

DOE OE Energy Storage Systems Safety Roadmap Focus on Codes and Standards – May 2018

The goal of the DOE OE ESS Safety Roadmap¹ 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 support that objective and realization of the goal:

- Review and assess codes and standards which affect the design, installation, and operation of ESS systems.
- Identify gaps in knowledge that require research and analysis that can serve as a basis for criteria in those codes and standards.
- 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.
- Develop input for new or revisions to existing codes and standards through individual stakeholders, facilitated task forces, or through laboratory staff supporting these efforts.

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 (IEC documents are listed last).

For the purposes of presenting this information documents covered are organized in relation to their scope relative to energy storage systems from the 'macro to the micro' (e.g. overarching covering considerable scope versus covering a single system component of an ESS). Note also that more 'macro' documents are likely to adopt by reference more 'micro' documents. ***Changes in current activity from the prior edition are shown in bold italics.***

Time-sensitive items (e.g. having a schedule/due date) are in bold type and highlighted in yellow.

What's Time Sensitive or New?

The first draft report for NFPA 855 is available at www.nfpa.org/855next. Click on "Submit Public Comment Online" by July 12, 2018 to submit a comment.

The first draft report for NFPA 70 (NEC) will be posted July 6, 2018 with a second draft public comment closing date of August 30, 2018.

Public input to NFPA 1, NFPA 791 and NFPA 5000 is due June 27, 2018.

The report of the committee action hearings on proposed changes to the I-Codes will be posted May 30, 2018 with public comments due July 16, 2018.

Change proposals to IEEE C-2 (NESC) are due July 16, 2018.

CSA Group is initiating work on a new standard C22.22 No. 304 covering battery management systems.



- Overarching Codes and Standards– the built environment at large that includes but is not limited to ESSs.
- Codes and Standards for ESS Installations– the installation of the energy storage system in relation to other systems and parts of the built environment.
- Codes and Standards for a Complete ESS.
- Components associated with the ESS.

¹ DOE OE Energy Storage Systems Safety Roadmap, PNNL-SA-126115 | 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 (new in the 2018 edition) includes requirements related to the installation of ESS. Requirements recognize both established battery technologies as well as new ESS technologies. Provisions apply to both new and existing applications of ESS.
Previous activity:	The 2018 edition of NFPA 1 was issued in the Fall of 2017 and was updated to include a fully revised Chapter 52 which expanded the scope from stationary battery systems to energy storage systems. The new ESS requirements address battery systems as well as other newer technologies (chemical, mechanical, thermal). Chapter 52 is organized as follows: • 52.1 General • 52.2 Lead-Acid and Nickel-Cadmium Batteries • 52.2.1 General • 52.2.2 Safety Features • 52.3 Additional Battery Technologies • 52.3.1 General • 52.3.2 Stationary Storage Battery Systems • 52.3.3 Capacitor Energy Storage Systems Access to the 2018 edition of NFPA 1 can be found at www.nfpa.org/1
Current activity:	The public input closing date is June 27, 2018. See http://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=1 for more information on NFPA 1. A pre-first draft meeting is scheduled for May 30 and 31, 2018 in Denver, CO and the first draft report is scheduled to be posted on March 27, 2019.
Date of next edition:	2021
Document:	NFPA 70-17 National Electrical Code
ESS relevance:	Article 706 (new in the 2017 edition) applies to energy storage systems and Article 480 remains applicable to batteries, in addition to other criteria in the NEC relevant to electrical equipment and installations.
Previous activity:	Proposed changes to the NEC were due September 7, 2017. Code Making Panel (CMP) public input reports (18) are posted at http://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=70&tab=nextedition. CMP 13, Task Group 4 is responsible for review and recommending actions on 280 public inputs (PIs) to Sections 480 and 706 of the NEC and provided recommendations on those PIs. A first draft meeting was held January 8 to 20, 2018 in Hilton Head, SC to discuss and act on all PIs leading to the development of a first draft report. Efforts continue to compile the outcome of the first draft meeting held January 8 to 20, 2018 that will comprise the initial first draft report. A first draft meeting was held May 8 to 12, 2018 in Deerfield, IL.
Current activity:	The first draft report is scheduled to be posted July 6, 2018 and will have a second draft public comment closing date of August 30, 2018.
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. The 2018 edition is available.
Current activity:	The public input closing date is June 27, 2018. See http://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=5000&tab=nextedition for more information on NFPA 5000. First draft meetings are scheduled in July and August, depending on the subjects covered, in Minneapolis, MN. The first draft is scheduled to be posted on February 27, 2019.
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 International Fire Code (IFC) to better address energy storage by proponents of individual changes to the IFC and also an ESS Advisory Group (AG) of the Fire Code Action Committee (FCAC). Changes approved pursuant to the ICC code development process, which was completed in 2016, were published in the 2018 edition of the IFC. The FCAC asked the ESS AG to continue their efforts and develop proposed changes to the 2018 IFC that are focused on energy storage systems and to submit them to the FCAC for consideration. The ESS AG conducted a number of phone meetings during the fall of 2017 leading up to finalization of proposed changes to the IFC for presentation to the ICC FCAC and their consideration to submit them to the ICC by the January 8, 2018 deadline. The FCAC approved code change proposals, one of which is considered a comprehensive ESS rewrite for the IFC, and submitted them to the ICC for consideration during the 2018/2019 code development cycle. One FCAC ESS code change proposal (F203-18) completely revises Section 1206 and includes a revised outline for Section 1206 on energy storage to provide a more user friendly way of organizing and presenting the requirements. Criteria cover electrochemical ESS and establish the scope of the provisions as a function of technology type and energy capacity. Subsections cover commissioning, decommissioning and O&M, safety-related requirements for the ESS equipment (e.g. product and its component parts) and then safety-related criteria for all ESS installations, specific criteria related to size and separation, maximum allowable quantities, elevation, fire detection and suppression, enclosure size, vegetation control, and means of egress separation. In addition provisions for exhaust ventilation, spill control and neutralization, explosion control, safety caps and thermal runaway are also provided as a function of technology type. Additional criteria are also provided as a function of ESS location. A separate subsection covers mobile ESS. All proposed changes to the ICC International Codes (I-Codes) were posted February 28, 2018 and committee action hearings held April 15 to 23, 2018 in

	Columbus, OH. https://cdn-web.iccsafe.org/wp-content/uploads/2018-2019-Code-Development-Schedule.pdf . See the <i>PNNL/Sandia Special Briefing Paper Unofficial Hearing Results April 2018 (PNNL-SA-134254/SAND2018-4446R)</i> at http://www.sandia.gov/energystoragesafety/codes-standards/status-of-codes-and-standards/ for a summary of changes to the I-Codes related to ESS. The ESS related proposals developed by the ESS AG and submitted by FCAC were approved (some with modifications) at the IFC hearings on April 22, 2018. Unofficial results can be found at https://www.cdpaccess.com/live/cah/listing/ .
Current activity:	The official results of the committee action hearings are posted at https://www.iccsafe.org/codes-tech-support/codes/code-development/current-code-development-cycle/ and the report of the committee action hearing will be posted on May 30, 2018. Public comments are due July 16, 2018 and the public comment agenda will be posted August 31, 2018. The final action hearings following that public comment agenda will occur October 21 to 31, 2018 in Richmond, VA.
Date of next edition:	2021
Document:	2018 IRC (Residential Code)
ESS relevance:	A section of the International Residential Code (IRC) covers energy storage systems.
Previous activity:	Development of proposed changes to better address energy storage safety within the IRC by proponents of individual changes to the IRC and also an advisory group of the Fire Code Action Committee (FCAC) and Building Code Action Committee. 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 current activity under the IFC above as to posting of proposed changes and committee action hearings. Note that changes addressing ESS in the IRC will likely be heard in the 2019 code development cycle.
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 International Building Code (IBC) support the new 2018 IFC ESS requirements.
Current activity:	See current activity under the IFC above as to posting of proposed changes and committee action hearings.
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 International Mechanical Code (IMC) related to energy storage systems were considered during the 2018 ICC code development cycle. Proposed changes to the IMC were due to ICC by January 8, 2018.
Current activity:	See current activity under the IFC above as to posting of proposed changes and committee action hearings.
Date of next edition:	2021

 Advancing Technology for Humanity	IEEE—www.ieee.org http://standards.ieee.org/about/nesc/
Document:	C2-17 National Electric Safety Code (NESC)
ESS relevance:	Covers electrical safety for utility systems and equipment.
Previous activity:	Completion and publication of the 2017 edition of the NESC.
Current activity:	<i>The final date to receive change proposals from the public for revision of the 2017 edition leading to the 2022 edition is July 16, 2018.</i> See http://standards.ieee.org/about/nesc/ and http://standards.ieee.org/about/nesc/nesc_2022_schedule.pdf for more information. <i>NESC Sub-Committees will then meet in September and October of 2018 to consider all change proposals and prepare recommendations.</i>
Date of next edition:	August 1, 2021 for publication of the 2022 edition.
Activity:	IEEE Energy Storage and Stationary Battery Committee (ESSB)
ESS relevance:	This is a growing subcommittee of the power and energy society that manages many of the standards around energy storage and battery technologies. http://sites.ieee.org/pes-essb/
Previous activity:	Meeting held June 2017. The ESSB has engaged with IEEE SCC 21, publishers of the IEEE 157 series of DER and ESS interconnectivity standards to form an SCC 21/PES ESSB Energy Storage Task Force (ESTF). The ESTF will be holding web meetings on the 4th Friday of each month. The General Meeting of the ESSB was held January 22 to 26, 2018 in Jacksonville FL. It included technical symposiums, and various Working Group sessions. One of the technical symposiums was a panel session on Safety Codes and Standards affecting Energy Storage.
Current activity:	The ESSB task force on codes and standards is organizing their future efforts associated with development of IEEE standards related to ESS as well as laying out their involvement in the development of codes and standards by other organizations that are related to ESS. <i>The ESSB will meet June 25 to 29, 2018 in Piscataway, NJ. Aside from their general meeting and meeting of the safety standards working group a number of their committees developing standards and guidelines related to ESS will conduct business.</i> See http://sites.ieee.org/pes-essb/ for more information.
Date of next edition:	N/A

 DNV GL	DNV GL—www.dnvgl.com/rules-standards/
Document:	DNVGL-RP-0043 Safety, Operation and Performance of Grid-connected Energy Storage Systems, December 2015 (GRIDSTOR)
ESS relevance:	The objective of this document (GRIDSTOR) 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 2 nd edition was developed and approved for public review (termed a public on-line hearing) in 2017. The document approved for public review was sent to the rules and standards group in DNV GL who initiated an on-line hearing and made 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). A public hearing started in early June and ran until July 2, 2017. All input received during the public hearing process on the 2 nd edition draft was processed by DNV GL for consideration and final approval of the 2 nd edition by those members of the consortium established to prepare and finalize the 2 nd edition. An internal meeting was held in August 2017 to finalize the document. The second edition of the document was officially published September 29, 2017. Go to https://www.dnvgl.com/news/dnv-gl-releases-updated-gridstor-recommended-practice-for-grid-connected-energy-storage-systems-102224 for more information.
Current activity:	Supporting the recent 2nd edition of GRIDSTOR.
Date of next edition:	TBD
Document:	HEATSTOR Joint Industry Project (JIP)
ESS relevance:	The objective of this document is to accelerate implementation of heat storage systems through creation of a globally recognized recommended practice for system safety, operation and performance. .
Previous activity:	None this is a new project.
Current activity:	An invitation is out to join the consortium that will develop HEATSTOR. For more information see https://www.dnvgl.com/article/heatstor-joint-industry-project-86759 .
Date of publication:	TBD

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:	The standard covers the safety of all energy storage systems and their installation in the built environment. Chapters of the standard cover equipment, protection and installation, limitations on ESS capacity as a function of technology and location and then also provide additional criteria focused on specific ESS technologies.
Previous activity:	Development of a draft standard by the technical committee from late 2016 until May 2017 and then formatting and editorial changes by NFPA staff resulting in a draft of the standard. The draft of the standard was considered by the NFPA Standards Council at their meeting in late August 2017. Information about submitting comments was provided at www.nfpa.org/855next and comments were due October 4, 2017, during the First Draft Stage. Comments received from the First Draft Stage were discussed and acted upon by the NFPA 855 Committee at their meetings in Dallas, TX on October 23 to 25, 2017 and Chicago, IL November 27 to 30, 2017. Based on the actions at those meetings a decision on each of the public inputs was decided and in the aggregate resulted in the basis for a first draft report. The Technical Committee on Energy Storage Systems ballot on the first revisions closed April 30, 2018. <i>Comments that were submitted as part of that ballot that were editorial were included in the second draft of the standard (and those that were not can be submitted during the public comment period.</i>
Current activity:	<i>The first draft report has been posted for public review and comment with a closing date of July 12, 2018.</i> See http://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=855&tab=nextedition for more information on NFPA 855. <i>A second draft meeting is scheduled for July 24 to 26, 2018 in Salt Lake City, UT and the second draft report is scheduled to be posted November 1, 2018.</i>
Date of first edition:	2020
Document:	NFPA 1078 Standard for Electrical Inspector Professional Qualifications
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 approved by the NFPA Standards Council and NFPA sought interest from appropriate individuals to on the committee responsible for this standard. This standard was open for public input with a closing date of February 14, 2018. See www.nfpa.org/1078 for more information. Public inputs received were compiled and considered by the NFPA 1078 Technical Committee at their meeting February 26 to 28, 2018 in Houston, TX. During that meeting the NFPA 1078 Committee considered 55 public inputs and approved 33 first revisions.
Current activity:	<i>The first draft report is being prepared and is scheduled to be posted August 22, 2018.</i>

Date of next edition:	2021
Document:	NFPA 78 Guide on Electrical Inspections (proposed edition).
ESS relevance:	This documents covers the minimum criteria to aid in organizing and conducting electrical inspections, including plan review and field inspection. Such plan reviews and electrical inspections would include, but not be limited to, energy storage systems.
Previous activity:	This standards project was approved by the NFPA Standards Council and NFPA sought interest from appropriate individuals to on the committee responsible for this standard. This standard was open for public input with a closing date of February 14, 2018. See www.nfpa.org/78 for more information. Public inputs received were compiled and considered by the NFPA 78 Technical Committee at their meeting February 26 to 28, 2018 in Houston, TX. During that meeting the NFPA 78 Committee considered 45 public inputs and approved 24 first revisions.
Current activity:	The first draft report is being prepared and is scheduled to be posted August 22, 2018.
Date of next edition:	2021

	National Electrical Contractors Association (NECA)—www.necanet.org	
	Document:	NECA 416-16 Recommended Practice for Installing Stored Energy Systems
	ESS relevance:	<i>National Electrical Installation Standards (NEIS)</i> 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. A new appendix containing a compliance checklist is under development.
	Current activity:	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 417-201x 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 and drafting of the document for industry review. This document addresses 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. A first draft was developed for industry review. A call requesting interest in participating in the industry review of the document was sent out by NECA on December 8, 2017 with a deadline to

	respond by December 22, 2017. An industry review of the draft document was open until February 2, 2018 and NECA staff compiled the comments received and prepared a revised draft. NECA 417 was out for first balloting until May 14, 2018. The draft was available for comment at http://www.necanais.org/ballot/neca-417-201x-recommended-practice-for-designing-installing-operating-and-maintaining-microgrids
Current activity:	<i>NECA staff are compiling the comments that were received during the public comment period for consideration by the drafting committee.</i>
Date of next edition:	The goal is 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 previously out for public review. Comments received during the public review were being resolved. The Ventilation Working Group responsible for the document met on January 25, 2018 in conjunction with the IEEE ESSB meeting.		
Current activity:	<i>A revised edition of the standard, based on input from the public review is at IEEE RevCom, who makes recommendations for approval or disapproval of standards submitted to the IEEE-SA Standards Board. Their approval or adoption is focused on whether IEEE-SA Standards Board procedural requirements have been satisfied.</i>		
Date of next edition:	TBD, however, a December 2017 draft is available from IEEE		
Document:	IEEE P1578 Recommended Practice for Stationary Battery Electrolyte Spill Containment and Management		
ESS relevance:	Covers how electrolyte spills can be contained and managed. Covered are vented lead-acid, valve regulated lead-acid, vented nickel-cadmium and partially recombinant Ni-Cd batteries.		
Previous activity:	Establishment of this new project and posting of an invitation to enroll in the ballot group which closed August 24, 2017. The document was available for comment until November 4, 2017. The comments were considered by the P1578 committee on January 25, 2018 in conjunction with the IEEE ESSB meeting.		
Current activity:	<i>The draft standard is about to be sent out for recirculation.</i>		
Date of next edition:	TBD		

	FM Global —http://www.fmglobal.com (https://www.fmglobal.com/research-and-resources/fm-global-data-sheets)
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. 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 published in January 2017.
Current activity:	Work to update the data sheet is likely to start in late 2018.
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 thermal energy storage systems.
Previous activity:	Establishment of a standards committee and efforts to prepare a first draft of the standard. A first draft was developed and the standards committee met on July 20, 2017. An initial committee ballot was issued and the committee discussed the results and further revisions during the meeting. The committee met again on September 14, 2017, which resulted in a draft standard that was circulated for a committee ballot. The ballot closed October 26, 2017 and the committee had a meeting via teleconference on November 2, 2017. Additional modifications to the draft were made in response to discussions during the November 2, 2017 meeting and were compiled in December for committee discussion and a ballot to approve the draft for public review. The draft standard was submitted for first consideration ballot and public review with a review period scheduled to close in late February. The link to the draft was https://cstools.asme.org/csconnect/Filedownload.cfm?thisfile=PublicReviewDraft2339.pdf&dir=ANSI.BSR8&43117.349919. The vote on the first consideration ballot was 9 for approval and 1 for disapproval resulting in disapproval by the TES Standards Committee and the ballot results returned to the TES Committee for consideration. The TES Standards Committee (TES SC) had a conference call on March 15, 2018 to review the ballot comments and revise the draft. Information was submitted for consideration in revising the draft standard and a ballot to approve the minutes of the March 15, 2018 and action items was sent to the TES SC for vote with a closing date of April 30, 2018.
Current activity:	<i>The revised TES-1 Draft has been circulated for First Consideration Ballot to the Committee for formal vote with a deadline of May 30, 2018. The next meeting of the TES SC will occur on June 26, 2018 in Orlando, FL.</i>
Date of next edition:	TBD

	National Electrical Manufacturers Association—www.nema.org
Document:	ESS-1-2017 Standard for Uniformly Measuring and Expressing the Performance of Electrical Energy Storage Systems
ESS relevance:	Provides safety related criteria for electrical energy storage systems.
Previous activity:	Establishment of a canvass committee and efforts to prepare a first draft of the standard. A first draft was developed and the canvass committee revised the draft. The goal of incorporating necessary revisions in preparation for a committee ballot of the draft was late December 2017. The first draft has been completed, was sent out for NEMA ballot to their Energy Storage Section and approved.
Current activity:	<i>The standard was approved by the NEMA Codes and Standards Committee and is currently being balloted through ANSI. The ballot closes July 2, 2018.</i>

Date of next edition:	August 2018
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	National Fire Protection Association (NFPA)—www.nfpa.org	
	Document:	NFPA 791-18 - 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:	The 2018 edition was finalized earlier in 2017 and is available.
	Current activity:	The public input closing date for the 2021 edition is June 27, 2018. See http://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=791&tab=nextedition for more information about NFPA 791. The first draft report is scheduled to be posted on February 27, 2019. <i>A task force of members of the NFPA 855 committee have completed work on proposed changes to NFPA 791 and will submit them prior to the public input closing date.</i>
Date of next edition:	2021	

 Underwriters Laboratories Inc.®	Underwriters Laboratories (UL)—www.ul.org	
	Document:	UL 9540 – Energy Storage Systems and Equipment
	ESS relevance:	Product safety standard for an ESS.
	Previous activity:	The first edition was published November 21, 2016. UL 9540 is an American National Standard and National Standard of Canada (ANSI/CAN). UL received proposals to revise the first edition of UL 9540 in April 2017, prompting a Call for Proposals to be sent to STP members and subscribers to the standards. Fully developed Proposal Requests (proposed changes and rationale) were to be submitted through UL's On-Line Collaborative Standards Development System (CSDS) at https://csds.ul.com/ by Thursday, July 20, 2017. Proposals to revise and enhance the first edition of UL 9540 were submitted in late 2017 by 6 individuals and UL has been putting together a bulletin for circulation based upon input received.
	Current activity:	<i>UL is preparing a proposed second edition of UL 9540 based on the proposal requests submitted. Once final input is received from the proposal submitters, the proposed second edition will be sent out for preliminary review.</i>
Date of next edition:	TBD	
	Document:	UL 9540A – Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems
	ESS relevance:	Provides a recommended practice for conducting testing with the results available to document the safety of BESS in relation to the separation requirements in codes and standards covering the separation of BESS from one another and structures.
	Previous activity:	Development of a draft by UL staff and publication of a first edition on November 2, 2017. Comments and suggested revisions were submitted on the first edition

	to UL staff for their consideration in enhancing the document. Based on those suggestions a second edition was released January 31, 2018.
Current activity:	
Date of next edition:	TBD

CODES AND STANDARDS FOR ESS COMPONENTS

 CSA Group	CSA GROUP (CSA)—www.csagroup.org
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
Document:	CSA C22.2 No. 340-201x Battery Management Systems
ESS relevance:	The standard covers the design, performance and safety of battery management systems (electronic or electromechanical systems that control or regulate a battery or batteries which may include external communication capabilities).
Previous activity:	ANSI PINs and SCC NOI have been filed for this standard and include a call for interested members to participate in the development of the standard. For further information on this activity contact Cathy Rake, (216) 524-4990 x88321, cathy.rake@csagroup.org
Current activity:	
Date of next edition:	TBD

 IEEE <i>Advancing Technology for Humanity</i>	IEEE—www.ieee.org
Document:	IEEE 1679.1-17 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. It provides recommendations on how to characterize lithium ion battery performance and safety in stationary applications. The guide is very general and non-prescriptive, offering common challenges and solutions with the caveat to 'consult the manufactures recommendations' for specific devices or technologies. The guide points to existing standards (e.g. UL 1642) and existing regulatory requirements (e.g. adoption of NFPA 70) wherever possible.
Previous activity:	Development of a draft that was completed and out for ballot to the drafting committee with comments with votes due May 25, 2017. The committee has resolved the comments, a resolution of comments was sent to commenters and the document approved. The document is published and available from IEEE.
Current activity:	
Date of publication:	2017
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. It provides recommendations on how to characterize sodium-beta battery performance and safety in stationary applications. The guide is very general and non-prescriptive,

	offering common challenges and solutions with the caveat to ‘consult the manufactures recommendations’ for specific devices or technologies.
Previous activity:	Development that was then completed and out for ballot to the drafting committee with comments and votes due June 15, 2017. The drafting committee had been focusing on resolution of comments received from the public review of the draft. A resolution of comments was recently sent to commenters and revisions to the document were finalized based on the actions taken on the comments.
Current activity:	<i>A revised version of the standard is about to be sent out for recirculation.</i>
Date of publication:	The unapproved draft is available from IEEE.

 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 1 st 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. Additional requirements for PV Rapid Shutdown Equipment and Systems were proposed and STP ballots and all comments were due October 2, 2017. Based on those comments a draft for recirculation was created. The recirculation period for the Additional Requirements for PV Rapid Shutdown Equipment and Systems closed December 18, 2017. The proposal maintained consensus with no new comments. UL published the 2nd edition of the standard December 22, 2017. On January 12, 2018 UL issued a re-circulation to remove Table 68.1 of the standards and in its place reference Tables 1 and 2 of the Standard for Interconnecting Distributed Resources with Electric Power Systems, IEEE 1547. Revisions were issued February 15, 2018 to the 2nd edition to delete Table 68.1, paragraphs 68.2 and 68.3 and add a reference to the Standard for Interconnecting Distributed Resources with Electric Power Systems, IEEE 1547.1. A certification requirement decision was issued for UL 1741 Ed. 2 on April 4, 2018. See https://www.shopulstandards.com/ProductDetail.aspx?UniqueKey=34185 for more information. A Bulletin was released April 24, 2018 highlighting and announcing proposed changes to the standard for preliminary review and

	comment. See https://www.shopulstandards.com/ProductDetail.aspx?UniqueKey=34227
Current activity:	
Date of next edition:	UL standards are under continuous maintenance and are updated as warranted.
Document:	ANSI/CAN/UL 1973, Standard for Batteries for Use in Stationary, Vehicle Auxiliary Power and Light Electric Rail (LER) 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 was initially an American National Standard and is now also a National Standard of Canada (ANSI/CAN). 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 opened June 30, 2017 and closed August 29, 2017. The UL bulletin for the draft 2nd edition that was to be a bi-national standard for the USA and Canada was voted affirmative. There was a circulation bulletin out for comment until November 20, 2017 with responses to comments and changes that resulted from comments received. The 2 nd Edition of ANSI/CAN/UL 1973 was published February 7, 2018. https://www.shopulstandards.com/ProductDetail.aspx?UniqueKey=33956
Current activity:	
Date of next edition:	TBD - UL standards are under continuous maintenance and are updated as warranted.
Document:	UL 1974 – Evaluation for Repurposing Batteries
ESS relevance:	This standard covers the sorting and grading process of battery packs, modules and cells and electrochemical capacitors that were originally configured and used for other purposes, such as electric vehicle propulsion, and that are intended for a repurposed use application, such as for use in stationary ESS and other applications. The process of sorting and grading these devices is essentially determining the state of health and other parameters to identify continued viability and the rating mechanisms the repurposing manufacturer may use for those that are determined suitable for continued use. This standard also covers application specific requirements for battery packs utilizing repurposed batteries and components.
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). The preliminary review work area in CSDS for the proposed first edition of the standard opened June 2, 2017 and closed July 7, 2017. UL considered the comments received during the preliminary review of the proposed 1 st edition of ANSI/CAN/UL 1974 and has revised the proposed standard accordingly for STP ballot and public review.
Current activity:	The proposed 1 st edition of ANSI/CAN/UL 1974 is out for ballot and public review. STP Ballots and all comments are due May 29, 2018.
Date of first 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 Sandia¹ 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.