Pacific Northwest NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965

Sandia National Laboratories

DOE OE Energy Storage Systems Safety Roadmap Focus on Codes and Standards – June 2017

The goal of the DOE OE ESS Safety Roadmap[1] is to *foster confidence in the safety and reliability of energy storage systems*.

There are three interrelated objectives to support the realization of that goal: research, codes and standards and communication/coordination. The objective focused on codes and standards is…..

> *To apply research and development to support efforts that are focused on ensuring that codes and standards are available to enable the safe implementation of energy storage systems in a comprehensive, non-discriminatory and science-based manner.*

The following activities are intended to support that objective and realization of the goal:

a. Review and assess codes and standards which affect the design, installation, and operation of ESS systems.
b. Identify gaps in knowledge that require research and analysis that can serve as a basis for criteria in those codes and standards.
c. Identify areas in codes and standards that are potentially in need of revision or enhancement and can benefit from activities conducted under research and development.
d. Develop input for new or revisions to existing codes and standards through individual stakeholders, facilitated task forces, or through laboratory staff supporting these efforts.

What's Noteworthy?

DNVGL-RP-0043 Safety, Operation and Performance of Grid-connected Energy Storage Systems – The online hearing process opened on June 8, 2017 and will close on July 2, 2017.

UL 9540 Standard for Energy Storage Systems and Equipment - A call for proposals has been issued. Any proposed revisions to the first edition are due by July 20, 2017.

UL 1974 Evaluation for Repurposing Batteries – The proposed first edition is out for comment only. Comments are due July 7, 2017.

UL 1973 Batteries for Use in Light Electric Rail and Stationary Applications - The proposal review work area in CSDS for the proposed second edition of the standard will open June 30, 2017 and close August 29, 2017.

The purpose of this document is to support the above activities by providing information on current and upcoming efforts being conducted by U.S. standards developing organizations (SDOs) and other entities that are focused on energy storage system safety. See page 10 for IEC related information.

For the purposes of presenting this information the model codes, standards and other documents (guidelines, recommended practices, etc.) covered are classified in relation to their scope relative to energy storage systems from the 'macro to the micro' as indicated below, noting that more 'macro' documents are likely to adopt by reference more 'micro' documents. ***Changes from the May 2017 edition are shown in bold italics.***

1) Overarching Codes and Standards– the built environment at large that includes but is not limited to energy storage systems.
2) Codes and Standards for ESS Installations– the installation of the energy storage system in relation to other systems and parts of the built environment.
3) Codes and Standards for a Complete ESS– the entire energy storage system in the aggregate.
4) Codes and Standards for ESS Components– components associated with the energy storage system.

[1] DOE OE Energy Storage Systems Safety Roadmap, May 2017 PNNL-SA-126115 I SAND2017-5140 R

OVERARCHING CODES AND STANDARDS

	National Fire Protection Association (NFPA)—www.nfpa.org
Document:	**NFPA 1-18 Fire Code**
ESS relevance:	Chapter 52 includes requirements related to ESS.
Previous activity:	Finalization of the 2018 edition through the NFPA standards development process at the NFPA Technical Meeting in June 2017 (subject to an appeal to and consideration of the appeal by the NFPA Standards Council subsequent to the technical meeting).
Current activity:	After the 2018 edition is published, public inputs for the 2021 edition will likely be due in July 2018.
Date of next edition:	2021
Document:	**NFPA 70-17 National Electrical Code**
ESS relevance:	Article 706 (new) applies to energy storage systems and Article 480 applies to batteries, in addition to other criteria in the NEC relevant to electrical equipment and installations.
Previous activity:	Development by the DC task group (under NFPA) of a new Article 706 covering energy storage systems and its inclusion in the 2017 edition of the NEC. An NEC task group has completed a draft of materials intended to align Articles 480 (batteries) and 706.
Current activity:	***A preliminary review of the draft materials aligning Articles 480 and 706 has been completed by members of the DC task group. It is anticipated that the work of the DC task group moving forward will dovetail into the NEC task group aligning Articles 480 and 706.*** Proposed changes to the NEC are due September 7, 2017. A review
Date of next edition:	2020
Document:	**NFPA 5000-18 Building Code**
ESS relevance:	Provides a basis for adoption and application of other standards.
Previous activity:	Finalization of the 2018 edition through the NFPA standards development process at the NFPA Technical Meeting in June 2017 (subject to an appeal to and consideration of the appeal by the NFPA Standards Council subsequent to the technical meeting).
Current activity:	After the 2018 edition is published public inputs for the 2021 edition will likely be due in July 2018.
Date of next edition:	2021

	International Code Council (ICC)—www.iccsafe.org https://www.iccsafe.org/codes-tech-support/codes/code-development/current-code-development-cycle/
Document:	**2018 IFC (Fire Code)**
ESS relevance:	Chapter 12 of the IFC covers energy systems and Section 1206 in that chapter covers electrical energy storage systems.
Previous activity:	Development of proposed changes to the IFC to better address energy storage by proponents of individual changes to the IFC and also an ESS task force of the Fire Code Action Committee (FCAC). Changes approved pursuant to the ICC code development process, which was completed in 2016, will be published in the 2018 edition of the IFC.
Current activity:	***An Advisory Group under the ICC FCAC is developing proposed changes to the IFC that are focused on energy storage systems. When completed the proposed changes will be submitted for consideration by the FCAC. Those proposed changes approved by the FCAC will be submitted by the FCAC by the January 8, 2018 code change deadline. The Advisory Group meets by phone once a month in addition to working off line between meetings via correspondence. The next meeting (call) is July 6, 2017.***
Date of next edition:	2021
Document:	**2018 IRC (Residential Code)**
ESS relevance:	A section of the IRC covers energy storage systems.
Previous activity:	Development of proposed changes to better address energy storage safety to the IRC by proponents of individual changes to the IFC and also a task force of the Fire Code Action Committee (FCAC). Changes approved pursuant to the ICC code development process, which was completed in 2016, will be published in the 2018 edition of the IRC. Those changes include some basic criteria to address the location and fire safety of stationary battery systems.
Current activity:	See IFC current activity.
Date of next edition:	2021
Document:	**2018 IBC (Building Code)**
ESS relevance:	Provides a basis for adoption and application of other standards and ICC model codes.
Previous activity:	Changes to the 2018 IBC support the new 2018 IFC ESS requirements.
Current activity:	See IFC current activity.
Date of next edition:	2021
Document:	**2018 IMC (Mechanical Code)**
ESS relevance:	Includes basic requirements for stationary fuel cell power systems and also criteria for ventilation and exhaust of spaces.
Previous activity:	No proposed changes to the IMC related to energy storage systems were considered during the 2018 ICC code development cycle.
Current activity:	Proposed changes to the IMC are due to ICC by January 8, 2018.
Date of next edition:	2021

IEEE—www.ieee.org	
Document:	**C2-17 National Electric Safety Code**
ESS relevance:	Covers electrical safety for utility systems and equipment.
Previous activity:	Completion and publication of the 2017 edition of the NESC.
Current activity:	Final date to receive change proposals from the public for revision of the 2017 edition is July 15, 2018.
Date of next edition:	2022

DNV GL—www.dnvgl.com/rules-standards/	
Document:	**DNVGL-RP-0043 Safety, Operation and Performance of Grid-connected Energy Storage Systems, December 2015**
ESS relevance:	The objective of this document is to provide a comprehensive set of recommendations for grid-connected energy storage systems. It aims to be valid in all major markets and geographic regions, for all applications, on all levels from component to system, covering the entire life cycle. End users, operators and other stakeholders can find specific guidance in the document as well as references to other relevant standards, codes and guidelines.
Previous activity:	First edition published in 2015 and a 2nd edition has been under development and was recently approved for public review (termed a public on-line hearing). The document approved for public review has been sent to the rules and standards group on DNV GL who will start the on-line hearing and make the document available for review to invited/registered parties (those collected by DNV GL and others suggested to be alerted by DNV GL of this process).
Current activity:	***The public hearing started in early June and will run until July 2, 2017. All input received on the 2nd edition draft will be processed and then final approval will be by those members of the consortium established to prepare and finalize the 2nd edition of this document. There is no obligation that comments will be processed if they are outside the consortium. An internal meeting is expected in late August for the purpose of finalizing the document.***
Date of next edition:	September 2017

CODES AND STANDARDS FOR ESS INSTALLATIONS

	National Fire Protection Association (NFPA)—www.nfpa.org
Document:	**NFPA 855 Standard for the Installation of Stationary Energy Storage Systems**
ESS relevance:	Covers the safety of all energy storage systems and their installation in the built environment.
Previous activity:	Development by the drafting committee from late 2016 until May 2017 of a first draft of the standard and formatting ***and editorial changes by NFPA staff***.
Current activity:	***A draft of the standard has been finalized by the 855 Committee and NFPA staff and provided to the NFPA Standards Council with a request for their approval to release the draft of the standard for public input.***
Date of next edition:	2019 (goal)
Document:	**NFPA [TBD] Standard for Electrical Inspectors and Electrical Plan Reviewers**
ESS relevance:	Addressed qualifications of those who would review and approve electrical plans and conduct electrical inspections. Such plan reviews and electrical inspections would include, but not be limited to, energy storage systems.
Previous activity:	In January NFPA invited comments by February 24, 2017, in support or opposition to the establishment of a committee to develop this new standard. This standards project was recently approved by the NFPA Standards Council.
Current activity:	Seeking interest from appropriate individuals serve on the committee responsible for this standard.
Date of next edition:	TBD

	National Electrical Contractors Association (NECA)—www.necanet.org
Document:	**NECA 416-16 Recommended Practice for Installing Stored Energy Systems**
ESS relevance:	*National Electrical Installation Standards* (*NEIS*) are designed to improve communication among specifiers, purchasers, and suppliers of electrical construction services and are intended to be referenced in contract documents for electrical construction projects. NECA 416-17 describes installation practices for Energy Storage Systems (ESS) such as battery systems, flywheels, ultra-capacitors, and smart chargers used for electric vehicle (EV) vehicle-to-grid (V2G) applications.
Previous activity:	Approved for publication.
Current activity:	A new appendix containing a compliance checklist is under development. In addition suggestions for revisions and improvements to this document are welcome and can be directed to NECA at www.neca-neis.org
Date of next edition:	TBD based on current activity.
Document:	**NECA 417-20xx Recommended Practice for Designing, Installing, Maintaining, and Operating Micro-grids**

ESS relevance:	*National Electrical Installation Standards* (*NEIS*) are designed to improve communication among specifiers, purchasers, and suppliers of electrical construction services and are intended to be referenced in contract documents for electrical construction projects. NECA 417 will cover the design, installation, maintenance and operation of micro-grids.
Previous activity:	Establishment of the drafting committee.
Current activity:	A first draft is being developed for industry review. This document will address many workmanship, quality, and performance issues related to the systems covered in the document. As NECA develops the canvass group for the ANSI process, it will be important to include the appropriate canvass group members in a balanced approach. As with NECA 416, the intention would be to include appropriate checklists for installers and inspection jurisdictions for consistency.
Date of next edition:	It is anticipated that a first draft will be complete and ready for initial (Non-ANSI) industry review by the Fall of 2017 with a goal to complete NECA-417 by mid-2018.

	IEEE—www.ieee.org
Document:	**IEEE 1635-12/ASHRAE Guideline 21-12 Guide for Ventilation and Thermal Management of Batteries for Stationary Applications**
ESS relevance:	Covers how energy storage systems are provided appropriate ventilation and thermal management.
Previous activity:	Proposed revisions were recently out for public review.
Current activity:	Comments received during the public review are being resolved.
Date of next edition:	September 2017 (projected approval date)

	FM Global —http://www.fmglobal.com
Document:	**FM Global Property Loss Prevention Data Sheet 5-33, Electrical Energy Storage Systems**
ESS relevance:	***The data sheet describes loss prevention recommendations for the design, operation, protection, inspection, maintenance, and testing of electrical energy storage systems (ESS. Energy storage systems can include batteries, battery chargers, battery management systems, thermal management and associated enclosures and auxiliary systems. The focus of this data sheet is primarily on lithium-ion battery technology.***
Previous activity:	***Data sheet was issued in January 2017.***
Current activity:	***None.***
Date of next edition:	***Development of an interim revision is planned for 2018 with publication expected in 2019.***

CODES AND STANDARDS FOR A COMPLETE ESS

	American Society of Mechanical Engineers (ASME)—www.asme.org
Document:	**TES-1 Safety Standard for Thermal Energy Storage Systems**
ESS relevance:	Provides safety related criteria for molten salt energy storage systems.
Previous activity:	Establishment of a drafting committee and efforts to prepare a first draft of the standard.
Current activity:	First draft is under development. ***Drafting committee meeting scheduled for July 20, 2017 with a goal of incorporating necessary revisions in preparation for a committee ballot of the draft (which could be issued initially as a guideline).***
Date of next edition:	TBD

	National Fire Protection Association (NFPA)—www.nfpa.org
Document:	**NFPA 791-14 - Recommended Practice and Procedures for Unlabeled Electrical Equipment**
ESS relevance:	Could form a basis for assessing an energy storage system that is not labeled. Note that recommended practices are guides and are not documents that can be enforced by jurisdictions.
Previous activity:	Finalization of the 2018 edition through the NFPA standards development process at the NFPA Technical Meeting in June 2017 (subject to an appeal to and consideration of the appeal by the NFPA Standards Council subsequent to the technical meeting).
Current activity:	After the 2018 edition is published, public inputs for the 2022 edition will likely be due in July 2019.
Date of next edition:	2022

	Underwriters Laboratories (UL)—www.ul.org
Document:	**UL 9540 – Energy Storage Systems and Equipment**
ESS relevance:	Product safety standard for an ESS.
Previous activity:	First edition was published November 21, 2016. UL 9540 is an American National Standard and National Standard of Canada (ANSI/CAN).
Current activity:	***UL has received Proposals to revise the first edition of UL 9540. Any fully developed Proposal Request (proposed changes and rationale) should be submitted through UL's On-Line Collaborative Standards Development System (CSDS) at https://csds.ul.com/ by Thursday, July 20, 2017.***
Date of next edition:	UL standards are under continuous maintenance and are updated as warranted.

CODES AND STANDARDS FOR ESS COMPONENTS

CSA Group	CSA GROUP (CSA)—www.csagroup.org
Document:	**283 – Battery Reuse**
previous activity:	A committee had been formed to develop the standard. (Note: As a result of Standards Council of Canada's (SCC's) Duplication Resolution Mechanism (DRM), SCC has decided that UL will proceed with the development of the binational Standard for Evaluation for Repurposing Batteries, ANS/CAN/UL 1974 as the National Standard of Canada. CSA will discontinue their efforts on CSA C283.)
Current activity:	See UL 1974 below.
Date of next edition:	N/A
Document:	**CSA C22.2 No. 107.1-2016 Power Conversion Equipment**
ESS relevance:	Applies to ac and dc type power conversion equipment, which can be associated with an ESS.
Previous activity:	Fourth edition of this standard, which was issued in 2016.
Current activity:	The standard is under continuous maintenance and updated as warranted.
Date of next edition:	TBD

IEEE Advancing Technology for Humanity	IEEE—www.ieee.org
Document:	**IEEE P1679.1 Guide for the Characterization and Evaluation of Lithium-Based Batteries in Stationary Applications**
ESS relevance:	Provides appropriate information on the safety attributes and operating conditions related to stationary applications of lithium-based batteries.
Previous activity:	Initiation of development of a draft.
Current activity:	Current draft was recently out for ballot to the drafting committee and comments and votes were due May 25, 2017.
Date of next edition:	TBD
Document:	**IEEE P1679.2 Guide for the Characterization and Evaluation of Sodium-Beta Batteries in Stationary Applications**
ESS relevance:	Provides appropriate information on the safety attributes and operating conditions related to stationary applications of sodium-beta batteries.
Previous activity:	Initiation of development of a draft.
Current activity:	Current draft is out for ballot to the drafting committee and comments and votes are due June 15, 2017.
Date of next edition:	TBD

Underwriters Laboratories Inc.®	Underwriters Laboratories (UL)—www.ul.org
Document:	**UL 810A – Electrochemical Capacitors**
ESS relevance:	Addresses safety of electrochemical capacitors, which can be used as an energy source in ESS.
Previous activity:	The first edition was published October 7, 2008. The 1st edition was reaffirmed on March 28, 2017.
Current activity:	
Date of next edition:	UL standards are under continuous maintenance and are updated as warranted.
Document:	**UL 1642 – Standard for Lithium Batteries**
ESS relevance:	
Previous activity:	The fifth edition was published March 13, 2012. Revisions to the Impact Test were published June 23, 2015.
Current activity:	
Date of next edition:	UL standards are under continuous maintenance and are updated as warranted.
Document:	**UL 1741 – Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources**
ESS relevance:	Applies to the subject technology when used in conjunction with an ESS.
Previous activity:	The second edition was published January 28, 2010. Revisions were published September 7, 2016 to incorporate Supplement SA - Grid Support Utility Interactive Inverters and Converters.
Current activity:	
Date of next edition:	UL standards are under continuous maintenance and are updated as warranted.
Document:	**UL 1973 – Batteries for Use in Light Electric Rail (LER) and Stationary Applications**
ESS relevance:	Battery systems that would be employed in ESS.
Previous activity:	The first edition was published February 15, 2013. Revisions were issued June 1, 2016. UL 1973 is an American National Standard and will be a National Standard of Canada (ANSI/CAN).
Current activity:	***The proposal review work area in CSDS for the proposed second edition of UL 1973 as an American National Standard and a National Standard of Canada will open June 30, 2017 and close August 29, 2017.***
Date of next edition:	UL standards are under continuous maintenance and are updated as warranted.
Document:	**UL 1974 – Evaluation for Repurposing Batteries**
ESS relevance:	Use of repurposes EV batteries for stationary applications, including ESS.
Previous activity:	UL's Standards Technical Panel (STP) for Repurposing Batteries, STP 1974, has been established and a chair for the STP has been named. UL 1974 will be an American National Standard and National Standard of Canada (ANSI/CAN). Proposed 1st edition of this binational standard for USA and Canada has been drafted and uploaded to UL's Collaborative Standards Development System (CSDS).
Current activity:	***The preliminary review work area in CSDS for the proposed first edition of the standard opened June 2, 2017 and will close July 7, 2017***
Date of next edition:	TBD based on work to be done after the above mentioned review.

International Electrotechnical Commission (IEC)

There are a number of standards development initiatives being conducted under the auspices of the IEC. ***These include the following (note this is not a complete list of all IEC standards that could apply to ESS and it may not cover the exact status of the standards, however, all are under development). Ongoing efforts moving forward will attempt to provide additional detail on these and other IEC standards.***

- ***IEC 60622: Secondary Cells and Batteries containing Alkaline or Other non-acid Electrolytes - Sealed NiCd Prismatic Rechargeable Cells***
- ***IEC 60623: Secondary Cells and Batteries containing Alkaline or Other non-acid Electrolytes - Vented NiCd Prismatic Rechargeable Cells***

- ***IEC 60896-11: Stationary Lead Acid Batteries Part 11: Vented Types - General Requirements and Methods of Tests***
- ***IEC 60896-21: Stationary Lead Acid Batteries Part 21: Valve Regulated Types – Methods of tests***
- ***IEC 60896-22: Stationary Lead Acid Batteries Part 22: Valve Regulated Types – Requirements***

- ***IEC 62932-1 Edition 1: Flow battery systems for stationary applications - Part 1: General aspects, terminology and definitions.***
- ***IEC 62932-2-1 Edition 1: Flow battery systems or stationary applications - Part 2-1: Performance general requirements & methods of test.***
- ***IEC 62932-2-2 Edition 1: Flow battery systems for stationary applications - Part 2-2: Safety requirements.***

- ***IEC 62933-1 Edition 1, Electrical Energy Storage (EES) systems – Part 1: Terminology***
- ***IEC 62933-2-1 Edition 1, Electrical Energy Storage (EES) systems – Part 2-1: Unit parameters and testing methods – General specifications.***
- ***IEC 62933-3-1 Edition 1, Electrical Energy Storage (EES) systems – Part 3-1: Planning and installation – General specifications.***
- ***IEC 62933-4-1 Edition 1, Electrical Energy Storage (EES) systems – Part 4-1: Guidance on environmental issues.***
- ***IEC 62933-5-1 Edition 1, Electrical Energy Storage (EES) systems – Part 5-1: Safety considerations related to grid integrated EES systems.***
- ***IEC 62933-5-2: Electrical Energy Storage (EES) systems - Part 5-2: Safety considerations related to grid integrated electrical energy storage (EES) systems – Batteries***

- ***IEC 62984-3-1: High Temperature Secondary Batteries, Part 3 Sodium-based batteries, Section 1 Safety requirements and tests***

An Important Note to Readers

Every effort is made by PNNL and Sandia[1] staff to ensure the accuracy of the information presented in this report. PNNL and Sandia very much appreciate the input from staff of the SDOs covered in the report as well as volunteers who are involved in one or more of the SDO initiatives covered in this document. Suggestions for revision, additions and enhancements to this document are welcome and encouraged. We at PNNL and Sandia, on behalf of the DOE OE ESS Program whose support has made this report possible, want this document to be 'the' source of information on codes and standards related to energy storage system safety. With your help we can make that happen and as outlined on page one achieve the codes and standards related objective in the ESS Safety Roadmap and the goal of fostering confidence in the safety and reliability of energy storage systems.

For more information on the ESS Safety Roadmap efforts visit http://www.sandia.gov/ess/. For questions related to or to provide input on this document please contact david.conover@pnnl.gov or pam.cole@pnnl.gov.

1. Sandia National Laboratories is a multimission laboratory managed and operated by National Technology and Engineering Solutions of Sandia, LLC., a wholly owned subsidiary of Honeywell International, Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.