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INNOVATION X LAB

ENERGY STORAGE SUMMIT

DOE System Test Facilities – Grid Storage

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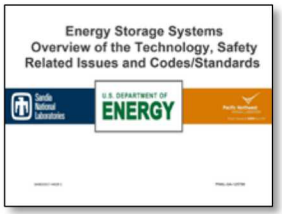
Grid Storage Testing

- **Challenge:** Customers and regulators must have confidence that new technologies can meet performance expectations safely and reliably
- **Approach:** Provide the physical infrastructure and technical knowledge for trusted third-party analysis of energy storage technologies and systems
- **Innovation:** The scale of DOE labs wide capabilities are significant. Leveraging this investment in facilities and personnel accelerates the development and integration of energy storage technologies in the grid

Grid Storage Testing: What is Needed?



Cell/System Testing

- Physical model parameterization for control design
- Duty-cycle application and performance analysis
- Third-party validation of technical performance

Safety and Reliability

- Diagnostics during battery failure
- Electrical, thermal, mechanical abuse testing
- Failure propagation testing on batteries/systems
- Large scale thermal and fire testing
- Systems engineering safety/reliability analysis

Standards and Protocols

- Duty-cycle development using use-statistics and technoeconomic modeling
- Development of national/international standards (NPFA, UL, CSA, IEEE, IEC, ICC)
- Development of new testing protocols for accelerated standards development

Cell/System Testing Facilities in the DOE System

Sandia National Labs

Energy Storage System Analysis Facility

Cells/Modules Testing:

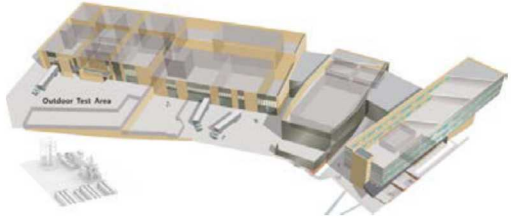
- Battery to module performance analysis
- Cell reliability and performance analysis
- High precision testing for cycle-life assessment

Systems:

- Scalable from 5 KW to 1 MW, 480 VAC, 3 phase
- 1 MW/1 MVAR load bank for either parallel microgrid, or series UPS operations
- Sub-cycle metering in feeder breakers for system identification and transient analysis
- Thermal imaging

National Renewable Energy Lab

Energy Systems Integration Facility



Systems:

- Research Electrical Distribution Bus (REDB)
- Thermal Energy Distribution Bus
- Supervisory Control and Data Acquisition (SCADA)
- 13.2 kV or 480 Vac PHIL Grid Simulation 2 x 1 MVA
- Power Hardware in the Loop DC Power Supply for vehicle load or battery emulation 660kW

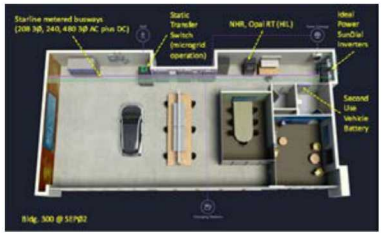
Capabilities:

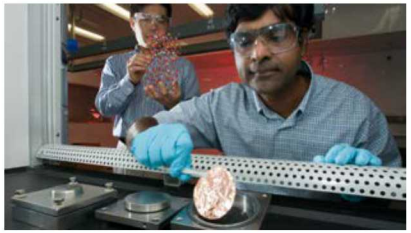
- Visualization and Analysis
- Data and Communications

Cell/System Testing Facilities in the DOE System

Argonne National Lab

Battery Testing at Argonne





Cells/Modules:

- The facility has 250 test channels and 59 environmental chambers
- Test channels span current range of ±10 nA to 1000 A and an upper voltage range of 6 to 900 V
- Testing equipment is modular. Power supplies and loads can be used in series or in parallel to accommodate the needs of the test
- EIS measurements

Smart Energy Plaza:

- Develop communication, control and market strategies for VGI that provide benefits to customers and business
- Common integration platform integrates the network of EVSE, PV, building systems and energy storage
- Multi-national automotive OEMs, charging equipment suppliers and utilities

Brookhaven National Lab

Energy Storage Testing Capability

Long Island Solar Farm

- 32 MWp commercial power plant
- ~200 acres

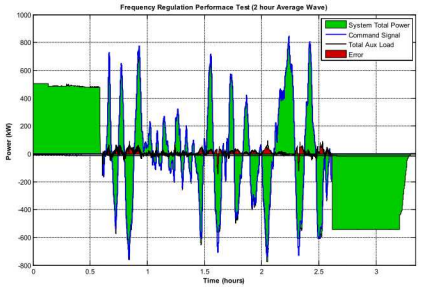
Solar Test Array for Testing Energy Storage :

- 1 MW Solar Array
- Segmentable
- Pads for energy storage integration
- ads for load simulator
- **Connected to BNL Grid**
- “behind the meter”
- 13.8 kV voltage
- 20 MW feeder (>50 MW utility system)

DOE Lab Testing Examples

Transpower 1MW/0.4MWh Lithium-Ion BESS

Install BESS at a DOE Lab (Sandia Test Pad)



Apply a performance testing protocol developed by DOE

Metric	Performance
Tracking Error RMS	22.5 kW
Tracking Error RMS %	2.3 %
Alt. % of time signal is tracked	73.5%

Derive advanced performance metrics from experimental data

Safety is critical to the full utilization of batteries on the grid.

The Lack of Safety:

Endangers Life
Loss of Property
Damages Reputation
Decreases Confidence in Storage




Consumer Cells (0.5-5 Ah) → Large Format Cells (10-200 Ah) → Transportation Batteries (1-50 kWh) → Utility Batteries (MWh)

Safety issues carry greater weight with increasing battery size

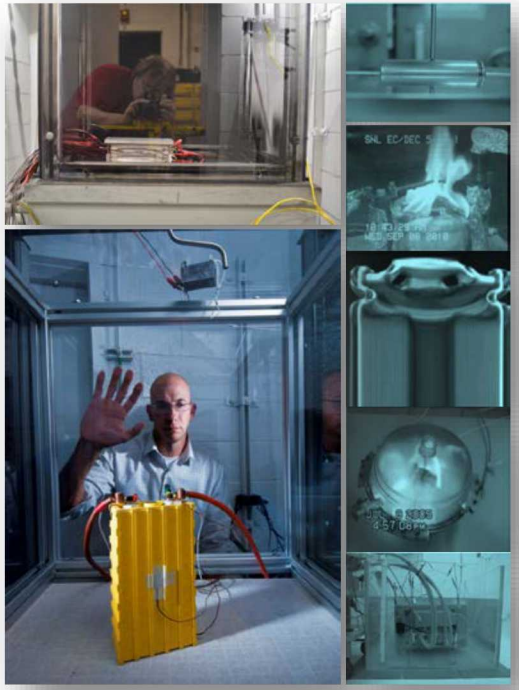
Image Credits
www.ford.com; www.samsung.com
www.saftbatteries.com

Safety and Reliability Testing Facilities in the DOE System

Understanding and preventing thermal runaway in emerging battery technologies.

Informing the development of new safety standards to integrate batteries in the grid infrastructure.

Cell and Module Testing
Battery Abuse Testing Laboratory



Battery Pack/System Testing
Thermal Test Complex

Battery Calorimetry

Development of Standards and Protocols

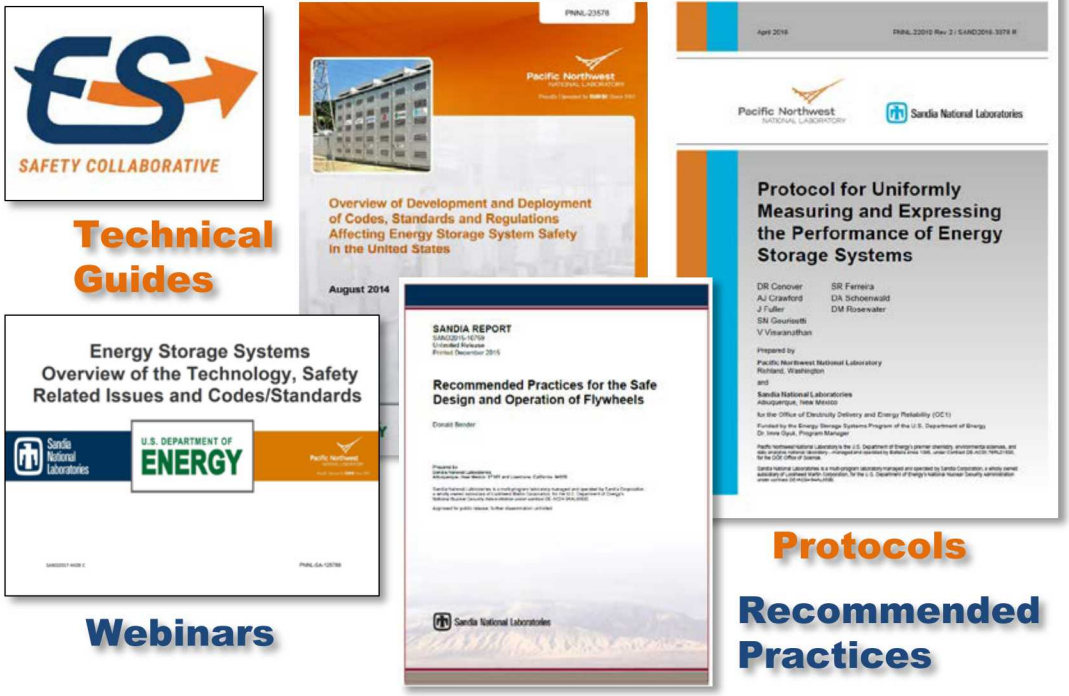
Energy Storage Performance and Safety Standards

The national laboratories work closely with industry on the development of new standards.

Labs first develop protocols which serve as the technical foundation of the industry standards.

Energy Storage Collaborative

www.sandia.gov/energystoragesafety-ssl/



DOE Global Energy Storage Database
www.energystorageexchange.org

DOE OE Grid Energy Storage Program Website
www.sandia.gov/ess
DOE Energy Storage Safety Collaborative Website
www.sandia.gov/energystoragesafety

Additional Resources
ANL – Energy Storage Program
www.anl.gov/ime/energy-storage
LBNL – Energy Storage and Distributed Resources
eta.lbl.gov/about-us/organization/esdr
NREL – Energy System Integration Facility (ESIF)
www.nrel.gov/esif/
PNNL – Energy Storage Program
energystorage.pnnl.gov/
ORNL – Energy Storage Program
www.ornl.gov/content/energy-storage
SNL – Energy Storage Program
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