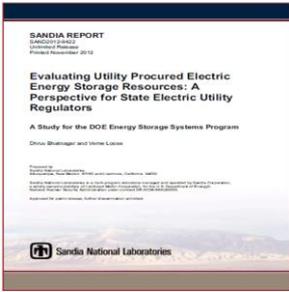
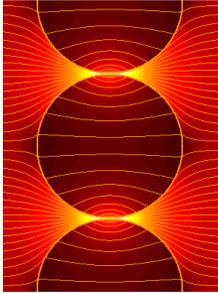


Energy Storage System Safety – Codes & Standards



David Rosewater

Presentation for
EMA Energy Storage Workshop

Singapore

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service
in the
national
interest*



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- **Guide to Safety in Utility Integration of Energy Storage Systems**
 - The ESIC is a forum convened by EPRI in which electric utilities guide a discussion with energy storage developers, government organizations, and other stakeholders to facilitate the development of safe, reliable, and cost-effective energy storage options for the utility industry.

Safety Standards & Certification

ESS System Safety Prescription

ESS
Components

Complete
Systems

ESS Installation

ESS
Commissioning

ESS O&M

Incident
Response

Structure of safety management in the ESS integration process

Energy Storage System Safety Standards

Energy Storage System Components



U.S. DEPARTMENT OF
ENERGY



Energy Storage System Components	Standard
Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures	UL 489
Electrochemical Capacitors	UL 810A
Lithium Batteries	UL 1642
Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources	UL 1741
Batteries for Use in Stationary Applications	UL 1973

Energy Storage Systems Standards



U.S. DEPARTMENT OF
ENERGY



Energy Storage System Type	Standard
Stationary Energy Storage Systems with Lithium Batteries – Safety Requirements (under development)	IEC 62897
Flow Battery Systems For Stationary Applications – Part 2-2: Safety requirements	IEC 62932-2-2
Recommended Practice and Requirements for Harmonic Control in Electric Power Systems	IEEE 519
Standard for Interconnecting Distributed Resources with Electric Power Systems	IEEE 1547
Recommended Practice and Procedures for Unlabeled Electrical Equipment Evaluation	NFPA 791-2014
Outline for Investigation for Safety for Energy Storage Systems and Equipment	UL 9540

ES Installation Standards



Energy Storage Installation	Standard
Transportation Testing for Lithium Batteries	UN 38.3
Safety of primary and secondary lithium cells and batteries during transport.	IEC 62281
Shipping, receiving and delivery of ESS and associated components and all materials, systems, products, etc. associated with the ESS installation.	DOT Regulations
Worker safety	Federal and state OSHA
Competency of Third Party Field Evaluation Bodies	NFPA 790
Fire and smoke detection	NFPA 1, NFPA 101, NFPA 5000, IBC, IFC, state and local codes
Fire suppression	NFPA 1, NFPA 13, NFPA 15, NFPA 101, NFPA 850, NFPA 851, NFPA 853, NFPA 5000, IBC, IFC, state and local codes
Fire and smoke containment	NFPA 1, NFPA 101, NFPA 5000, IBC, IFC, state and local codes

ES Installation *(continued I)*



Energy Storage Installation	Standard
Ventilation, exhaust, thermal management and mitigation of the generation of hydrogen or other hazardous or combustible gases or fluids	NFPA 1, IEEE/ASHRAE 1635, IMC, UMC, state and local codes
Egress (operating and emergency)	NFPA 1, NFPA 101, NFPA 5000, IBC, IFC, state and local codes
Access (operating and emergency)	NFPA 1, NFPA 101, NFPA 5000, IBC, IFC, state and local codes
Working space	OSHA 29 CFR 1910.305(j)(7) and OSHA 29 CFR 1926.441 (if applicable), NFPA 70E, Article 320
Physical security	NFPA 1, NFPA 101, NFPA 5000, IBC, IFC, state and local codes
Illumination (operating and emergency)	NFPA 1, NFPA 101, NFPA 5000, IBC, IFC, state and local codes

ES Installation *(Continued II)*



Energy Storage Installation	Standard
Fire department access	NFPA 1, NFPA 101, NFPA 5000, IBC, IFC, state and local codes
Anchoring and seismic protection	NFPA 5000, IBC, state and local codes
Buildings, enclosures and protection from the elements	IEC 60529, UL 96A, NFPA 5000, IBC, state and local codes
Signage	ANSI Z535, IEEE C-2, NFPA 1, NFPA 70E, NFPA 101, NFPA 5000, IBC, IFC, state and local codes
Emergency shutoff	IEEE C-2, NFPA 1, NFPA 101, NFPA 5000, IBC, IFC, state and local codes
Spill containment, neutralizing and disposal	NFPA 1, IPC, UPC, IFC, IEEE1578, state and local codes
Electrical safety	IEEE C-2 (National Electrical Safety Code), NFPA 70E, FM Global DS 5-10, DS 5-1, DC 5-19
Communications networks and management systems	IEC 61850



Commissioning Standards

Energy Storage Commissioning	Standard
Recommended Practice for Commissioning of Fire Protection and Life Safety Systems	NFPA 3
Building and Systems Commissioning	ICC 1000

ES Operation and Maintenance

Energy Storage Operations and Maintenance	Standard
Hazardous materials storage, handling and use	NFPA 400
Standard on Maintenance of Electrical Equipment	NFPA 70B

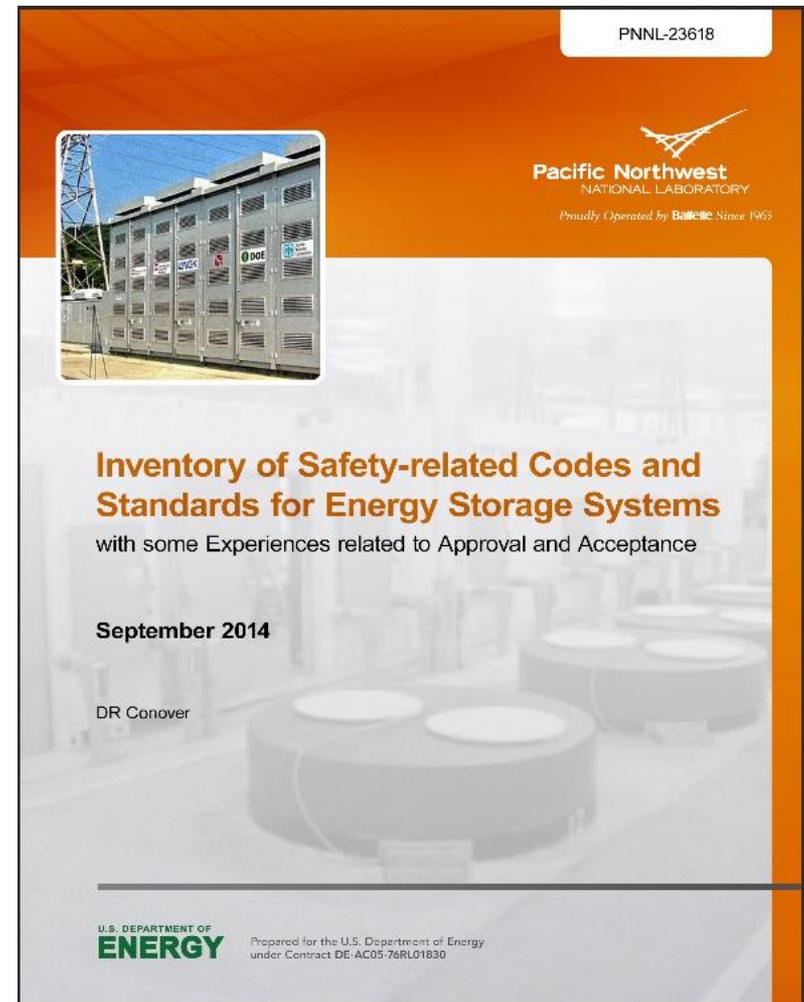


Incident Preparedness Standards

Incident Preparedness	Standard
Standard for Technical Rescuer Professional Qualifications	NFPA 1006
Standard for Fire Fighter Professional Qualifications	NFPA 1001
Standard for Fire Department Occupational Safety	NFPA 1500
Standard System for the Identification of the Hazards of Materials for Emergency Response	NFPA 704
Guide for Substation Fire Protection	IEEE 979
Fire Fighting	Emergency Planning and Community Right-to-Know Act (EPCRA)
Fire and Explosion Investigations	NPFA 921
Fire Safety Concepts Tree	NFPA 550

Inventory of Safety Codes and Standards

- Complete as of September 2014 for US and many international Safety CSRs
- Not eclectic utility specific
- Organized by the same integration stages



Certification

Note: *Sandia does **NOT** participate in Energy Storage device/equipment/system certification.*

- 3 US Certification Companies: (In no specific order)
 - DNVGL
 - Intertek
 - UL

Certification Challenges

Complex System → Complex Investigation

- Challenges to Testing
 - Large systems present a challenge to testing
 - Multiple labs may be required for testing
 - Environmental chamber limitations
 - Availability of samples for testing
 - Fire Testing
 - Lab safety
 - Unique/New chemistries may present a challenge
- Challenges to construction review
 - Stakeholders unfamiliar with process
 - FMEA
 - Functional Safety
 - Components without appropriate
 - Certifications/ratings
 - Determine cells are within operating region
 - Obtaining necessary information to determine compliance





Certification Combined with Hazard Analysis and Testing

- Code compliance is primarily focused on standardization
- Compliance alone will not guarantee system safety
- Only a combination of hazard analysis and code compliance will enable risk to be factored into business decisions

Thank you!

Additional recourses available at:

<http://www.sandia.gov/ess/safety.html>

Appendix

Codes/Standards

Extended & Facilitated Discussion

D. Rosewater Presentation

EMA Technical Workshop

- Construction Criteria
 - Materials
 - Enclosures
 - Electrical Spacings
 - Electrical Wiring and Controls
 - FMEA and Functional Safety
 - Thermal management systems
 - Cells and electrochemical capacitors
 - Lithium ion, nickel, sodium, LA, flow, electrochemical capacitors
 - Marketing and Instructions
- Tests
 - Electrical
 - Overcharge
 - Short Circuit
 - Overcharge Protection
 - Imbalanced Charging
 - Temperature
 - Dielectric Withstand
 - Grouping Continuity
 - Failure of Cooling/Thermal Stability System
 - Mechanical Tests
 - Enclosure Tests
 - Drop Test
 - Environmental Tests
 - External Fire
 - Internal Fire
 - IP Exposure Tests

UL Subject 9540

■ ES Technology References

- Batteries
 - UL 1973
- Electrochemical Capacitors
 - UL 1973 and UL 810A
- Fuel Cell Systems
 - CSA-America FC1
- Hydrogen Storage and Equipment
 - NFPA 2 (ISO 22734-1, -2)
- Engine Generators
 - UL 2200
- Flywheels
 - SAE, AIAA, ISO

■ Equipment Standard References

- Inverters
 - UL 1741, IEEE 1547 series
- Electrical Equipment
 - NFPA 70, IEEE C2
- Functional Safety
 - IEC 61508, IEC 60730-1, UL 991/1998
- Pressure Vessels
 - ASME B & PV Code
- Piping Systems
 - ASME B31 series
- Hazardous Locations
 - NFPA 70, NFPA 497

Impact on UL Standards Development

- UL Standards development process is ongoing
 - Not subject to a specific development schedule
 - Proposals can be submitted for review and balloting at any time
 - Lessons learned from certification experience may impact standards development
- UL New & Innovative Investigation Program
 - New technology/product
 - No current published requirements
 - Development of requirements through discussions
 - Client
 - UL Technical Staff
 - UL Councils

Certification Programs

- **Disclaimer:** SNL and DOE DO NOT do certifications.
- UL ES Certification Programs
 - UL Certification Programs including evaluation and ongoing production evaluation
 - UL 1973
 - BAFX, BAFX7. BAFX8
 - UL Subject 9540
 - To be set up after publication
- UL Field Evaluation Program
 - Applied to one product (not ongoing production)
 - Often conducted after installation of production
- IEC EE Certification Program
 - CB Scheme
 - Applied to IEC standards determined to be part of the CB Scheme
 - Does not include ongoing production inspections
 - CE marking is a manufacturer's self declaration
 - ETF13 BATT
 - IEC 62133
 - IEC 60896-1
 - IEC 60896-21
 - IEC60896-22
 - (IEC 62619, 62485-2, etc.)
 - Includes IEC 62282 fuel cell standards
 - CE marking is mfg.'s self cert. mark

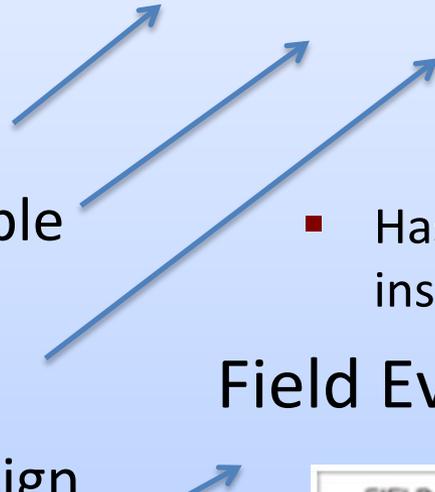


UL Certification Options

Is the Energy Storage System –

Regular UL Listing or Recognition

- Part of a family of systems?
- Intended for multiple locations?
- A modular design?
- A one of a kind design intended only for one site?



- Has ongoing production inspections



Field Evaluation



- Is a one time event