- An **entire system** (generation, demand, and storage) perspective in a **real-world** context for future energy systems
- **Partnerships** to increase impact and accelerate innovation



An aerial photograph of a large-scale renewable energy project in a dry, open landscape. In the foreground, several white and blue storage containers are visible, with two prominently displaying the 'TOYOTA' logo. To the right, a large array of dark solar panels is installed on a slope. In the background, a tall red and white tower stands next to a large white wind turbine. The sky is clear and blue.

Thank You



NREL
Transforming ENERGY