Oak Ridge National Laboratory Energy Storage Program

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Energy Storage Research

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

Energy Storage + System Integration Technologies
Energy Storage System Technologies

Systems

Energy Storage System

Stack

Thermal Management

Battery Management Systems

Subsystems

Cathode, Anode Aqueous/Nonaqueous chemistries

Interfaces & Packaging, Passive Elements, Active Elements

Logic Controllers, Thermocouples Auxiliary Circuits Balancing Circuits Analytics

Components

ORNL Research Going Forward
Systems Integration of Energy Storage Technologies

**Systems**

**Application Specific Grid Interfacing System**

**Subsystems**

- **Power Stage**
  - Semiconductor Devices, Capacitors, Inductors & Transformers

- **Control & Protection**
  - Logic Controllers, Current & Voltage Sensors, Contactors, Circuit Breakers & Fuses, Auxiliary Circuits

- **Thermal Management**
  - Interfaces & Packaging, Passive Elements, Active Elements

- **Interface Integration**
  - Agent Systems, Communication Interfaces, Computational Platform, State Machines

**Components**

- ORNL Research (low -> high TRL)
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

**Industry Acceptance**
- **Systems Integration:** Secondary Use Development of a Battery Chemistry Agnostic Secondary Use Energy Storage System
  - Michael Starke

**Validated Safety and Reliability**
- **Establishing Safety Database:** Establishing Thermal Runaway Risk Test Protocols and Database – An ORNL and SNL Collaborative Research on Battery Safety
  - Hsin Wang

**Equitable Regulatory Environment**
- **Advanced Manufacturing:** Low-Cost, Durable Electrochemical Energy Storage for Electricity Grid Applications
  - David Wood

**Metals Air Batteries:** Development of Components and Cell Architectures for High Performance 'Open' Batteries for Grid Applications
- Tom Zawadinski

**Compressed Air Hybrid:** A near-isothermal-isobaric compressed gas energy storage combined with ground-level pumped-hydro storage
- Ayyoub Momen

**New Grid Interconnections:** Direct-Tied Medium Voltage Energy Storage System Development
- Madhu Chinthavali

**FY20:** $2.5M: 7 Projects
Energy Storage Projects Under DOE OE Energy Storage Program

Cost Competitive

- Sodium-Ion Based Flow Battery: Low Cost Membranes for High Energy Density Non-aqueous Redox Flow Batteries
  - Jagjit Nanda

- Sodium and Potassium Battery: Low Cost Anode and Electrolyte Materials
  - Ilias Belharouak

- Metal Air Batteries: Development Of Components and Cell Architectures for High Performance ‘Open’ Batteries for Grid Applications
  - Tom Zawadinski

Industry Acceptance

  - Michael Starke

- New Grid Interconnections: Direct-Tied Medium Voltage Energy Storage System Development
  - Madhu Chinthavali

- Simulation: Cell modeling of secondary use systems to understand life impacts following primary application
  - Sritkanth Allu

Validated Safety and Reliability

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

- New Sensing Concepts: Development of new paint that off gases with temperature
  - Hsin Wang

Equitable Regulatory Environment

- Advanced Manufacturing: Low-Cost, Durable Electrochemical Energy Storage for Electricity Grid Applications
  - David Wood

GOING INTO FY21: $2.5M: 9 Projects
Program Output

Conference Papers: 4
Journals: 11
Intellectual Property: 3
GRID-C Facility Crosscutting Research

**Vision:** accelerate the transition and deployment of early stage components to systems R&D to enable autonomous operation of the grid

**Cyber Security Research (DarkNet)**
Secure, resilient communications architecture for the grid.

**Grid Operations Analytics Laboratory**
Cyber-physical security, sensors, modeling, and data analytics test bed simulating a control room operation.

**Battery Manufacturing Facility**
Open-access DOE lab featuring materials synthesis, scale-up, roll-to-roll manufacturing, and prototyping vehicle and grid-level battery systems.

**Advanced Component Development Lab**
Sensors R&D platform, High voltage Semiconductors packaging and process development.

**1+ MW Hybrid AC-DC 480V, 1.5 kV Grid Network**
Future Substation, network of Micro grids
All power electronics grid research, Distributed energy resources, and energy storage, HIL platforms

**Advanced High voltage Component Characterization Lab**
High voltage component evaluation and transmission and sub-transmission scale PE-HIL test beds

**Electric Drive train Evaluation Facility**
Open-access DOE lab for LD, MD, HD vehicle drivetrain evaluation

**240/120 V Scale Grid**
Home and neighborhood emulation, transactive controls, and grid integration test beds.

**Medium Voltage Distribution Scale Grid**
Medium voltage PE interfaces, MV DC test beds

**Extreme-fast Charging**
Extreme-fast wired and wireless vehicle charging ecosystem and grid integration test bed.

**Vision:**

- Accelerate the transition and deployment of early stage components to systems R&D to enable autonomous operation of the grid.
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