

Documenting and Verifying the Safety of Energy Storage Systems through Codes and Standards



Sandia
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ENERGY



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Pam Cole

Dave Conover

Pacific Northwest National Laboratory

DOE OE Energy Storage Peer Review

Washington, DC

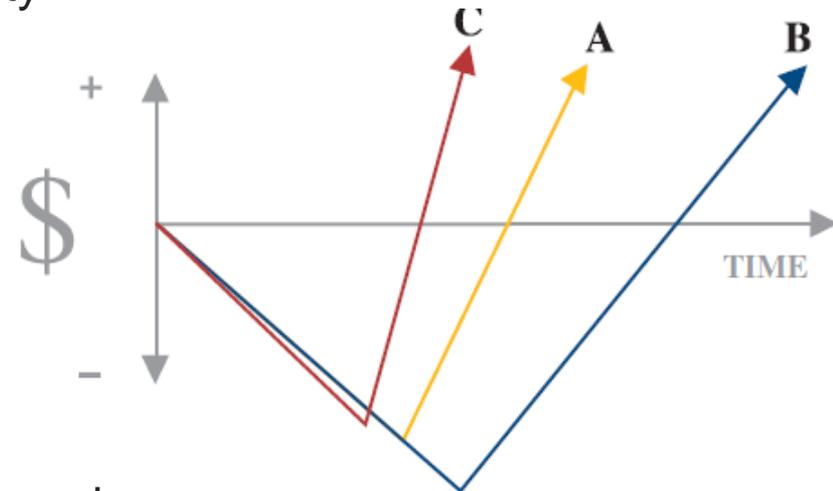
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Purpose and Expected Outcomes

- ❖ **Purpose** - to emphasize the value of focusing on safety related codes and standards (CS) to successful ESS deployment (*or why didn't I get involved with CS sooner because I am behind the 8-ball*)
- ❖ **Expected Outcomes**
 - Recognition that while codes and standards can facilitate technology acceptance they can also adversely impact technology deployment
 - A better understanding of key codes and standards affecting energy storage systems (ESS) and how they are developed and deployed
 - Familiarity with the processes associated with documenting and verifying the acceptability of ESS in relation to the criteria in codes and standards
 - A desire to collaborate with others and increase involvement in codes/standards development in order to support more uniform, timely and easier deployment of safe ESS

What's the Big Deal?

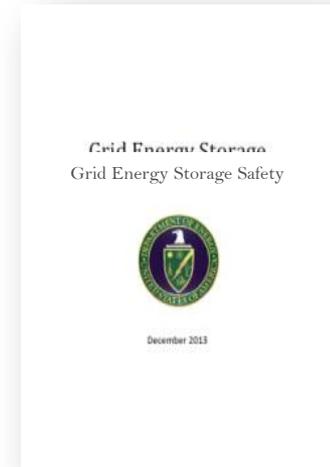
- ▶ Technology has many drivers to spur its development and deployment – a key driver is return on investment which is impacted by the resources required to address challenges and the timeframe over which those resources are needed
- ▶ The acceptance of technology (and ROI) is influenced by codes, standards and other criteria (or the lack of those criteria)
- ▶ Codes and standards focused on public safety need to be revised and then adopted and implemented in a timely manner
- ▶ Activities needed to bridge the gap between technology and a 'slam dunk' approval with respect to safety take time and \$\$ and are challenging to accomplish in parallel
- ▶ An investment in addressing codes and standards early on (C) can impact ROI compared to typical (A) or 'flying blind (B) regarding CS



Summary of DOE OE ES Safety Efforts



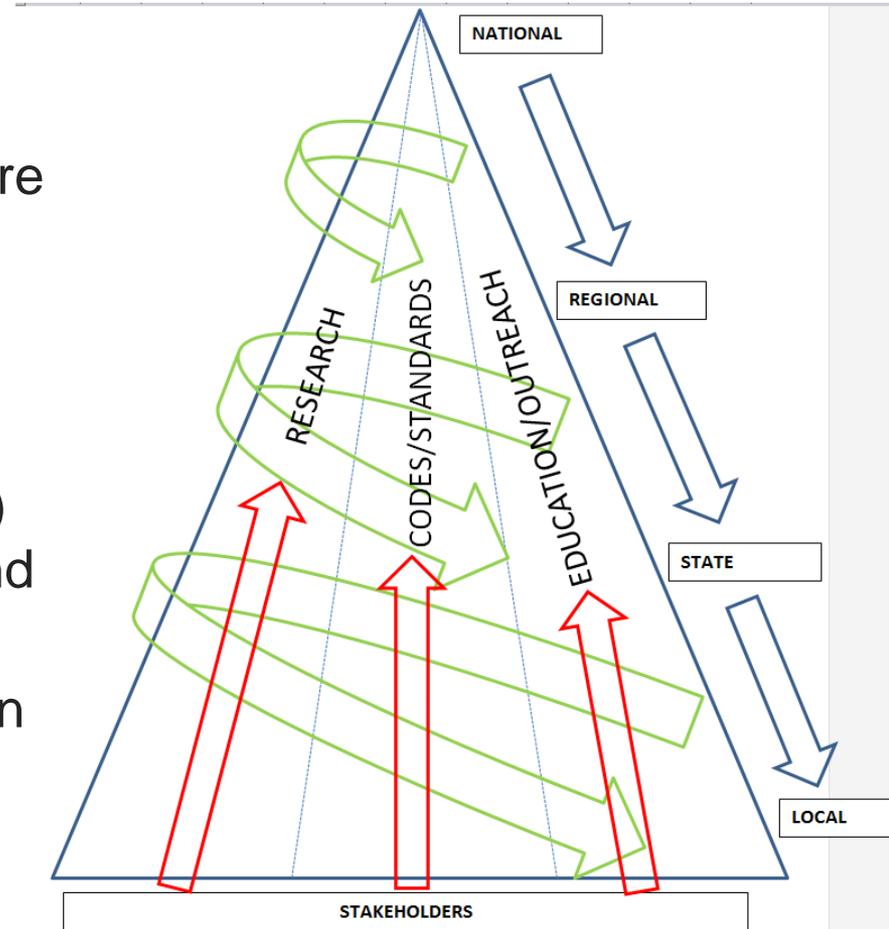
- ▶ Strategic Plan developed, being implemented and evolving to respond to technology and safety needs
- ▶ Engaging a wide range of organizations and entities to foster increased cooperation and collaboration on safety
- ▶ Ensure research needed to address safety questions and issues is identified, conducted and coordinated and the results available for application in the development and deployment of safe ESS
- ▶ Facilitate acceptance of ESS through codes and standards
- ▶ Develop new and update existing codes and standards to provide appropriate criteria to guide the development and deployment of safe ESS
- ▶ Ensure everyone involved in the development and deployment of ESS have information necessary to perform their role in ensuring ESS safety
- ▶ Evolve and 're-boot' as we learn more and ESS technology changes



“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”

The Big Picture

- ✓ Research, CS and education are all interrelated
- ✓ Uniformity, validity, value and impact are enhanced when core work is done collaboratively at the national level for adoption 'down the line'
- ✓ Communication with and getting input from stakeholders (e.g. the customers) enhances the national level content and likelihood of its adoption
- ✓ The DOE OE ESS Safety Program is in an excellent position to act as a interested but neutral party to foster success



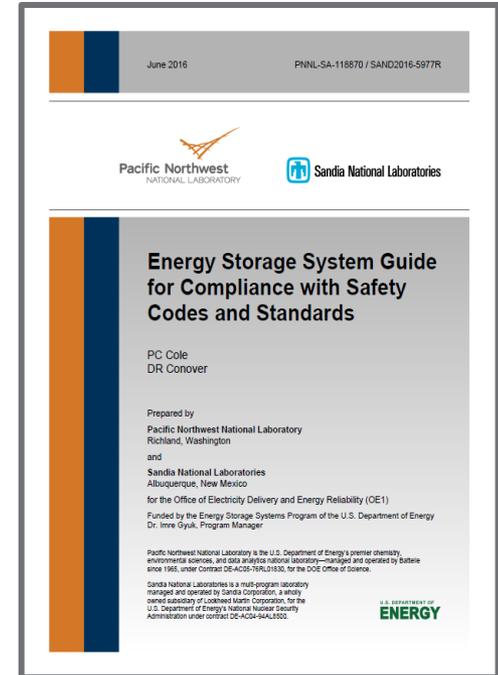
Codes and Standards Overview

- Many ESS 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 only to a particular energy storage technology
- Current codes and standards provide a basis for documenting and validating system safety
 - prescriptively
 - on a performance basis
- Codes and standards are being updated and new ones developed to address gaps between ESS technology/applications and criteria needed to guide and foster initial and ongoing system safety

Guide for Compliance with Safety Codes and Standards

Challenge – Codes and standards (published or adopted) may not have ‘caught up to’ ES technologies and their applications and where they have there is still a need for guidance on documenting and verifying compliance

- Purpose –
 - ✓ facilitate timely review and approval of ESS technology installations under current CSR
- Intended uses –
 - ✓ help those who need to document compliance
 - ✓ help those responsible for verifying compliance
- Frequently asked questions –
 - ✓ Twenty common questions (and detailed answers)
 - ✓ Cover what is needed to understand documenting and verifying compliance under current CSR



Safety-Related Issues in Codes and Standards

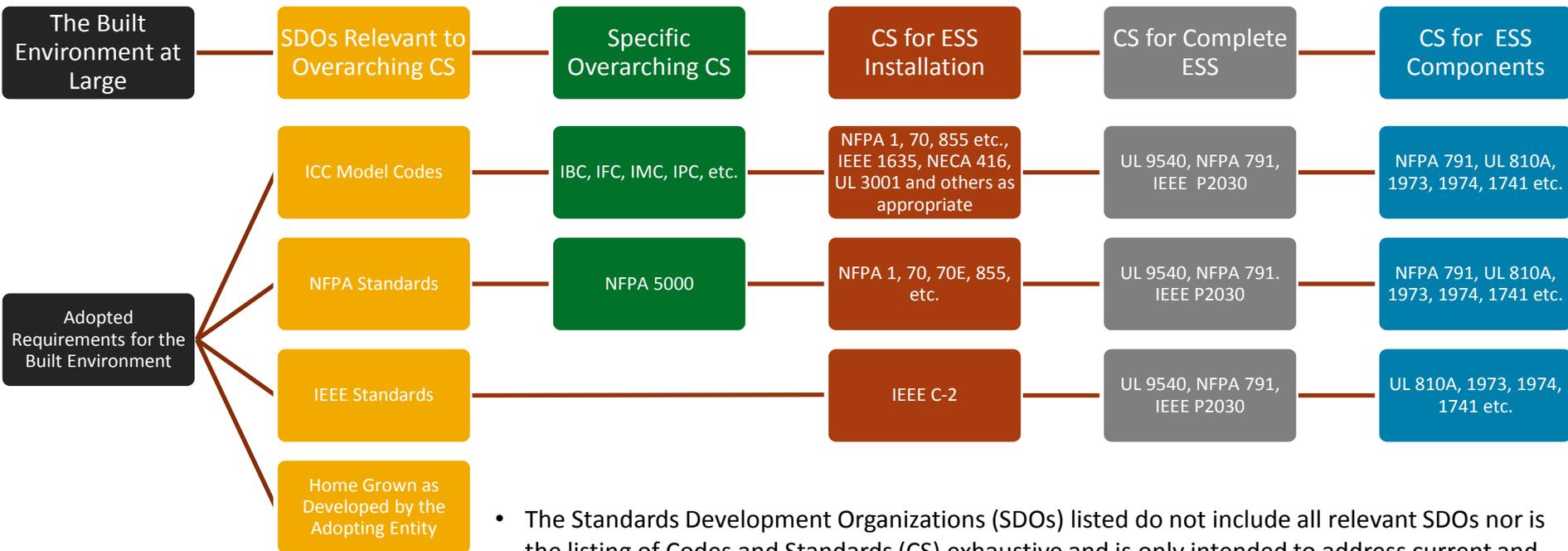
- ❖ ESS 'product' configuration and how safety of the ESS is validated
- ❖ New versus existing systems and new versus existing building/facility applications
- ❖ Siting (location, loads, protection, egress/access, maximum quantities of chemicals, separation, etc.)
- ❖ Ventilation, thermal management, exhausts (when necessary, flow rates, how controlled, etc.)
- ❖ Interconnection with other systems (energy sources, communications, controls, etc.)
- ❖ Fire protection (detection, suppression, containment, smoke removal, etc.)
- ❖ Containment of fluids (from the ESS and from incident response)
- ❖ Signage and markings

Factors that Affect the Critical Nature of an Issue

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



Codes and Standards Hierarchy for ESS



- The Standards Development Organizations (SDOs) listed do not include all relevant SDOs nor is the listing of Codes and Standards (CS) exhaustive and is only intended to address current and newly developing CS that are considered directly relevant to ESS safety

- The information reads from left (macro level) to right (micro level) covering the built environment at large, then a more specific focus on entire buildings and facilities, then the installation of an ESS, then the ESS as a complete product and finally the components (parts) of the ESS product – what is left is intended to be considered the ‘parent’ to what is immediately to the right
- The CS covered are developed in the voluntary sector by SDOs – those who adopt those documents (in total or in part) or who adapt them and develop their own ‘home grown’ provisions include Federal, state, local, territorial and tribal agencies as well as certain regulated utilities such as communications providers (on the customer side of the meter) and regulated utilities on the grid side of the meter

Criteria to Address Safety – ESS Components and Entire Systems

CS for ESS Components

Test and list the component to document and validate it complies with the relevant standard

- UL 489 (Circuit Breakers)
- UL 810A (Electrochemical Capacitors)
- UL 1642 (Lithium Batteries)
- UL 1741 (Inverters)
- UL 1973 (Batteries for Stationary Applications)
- UL 1974 (Second Use Batteries)
- UL 791 (Evaluation of unlisted electrical equipment)

CS for Complete ESS

Test and list the system to document and validate it complies with the relevant standard

- UL 9540 (Safety for ESS)
- UL 3001 (Safety for Distributed Energy Generation and ESS)
- ASME TES-1 (Molten Salt Thermal Energy Storage Systems)
- UL 791 (Evaluation of unlisted electrical equipment)

Criteria to Address Safety – ESS Installation and Incident Response

CS for ESS Installation

Document and validate that the ESS as installed meets criteria in relevant codes and standards

- ICC model codes (IBC, IMC, IPC, IFC, IRC)
- NFPA 70 (National Electric Code)
- NFPA 1 (Fire Code)
- NFPA 855 (Installation of ESS)
- IEEE C-2 (National Electrical Safety Code)
- IEEE 1635/ASHRAE Guideline 21 (Ventilation and Thermal Management of ESS)

Criteria for Incident Response

Ensure that ESS-relevant criteria are provided in appropriate standards

- NFPA 921 (Fire Investigations)
- IEEE 979 (Guide for Substation Fire Protection)

Codes and Standards Development

Involvement in the development of standards/model codes

- ✓ Active participation on a working group that developed a new Article 706 on ESS safety that will appear in the 2017 NEC
- ✓ Active participation in development of a new Chapter on ESS for the ICC International Fire Code
- ✓ Active participation in development of a new UL standard 9540 on ESS safety
- ✓ Active participation in development of ASME TES-1 on molten salt thermal storage system safety
- ✓ Development of a pre-standard addressing ESS installation safety that will be used by a new NFPA committee charged with development of an NFPA 855 on ESS installation safety
- ✓ Ongoing participation in IEC TC 120 activities developing ESS safety related standards
- ✓ Ongoing participation in EPRI ESIC activities developing ESS safety guidelines for utilities
- ✓ Track and report on C/S activities relevant to ESS safety



9540
Outline of Investigation for Energy Storage Systems and Equipment

Example of Involvement in CS – ICC IFC and NFPA 855

CS for ESS
Installation

➤ ICC IFC

- ✓ Code change proposal F95-16 by the ICC Fire Code Action Committee (FCAC) revises Section 608 on stationary battery storage systems to address more than the current code (lead acid)
- ✓ Input to the proposal provided under the ESS Safety Plan
- ✓ The proposal was approved as modified at the public hearings (April 2016)
- ✓ Public Comments have been submitted by the FCAC to enhance the proposal editorially and technically based on comments provided during the public hearings and subsequent work by an energy storage task group under the FCAC

➤ NFPA 855

- ✓ Draft pre-standard finalized based on input from the single standard task force of the CSR WG under the ESS Safety Plan and the document forwarded to NFPA
- ✓ NFPA filed a Project Initiation Notification (PINS) with ANSI for such a standard and voted to establish a new committee to draft a standard (855) in April 2015
- ✓ The NFPA Standards Council has appointed the members of the new technical committee (TC) and those members were notified in late August
- ✓ The TC is now charged with development of the official scope for the standard for presentation to the SC for approval

Summary and Key Takeaways

- ✓ Energy storage technology includes more than just batteries and has a wide range of potential applications
- ✓ Current and future battery technology is a foundation for energy storage technology
- ✓ CS provide a basis for the safe installation, application and use of ESS
- ✓ CS lag technology development and need to be updated to address all ESS technologies and potential applications
- ✓ Current CS contain the basis for prescriptively documenting and evaluating safety of some batteries and some ESS
- ✓ Current CS contain the foundation for documenting and evaluating safety of all ESS based on equivalent safety via alternative methods and materials
- ✓ Until CS are updated and contain necessary and relevant prescriptive guidance documenting and validating the safety of an ESS is more likely to be on a case-by-case basis
- ✓ Collaboration on the enhancement of the compliance guide and updating of current CS to cover more ESS technologies and applications can foster more timely consideration and acceptance of ESS

ESS Safety Related Resources

Tools

The ESS Program continually documents progress in the world of energy storage. That progress takes many forms and comes from many sources.

ESS Program Tools

- **DOE/EPRI 2015 Electricity Storage Handbook in Collaboration with NRECA** – The DOE/EPRI 2015 Electricity Storage Handbook in Collaboration with NRECA is a how-to guide for utility and rural cooperative engineers, planners, and decision makers to plan and implement energy storage projects.
- **PUC Handbook** – A perspective on issues pertaining to the deployment of utility procured electrical energy storage resources. The intended audience includes state electric utility regulatory authorities, their staffs and the planning personnel in the utilities they regulate.
- **DOE Global Energy Storage Database** – Free, up-to-date information on grid-connected energy storage projects and relevant state and federal policies. All information is vetted through a third-party verification process. All data can be exported to Excel or PDF.
- **ES-Select Tool™** – The ES-Select™ Tool aims to improve the understanding of different electrical energy storage technologies and their feasibility for intended applications in a simple, visually comparative form. It treats the uncertainties in technical and financial parameters as statistical distributions.
- **Protocols** – A listing of DOE-published protocols for download.



A screenshot of the ESS Program Publications page. The page header includes the U.S. Department of Energy logo and navigation links for Events/News, Publications, Tools, Resources, Projects, and Awards. The main content area is titled "Publications" and includes a sub-header "ESS Program Publications". Below this, there are several sections: "Journal Articles and Books" (listing DOE Office of Electricity, Sandia National Laboratories, Pacific Northwest National Laboratory, and Oak Ridge National Laboratory), "Conference Archives" (listing DOE Energy Storage Systems Peer Review Meetings and EESAT Conferences), "Webinars" (listing Energy Storage in State RPS: State-Federal RPS Collaborative Webinar), "DOE/EPRI/NRECA" (listing DOE/EPRI 2015 Electricity Storage Handbook), "NYSERDA/DOE" (listing Joint Initiative Publications), "Factsheets" (listing DOE and SNL), and "R&D 100 Awards" (listing R&D 100 Awards).

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*For more information on DOE OE ESS safety
activities contact
energystorage@sandia.gov*