OAK RIDGE National Laboratory

Oak Ridge National Laboratory Energy Storage Program Review 2019

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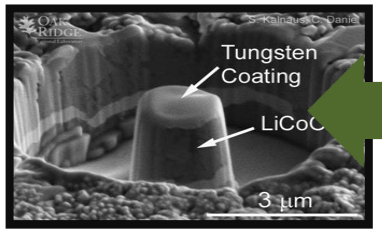
ORNL is managed by UT-Battelle, LLC for the US Department of Energy

U.S. DEPARTMENT OF ENERGY

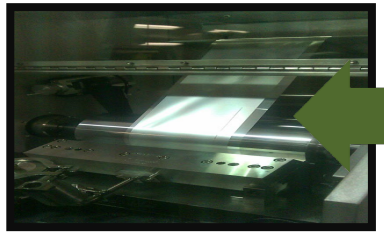
Core ORNL Strengths Linkages to Program

Oak Ridge Core Thrusts

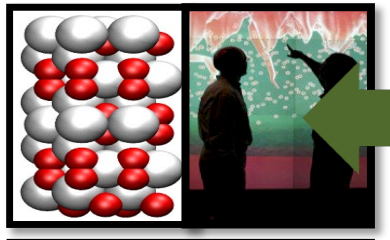
Materials



Advanced Manufacturing



Computation and Analytics



Systems and Systems Integration

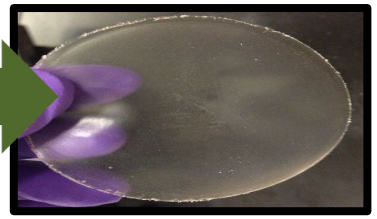
Interdisciplinary R&D

New Battery Technology

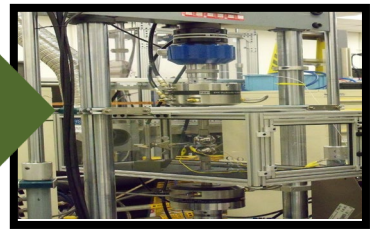
Systems Integration

Low Cost Energy Storage

DOE Energy Storage Program

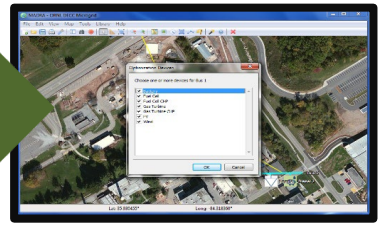


Cost Competitive



Validated Safety and Reliability

Industry Acceptance



Equitable Regulatory Environment

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Energy Storage Projects Under DOE OE Energy Storage Program

Cost Competitive

Flow Battery:

Low Cost Membranes for High Energy Density Non-aqueous Redox Flow Batteries

Jagjit Nanda

Materials

Metal Air Batteries:

Development Of Components and Cell Architectures for High Performance 'Open' Batteries for Grid Applications

- Tom Zawadinski

Materials

Compressed Air Hybrid:

A near-isothermal-isobaric compressed gas energy storage combined with ground-level pumped-hydro storage

– Ayyoub Momen

Systems

Industry Acceptance

Systems Integration:

Secondary Use Development of a Battery Chemistry Agnostic Secondary Use Energy Storage System

- Madhu Chinthavali

Systems

Demonstration:

Collaborative Demo for Secondary Use and Use Case Validation

- Michael Starke

Validated Safety and Reliability

Establishing Safety Dabase:

Establishing Thermal Runaway Risk Test Protocols and Database – An ORNL and SNL Collaborative Research on Battery Safety

-Hsin Wang

Modeling

Advanced Manufacturing:

Engineering Routes Towards Synthesis and Performance of Layered Oxide Cathode Materials for Sodium-ion Batterie

- David Wood

Manufacturing

Equitable Regulatory Environment

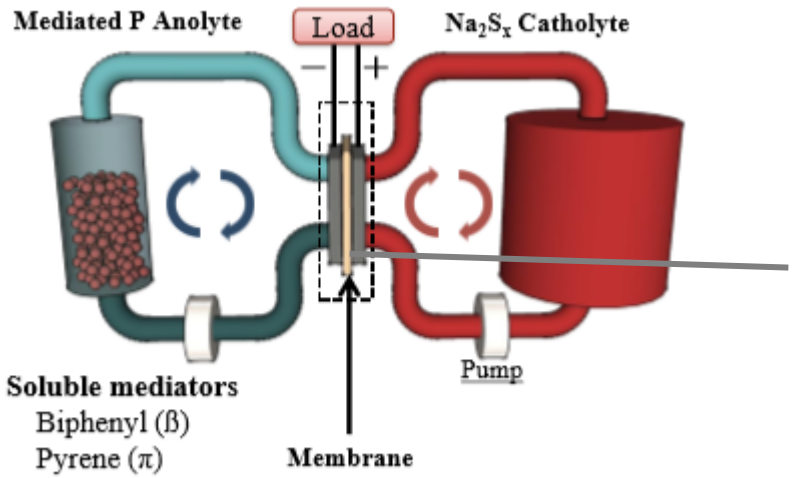
Testbeds:

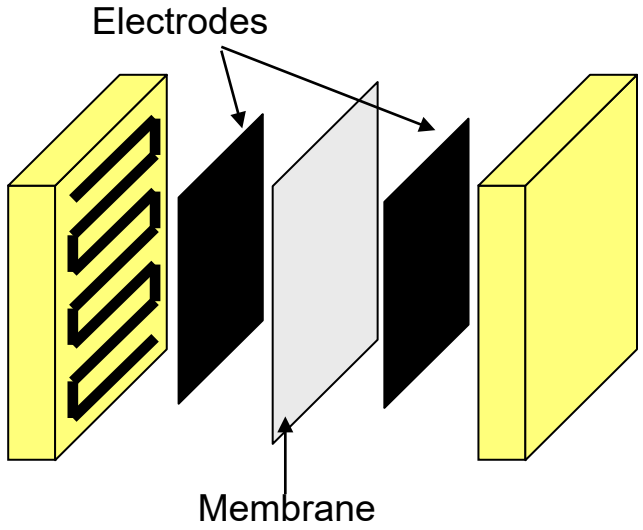
Southern Research Testbed

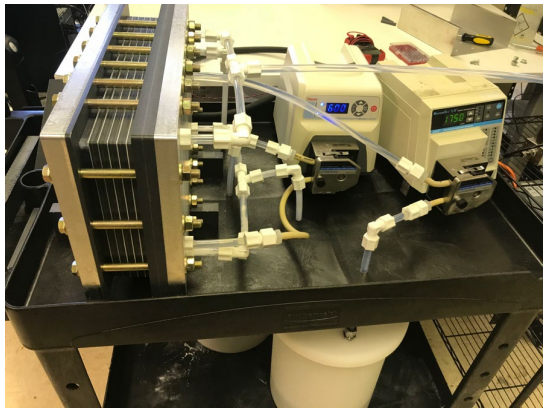
- Cory Tyree

(Southern Research Institute)

Materials and Components Research

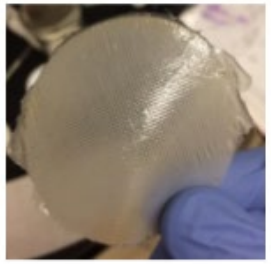




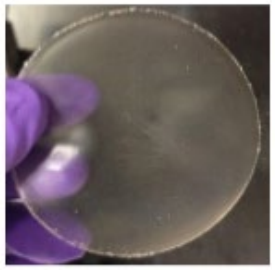


Pull-apart stack design

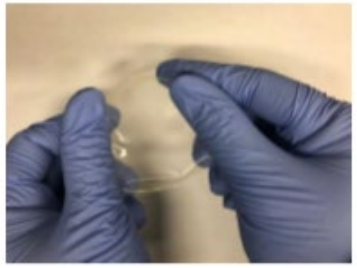
PEO-Glass Fiber Composite

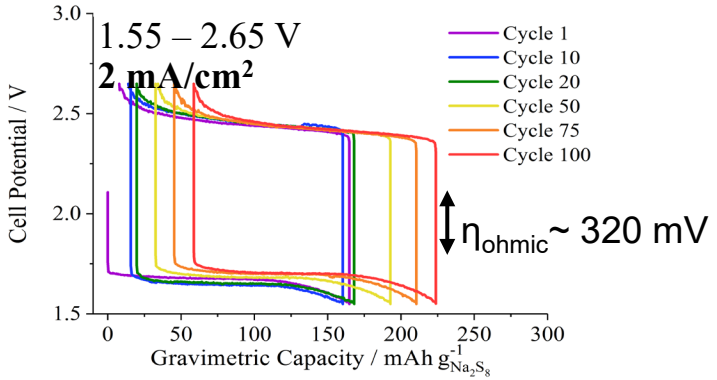


Crosslinked PEO



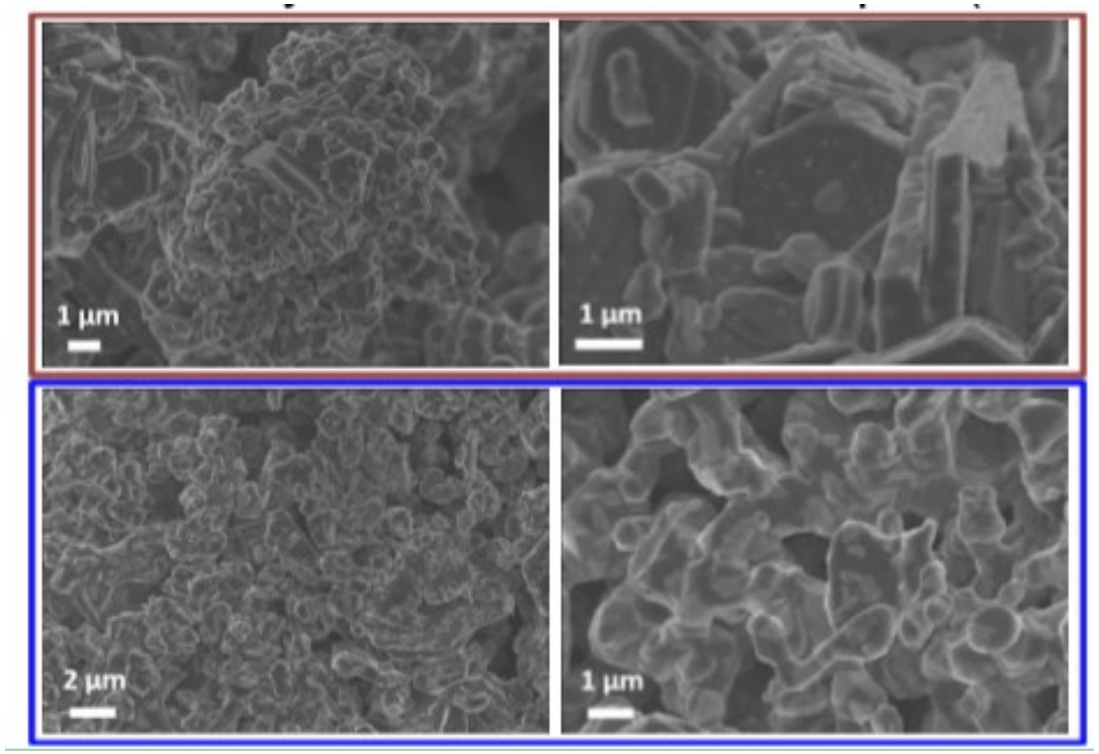
Stretchable Ionomer

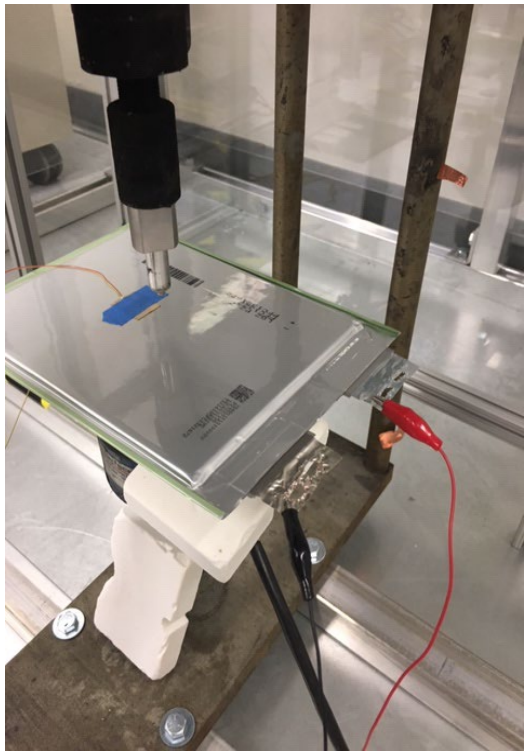


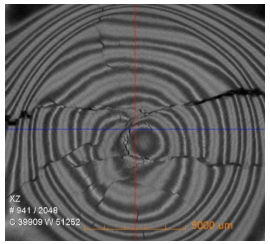


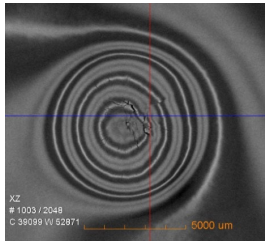
- Development and testing of new membranes.
- Investigation into electrodes
- Identified radical mediators to mediate reversible Na storage
- A custom redox flow cell was designed to demonstrate a mediated red phosphorus anode

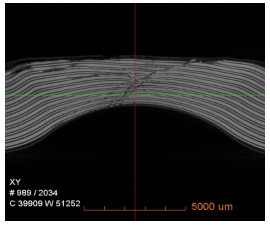
Manufacturing and Modeling

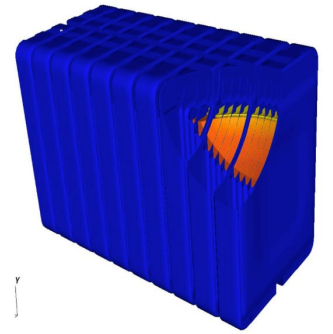


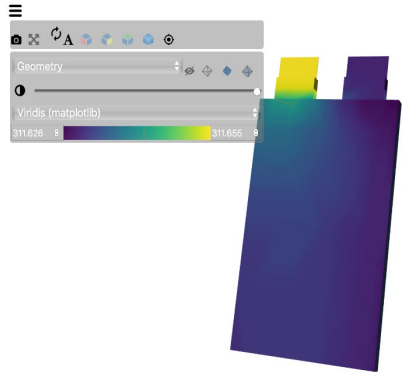












- Finding Methods to reduce the cost of manufacturing (new novel synthesis methods developed for sodium ion batteries)
- Establishing thermal runaway risk of different technologies and development of appropriate modeling and recognition approaches.

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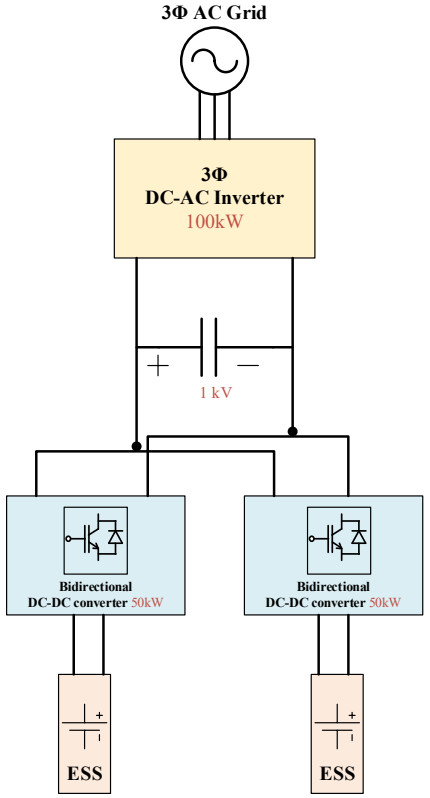
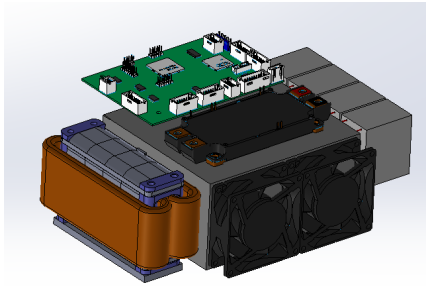
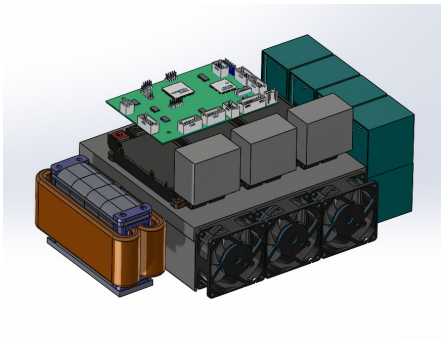
Systems Integration

New Energy Storage Technologies to Full Grid Connectable Prototypes







- Developing new approaches for energy storage (hybrid compressed air energy storage prototype)
- Working with industry partners to develop and deploy technologies (deployed a secondary use system with ORNL power electronics and integration software)
- Creating new techniques for integration of energy storage systems (new plug and play solutions)

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Program Output

Journals
11

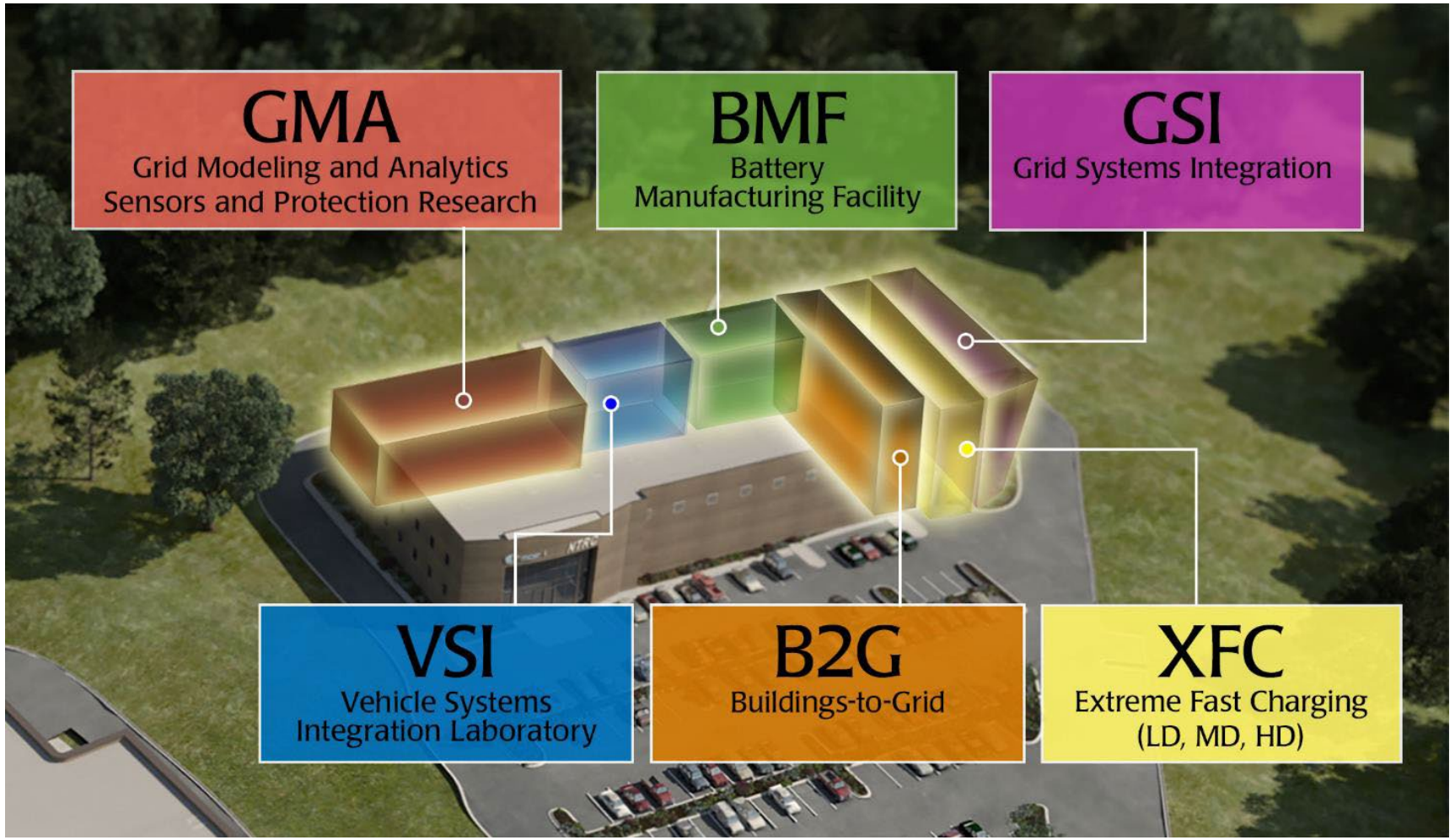
Conference
4

Talks
25

Intellectual Property
5

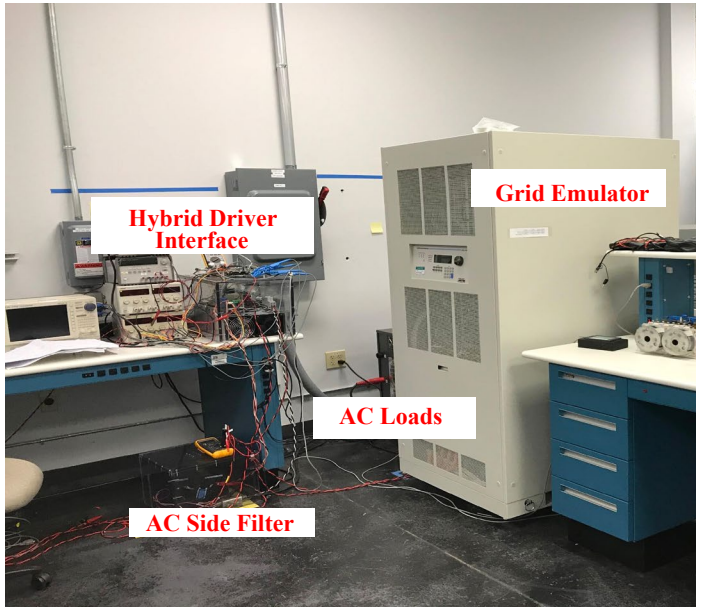
Additional ORNL Means for Supporting ES Progam

- Internal ORNL investments through LDRD processes
- Internal ORNL investments in new facilities
  - 52,000 sqft
- Cross program engagements to leverage funded work and push OE Program achievements



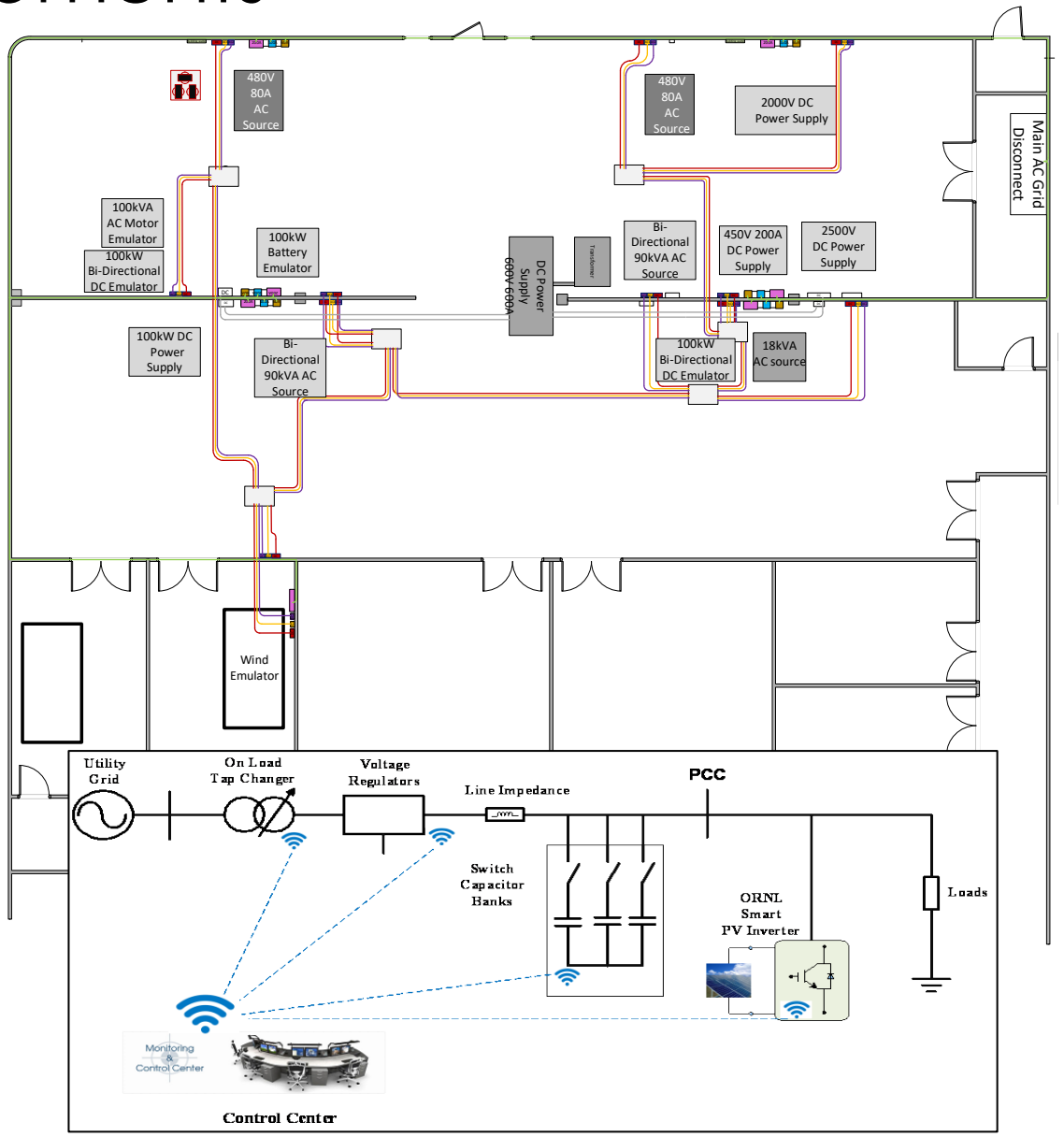
Example of Grid System Developments

- Hybrid AC/DC networks within the building
  - 2 x 480V networks
  - 1.5kV DC
- Grid Emulation exceeding 1MW with NHR and Ametek Grid Emulators.
- Device Characterization up to 10kV
- Distribution Line with actual equipment.
- Actual Loads Using building equipment and load emulators.



Initial PE prototype validation

PE Device Characterization



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Acknowledgments

- Department of Energy,
  - Office of Electricity, Dr. Imre Gyuk, Director of the Energy Storage Program
- Collaborators:
  - Industry, utilities, and universities
- Partner Laboratories
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  - Sandia National Laboratory
- ORNL team:
  - Jagjit Nanda, Tom Zawodzinski, Madhu Chinthavali, David Wood, Hsin Wang, Ayyoub Momen