

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

The goal of the DOE OE ESS Safety Roadmap<sup>1</sup> 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.

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 efforts are listed on the last page).

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 in current activity from the prior 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.  
**Codes and Standards for ESS Components**– components associated with the energy storage system.

## What's Noteworthy?

***The first draft report for NFPA 855 will be posted April 11, 2018 with a public comment closing date of June, 20, 2018.***

***The IEEE ESSB and associated working groups responsible for ESS related standards under the ESSB will be meeting January 22 to 26, 2018 in Jacksonville, FL.***

***UL 9540A – Test Method for Evaluating Thermal Runaway Fire Propagation in Battery ESS has been published.***

***Proposed changes to the IFC related to ESS have been approved by the FCAC and will be submitted to the ICC for consideration at the April 2018 ICC code development hearings.***

***ASME TES-1 has been approved for public review closing in late February 2018***

<sup>1</sup> 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](http://www.nfpa.org)

<b>Document:</b>	<a href="#"><b>NFPA 1-18 Fire Code</b></a>
ESS relevance:	<b><i>New Chapter 52 includes requirements related to the installation of ESS. Requirements recognize both established battery technologies as well as new technologies. Provisions apply to both new and existing applications of ESS.</i></b>
Previous activity:	<p><b><i>The 2018 edition of NFPA 1 was issued fall 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:</i></b></p> <ul style="list-style-type: none"> <li>• <b><i>52.1 General</i></b></li> <li>• <b><i>52.2 Lead-Acid and Nickel-Cadmium Batteries</i></b></li> <li>• <b><i>52.2.1 General</i></b></li> <li>• <b><i>52.2.2 Safety Features</i></b></li> <li>• <b><i>52.3 Additional Battery Technologies</i></b></li> <li>• <b><i>52.3.1 General</i></b></li> <li>• <b><i>52.3.2 Stationary Storage Battery Systems</i></b></li> <li>• <b><i>52.3.3 Capacitor Energy Storage Systems</i></b></li> </ul> <p><b><i>Access to the 2018 edition of NFPA 1 can be found at <a href="http://www.nfpa.org/1">www.nfpa.org/1</a></i></b></p>
Current activity:	The public input closing date for the 2021 edition is June 27, 2018. See <a href="http://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=1">http://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=1</a> for more information on NFPA 1.
Date of next edition:	2021
<b>Document:</b>	<a href="#"><b>NFPA 70-17 National Electrical Code</b></a>
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:	Proposed changes to the NEC were due September 7, 2017. Code making panel (18) public input reports are posted at <a href="http://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=70&amp;tab=nextedition">http://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=70&amp;tab=nextedition</a> . A first draft meeting is scheduled for January 8 to 20, 2018 in Hilton Head, SC. First draft reports are scheduled to be posted July 6, 2018 <b><i>and will have a public comment closing date of August 30, 2018.</i></b>
Current activity:	<b><i>Code Making Panel 13, Task Group 4 is responsible for review and recommending actions on 280 public inputs to Sections 480 and 706 of the NEC. They have conducted a number of teleconferences to finalize their input to CMP 13 on their assigned public inputs, which will be acted upon at the first draft meeting in January.</i></b>
Date of next edition:	2020
<b>Document:</b>	<a href="#"><b>NFPA 5000-18 Building Code</b></a>
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 for the 2021 edition is June 27, 2018. <b>See <a href="http://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=5000&amp;tab=nextedition">http://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=5000&amp;tab=nextedition</a> for more information on NFPA 5000.</b>
Date of next edition:	2021



**International Code Council (ICC)—[www.iccsafe.org](http://www.iccsafe.org)**  
<https://www.iccsafe.org/codes-tech-support/codes/code-development/current-code-development-cycle/>

<b>Document:</b>	<b><a href="#">2018 IFC (Fire Code)</a></b>
ESS relevance:	Chapter 12 of the IFC covers energy systems and Section 1206 in that chapter covers electrical energy storage systems.
Previous activity:	<p>Development of proposed changes to the 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, will be published in the 2018 edition of the IFC. The AG has been 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 FCAC has advised the AG to pursue specific code changes to the 2018 IFC requirements. These include the following:</p> <ol style="list-style-type: none"> <li>1. Develop requirements to address various installation scenarios, including: indoor installations in mixed use/occupied buildings, dedicated ESS buildings occupied only by maintenance and service personnel; outdoor containers/units located near buildings or exposures, outdoor containers/units NOT located near buildings or exposures and rooftop/parking garage/occupied work centers/ others</li> <li>2. Update signage requirements to better address installation scenarios.</li> <li>3. Require all ESS to be listed to UL 9540, consistent with NFPA 1 and NFPA 855 initial draft. (Exception for lead acid or telecom systems – approach TBD)</li> <li>4. If (3) is approved, determine if terms “prepackaged” and “pre-engineered” ESS can be eliminated.</li> <li>5. Update battery management system requirements to focus on shutdown and not remote annunciation, change EMS references to BMS.</li> <li>6. Delete references to UL 1973, since UL 9540 requires testing and compliance with UL 1973.</li> <li>7. Explore changing “Battery array” references to “Size and spacings” for clarity and consistency with NFPA 855.</li> <li>8. Include combustible vegetation clearances for outdoor installations.</li> <li>9. Explore adding exhaust and deflagration venting to better deal with potentially explosive gases produced during battery venting/fire events.</li> <li>10. Adding basic commissioning and decommissioning requirements to the IFC.</li> </ol> <p>The advisory group 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. Their efforts resulted in a revised outline for Section 1206 on energy storage to provide a more user friendly way of organizing and presenting the</p>

	requirements. .
Current activity:	<b><i>Finalization of proposed changes to Chapter 12 of the IFC for consideration by the ICC FCAC. Proposed changes to the IFC will be posted February 28, 2018 and committee action hearings held April 15 to 25, 2018 in Columbus, OH. <a href="https://cdn-web.iccsafe.org/wp-content/uploads/2018-2019-Code-Development-Schedule.pdf">https://cdn-web.iccsafe.org/wp-content/uploads/2018-2019-Code-Development-Schedule.pdf</a></i></b>
Date of next edition:	2021
<b>Document:</b>	<b><a href="#">2018 IRC (Residential Code)</a></b>
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 an advisory group (see above IFC information) 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
<b>Document:</b>	<b><a href="#">2018 IBC (Building Code)</a></b>
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
<b>Document:</b>	<b><a href="#">2018 IMC (Mechanical Code)</a></b>
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](http://www.ieee.org)  
<http://standards.ieee.org/about/nesc/>

<b>Document:</b>	<b><a href="#">C2-17 National Electric Safety Code</a></b>
ESS relevance:	Covers electrical safety for utility systems and equipment.
Previous activity:	Completion and publication of the 2017 edition of the NESC. The final date to receive change proposals from the public for revision of the 2017 edition leading to the 2022 edition is July 15, 2018. Change proposals will then be compiled and NESC Subcommittees then consider those proposals and prepare their recommendations in September/October of 2018.
Current activity:	A preprint of the change proposals is slated to be available and ready for acceptance in early 2018. See <a href="http://standards.ieee.org/about/nesc/">http://standards.ieee.org/about/nesc/</a> and <a href="http://standards.ieee.org/about/nesc/nesc_2022_schedule.pdf">http://standards.ieee.org/about/nesc/nesc_2022_schedule.pdf</a> for more information.
Date of next edition:	August 1, 2021 for publication of the 2022 edition.
<b>Activity:</b>	<b>IEEE Energy Storage and Stationary Battery Committee (ESSB)</b>

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. <a href="http://sites.ieee.org/pes-essb/">http://sites.ieee.org/pes-essb/</a>
Previous activity:	Meeting held June 2017. The ESSB has engaged with IEEE SCC 21, publishers of the IEEE 1547 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 next meeting of the ESSB is in Jacksonville Florida, January 22 to 25, 2018.
Current activity:	<b><i>The January 2018 General Meeting of the ESSB will include technical symposiums, and various Working Group sessions. One of the technical symposiums will be a panel session on Safety Codes and Standards affecting Energy Storage. For more details and an agenda for this Conference go to <a href="http://sites.ieee.org/pes-essb">http://sites.ieee.org/pes-essb</a>.</i></b>
Date of next edition:	N/A

	<b>DNV GL—<a href="http://www.dnvgl.com/rules-standards/">www.dnvgl.com/rules-standards/</a></b>
<b>Document:</b>	<b>DNVGL-RP-0043 Safety, Operation and Performance of Grid-connected Energy Storage Systems, December 2015</b>
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 2 <sup>nd</sup> edition has been under development and was 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 <sup>nd</sup> edition draft was processed by DNV GL for consideration and final approval of the 2 <sup>nd</sup> edition by those members of the consortium established to prepare and finalize the 2 <sup>nd</sup> edition. An internal meeting was held in August to finalize the document. The second edition of the document was officially published September 29, 2017. Go to <a href="https://www.dnvgl.com/services/gridstor-recommended-practice-for-grid-connected-energy-storage-52177">https://www.dnvgl.com/services/gridstor-recommended-practice-for-grid-connected-energy-storage-52177</a> for more information.
Current activity:	Supporting the recent 2nd edition of GRIDSTOR.
Date of next edition:	TBD

## CODES AND STANDARDS FOR ESS INSTALLATIONS



National Fire Protection Association (NFPA)—[www.nfpa.org](http://www.nfpa.org)

<b>Document:</b>	<b>NFPA 855 Standard for the Installation of Stationary Energy Storage Systems</b>
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 <a href="http://www.nfpa.org/855next">www.nfpa.org/855next</a> 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. <b>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.</b>
Current activity:	<b>A first draft report is being prepared based on the recent actions of the 855 Committee and will be posted on April 11, 2018 for review and comment. See <a href="http://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=855&amp;tab=nextedition">http://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=855&amp;tab=nextedition</a> for more information on NFPA 855.</b>
Date of first edition:	<b>2019</b>
<b>Document:</b>	<b>NFPA 1078 Standard for Electrical Inspector Professional Qualifications</b>
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.
Current activity:	<b>This standard is now open for Public Input with a closing date of February 14, 2018. See <a href="http://www.nfpa.org/1078next">www.nfpa.org/1078next</a> to submit a public input for the next edition.</b>
Date of next edition:	<b>2020</b>



National Electrical Contractors Association (NECA)—[www.necanet.org](http://www.necanet.org)

<b>Document:</b>	<b><u><a href="#">NECA 416-16 Recommended Practice for Installing Stored Energy Systems</a></u></b>
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.
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 <a href="http://www.neca-neis.org">www.neca-neis.org</a>
Date of next edition:	TBD based on current activity.
<b>Document:</b>	<b>NECA 417-201x Recommended Practice for Designing, Installing, Maintaining, and Operating Micro-grids</b>
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 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.
Current activity:	A first draft <b><i>has been</i></b> developed for industry review. <b><i>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.</i></b>
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](http://www.ieee.org)

<b>Document:</b>	<b><u><a href="#">IEEE 1635-12/ASHRAE Guideline 21-12 Guide for Ventilation and Thermal Management of Batteries for Stationary Applications</a></u></b>
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. The Ventilation Working Group responsible for the document will meet on January 25, 2018 in conjunction with the ESSB meetings noted above.
Date of next edition:	<b>TBD</b>
<b>Document:</b>	<b>IEEE P1578 Recommended Practice for Stationary Battery Electrolyte Spill Containment and Management</b>
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.
Current activity:	The comments are being compiled for consideration by the P1578 committee who will meet on January 25, 2018 in conjunction with the ESSB meetings noted above.
Date of next edition:	TBD



FM Global —<http://www.fmglobal.com>

(<https://www.fmglobal.com/research-and-resources/fm-global-data-sheets>)

<b>Document:</b>	<b>FM Global Property Loss Prevention Data Sheet # 5-33, Electrical Energy Storage Systems</b>
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:	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

	<b>American Society of Mechanical Engineers (ASME)—<a href="http://www.asme.org">www.asme.org</a></b>
<b>Document:</b>	<a href="#"><b>TES-1 Safety Standard for Thermal Energy Storage Systems</b></a>
ESS relevance:	Provides safety related criteria for molten salt energy storage systems.
Previous activity:	Establishment of a standards committee and efforts to prepare a first draft of the standard. A first draft has been developed. 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.
Current activity:	<b><i>The draft standard has been approved for first consideration ballot and public review with a review period scheduled to close in late February.</i></b>
Date of next edition:	TBD

	<b>National Electrical Manufacturers Association—<a href="http://www.nema.org">www.nema.org</a></b>
<b>Document:</b>	<b>ESS-1-2017 Standard for Uniformly Measuring and Expressing the Performance of Electrical Energy Storage Systems</b>
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.
Current activity:	A first draft has been developed and the canvass committee is revising. The goal of incorporating necessary revisions in preparation for a committee ballot of the draft is late <b>December 2017. At the present time NEMA is awaiting a few comments from the canvas committee members to come in on the document.</b>
Date of next edition:	TBD



National Fire Protection Association (NFPA)—[www.nfpa.org](http://www.nfpa.org)

<b>Document:</b>	<b>NFPA 791-18 - Recommended Practice and Procedures for Unlabeled Electrical Equipment</b>
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. <b>See <a href="http://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=791&amp;tab=nextedition">http://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=791&amp;tab=nextedition</a> for more information about NFPA 791.</b>
Date of next edition:	2021



Underwriters Laboratories (UL)—[www.ul.org](http://www.ul.org)

<b>Document:</b>	<b>UL 9540 – Energy Storage Systems and Equipment</b>
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 <a href="https://csds.ul.com/">https://csds.ul.com/</a> by Thursday, July 20, 2017.
Current activity:	Proposals were received for UL 9540 and UL is in the process of putting together a bulletin for circulation based upon input received. <b><i>The goal is for the bulletin to go out for preliminary review first quarter of 2018 and to include requirements referencing UL 9540A.</i></b>
Date of next edition:	<b>TBD.</b>
<b>Document:</b>	<b>UL 9540A – Test Methods for Evaluating Thermal Runaway Fire Propagation in Battery ESS</b>
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.
Current activity:	<b><i>The document has been published.</i></b>
Date of first edition:	<b><i>November 2, 2017</i></b>

## CODES AND STANDARDS FOR ESS COMPONENTS

	<b>CSA GROUP (CSA)—<a href="http://www.csagroup.org">www.csagroup.org</a></b>
<b>Document:</b>	<b>CSA C22.2 No. 107.1-2016 Power Conversion Equipment</b>
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

	<b>IEEE—<a href="http://www.ieee.org">www.ieee.org</a></b>
<b>Document:</b>	<b>IEEE 1679.1-17 Guide for the Characterization and Evaluation of Lithium-Based Batteries in Stationary Applications</b>
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.
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.
Current activity:	<b><i>The document is available.</i></b>
Date of publication:	<b>2017</b>
<b>Document:</b>	<b>IEEE P1679.2 Guide for the Characterization and Evaluation of Sodium-Beta Batteries in Stationary Applications</b>
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.
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.
Current activity:	A resolution of comments was recently sent to commenters.
Date of publication:	<b><i>The unapproved draft is available from IEEE.</i></b>

<b>Document:</b>	<b>UL 810A – Electrochemical Capacitors</b>
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 <sup>st</sup> edition was reaffirmed on March 28, 2017.
Current activity:	
Date of next edition:	UL standards are under continuous maintenance and are updated as warranted.
<b>Document:</b>	<b>UL 1642 – Standard for Lithium Batteries</b>
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.
<b>Document:</b>	<b>UL 1741 – Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources</b>
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.
Current activity:	<b><i>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 will proceed with publishing these new requirements,</i></b>
Date of next edition:	UL standards are under continuous maintenance and are updated as warranted. <b><i>The additional requirements were anticipated to be published and available December 22, 2017 for the 2<sup>nd</sup> edition of the standard.</i></b>
<b>Document:</b>	<b>UL 1973 – Batteries for Use in Light Electric Rail (LER) and Stationary Applications</b>
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). 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. <b><i>The UL bulletin for the draft 2nd edition that will 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.</i></b>
Current activity:	<b><i>The 2<sup>nd</sup> edition of UL 1973, which is a Joint National Standard for the USA and Canada, has been approved and is anticipated to be published in January 2018. It will have a new title: ANSI/CAN/UL 1973, Standard for Batteries for Use in Stationary, Vehicle Auxiliary Power and Light Electric Rail (LER) Applications</i></b>

Date of next edition:	<b><i>TBD - UL standards are under continuous maintenance and are updated as warranted.</i></b>
<b>Document:</b>	<b>UL 1974 – Evaluation for Repurposing Batteries</b>
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). 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 <sup>st</sup> edition of ANSI/CAN/UL 1974 and has been revising the proposed standard accordingly for STP ballot and public review.
Current activity:	<b><i>UL is in the process of developing a bulletin for the first edition of UL 1974 to go out for review and balloting in 2018.</i></b>
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 Sandia<sup>1</sup> 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](mailto:david.conover@pnnl.gov) or [pam.cole@pnnl.gov](mailto: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.

