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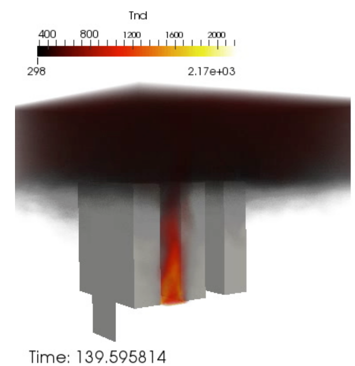

Energy Storage System Overview: Addressing System Safety for Code Officials and First Responders

4/7/2016

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U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

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Energy Storage System Overview and Addressing System Safety

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- Purpose - to acquaint code and fire officials with energy storage systems (ESS) so they ….
  - understand and can follow ESS technology development and deployment
  - are better prepared to review and assess ESS installations today and in the future
  - can consider future changes to codes and standards intended to address energy storage systems

- Expected outcomes
  - a better understanding of ESS technology
  - enhanced ability to review of ESS technology and its installation
  - knowledge to help guide revisions to codes and standards
  - safer deployment of ESS
  - ability to better address incidents associated with ESS installations

Agenda

- Introduction to energy storage system technology
- Overview of energy storage system applications
- Examples of energy system installations in buildings
- Overview of codes and standards provisions related to energy storage systems
- Overview of incident response issues
- Summary and key takeaways
- Q/A

Background and Foundation

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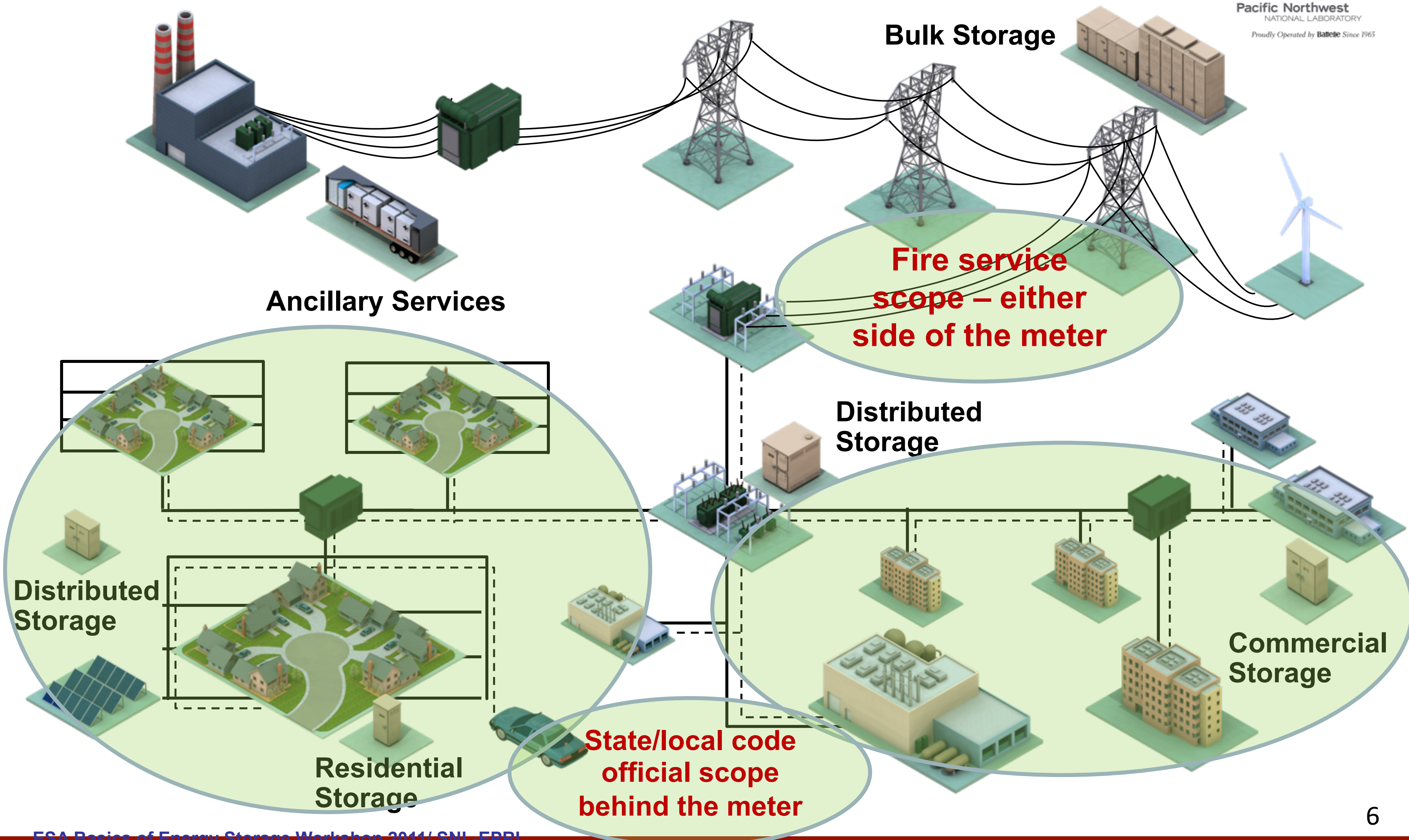
- Batteries are one of many energy storage technologies
- Energy storage systems may involve batteries
- There are a wide range of battery types and chemistries
- You have likely been involved in the review and approval of lead acid and possibly Li-Ion stationary battery installations
- The I-Codes and referenced standards like the NEC provide criteria for more traditional battery types and chemistries
- Referenced test standards (e.g. UL, NEMA, ASME, etc.) address some and are evolving to address other ESS technologies
- You will likely see new types of batteries, new chemistries and beyond that more types of energy storage systems in the future

Energy Storage Deployment



Energy Storage Technologies

Energy

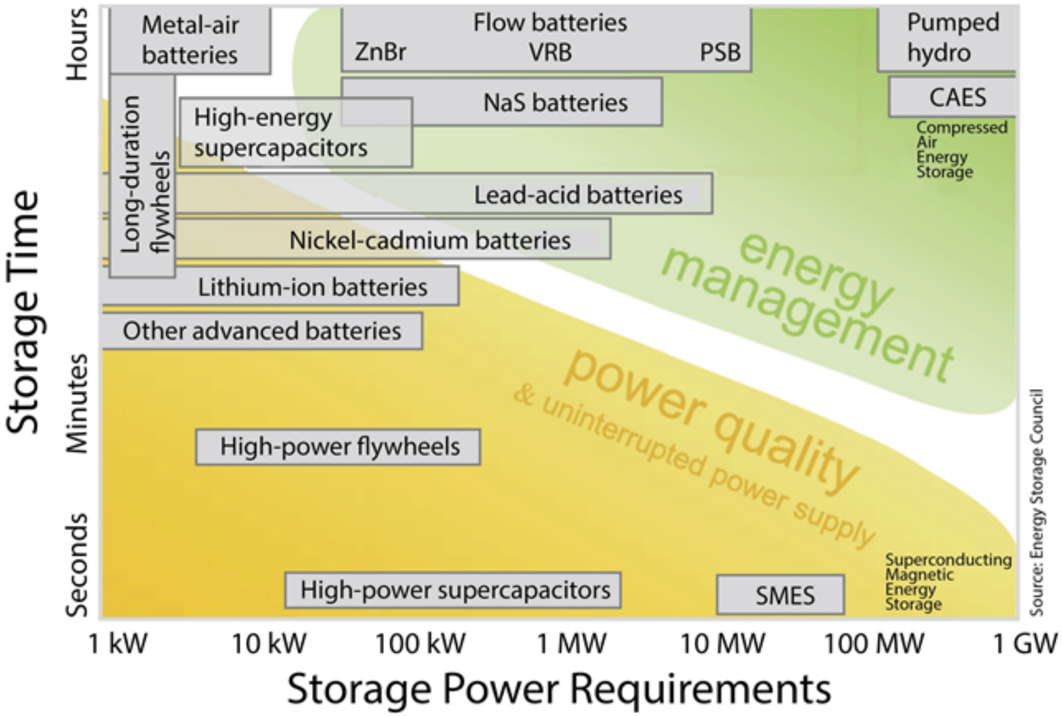
- Pumped Hydro
- Compressed Air Energy Storage (CAES)
- Batteries
  - Sodium Sulfur (NaS)
  - Flow Batteries
  - Lead Acid
  - Advanced Lead Carbon
  - Lithium Ion
- Flywheels
- Electrochemical Capacitors

Power

Two regimes, multiple technologies:

Power – short discharges (sec to min): flywheels, capacitors, SMES, some batteries

Energy – long discharges (min to hr): batteries, H_2 fuel cells, CAES, pumped hydro



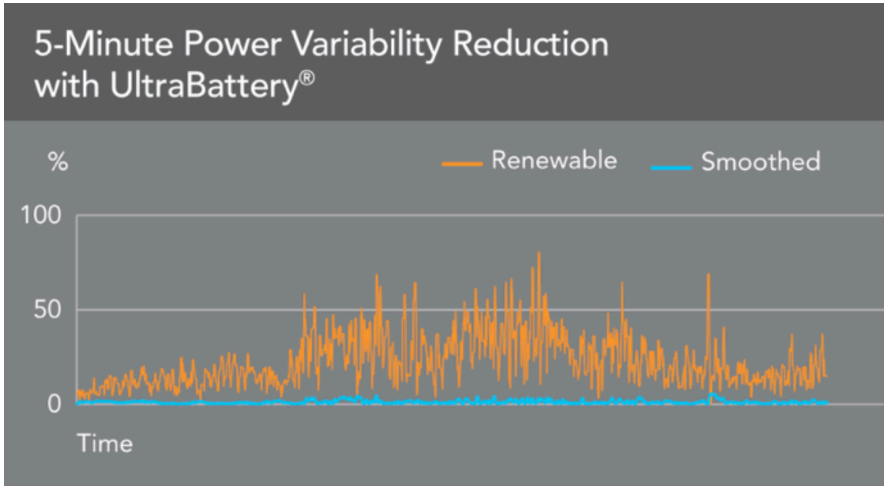
SOURCE – SANDIA NATIONAL LABORATORIES

Uses of Energy Storage

Backup Power:

Short duration (seconds)-systems to maintain power until other power sources can be activated (generator).

Long duration (hours)-maintaining power throughout the black or brown out.

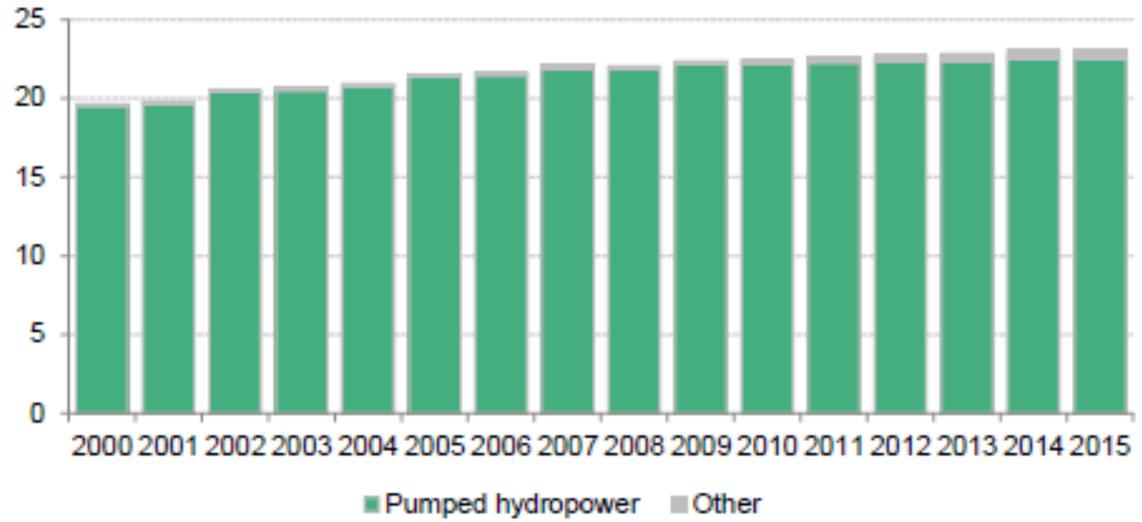


Renewables Integration:

Energy storage can provide support or renewable energy through decreasing curtailment and upstream perturbations such as smoothing, firming, schedule management and time shifting

SOURCE – SANDIA NATIONAL LABORATORIES

US Energy Storage Deployment in MW



- Pumped hydropower storage projects account for over 97% of installed energy storage capacity in the US.
- As of October 2015, FERC counted three pending licenses for further pumped storage projects, totaling 1,640MW in new capacity. The largest project is a 1,000MW closed-loop facility in Utah, and the other are closed-loop facilities in Montana (400MW) and New York (240MW).
- State-level energy storage mandates or solicitations generally exclude pumped storage.

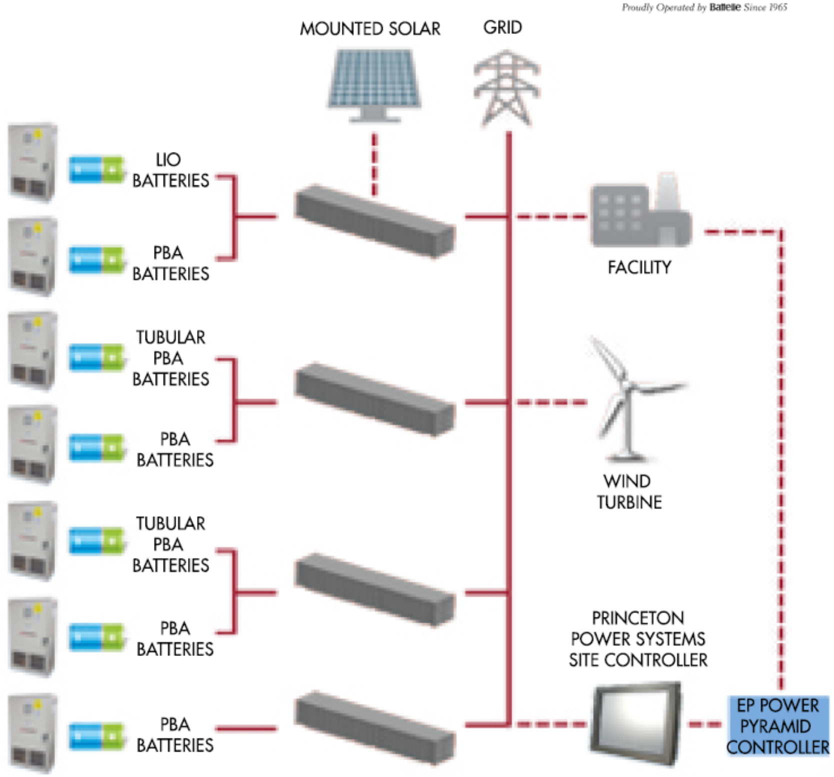
Source – EIA, FERC, Bloomberg New Energy Finance

Examples of Energy Storage Applications in Buildings – Emerson Network Power

- Five UPS ESS
- Typically 480 VAC
- Available 208 to 600 VAC I/P
- Many different O/P voltages available

Examples of Energy Storage Applications in Buildings – Princeton Power

- Adjacent a parking structure
- Containerized
- Used in conjunction with PV
- Shift electric vehicle charging to off peak



Examples of Energy Storage Applications

Iron Edison - 700Ah 24V Nickel Iron PWP

This 700Ah 24V Nickel Iron battery is powered by 2.8kW of solar panels. This system utilizes the Apollo Solar Pre-wired Panel (PWP) with a 3200 Watt pure sine wave inverter, and dual 80 amp MPPT charge controllers.

Technology Type	Nickel Iron Battery
Rated Power in kW	17
Duration at Rated Power (HH:MM)	10:00.00
Weblink	**http://ironedison.com**

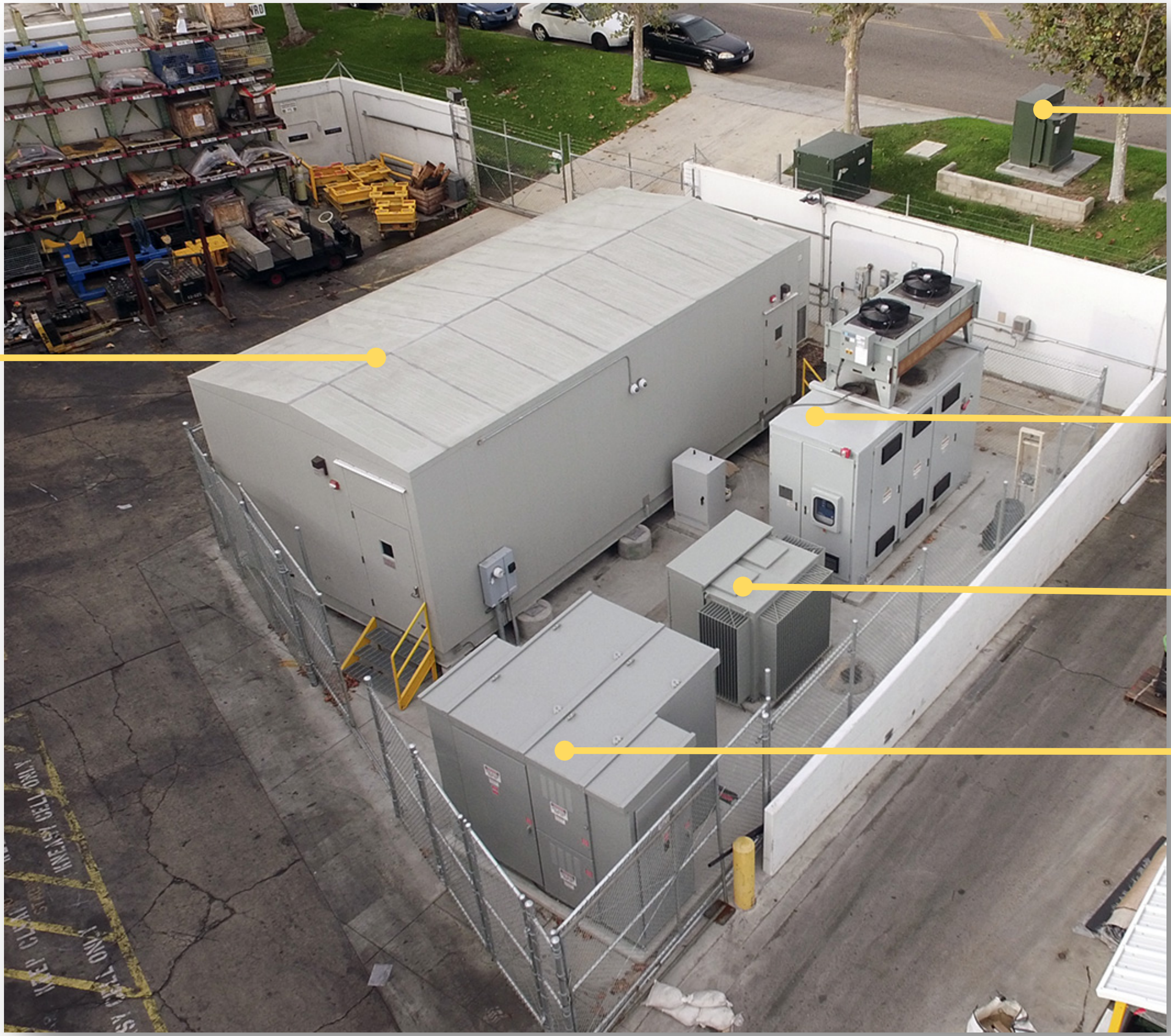
DOE ESS Database http://www.energystorageexchange.org/

Examples of Energy Storage Applications – SCE Distributed Integration (DESI) Pilot 1

- Installed to support overloaded 12kV distribution circuit
- Rated at 2.5MVA / 3.9MWh
- Located in dense urban area environment
  - Sited on customer easement
- Extremely compact system
  - Entire system fits within a 1,600 sq. ft. easement (including 12kV transformer, switchgear and protection)

Source - Southern California Edison

Examples of Energy Storage Applications – SCE DESI Site



Source - Southern California Edison

Database of Energy Storage Applications

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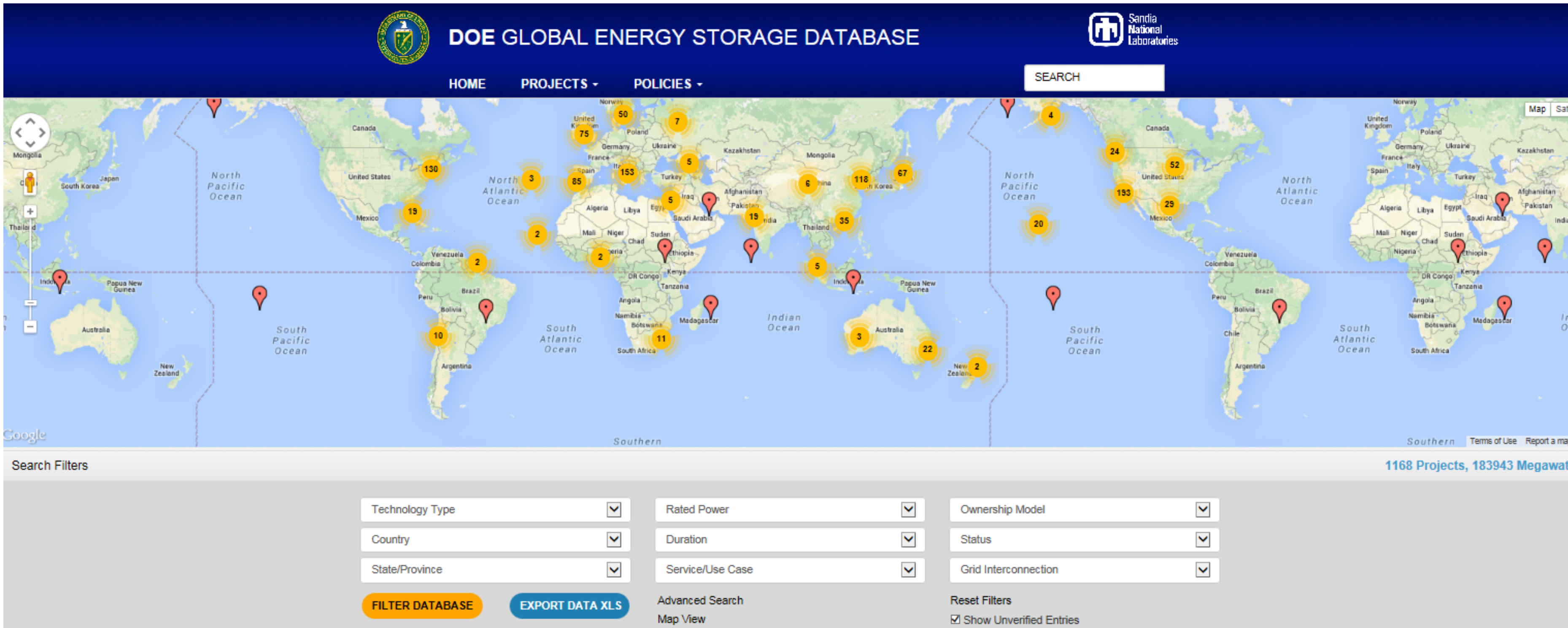
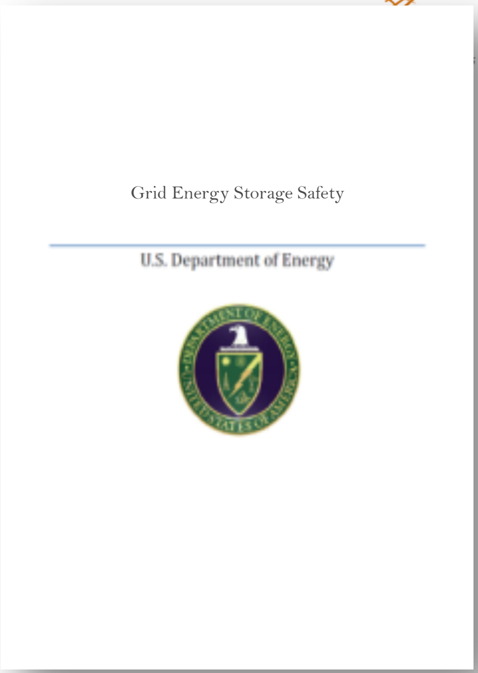


http://www.energystorageexchange.org/

DOE OE Strategic Plan on ESS Safety


Grid Energy Storage Safety

U.S. Department of Energy

Lack of standardized validation protocol

- Science based testing protocols are needed
- Validation protocols must link the materials and cell full systems integration into the grid
- Knowledge gained in testing and analysis must be back to develop new safer materials

Fostering incident preparedness

- Fire control systems, e.g. fire suppression materials need to be identified for each storage technology
- First responders education
- Post-incident response

Incomplete and dispersed codes, standards and regulations (CSR)

- The CSR's for energy storage a dispersed throughout many sources (NFPA, IEEE, ICC, UL, etc.). There is currently no centurial index of all the CSR's
- The CSR's need continual updating due to rapid advances in storage technologies and new citing locations

Energy Storage Safety Working Group Scope of Work

Focused on the safety of all stationary ESSs, and projects to address the gaps identified are going to be organized and conducted through coordinated actions focusing on the priority gaps identified by the ESSPT in each of three ESSWG areas:

- *Safety Validation and Risk Assessment*
- *Codes and Standards*
- *Safety Outreach and Incident Response*

"Facilitating the timely development and deployment of safe ESS by implementing the DOE ESS Safety Plan through collaboration of all interested parties and key stakeholders"

http://www.sandia.gov/ess/resources/energy-storage-safety/ess-safety-plan-overview/education-overview/

Safety Documentation

Current State

- Storage technologies are subject to federal, state and local legal requirements designed to protect workers, the public, and the environment
- Safety documentation ineffective in validating the safety of energy storage technologies
- Drafting effective safety documentation difficult
  - Various different stakeholders involved
  - Complex documentation required for each component, module, system, and deployment environment

Gap Areas

- Components of a system have individual CSR while similar documentation often does not exist for the systems as operational entities
- Safety regulations may differ across different municipalities
- Growing body of experience and results of other ESS Safety initiative activities must be transitioned into future CSR

Desired End State

- Safety documentation must be standardized and specific to each chemistry, component, module, and deployment environment of each type of system
- Energy storage industry participants must be aware of multiple sets of regulatory requirements as they relate to the various U.S. and international standards

Incident Preparedness

Current State

- Fire departments do not categorize ESS as stand-alone infrastructure capable of causing safety incidents independent of the systems which they support
- Energy storage industry expanding faster than correlating safety documentation (Codes, standards and regulations)

Gap Areas

- Fire control systems and ventilation
- Commodity classification
- First responder education
- Verification and control of stored energy
- Post-incident response and recovery

Desired End State

- Because of low frequency of energy storage incidents, wide variety of systems sizes and technologies, and deployment options there is a need to develop comprehensive emergency preparedness plans
- Education and training currently provided to first responders needs to be enhanced

Technology Takeaways

- Batteries are much more than just lead acid or Li Ion
- Batteries are a subset of energy storage
- Energy storage technology development is evolving at a considerable rate
- Energy storage technology deployment is increasing in scope, location and size of installation
- Economic incentives and increased use of renewables are spurring more demand for energy storage
- There is a need to ensure that energy storage system installations are safe

Energy Storage Hazard Identification

As an increasing number of energy storage systems are deployed, the risk of safety incidents increases.

Damage to Facilities

2012 Battery Room Fire at Kahuku Wind-Energy Storage Farm

- There were two fires in a year at the Kahuku Wind Farm
- There was significant damage to the facility
- Capacitors in the power electronics are reported to be associated with the failure

Impact to First Responders

2013 Storage Battery Fire, The Landing Mall, Port Angeles WA

- First responders were not aware of the best way to extinguish the fire
- The fire reignited a week after it was thought to be extinguished

Properties in Battery Systems that Can Develop Hazards

Voltage

Arc-Flash/Blast

Fire

Combustion

Toxicity

Voltage

The number of battery cells per string in grid energy storage can be higher than in mobile applications, resulting in higher DC voltage and a need for additional precautions. In the voltage range 100-1000V DC, the National Fire Protection Association (NFPA) standard 70E on electrical safety in the workplace establishes a limited approach boundary for unqualified workers at 1.0m. This boundary is to prevent those who are unable to avoid hazards from coming within arms reach of the exposed electrical conductors.

Source: NFPA70E

Properties in Battery Systems that Can Develop Hazards

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Voltage

Arc-Flash/Blast

Fire

Combustion

Toxicity

Arc-Flash/Blast

High string voltage affects both the potential for shock and the potential for arc-flash/blast. The equations below show the maximum power point method for calculating the incident energy in DC arc-flash. Incident energies calculated by this equation are described as "conservatively high" and other methods are being explored for calculating and classifying the potential harmful energy in a DC arc-flash. Arc-blast results from explosive components of an electric arc (e.g. vaporized copper) and depends greatly on the equipment and environment involved in the arc. Common controls to prevent injury from arc flash include increasing separation between positive and negative conductors, regular maintenance to prevent equipment failure, and arc-rated PPE for electrical workers.

$$I_{arc} = 0.5 I_{bf}$$

$$IE = 0.01 V_{sys} I_{arc} T_{arc} / (D^2)$$

Source: NFPA70E

Where:
Iarc = Arcing current (amps)
Ibf = System bolted fault current (amps)
IE = incident energy at a given working distance (cal cm^2)
Vsys = System voltage (volts)
Tarc = Arcing Time (sec)
D = working distance (cm)

Properties in Battery Systems that Can Develop Hazards

Voltage

Arc-Flash/Blast

Fire

Combustion

Toxicity

Fire

As a Fuel Source

Plastic burns, some electrolytes are flammable.

Thermal Runaway

Thermal runaway is chemical process where self-heating in a battery exceeds the rate of cooling causing high internal temperatures, melting, off-gassing/venting, and in some cases, fire or explosion. Thermal, mechanical, and electrical abuse can lead to thermal runaway; internal short circuit from manufacturing defects; or the development of metallic dendrites that form an internal short over time.

Source: David Rosewater, Adam Williams, Analyzing system safety in lithium-ion grid energy storage, Journal of Power Sources, Volume 300, 30 December 2015, Pages 460-471, ISSN 0378-7753

Properties in Battery Systems that Can Develop Hazards

Voltage

Arc-Flash/Blast

Fire

Combustion

Toxicity

Combustion

Hydrogen buildup from charging

Charging aqueous batteries can crack water into hydrogen and oxygen. Without proper ventilation this hydrogen can build up in an enclosed space. The Lower Explosive Limit (LEL) for hydrogen is 4% concentration in air. Battery system with this hazard are equipped with alarm systems.

Vent gas combustion from thermal runaway

Lithium-ion batteries undergoing thermal runaway can vent their internal contents in the form of gas. Without proper ventilation a combination of gasses can build up in an enclosed space. The Lower Explosive Limit (LEL) for this mixture can very. Oxygen starvation fire suppression in lithium-ion battery systems is not recommended.

Properties in Battery Systems that Can Develop Hazards

Voltage

Arc-Flash/Blast

Fire

Combustion

Toxicity

Toxicity

Smoke

Smoke can be toxic and smoke from batteries is no exception. Use of a positive pressure breathing apparatus is recommended whenever responding to battery system fires.

Liquid Electrolyte

Some flow-batteries contain electrolyte which can be toxic to the environment or to people. The MSDS should provide proper safety measures for handling and exposure. Liquid electrolyte can also be corrosive so avoid contact with the skin or eyes.

Safety through Codes and Standards

- Batteries are not new to buildings
- Energy storage includes batteries
- Many safety related issues are identical or similar to those associated with other technologies
- Some safety issues are unique to energy storage in general and others to particular energy storage technologies
- Current codes and standards provide a basis for documenting and validating system safety
  - prescriptively
  - through alternative methods and materials criteria

Safety-Related Issues

- ESS 'equipment' configuration and how safety validation is addressed
- New versus existing systems and new versus existing building applications
- Siting (location, loads, protection, egress/access, maximum quantities of chemicals, separation, etc.)
- Ventilation, thermal management, exhausts (when necessary, flow rates, etc.)
- Interconnection with other systems (electrical, any non-electrical sources)
- Fire protection (detection, suppression, containment, smoke removal, etc.)
- Containment of fluids
- Signage

Safety-Related Research

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Short term priorities identified

- Fire Suppression testing and analysis
- Thermal runaway research
- System scale burn test
- Commodity classification development
- Fire and vent gas modeling and analysis

Longer term priorities: as resources allow

- DC fusing recommendations
- How to handle stranded energy
- Access control guidance
- Guide to ESS safety analysis
- R&D to address gaps found in standards

Criteria to Address Safety

ESS System Safety

Analysis

- FMEA
- SSA

Prescription

- ESS Components
- Complete Systems
- ESS Installation
- ESS Commissioning
- ESS O&M
- Incident Response

Factors to Consider

- ESS technology type
- Chemistry of any batteries
- Location in relation to the built environment and public
- Size/capacity
- Anticipated natural and man made influences

Technical Issues

- The system - components and/or systems tested, listed and labeled
- The application – intended environment
  - Fire and smoke detection and fire suppression
  - Ventilation and exhaust
  - Access and egress
  - Electrical safety
  - Signage and fire department access
  - Spill control

Risk Analysis

- Failure Modes and Effects Analysis (FMEA) – ESS and components
  - Probability of failure and severity of failure where data exist
  - Qualitative determination of likelihood of failure
  - Design choices made to reduce the more risky aspects of the ESS
  - IEC 60812 and 61508
  - May include fault tree analysis (FTA) – IEC 61025

Analysis

FMEA

Risk Analysis

- System Safety Analysis (SSA) – Installation of the ESS
  - Assessment of surrounding events that could impact the safety of the ESS (e.g. seismic, external fire, etc.)
  - Taking action through design, construction considerations, commissioning and O&M to ensure a safe installation
  - Codes and standards memorialize needed actions when updated to address relevant safety issues

Risk Analysis

- Components of ESS or an entire ESS
  - Where tested, listed and labeled safety of the item should be addressed
  - Where not tested, listed and labeled an FMEA or assessment commensurate with unlisted equipment can document safety
- Installation and integration with the surrounding environment
  - Where tested, listed and labeled install per listing and as provided in applicable codes (e.g. IBC, IFC, IMC, NEC, etc.)
  - Where not tested, listed and labeled but covered in applicable codes install per FMEA/safety assessment and applicable codes
  - Where not tested, listed and labeled and not covered in applicable codes install per FMEA and SSA under alternative methods and materials

SMALL AND ISOLATED → **INCREASING SAFETY CHALLENGES** → **LARGE AND BUILDING INTEGRATED**

System Components

- Testing, listing and labeling batteries, inverters, controls, etc. to applicable standards
- Addresses just the component not their assembly as an ESS nor the installation of the ESS
- Standards listed provide examples that may or may not be vetted and is not a list of all standards

Prescription

ESS Components

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
Second Use Batteries	UL 1974 (proposed)
Recommended Practice and Procedures for Unlabeled Electrical Equipment Evaluation	NFPA 791

ES Systems

- Testing, listing and labeling to applicable standards
- Addresses the entire ESS but not the installation of the ESS
- Standards listed provide examples that may or may not be vetted and is not a list of all standards

Prescription

ES Systems

Standard for Interconnecting Distributed Resources with Electric Power Systems	IEEE 1547
Recommended Practice and Procedures for Unlabeled Electrical Equipment Evaluation	NFPA 791
Outline for Investigation for Safety for Energy Storage Systems and Equipment	UL 9540 (proposed)
Safety for Distributed Energy Generation and Storage Systems	UL 3001 (proposed)
Safety Standard for Molten Salt Thermal Energy Storage Systems	ASME TES-1 (proposed)

ES Systems – UL 9540

Prescription

ES Systems

Scope: Covers **energy storage systems** that are intended to store power or other sources and provide electrical or other types of energy to loads or power conversion equipment. The energy storage systems may include **equipment for charging**, **discharging, control, protection, communication, controlling the system environment, fuel or other fluid movement and containment**, etc. The system may contain other **ancillary equipment** related to the functioning of the energy storage system.

CONSTRUCTION

ES Systems – UL 9540

Prescription

ES Systems

PERFORMANCE

ES Systems – UL 3001

Scope: Covers the safety and performance of distributed energy resource systems. These systems may be comprised of distributed energy sources such as photovoltaic arrays or wind turbines in homogenous or hybrid configurations, energy storage systems, grid interface equipment and related equipment to accomplish functionality of the distributed energy system. These requirements address the safety of system design, integration and operation. They also cover the performance of these systems as it relates to grid operability, interface with premises wiring systems, and performance of the equipment in the various modes of system operation.

Prescription

ES Systems

ESS Installation

Prescription

ESS Installation

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Fire and Smoke Detection, Fire Suppression, Fire and Smoke Containment	NFPA 1, NFPA 13, NFPA15, NFPA 101, NFPA 850, NFPA 851, NFPA 853, IBC and IFC
Ventilation, Exhaust, Thermal Management and Mitigation of the Generation of Hydrogen or other Hazardous or Combustible Gases or Fluids	NFPA 1, IEEE 1635/ASHRAE 21, IMC
Egress and Access (normal operations and emergency), Physical Security and Illumination	NFPA 1, NFPA 101, IBC, IFC and local zoning codes
Electrical Safety, Emergency Shutoff, Working Space	NFPA 70 and 70E
Anchoring and Protection from Natural Disasters (seismic, flood, etc.) and the Elements (rain, snow, wind, etc.)	IEC 60529, IEEE 1375, UL 96A, IBC, IFC and NFPA 70
Signage	ANSI S535, NFPA 1, NFPA 70, NFPA 70E, NFPA 101, IBC and IFC
Spill Containment, Neutralizing and Disposal	NFPA 1, IPC, IFC, and IEEE 1578
Communications Networks and Management Systems	IEC 61850

Standards listed provide examples that may or may not be vetted and is not a list of all standards

ESS Installation – Single Standard

Prescription

ESS Installation

- Comments on a draft pre-standard are being incorporated into a revised draft document
- NFPA has officially filed a Project Initiation Notification (PINS) with ANSI for such a standard
- Interested parties could also apply for membership by going to http://www.nfpa.org/codes-and-standards/standards-development-process/new-projects-and-draft-documents/stationary-energy-storage-systems by March 1, 2016
- Further information can be obtained at http://www.nfpa.org/sess
- All comments and information submitted on this project will be addressed by the NFPA Standards Council at the next meeting April 5-6, 2016
- If approved the revised draft pre-standard is likely to be considered by a committee of NFPA developing this standard

ESS Installation – Single Standard

Prescription

ESS Installation

- Chapter 1 - Administration (scope, purpose, application, retroactivity, equivalency, units and formulas
- Chapter 2 - Reference standards (includes UL 9540)
- Chapter 3- Definitions
- Chapter 4 – General equipment configuration (general, self-contained/ prepackaged, pre-engineered, engineered/field constructed, repairs, additions, renewal/renovation)
- Chapter 5 – Siting (general, outdoor, rooftop, interior)
- Chapter 6 – Interconnections with other systems
- Chapter 7 – Ventilation and thermal management (general, ventilation air and thermal management, exhaust systems)
- Chapter 8 – Fire protection (fire and smoke detection, fire suppression, fire containment, removal of smoke, containment of fluids, signage
- Chapter 9 - Commissioning

ESS Commissioning and O&M

Prescription

ESS Commissioning and O&M

Recommended Practice for Commissioning of Fire Protection and Life Safety Systems	NFPA 3
Building and Systems Commissioning	ICC 1000
Hazardous materials storage, handling and use	NFPA 400
Supply Chain Best Practices	NEMA Guideline (under development)

Standards listed provide examples that may or may not be vetted and is not a list of all standards

Prescription

ESS Incident Preparedness

ESS Incident Preparedness

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

Standards listed provide examples that may or may not be vetted and is not a list of all standards

2017 National Electrical Code Summary (still in process)

- New Article 706 on Energy Storage Systems being considered
- General Criteria
  - Scope, Definitions and Precedence over other Articles
  - Components must be listed and pre-packaged self-contained systems can be listed as a complete ESS
  - Multiple systems are acceptable
  - Disconnecting means
  - Connection to other energy sources
  - ESS locations (ventilation, guarding of live parts, working spaces, egress and illumination)
  - Directory (schematic plaque)
- Circuit Criteria
  - Sizing and current
  - Overcurrent protection
  - Wiring (to and from)
  - Charge control

2017 National Electrical Code Summary (still in process)

- Electrochemical ESS
  - Installation of batteries
  - Battery and cell terminations
  - Battery locations
  - Vents
- Flow Battery ESS
  - General
  - Electrolyte classification and containment
  - Flow controls
  - Pumps and other fluid handling equipment
- Other ESS
  - General (consider same as a generator – Article 445)

2015 International Building Code Summary

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- Outside scope if owned/operated by a public service agency (utility)
- In scope if power supply including that for radio/TV
- Building official must release before connecting service utilities (but may need service utilities to fully check ESS)
- Stationary batteries are not Group H if they have safety venting caps and the area is vented per the IMC
- Group S includes dry cell battery storage

2015 International Building Code Summary

- ESS can serve as a source of required emergency power
- Hazardous materials
  - the type of ESS and maximum quantity triggers separation, ventilation, egress, alarm, width of service aisles, fire and smoke protection, etc. criteria
  - IFC refers to specific stationary storage battery criteria in Section 608 in lieu of Chapter 50 on hazardous materials
- Emergency and back up power installations to meet NFPA 110 and 111

2015 International Fire Code Summary

- Permit required if over 50 gallon liquid in a stationary storage battery
- ESS type and amount of materials used in the ESS may create hazardous materials designation
- Battery types defined
  - Lithium ion
  - Lithium metal polymer
  - Nickel cadmium
  - Nonrecombinant battery (H and O created are vented to outside air)
  - Recombinant (H and O are converted back to water inside the battery)
  - Stationary storage battery
  - Valve-regulated lead-acid (VRLA)
  - Vented lead-acid

2015 International Fire Code Summary

- Group H – does not include stationary batteries with safety venting caps and ventilation per the IMC
- Group S-2 – dry cell batteries
- Fire safety and evaluation plan
- Fire service features (consider as before but now include ESS)
- Emergency and standby power per NFPA 110 and 111
- Emergency lighting annual power test if battery-powered
- Stationary storage battery systems
  - over 50 gallons for flooded lead acid, Ni-Cd and VRLA or over 1,000 pounds for Li-Ion and LMP must meet Section 608
  - enclosure per the IBC
  - can be in open rack when in separate room
  - VRLA, Li-Ion or other sealed and non-vented can be in a work center if housed in noncombustible cabinet or other enclosure to prevent unauthorized access
- Hazardous materials provisions in Chapter 50 refer to Section 608

2015 International Fire Code Summary

TOPIC	SUMMARY OF REQUIREMENT
Safety Caps	Venting caps for **flooded lead acid** and **Ni-Ca** batteries Self-sealing flame-arresting caps for **VRLA** batteries None for **LI-ion** or **Li-metal** batteries
Thermal Runaway Management	Required for VRLA and Li-metal batteries (must be listed or other approved device)
Spill Control	Required for flooded lead acid and Ni-Ca batteries
Neutralization	Required for flooded lead acid, Ni-Ca and VRLA batteries
Ventilation	Required for flooded lead acid, Ni-Ca and VRLA batteries
Signage	Required for all five types (rooms and building as well as cabinets
Seismic Protection	Required for all five types per IBC
Smoke Detection	Required for all five types and install per IFC

ICC IFC Code Changes

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- Proposed code changes developed by FCAC ESS Task Group
- Re-organizing and re-locating current provisions in the IFC to a new chapter on energy systems
- Proposed changes sent to CSR WG IFC TG and input received provided to the FCAC ESS EG
- FCAC has voted on changes and they have been submitted to ICC
- Energy systems
  - General
  - Definitions
  - Emergency standby power
  - Solar PV
  - Fuel cells
  - Energy storage systems

ICC IFC Code Changes

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202, 0, 602.1

Proponent : Michael O'Brian (fcac@iccsafe.org)

2015 International Fire Code

Delete without substitution:

SECTION 202 DEFINITIONS

BATTERY SYSTEM, STATIONARY STORAGE.
A rechargeable energy storage system consisting of electrochemical storage batteries, battery chargers, controls, and associated electrical equipment designed to provide electrical power to a building. The system is typically used to provide standby or emergency power, an uninterruptable power supply, load shedding, load sharing or similar capabilities.

Revise as follows:

BATTERY TYPES.

Flow battery. A type of storage battery which includes chemical components dissolved in two different liquids. Ion exchange, which provides the flow of electrical current, occurs through the membrane while both liquids circulate in their own respective space.

Lead acid battery. A storage battery that is comprised of lead electrodes immersed in sulphuric acid electrolyte.

Lithium-ion battery. A storage battery with lithium ions serving as the charge carriers of the battery. The electrolyte is a polymer mixture of carbonates with an inorganic salt and can be in a liquid or a gelled polymer from. Lithiated metal oxide is typically a cathode and forms of carbon or graphite typically form the anode.

Lithium metal polymer battery. A storage battery that is similar to the lithium ion battery except that it has a lithium metal anode in the place of the traditional carbon or graphite anode .

Nickel cadmium (Ni-Cd) battery. An alkaline storage battery in which the positive active material is nickel oxide, the negative contains cadmium and the electrolyte is potassium hydroxide.

ICC IFC Code Changes

Pre-engineered stationary storage battery system. An energy storage system consisting of batteries, a battery management system, components and modules that are produced in a factory, designed to comprise the system when assembled and shipped to the job site for assembly.

Prepackaged stationary storage battery system. An energy storage system consisting of batteries, a battery management system, components and modules that is factory assembled and shipped as a complete unit for installation at the job site.

Sodium-beta storage battery. A storage battery also referred to as Na-beta batteries or NBBs which uses a solid beta-alumina electrolyte membrane that selectively allows sodium ion transport between a positive electrode such as metal halide and a negative sodium electrode.

Stationary storage battery. A group of electrochemical cells interconnected to supply a nominal voltage of DC power to a suitably connected electrical load, designed for service in a permanent location.

Valve-regulated lead-acid (VRLA) battery. A lead-acid battery consisting of sealed cells furnished with a valve that opens to vent the battery whenever the internal pressure of the battery exceeds the ambient pressure by a set amount. In VRLA batteries, the liquid electrolyte in the cells is immobilized in an absorptive glass mat (AGM cells or batteries) or by the addition of a gelling agent (gel cells or gelled batteries).

602.1 Definitions. The following terms are defined in Chapter 2:

BATTERY SYSTEM, STATIONARY ~~LEAD ACID~~ STORAGE.
BATTERY TYPES.
COMMERCIAL COOKING APPLIANCES.
CRITICAL CIRCUIT.
EMERGENCY POWER SYSTEM.
HOOD.
Type I.
Type II.
REFRIGERANT.
REFRIGERATION SYSTEM.
STANDBY POWER SYSTEM.

ICC IFC Code Changes

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R201 (New), , R327.1 (New), R327.2 (New), R327.3 (New), R327.4 (New), R327.5 (New), R327.6 (New)
Proponent : Michael O'Brian (fcac@iccsafe.org)

2015 International Residential Code

Add new definition as follows:

SECTION R201 DEFINITIONS

BATTERY SYSTEM, STATIONARY STORAGE. A rechargeable energy storage system consisting of electrochemical storage batteries, battery chargers, controls, and associated electrical equipment designed to provide electrical power to a building. The system is typically used to provide standby or emergency power, an uninterruptable power supply, load shedding, load sharing or similar capabilities.

Add new text as follows:

CHAPTER PART R327— STATIONARY STORAGE BATTERY SYSTEMS
R327.1 General. *Stationary storage battery systems*, where provided, shall comply with the provisions of this section.

R327.2 Equipment listings. *Stationary storage battery systems* shall be listed and labeled for residential use in accordance with UL 9540.
Exceptions:

1. Where approved, repurposed unlisted battery systems from electric vehicles shall be permitted to be installed outdoors or in detached sheds located a minimum five feet (1524 mm) from exterior walls, property lines and public ways.
2. *Battery systems* that are an integral part of an electric vehicle shall be permitted provided the installation complies with Section 625.48 of NFPA 70.
3. Battery systems less than 1 KWh (3.6 Mega joules).

ICC IFC Code Changes

R327.3 Installation. *Stationary storage battery systems* shall be installed in accordance with the manufacturer's instructions and their listing, if applicable, and shall not be installed within a dwelling unit.

R327.4 Electrical installation. *Stationary storage battery systems* shall be installed in accordance with NFPA 70. Inverters shall be listed and labeled in accordance with UL 1741 or provided as part of the UL 9540 listing. Systems connected to the utility grid shall use inverters listed for utility interaction.

R327.5 Ventilation. Indoor installations of *stationary storage battery systems* that include batteries that produce hydrogen or other flammable gases during charging shall be provided with ventilation in accordance with Section M1307.4.

R327.6 Protection from impact. *Stationary storage battery systems* shall not be installed in a location subject to vehicle damage except where protected by *approved* barriers.

ICC IFC Code Changes

[F] 307.1.1, 509, 105.6.44 (New), [A] 105.7.2, 202 (New), 608, 608.1, 907.2.23, Chapter 80 # Here] (New)
Proponent : Michael O'Brian (fcac@iccsafe.org)

2015 International Building Code

Revise as follows:

[F] 307.1.1 Uses other than Group H. An occupancy that stores, uses or handles hazardous materials as described in one or more of the following items shall not be classified as Group H, but shall be classified as the occupancy that it most nearly resembles.

9. Stationary ~~batteries utilized for facility emergency power, uninterruptable power supply or telecommunication facilities, provided that the batteries are provided with safety venting caps and ventilation is provided~~ storage battery systems installed in accordance with the *International* ~~*Mechanical*~~ *Fire Code*.

ICC IFC Code Changes

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TABLE 509
INCIDENTAL USES

ROOM OR AREA	SEPARATION AND/OR PROTECTION
Stationary storage battery systems having an energy a liquid electrolyte capacity greater than the threshold quantity specified in Table 608.1 of the *International Fire Code*, of more than 50 gallons for flooded lead-acid, nickel cadmium or VRLA, or more than 1,000 pounds for lithium-ion and lithium metal polymer used for facility standby power, emergency power or uninterruptable power supplies	1 hour in Group B, F, M, S and U occupancies; 2 hours in Group A, E, I and R occupancies.

ICC IFC Code Changes

- **Deletes current Section 608 on stationary battery systems and replaces it with more robust criteria applicable to more systems than currently covered in the IFC**
- **Table with liquid electrolyte capacity threshold in KWh as a function of battery type provided and establishes if stationary storage battery system is covered**
- **When covered - criteria are provided for**
  - Permitting and required information on the permit application
  - Conduct of a hazard mitigation analysis
  - Seismic and structural design
  - Vehicle impact protection
  - Testing, maintenance and repairs
- Location and construction of rooms or areas containing SSBS
- Signage
- Separation, means of egress, security
- Maximum allowable quantities in KWh that 'trigger' classification as Group H occupancy
- Listing of SSBS
- Fire detection and protection systems
- Smoke detection systems
- Mechanical ventilation
- Spill control and neutralization

Emergency Response Planning

Sections

1. Facility Information
   - Location, site map, company names
2. Emergency Coordinator and Backup
3. Fire Department / District Having Jurisdiction
4. Description of the hazards
5. Days of the week and time in operation
6. Emergency response procedures
   - Training, emergency units, notification procedures, evacuation plans
7. Automated safety systems for detection and control of hazards
8. Additional information

Resources

1. Emergency Planning and Community Right-to-Know Act
2. State Emergency Response Commissions
   - http://www2.epa.gov/epcra/state-emergency-response-commissions
3. Local Emergency Planning Committees
   - http://www2.epa.gov/epcra/local-emergency-planning-committees

Example Local Template

Washington State Emergency Response Commission

Local Emergency Planning Committee (LEPC)
Hazardous Materials Emergency Response Plan
TEMPLATE

None of the wording in this template need be used verbatim in local plans. Rather the template identifies the information U.S. Code (USC) Title 42 requires the LEPC include in their Hazardous Materials Response Plan and provides options the LEPC can consider in presenting the information.

September 2011

Source: http://mil.wa.gov/other-links/plans

Incident Response Support

Outline

1. Introduction
2. Energy storage types and maturity
3. Safety codes and standards
4. Research and development
5. Emergency Preparedness
6. Conclusion

Actions Identified for the Safety Outreach and Incident Response working group

- Action (Prepare an info. Packet Something for City and counties (non-Legislative))
- Action (Prepare an info. Packet for testing and certification for of ESS products and safety validation)
- Action (Prepare an info. Packet for State and local entities)
- Action (Prepare a Fact Sheet for the general public)
- Action (Prepare a webinar for UL- Regional Training Events)
- Action (Prepare a presentation for UL- Regional Training Events)
- Action (adapt ESS101 for building owners) what it is and how it is of value in our EE portfolio
- Action (Prepare a presentation for ESA General Meeting (April 2016), EESAT ESS safety)
- Action (Prepare a presentation for IEEE PES Meeting)

Summary and Key Takeaways

- Energy storage technology includes more than just batteries and has a wide range of potential applications
- CSR provide a basis for the safe installation, application and use of ESS
- CSR need to be updated to address all ESS technology
- CSR contain the basis for prescriptively documenting and evaluating safety of some batteries and some ESS
- CSR contain the foundation for documenting and evaluating safety of all ESS based on equivalent safety via alternative methods and materials
- Until CSR are updated and contain necessary and relevant prescriptive guidance there will be increased reliance on third party documentation of safety

Summary

- Energy storage is a vital part of a sustainable gird
- Properties of Batteries that Can Produce a Hazard
  - Voltage
  - Arc-Flash/Blast
  - Fire
  - Combustion
  - Toxicity
- Properties of Flywheels that Can Produce a Hazard
- Working with installers and other stakeholders is vital

Bottom Line

Energy storage technologies are no more hazardous nor less safe than technologies with which you are familiar. Proper procedures can be applied to protect life and property when energy storage is involved in a fire or other safety incident.

Thanks
Contact Information
Q/A

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Join a working group by e-mailing: energystorage@sandia.gov and including the working group of interest in the title.