

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

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 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. 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.



- 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.

What's Noteworthy?

NFPA 855 Standard for the Installation of Stationary Energy Storage Systems – The first draft was recently finalized and will be sent to the NFPA Standards Council for approval to release for public input this Fall.

ICC International Fire Code – A task force of the Fire Code Action Committee has initiated work on development of proposed changes to the 2018 IFC related to energy storage systems.

UL 1974 Evaluation for Repurposing Batteries - A Standards Technical Panel (STP) has been established and a proposed first edition is planned to be out for review this Summer.

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

OVERARCHING CODES AND STANDARDS



National Fire Protection Association (NFPA)—www.nfpa.org

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| Document: | <u>NFPA 1-18 Fire Code</u> |
| 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: | <u>NFPA 70-17 National Electrical Code</u> |
| 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. |
| Current activity: | An NEC task group has completed a draft of materials intended to align Articles 480 (batteries) and 706 (energy storage systems) in the future. The DC task group will review and comment on that draft and then begin development of proposed changes to Article 706 that when approved would be made available for public input. Proposed changes to the NEC are due September 7, 2017. |
| Date of next edition: | 2020 |
| Document: | <u>NFPA 5000-18 Building Code</u> |
| 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/>**

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| Document: | <u>2018 IFC (Fire Code)</u> |
| 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 |

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| | 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: | A Task Group reporting to the ICC FCAC is developing proposed changes to the IFC that are focused on energy storage systems and when completed will be submitted to the FCAC and if approved by them the FCAC will submit them by the January 8, 2018 deadline for consideration. |
| Date of next edition: | 2021 |
| Document: | <u>2018 IRC (Residential Code)</u> |
| 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: | <u>2018 IBC (Building Code)</u> |
| 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: | <u>2018 IMC (Mechanical Code)</u> |
| 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

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| Document: | <u>C2-17 National Electric Safety Code</u> |
| 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 |



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| 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). |
| Current activity: | The document approved for public review is being sent to the rules and standards group on DNV GL who will start the on-line hearing in June 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). There is no obligation that comments will be processed if they are outside the consortium, but that said they get the opportunity to provide input. All input will be processed and then final approval will be by those members of the consortium established to prepare and finalize the second edition of this document. Process comments late June, internal meeting in late August to finalize the document. |
| Date of next edition: | September 2017 |

CODES AND STANDARDS FOR ESS INSTALLATIONS



National Fire Protection Association (NFPA)—www.nfpa.org

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| 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. |
| Current activity: | First draft being finalized for review and approval by the Standards Council for release for public input from August to October 2017. |
| 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

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| Document: | <u>NECA 416-16 Recommended Practice for Installing Stored Energy Systems</u> |
| 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 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: | <i>National Electrical Installation Standards (NEIS)</i> are designed to improve |


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| | 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

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| Document: | <u>IEEE 1635-12/ASHRAE Guideline 21-12 Guide for Ventilation and Thermal Management of Batteries for Stationary Applications</u> |
| 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) |


CODES AND STANDARDS FOR A COMPLETE ESS


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|  | American Society of Mechanical Engineers (ASME)—www.asme.org |
| Document: | <u>TES-1 Safety Standard for Thermal Energy Storage Systems</u> |
| 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. |
| Date of next edition: | TBD |

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|  | 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 |

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|  | 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: | Proposed changes can be submitted at any time. PNNL has developed some changes intended to enhance the standard and they are under review by UL staff. |
| Date of next edition: | UL standards are under continuous maintenance and are updated as warranted. |

CODES AND STANDARDS FOR ESS COMPONENTS

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|  | 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 |

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|  | 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 |

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| 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: | UL standards are under continuous maintenance and are updated as warranted. 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. |
| Current activity: | UL 1973 is an American National Standard and will be a National Standard of Canada (ANSI/CAN). Proposed 2nd edition of binational standard for USA and Canada will be out for review and balloting in Summer of 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. |
| Current activity: | UL 1974 will be an American National Standard and National Standard of Canada (ANSI/CAN). Proposed 1 st edition of this binational standard for USA and Canada is planned to be out for review in Summer 2017. The preliminary review work area for the first edition of the standard will open June 2, 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. Those will be included in the June 2017 and enhanced through subsequent editions of this report.

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.