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Energy Storage System Guide for Compliance with Safety Codes and Standards

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June 2016

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for the Office of Electricity Delivery and Energy Reliability (OE1)

Funded by the Energy Storage Systems Program of the U.S. Department of Energy
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operated by
BATTELLE
for the
UNITED STATES DEPARTMENT OF ENERGY
under Contract DE-AC05-76RL01830

Printed in the United States of America

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(8/2010)

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Acknowledgements

This document would not have been possible without valuable input from a number of organizations and individuals. Under the Energy Storage Safety Strategic Plan, developed with the support of the Department of Energy's Office of Electricity Delivery and Energy Reliability Energy Storage Program by Pacific Northwest Laboratory and Sandia National Laboratories, an Energy Storage Safety initiative has been underway since July 2015. One of three key components of that initiative involves codes, standards and regulations (CSR) impacting the timely deployment of safe energy storage systems (ESS). A CSR working group has been monitoring the development of standards and model codes and providing input as appropriate to those development activities. The timely deployment of safe ESS is how to document and validate compliance with current CSR. A task force under the CSR working group was formed to address compliance with current CSR and through their efforts this document was developed.

Members of that Compliance Guide Working Group Task Force are listed below. In addition Dr. Imre Gyuk the Program Manager for the U.S. Department of Energy Energy Storage Program should be recognized for his support of this effort.

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Executive Summary

Codes, standards and regulations (CSR) governing the design, construction, installation, commissioning and operation of the built environment are intended to protect the public health, safety and welfare. While these documents change over time to address new technology and new safety challenges there is generally some lag time between the introduction of a technology into the market and the time it is specifically covered in model codes and standards developed in the voluntary sector. After their development, there is also a timeframe of at least a year or two until they are adopted. Until existing model codes and standards are updated or new ones developed and then adopted, one seeking to deploy energy storage technologies or needing to verify an installation's safety may be challenged in applying current CSRs to an energy storage system (ESS).

This Compliance Guide (CG) is intended to help address the acceptability of the design and construction of stationary ESSs, their component parts and the siting, installation, commissioning, operations, maintenance, and repair/renovation of ESS within the built environment. The bases for addressing acceptability are CSRs that have been adopted as of the publication date of this CG. Until those CSRs are updated, specific criteria for some ESS may not be provided in the CSR and as a result the acceptability of the ESS may be more challenging in terms of documenting and verifying it for safety.

The CG is intended to facilitate the timely deployment of stationary ESSs within an infrastructure of safety-related regulations, specifications, and other governing (adopted) criteria based upon voluntary sector standards and model codes that may not have been updated to specifically cover all ESS technologies or their intended application. The availability of this CG hopefully will assist those that need to document compliance with current safety-related codes and standards and guidance that what is proposed is safe. The CG is also intended to assist those responsible for verifying compliance with those same codes and standards.

The document first covers frequently asked questions in order of how they are likely to occur along the timeline associated with development and deployment of an ESS. It then addresses the ESS as a product or combination of components followed by the installation of the ESS in the built environment. Guidance for documenting or verifying compliance with current CSR is also provided to facilitate the review and approval of ESS installations. Appendices are provided that augment the core materials provided in the body of the CG.

Due to the current evolution in ESS technology development and deployment, anticipated use of this document and future availability of details associated with particular ESS technology installations, it is recognized this document can be further enhanced. The authors welcome suggestions for future enhancements of this document.

Acronyms and Abbreviations

AHJ	authority having jurisdiction
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
BESS	battery energy storage systems
BMS	battery management system
CG	Compliance Guide
CSA	Canadian Standards Association
CSR	codes, standards, and regulations
CWA	CENELEC Workshop Agreement
EES	electrical energy storage
EMC	electromagnetic compatibility
EPCRA	Emergency Planning and Community Right-to-Know Act
EPS	electric power system
EPSS	emergency or standby power supply system
ESS	energy storage system
EV	electric vehicle
FEB	Field Evaluation Bureaus
FMEA	failure modes and effects analysis
FMECA	failure mode, effects and criticality analysis
FTA	fault tree analysis
GR	generic requirements
IBC	International Building Code
ICC	International Code Council
ID	identification
IEC	International Electrotechnical Commission
IFC	International Fire Code
IMC	International Mechanical Code
IPC	International Plumbing Code
ISE	interconnection system equipment
ISPSA	International Swimming Pool and Spa Code
ITE	information technology equipment
NEC	National Electrical Code
NFPA	National Fire Protection Association
NRTL	Nationally Recognized Testing Laboratories
NWIP	New Work Item Proposal
PV	photovoltaic

PVES	photovoltaic energy systems
RD	reference document
SDO	standards development organizations
TES	thermal energy storage
UL	Underwriters Laboratory
UPS	uninterruptable power supply
VRLA	valve-regulated lead acid
WG	Working Group
WT	wind turbine
WTC	wind turbine converter
WTUISE	wind turbine utility interconnection systems equipment

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1.0 Introduction

This Compliance Guide (CG) covers the design and construction of stationary energy storage systems (ESS), their component parts and the siting, installation, commissioning, operations, maintenance, and repair/renovation of ESS within the built environment with evaluations of those ESSs against voluntary sector standards and model codes that have been published and adopted as of the publication date of this CG. The fundamental premise behind the development of the CG is that technology generally evolves and is deployed before development and adoption of codes and standards that specifically and prescriptively provide criteria that can be used to assess the acceptability of the technology. Until codes and standards are available that provide such criteria, those seeking to document or verify that what is proposed complies with those codes and standards must do so on the basis of equivalent performance; that is, they must show that what they are proposing, while not specifically covered by the criteria, is neither no more hazardous nor less safe than a similar technology that is covered by the criteria.

1.1 Purpose

The purpose of the CG is to facilitate the timely deployment of stationary ESSs in relation to existing safety-related codes, specifications, and regulations, (CSR), and other governing (adopted) criteria that are based on voluntary sector standards and model codes that may not have been updated to specifically and prescriptively cover all ESS technologies or their intended application. In this role, the CG is intended to address challenges to documenting and verifying compliance with CSRs that have not been updated to more specifically address ESS technology.

1.2 Intended Use

This CG is intended to provide 1) assistance to those who need to document compliance with current safety-related codes and standards in order to develop and deploy ESSs and 2) guidance to those responsible for approving and/or accepting ESSs or for verifying compliance with those same codes and standards on an ongoing basis.

2.0 Frequently Asked Questions

This chapter presents answers to common questions associated with documenting and verifying compliance of ESS with existing codes and standards. Users of this guide may use this section to learn more about documentation and verification and as a starting point to pursue these and other questions in more detail.

Q. What does ‘documenting compliance’ with codes and standards mean?

A. It means collecting the information necessary to support a statement or position that an ESS meets requirements contained in codes and standards are available.

Q. What does ‘documenting compliance’ entail?

A. Documenting compliance could include generating/collecting plans, specifications, calculations, test results, certifications or listings, and other information to support a statement or position of compliance with the applicable codes and standards for the ESS equipment itself as well as the relationship between the ESS and the surrounding environment (e.g., buildings, structures, roads, parking, etc.).

Q. Who is involved with ‘documenting compliance?’

A. The ESS manufacturer, designers involved in the ESS installation, contractors, system integrators, and/or third-party conformity-assessment entities would be involved in the preparation of documentation. Submittal of the documentation would be by an entity representing the ESS project and depending on the type of project and regulations adopted by the authority having jurisdiction (AHJ). Such documentation may have to be prepared by a registered professional or other approved agency.

Q. What does ‘verifying compliance’ with codes and standards mean?

A. It means ensuring that the submitted documentation shows that what is proposed is compliant with applicable codes and standards covering ESS safety and the verification that the ESS and its proposed installation does or does not satisfy the applicable (e.g., adopted) codes and standards.

Q. What does ‘verifying compliance’ entail?

A. Identifying the codes and standards applicable, a thorough comparison of the submitted documentation with the applicable provisions of adopted codes and standards and an onsite assessment of the ESS and its installation to verify compliance with the adopted codes and standards and consistency with the submitted documentation.

Q. Who is involved in verifying compliance?

A. One or more authority having jurisdiction (AHJs) will verify compliance based on the codes and standards they have adopted along with the entity that is seeking approval for the ESS and its installation. After a determination has been made that the submitted documentation supports compliance with applicable codes and standards, the ESS will be inspected during installation and commissioning to verify compliance with the approved plans and specifications (and consequently the adopted codes and standards) by the AHJ or a third party approved by the AHJ.

Q. What authority has jurisdiction?

A. AHJ is an entity that is responsible for the review and approval of an ESS and its installation. There can be more than one AHJ involved in a project depending upon the ESS and its intended installation location. AHJs include interconnecting utilities, the fire service (e.g., fire chief or fire marshal), code officials (building, fire, mechanical, electrical, etc.) and third-party entities that may conduct verification activities upon which AHJs rely, including testing and certification entities, insurance carriers, and registered design professionals.

Q. Where do the codes and standards used to document and verify compliance come from; how are they adopted, and by whom?

A. Generally, the codes and standards adopted in the United States are developed initially in the private sector by standards development organizations (SDOs) by interested and affected parties (e.g., stakeholders) who choose to participate in their development. Codes and standards are also developed at the international level by participating countries and their representatives of each country based on a process each country implements to bring their input (e.g., in the United States this generally involves a U.S. Technical Advisory Group under the auspices of an SDO). The review and comment on draft international standards is facilitated within each participating country and the final voting is a 'one country – one vote' process. Once developed, voluntary sector codes and standards are made available to anyone seeking to implement specific criteria on a topic covered by the codes and/or standards. Codes and standards may be adopted by public or private entities (e.g., federal, state or local governments, Indian tribes, utilities, and insurance carriers and may also be used as agreed upon 'norms' in contracts and specifications between sellers and buyers or developers and owners. An Overview of CSR Development, Adoption, and Compliance Verification of ESS are included in Appendix A.

Q. What legal obligations are associated with codes and standards?

A. Adoption of voluntary sector codes and standards by a federal, state, local, territorial, or tribal government (e.g., through legislation or by rulemaking) may create a legal obligation with which an ESS manufacturer, integrator, and/or an installer must comply. Alternatively, if voluntary sector codes and standards are incorporated into a contract, a party under the contract will need to meet the specified codes and standards to satisfy the requirements of the terms of the contract. Legal obligations also may be created indirectly by the adoption of codes and standards by professional credentialing entities. These entities may be authorized to establish licensing criteria for prospective or current professionals or contractors, and may require those professionals or contractors to demonstrate knowledge and application of current codes and standards as practiced in a particular field. Legal obligations also may be imposed (especially as it concerns claims of negligence).

Q. Can you summarize the scope of these codes and standards as applicable to the development, manufacturer, and installation of ESS?

A. Collectively, codes, and standards are intended to cover the safety-related aspects of all stationary ESS technologies and installations from development to installation and commissioning and then operation, maintenance, and through to decommissioning and even beyond that to any repurposing for a second use. Individually, codes and standards address specific aspects of the ESS technologies and the components that comprise the system as well as a number of functions supported by an ESS as installed and operated

during its life cycle (including siting/clearances, ventilation, fire detection and suppression, fire department access, and electrical safety).

Q. Is there any distinction made between 1) an ESS that is from a single manufacturer (e.g., unitary, prepackaged, self-contained or matched components) and 2) an ESS that is an assembly of different components from different manufacturers that is produced by someone other than a single ESS manufacturer?

A. Yes. Codes and standards seldom stop at covering one unitary product or finished system. They often make reference to other standards self-contained or prepackaged (e.g., a singular ‘product’ or ESS equipment), which when taken together for all of the components of an ESS, comprise the applicable codes and standards used to manufacturer or build an ESS, and thus create a single safety standard. To the extent that components are designed, manufactured, and assembled by a single manufacturer in a uniform manner the manufacturer can direct how the ESS should be assembled and that assembly would likely be covered by a product standard or standards. In that case, much of the complexity of documenting and verifying compliance of the ESS ‘product’ can be addressed by the single manufacturer, leading to standardization of the ESS ‘product.’ When the ESS components come from several manufacturers, and no single manufacturer is responsible, each component may have its own compliance standard and the standards of each component may or may not be compatible with the assembly of the ESS as a whole. In this case, other codes and standards will become more relevant as the ESS construction occurs in conjunction with its site installation. The more standardized the ESS as a product, the greater the role that third-party testing and certification can play in documenting and verifying the safety of the product. The less standardized the ESS (i.e., more reliant on installation of different components onsite), the greater the role that AHJs will have in ensuring that proper documentation has been obtained and in verifying that the ESS installation is safe.

Q. Does the ESS or its component parts, whether unitary, matched assemblies, or mix-matched components, need to be tested and listed¹ by a third party?

A. Not necessarily because the entity that adopts the codes and standards is ultimately responsible for verification of compliance. The AHJ can undertake any activities it chooses to verify compliance and, as a result of that process, it determines what documentation of compliance with the adopted CSR must be provided. Because of the challenges associated with documenting and verifying compliance with codes and standards applicable to equipment, such as an ESS and its component parts, AHJs relies heavily on guidance provided by accredited third-party entities, although not too long ago, some local government agencies had their own testing laboratories for product testing. These third-party entities will document and verify compliance with standards, and ultimately provide certification of compliance through ‘listing and labeling.’ If the ESS is not tested and then listed or if component parts of matched or mix-matched systems are not tested and listed, there are standards and procedures available that can help guide how their safety can be documented and verified outside the traditional testing and listing process. However, if safety has not been documented through such third-party activities, there is a greater likelihood that an

¹ The term “listed” in the National Electrical Code, is defined as equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or services meets identified standards or has been tested and found suitable for a specified purpose.

AHJ would approach verification of ESS safety differently; even possibly denying a permit until such third-party verification is available.

Q. Who has authority and over what in the review and approval of a proposed ESS installation?

A. Any entity that is part of the review, approval, permitting and inspection process that is established administratively by the entity adopting the codes and standards has some authority over approving an ESS ‘product’ and its installation. For instance, where the adoption process for a code or standard is contractually between a manufacturer and owner, each would take action to determine that the safety provisions, as set forth in the contract, were met. If an ESS is located on the grid side of the meter (i.e., interconnected with a utility) the utility would determine that steps had been taken to ensure that ESS safety standards provisions have been met by the ESS manufacturer, the ESS component manufacturers, the system integrator and/or those performing the installation. Based on the location of the ESS installation and/or reliance on the local government for incident response, one or more federal, state, local, territorial, or tribal agencies also may be involved. If the installation is on the customer side of the meter, the extent to which federal, state, local, territorial and/or tribal entities may be involved will depend on the location of the ESS and the scope of the codes and standards adopted. The serving utility also may be involved if the customer side of the metered ESS is connected to the grid.

Q. Are utilities likely to adopt codes and standards for an ESS on the grid side of the meter that are different than those adopted by federal, state, local, or tribal entities on the customer side of the meter?

A. Yes and no. Utilities play, in part, the role of an AHJ, but they are part owner and operator, as well. That is, they will act on their own to ensure ESSs they procure, install, operate, and maintain are safe. While utilities generally will adopt codes and standards developed in the voluntary sector, they also are likely to adopt and administer additional criteria that they develop individually or collectively. These additional criteria may reflect the type of issues faced by an owner or operator that wants to safely operate an ESS as a component of its electrical grid.

Q. What do codes and standards that relate to an ESS cover?

A. Collectively, the codes and standards covering ESS safety are intended to cover any and all aspects of the ESS: design, manufacture, installation, construction, commissioning, operation, and maintenance of the ESS and its component parts. More specifically, they include installation in, on and adjacent to buildings or private and public areas, renewal or refurbishing or decommissioning of the ESS or its components, and incident response. The details and criteria of codes and standards applicable to ESSs cover a wide range of topics, each of which may vary depending on ESS size, type of system or chemistry used, and location of the ESS inside, on, adjacent to or otherwise in proximity to a building or private or public space. These topics include, but are not limited to, signage, clearances, first responder access, protection from natural and manmade hazards, fire detection, and suppression, ventilation, exhaust and thermal management, and electrical safety.

Q. For any particular ESS ‘product’ and its installation will there ever be duplicative or contradictory requirements?

A. Yes. Multiple AHJs may have overlapping authority for an ESS installation. An ESS located in a health care facility could be subject to criteria that are dependent on factors other than the ESS involved or the location of the ESS in services through Medicare and Medicaid must comply with criteria adopted

by the U.S. Department of Health and Human Services, Center for Medicare and Medicaid Services. In addition, codes and standards adopted by federal agencies would apply to facilities owned by the federal government, while adopted state or local building regulations could apply to other structures, which are not federally-owned. If leased to the federal government both federal and state or local regulations would apply. Further, there is the potential that a patchwork of voluntary codes and standards that form the basis for what is adopted could cover the same or similar issues without being harmonized.

Q. Do codes and standards that relate to an ESS cover commissioning and/or operations?

A. Yes, codes and standards are intended to apply to each phase of the life cycle of an ESS, including commissioning and renovation or renewal of systems once placed in operation. The phase of a project to which codes and standards apply will vary as will the involvement of an AHJ. For instance, an installation on the customer side of the meter might involve a local building department up to and including an initial approval of the installation and then, once placed in operation, the local fire marshal would be the AHJ to ensure continued safety.

Q. Will codes and standards that relate to an ESS change?

A. Yes, codes and standards developed by SDOs typically are reviewed on cycles of between three and five years, depending on the SDO. Revisions to existing codes and standards, or development of new codes and standards to address new issues and/or technology, are continually under development, and are intended to ensure the criteria represent the latest research and safety-related information with which to guide the safe design and construction of ESSs and their application and use. Beyond the development of codes and standards by SDOs, the timing of their adoption also must be considered. At best, government agencies adopt new codes and standards within 1 year of their publication, and at worst, the time lag may be over 5 years until they are adopted. On average, adoption of a new code or standard occurs about 2 years after its publication by an SDO. In short, codes and standards can lag technology development and deployment, but with research and proactive involvement by ESS proponents and interested parties with SDOs, they can be developed (for new technology) or updated (for existing technology) in a more timely and robust manner and then adopted more quickly. While this process is happening now and will form the future basis for documenting and verifying the safety of current and future ESSs, the reality is that today's codes and standards may not provide the specific detail needed to easily document or verify the safety of an ESS. This document is intended to help address that gap assessing the safety of today's ESS's in relation to today's codes and standards.

Q. What is the most important recommendation for someone documenting the safety of an ESS?

A. The key to documenting the safety of an ESS is to identify who will be involved in the review and approval of the ESS (e.g., the AHJs), determine how their review and administrative process functions, determine what they will need from you, and review what code, standard, and/or regulation (CSR) they have adopted and will be used to assess the safety of the ESS that is proposed.

Q. Are there resources that can help an AHJ verify the safety of an ESS in relation to adopted CSRs?

A. Those persons that need to verify the safety of an ESS (e.g., AHJs or adopters of the codes and standards) need to develop a general familiarity with ESS technology and the safety issues that need to be addressed for specific ESS technologies, the provisions in adopted CSR, and a list of safety-related questions to ask of those proposing an ESS. Ideally, ESS proponents will have checklists to guide 1) their

review and approval processes and 2) development of materials to document the safety of their proposed ESSs. Such a checklist is provided in Chapter 5.0.

3.0 Energy Storage System Product and Component Review and Approval

The purpose of this chapter is to provide a high-level overview of what is involved in documenting or validating the safety of an ESS, either as a complete ‘product’ or as an assembly of various components. This information does not cover the installation of the ESS, which is covered in Chapter 4. Documenting or verifying that an ESS, its components, and its installation meet specific codes or standards are generally considered conformity assessment. Appendix B provides more detail on the steps associated with documenting and validating the acceptability of ESS as products and their component parts. The following is a summary of the steps that should be considered in documenting and validating the safety of an ESS as a product and the component parts of an ESS. As previously noted, the less the ESS resembles a product, either a self-contained piece of equipment or assembly of matched components, the greater the reliance on installation criteria as opposed to product and component standards as a basis for determining the safety of the ESS (e.g., the ESS ‘product’ is essentially constructed in the field as opposed to a factory). Figure 3.1 provides a general flow chart of the process to document and validate the safety of an ESS product or component, noting if no standards are available that cover the ESS product or its components (or one chooses to not document safety to standards that are available), then alternative methods to evaluate and document safety will likely be needed . More information is provided after the figure to explain in more detail the various steps associated with the process of ESS product and component review and approval.

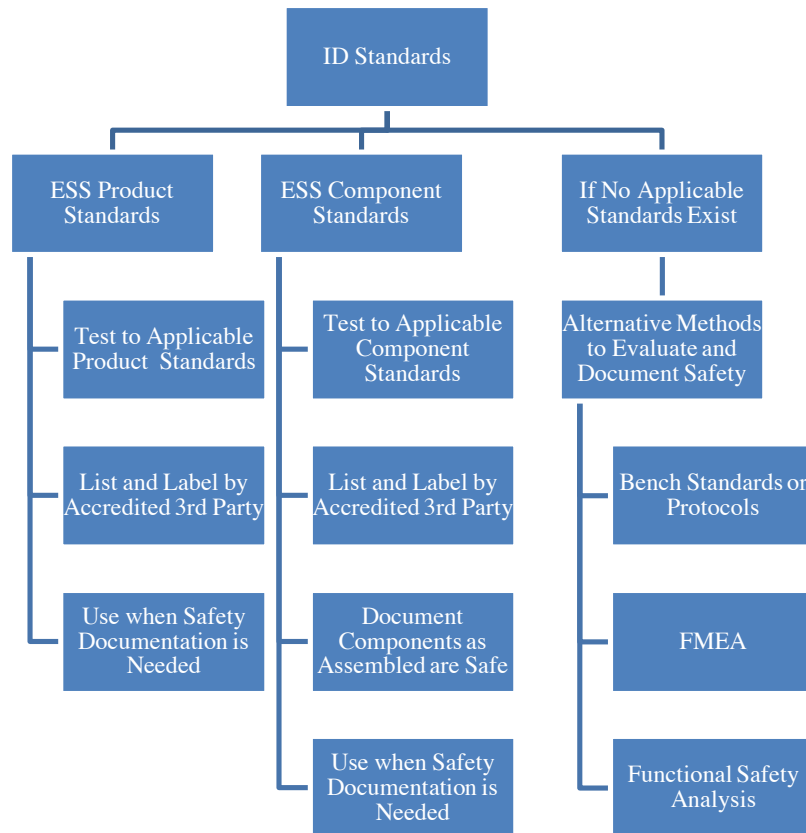


Figure 3.1. Review and Approval of ESS Products and their Component Parts

1. Determine safety-related testing standards that are applicable to the ESS as a complete prepackaged system or to the components of an ESS when it is not a complete prepackaged system. These will either be included in existing codes and standards applicable to the built environment and if not could be under development by SDOs. Table 3.1 provides a listing of some safety-related testing standards for systems and system components. More detail on these and additional standards is provided in Appendix C (components) and Appendix D (systems). In addition to the standards listed in Table 3.1, there may also be specifications and related documents promulgated by utilities that address the acceptability of an ESS for location on or interconnection with the power grid. These include IEEE 1547 noted below and may include other standards beyond those listed in Table 3.1 that are adopted by reference in the National Electrical Safety Code (IEEE C2).

Table 3.1. Energy Storage System and Component Standards

Title	Designation
Molded-case circuit breakers, molded-case switches, and circuit-breaker enclosures	UL ^(a) 489
Electrochemical capacitors	UL 810A
Lithium batteries	UL 1642
Inverters, converters, controllers and interconnection system equipment for use with distributed energy resources	UL 1741
Batteries for use in stationary applications	UL 1973
Second-use batteries	UL 1974 (proposed)
Recommended practice and procedures for unlabeled electrical equipment evaluation	NFPA ^(b) 791
Standard for interconnecting distributed resources with electric power systems	IEEE 1547
Recommended practice and procedures for unlabeled electrical equipment evaluation	NFPA 791
Outline for investigation for safety for ESSs and equipment	UL 9540 (proposed)
Safety for distributed energy generation and storage systems	UL 3001 (proposed)
Safety standard for molten salt thermal energy storage systems	ASME TES ^(c) -1 (proposed)

a. UL = Underwriters Laboratory

b. NFPA = National Fire Protection Association

c. ASME TES = American Society of Mechanical Engineers Thermal Energy Storage

2. If relevant testing standards are not identified, it is possible they are under development by an SDO or by a third-party testing entity that plans to use them to conduct tests until a formal standard has been developed and approved by an SDO. Documents that precede formal standards developed by an SDO can be referred to as ‘bench standards,’ ‘protocols,’ or ‘acceptance criteria,’ and can provide some guidance on testing until a formal standard is published. In many cases these documents form the initial draft of a standard developed by an SDO.
3. As a manufacturer of an ESS system or component, conduct internal testing (e.g., self-testing) as required by the standards (or, as noted in Step 2 above, as bench standards, protocols, or acceptance criteria) found applicable to the ESS system or component and based on the test results, determine if changes are needed to the system or component design or construction, implement those changes, and re-test/make changes until the system or component tests indicate compliance. If there is a question concerning what standards to use as a basis for testing secure advice from a third-party testing agency and/or AHJs the are likely to be involved in the review and approval of the ESS system or component.

4. In conducting internal tests as a manufacturer it is probable that those experiences will lead to questions about the test standard being used or even suggested changes to improve the usability or accuracy of the standard. If that occurs serious, consideration should be given to providing those findings and recommendations to the applicable SDO for consideration in revising the standard.
5. Secure the services of an approved third-party testing agency that can test the ESS system or component to determine if it complies with applicable standards. AHJs should be able to provide advice about the acceptability of third-party testing agencies along with entities that accredit those agencies to ISO standard 17025 such as the International Accreditation Service or National Voluntary Laboratory Accreditation Program.
6. Where there is no standard available with which to evaluate the safety of an ESS system or component and a new standard is not under development, a bench standard or protocol may be available as covered above and could be developed by a third-party testing agency for use in assessing the acceptability of the ESS system or component from a safety standpoint.
7. In advance of any standard or bench standard, a failure modes and effects analysis (FMEA) could be prepared to document the safety of the ESS equipment or its component parts from a reliability standpoint based on the application and use of IEC 60812, *Analysis Techniques for System Reliability – Procedure for Failure Mode and Effects Analysis*, or NFPA 791 applied as it covers how to assess the acceptability of unlisted electrical equipment. Also consider a functional safety analysis to augment the FMEA based on the application and use of IEC 61508, *Functional Safety of Electrical/Electronic/Programmable Electronic Safety-related Systems*.
8. After an ESS system or component has been found to comply with one or more appropriate safety standards, bench standards, protocols, etc., via testing by an approved third-party testing agency and their issuance of one or more relevant test reports, the test report can be used as a component of safety documentation. It will also be necessary to ensure that continued production of the ESS system or component is acceptable (e.g., continued production is identical to the system or component that was tested and found to comply with the applicable standard(s) and/or other relevant criteria).
9. Secure the services of an approved third-party certification agency that can conduct ongoing monitoring of the continued production of the ESS system or component as well as the manufacturer's quality control and manufacturing processes.
10. Through those services the third-party agency is then in a position to authorize the manufacturer of the ESS system or component, depending on the scope of the safety testing conducted and their findings associated with the review of ongoing production and quality control processes, to label the system or component as complying with the criteria (standard, protocol, etc.) used as a basis for safety testing.
11. Utilize the results from the activities above (testing and listing) when documenting compliance with safety-related codes and standards for AHJs. Because the proponent of the system or component is able to show that their product has been tested and listed, the AHJ can rely on that in verifying compliance with the standards used as a basis for the testing; those standards being those adopted in CSR covering the installation of an ESS.
12. After documenting or verifying the acceptability of the ESS as a system or individual ESS components, the safety of their application in, on, or around buildings and facilities must be addressed

(see Chapter 4).

13. Looking toward an actual installation, those who are pursuing application and use of the ESS or ESS components should identify the AHJ or AHJs having authority over the ESS installation and the CSRs they have adopted to address its safety.

Note that multiple entities may be involved in pursuing the above activities. The manufacturer of an ESS or system component should be the primary entity involved in ensuring the required safety testing is conducted and their product is listed. If that is not done by the manufacturer then that burden will likely fall on the entity that is pursuing the installation (e.g., owner/developer, contractor, utility, etc.) and it may be time consuming and costly for them to undertake this on their own, suggesting ESS or system components that are not tested and listed when sold or in some other way do not have their safety documented are less inclined to be readily deployed (e.g., sold). Even if tested and listed, those pursuing an installation of an ESS or components they have purchased or are installing will have to use that information in documenting the safety of the ESS to AHJs (e.g., the manufacturer of the ESS or component may consider their responsibility to end when a sale is made). It is relevant to note that proponents of ESS equipment or components that have not reviewed CSR related to the safety of an ESS installation are more likely to provide ESS equipment or components that, while tested and listed as being safe, may not be able to be installed as envisioned or when installed have to meet additional unanticipated requirements. For these reasons, it is suggested that proponents also consider how their product will be impacted by topic covered in Chapter 4 and if not directly involved in the application of the product in the field provide information on their product that will support those who will be addressing the issues covered in Chapter 4.

It is important to recognize that the information above is applicable to new ESS systems and components in new and existing buildings and facilities. Depending on the scope of the adopted regulations those regulations are also likely to apply to the repair or renewal of existing (e.g., repurposed or refurbished) components or systems. Once an ESS system has been tested and listed as complying with applicable standards it need not be re-tested or re-listed unless it is subsequently modified in the field that in some way will change the original conditions of approval in such a way as to void the listing. Modifications to existing systems that come about due to repair, renewal, renovation, etc. that are likely to fall into this situation are replacement cells, batteries or modules associated with non-flow ESS or a change in electrolyte in flow batteries.

Another situation where testing and certification will be relevant is second-use batteries where batteries designed and constructed for one application are repurposed for application in a stationary ESS. It is important to note that second-use batteries should be listed separately (e.g., UL 1974) and not as new batteries (e.g., UL 1973). Such batteries also will need to be documented and verified (e.g., tested and certified¹) as satisfying applicable standards, whether applied in new ESS or supporting repair, renovation

¹ The term “certified” as defined in NFPA standards involves a system whereby an entity involved in conformity assessment determines that a manufacturer has demonstrated the ability to produce a product that complies with the requirements of a specific standard or standards, authorizes the manufacturer to use a label on products that comply with the requirements of the standard (e.g., they are listed), and establishes and conducts a follow-up program of continued production as a check on the technical, administrative and quality control processes the manufacturer uses in order to validate that continued production is consistent with that originally tested and found to comply with the standards to which is was tested.

or renewal of existing ESS. Note also that the application of a second-use battery in an existing system may necessitate another evaluation of the safety of the resultant system as it relates to its installation. If such an assessment is found necessary and not undertaken it could result in a violation of adopted regulations as well as void the prior testing, listing, and approval of the existing ESS. Because of the current lack of standards to test and list second-use batteries (although as noted above standards are under development to address an assessment of their safety), it may be challenging to document or validate the safety of a second-use battery unless the first use of the battery was in a stationary ESS application. Beyond addressing the safety of that second-use battery, currently adopted regulations covering ESS installations are not likely to provide specifics for second-use batteries. That said, if the second-use battery can be documented and validated as safe, then its application in an existing system should be capable of being assessed under adopted regulations in a manner similar to if the battery were new.

4.0 Energy Storage System Installation Review and Approval

The purpose of this chapter is to provide a high-level overview of what is involved in documenting or validating the safety of an ESS as installed in, on, or adjacent to buildings or facilities. This information does not cover the safety of the ESS as a complete ‘product’ or individual components of the ESS, which are covered in Chapter 3. Note that the more the ESS can be considered a product of an assembly of matched components the greater the relevance of the information in Chapter 3 is in addressing the safety of the ESS, noting the installation criteria discussed in Chapter 4 will still apply in conjunction with installation-related criteria that are part of the ESS ‘product’ or component certification. The more the ESS becomes an assembly of component parts that are not matched but are combined onsite in conjunction with the ESS installation, the more the installation criteria discussed in Chapter 4 will apply to the ESS; that is, the more the entire issue of the safety of the ESS will be determined through the application of CSR at the point of installation as opposed to reliance on third-party testing and listing agencies (which provide value related to the time and cost associated with documenting and verifying ESS safety). Documenting or verifying that an ESS, ESS components, and an ESS installation meet specific codes or standards are generally all considered elements of a conformity-assessment process. Appendix B provides more detail on the steps associated with conformity assessment (e.g., documenting and validating the acceptability of an ESS installation).

Following is a summary of the steps that should be considered in documenting and validating the safety of an ESS installation. Again, the degree to which the ESS as a ‘product’ or its component parts have been tested and listed as covered in Chapter 3 is likely to eliminate the need for AHJs to have to individually address the safety of their design and construction.

Topics that will be addressed in documenting and validating the safety of an ESS installation are listed in Table 4.1.

Steps to consider in addressing the topics in Table 4.1 and documenting or verifying compliance with CSR related to an ESS installation are listed after the table. Note that the conduct of these steps is likely to involve a number of entities based on their role associated with the ESS installation. In most instances, the manufacturer of an ESS or an ESS component will not be directly involved in an installation unless they choose to be involved, are contacted by those pursuing the installation, or may be supporting distributors/contractors that deploy the technology. In most instances those entities will include designers/engineers, systems integrators, contractors, and possibly commissioning agents, all acting on behalf of the owner/developer of the project associated with the ESS installation. An exception to this would be a situation where the owner and the AHJ are the same entity, such as a utility or a federal, state, or local owner of the ESS. In these cases the entity or agency could be documenting and verifying compliance concurrently; that is, checking themselves or those performing the work on their behalf.

Table 4.1. Topics Associated with an Energy Storage System Installation

Administration	The scope and purpose of the CSR and how it applies to new and existing ESS installations – these provisions will define what is covered in the CSR and how the provisions will apply to the ESS as a product or components and their installation.
References	Any other code, standard, or regulation document that is related to the installation of the ESS will generally be referenced and as such becomes part of the CSR in which is it referenced.
Definitions	All relevant terms are defined – these can be critical in ‘sorting out’ what does and does not apply to an ESS installation and if applicable how the provisions are to be implemented.
ESS equipment and components	How to define the ESS (product, factory-matched components, field designed, and assembled) and what applies to documenting and verifying the safety of the ESS related to any design or construction that takes place off-site (e.g., as manufactured).
Siting	Location in relation to various aspects of the site (e.g., parking, roads, buildings, etc.) as well as criteria relevant to location in, on, or adjacent to one or more buildings.
Interconnection with other systems	Connections to communications, electrical inputs and outputs, and other energy-related systems on the site as well as any interconnections with an electric utility.
Ventilation, exhaust, and thermal management	Air flows, relative pressures, temperature and intake, and exhaust locations associated with the normal operation of the ESS.
Fire protection	Fire and smoke detection, fire suppression, containment of fire and smoke, smoke removal, containment of fluids and effluent from, firefighting operations, access/egress and signage.
Commissioning	Validating the proper operation of the ESS and all control and emergency systems associated with the ESS.

It is also important to build on past experiences associated with ESS safety documentation and validation. Where ESS installations are expected to be identical or similar there are significant advantages to developing a thorough and robust documentation package that can be based on national codes and standards and used as a foundation for all ESS deployments. Similarly as AHJs secure a better understanding of ESS technology, safety issues, and the applicable CSR they can pursue individually or collectively the development of uniform safety verification guidance. The template in Chapter 5 provides an example of what might be considered in development of a form to guide uniform and complete safety documentation and verification activities.

1. Based on the location of the intended installation, determine which agencies, authorities, etc., have some responsibility in the review and approval of the installation. Where an AHJ is also the owner of the ESS (e.g., utility, federal, state or local building, etc.), that AHJ may have complete authority over the installation or at least be a ‘one-stop’ source for addressing this issue. For other installations (e.g., private sector or non-utility) there may be a number of agencies and offices that will need to be identified, the scope of their responsibility determined, and their review and approval processes outlined in relation to the project timeline.
2. Determine the CSRs that are applicable to the ESS installation. This will be based on an identification of the relevant AHJs as covered in item 1 above and then the scope of their authority and what CSR they have adopted to cover the installation of an ESS. Table 4-2 provides a listing of some installation-related standards and model codes. More detail on codes and standards applicable to ESS installations is provided in Appendix E.

3. Determine if the identified CSR apply to the intended ESS installation. If they do not apply then document why and verify that with applicable AHJs based on the intended installation (e.g., utility, fire marshal, code official, zoning, etc.).
4. If one or more CSR are applicable, then review them in relation to the ESS technology being considered and the intended installation of the ESS to identify the specific provisions that will apply. If in doubt, identify the provisions and mark them for additional discussion with the applicable AHJs. Note that AHJs will generally have a library of the CSRs that they have adopted and would be applicable to an ESS installation, although in pursuing multiple ESS installations, it may be advantageous to secure a copy of the applicable voluntary sector codes and standards upon which most adopted CSRs are based.
5. Visit with the applicable AHJs for a preliminary discussion about the project, what is intended and to secure clarification about the CSR provisions they will be applying based on the information prepared under Step 3 above.
6. Based on the information gathered in meeting with the AHJs, prepare the plans, specifications, calculations, and other necessary and relevant documentation to outline what is proposed regarding the installation and how what is proposed complies with the CSR provisions to be applied to the project. This information should address all the topics listed in Table 4.1 as provided for in the adopted CSR.
7. Submit the plans and specifications to the AHJs. As discussed under item 1 above, this could involve multiple AHJs in parallel and/or series, each of whom may be responsible for one or more aspects of the ESS installation but not necessarily the entire project.
8. In submitting the plans and specifications after due consideration of the steps above, the approval process is less likely to uncover issues. That said, if any AHJ has questions or needs additional documentation, it should be provided in a timely manner. As previously noted, the degree to which the plans, specifications, calculations, and other safety-related documentation of CSR compliance can be ‘standardized’ using national codes and standards and a few typical ESS installations, the increased probability that over time the materials documenting the acceptability of the ESS installation will be more uniformly approved in a timelier manner by AHJs. Third-party agencies may also be able to assist in the development of a ‘safety documentation package’ based on national codes and standards that can be used as a foundation for all ESS installation applications.
9. After receiving the necessary approvals, initiate the installation of the ESS and as required during the installation and commissioning, and secure the necessary inspections and approvals leading up to a final approval from all applicable AHJs.
10. While the local fire department may not be involved in the approval of the ESS installation plans and inspection, consider inviting them to the site during construction and most importantly at commissioning to familiarize them with the installation, its operation and safety features, as well as emergency procedures, and access to the ESS.

Table 4.2. Energy Storage System Installation Codes and Standards

Fire and smoke detection, fire suppression, fire and smoke containment	NFPA 1, NFPA 13, NFPA15, NFPA 101, NFPA 850, NFPA 851, IBC, and IFC
Ventilation, exhaust, thermal management, and mitigation of the generation of hydrogen or other hazardous or combustible gases or fluids	NFPA 1, IEEE 1635/ASHRAE 21, IFC, IMC, NFPA 70
Egress and access (normal operations and emergency), physical security and illumination	NFPA 1, NFPA 101, IBC, IFC and local zoning codes
Electrical safety, emergency shutoff, working space, electrical connections/installation for installations on the customer side of the meter	NFPA 70 and 70E
Electrical safety, emergency shutoff, working space, electrical connections/installation for installations on the utility side of the meter	IEEE C2
Anchoring and protection from natural disasters (seismic, flood, etc.) and the elements (rain, snow, wind, etc.)	IEC 60529, IEEE 1375, UL 96A, IBC, IFC and NFPA 70
Signage	ANSI S535, NFPA 1, NFPA 70, NFPA 70E, NFPA 101, IBC and IFC
Spill containment, neutralizing and disposal	NFPA 1, IPC, IFC, and IEEE 1578
Communications networks and management systems	IEC 61850

5.0 Suggested Template for Energy Storage System Review and Approval

The information in Chapters 3 and 4 above provide some general guidance for ensuring ESS safety through documentation and verification of compliance with safety-related codes and standards. The template provided below is intended to serve as a checklist for those seeking to document that an ESS meets CSRs applicable to the ESS and its installation. Those seeking approval for an ESS should consider completion of this or a similar document in conjunction with any plans and specifications submitted for consideration by an AHJ. This template can also help guide AHJs in focusing on verifying compliance with their adopted codes and standards when an ESS proponent may not have provided the information needed for the AHJ to verify compliance. Where multiple ESSs are anticipated at one site (e.g., two or more of the same system in the same location, two or more different systems in different locations, etc.) it is suggested the information beyond the general information be duplicated.

General Information	
Project Name	
Address	
Facility Owner (owner of the facility where the ESS is installed)	
ESS Owner (owner of the ESS if different from the owner of the facility)	
System Developer	
System Operator	
System Name	
System Location	
Services Provided	
AHJ, Scope and CSR Adopted	
AHJ, Scope and CSR Adopted	
AHJ, Scope and CSR Adopted	
AHJ, Scope and CSR Adopted	
AHJ, Scope and CSR Adopted	
AHJ, Scope and CSR Adopted	
ESS Technology Information	
Type of ESS	
ESS chemistry (if electrochemical)	
Enclosure Type	
Footprint Area (ft. ²)	
Height (ft.)	
Weight (lbs.)	
Overall Dimensions (ft.)	

Rated Continuous Discharge Power (kW)	
Output Voltage Range (V AC)	
Rated Discharge Energy (kWh)	
Minimum Discharge Time (min.)	
Maximum Discharge Time (min.)	
Operating Temperature Range (°F)	
Stored Energy Capacity (kW)	
Self-discharge Rate (% energy loss/day)	

ESS Equipment or Component Safety Documentation

ESS Unitary or Prepackaged Equipment ID and Testing and Listing Information	
ESS Pre-Engineered with Two or More Factory-Matched Modular Components ID and Testing and Listing Information	
ESS Component ID and Testing and Listing Information	
ESS Component ID and Testing and Listing Information	
ESS Component ID and Testing and Listing Information	
ESS Component ID and Testing and Listing Information	
ESS Engineered and Field-constructed ID and FMEA, NFPA 791 or other Safety Documentation	

ESS Installation – Location Related Information

Foundation type and documentation that it will carry anticipated loads	
Details on protection against external elements (wind, rain, snow, etc.) as applicable	
Details on anchoring to resist seismic loads as applicable	
Distance above base flood elevation	
Methods to protect against unauthorized access	
Description of means of access to and egress from the ESS location when in or on a building	
Description of means of access to the ESS location for the fire department or first responder needs	
Listed for hazardous atmospheres if so located	
Service and maintenance accessibility and illumination	
Distance from stored combustible materials and similar hazards	
Potential means of physical damage and means of protection	

Where there are multiple ESS they are protected from each other	
Amount of chemicals associated with the ESS and their acceptability as a function of building type, height above grade and/or distance from buildings and facilities	
If outdoors designed for that location and interconnected with required central control or monitoring systems	
Air inlets and exhausts not adversely affected by other systems	
If on a rooftop the roof is of noncombustible construction and not over 75 ft. above grade	
Rooftop access provided for emergency access as applicable	
Rooftop service walkways provided as applicable	
If indoors the room containing the ESS is not over 75 ft. above the lowest level of fire department access and more than 30 ft. below the finished floor of the lowest level of exit discharge	
Required egress provided	
Required fire and smoke separations provided between the room containing the ESS and other spaces	
Openings in required fire and smoke separations protected by fire doors or fire or smoke dampers as applicable	

ESS Installation – Interconnection Related Information

All electrical wiring and connections to and from the ESS meet adopted electrical codes	
All electrical wiring between field erected ESS components meets adopted electrical codes	
Any connections between the ESS and non-electrical energy sources meet applicable adopted codes	
All connections to and from the ESS to mechanical systems meet applicable adopted mechanical codes	
All connections to and from the ESS to plumbing systems meet applicable adopted plumbing codes	
All connections to and from the ESS to fire detection and suppression systems meet applicable adopted fire codes	
All connections to and from the ESS to control systems meet applicable adopted codes addressing such systems	
All mechanical, plumbing, fire detection and suppression and control connections between field	

erected ESS components meet adopted codes	
---	--

ESS Installation – Ventilation, Thermal Management and Exhaust Information

Separate systems to provide ventilation and exhaust air to and from the ESS are provided that have the necessary air flow at all times and can be manually shut down	
--	--

Systems and equipment are provided as necessary to ensure the environment in which the ESS operates will remain within design temperature and humidity ranges	
---	--

Systems provided for ventilation, thermal management and exhaust will maintain any indoor area having an ESS at a negative pressure in relation to other spaces	
---	--

ESS Installation – Fire Protection

Fire protection and detection systems provided that are acceptable for use with the ESS and interconnected to any required fire and smoke detection systems	
---	--

Rooms or areas housing ESS are separated from other areas in accordance with building and fire codes	
--	--

Smoke control systems provided for ESS located indoors	
--	--

Signage provided indicating the type of ESS, means of access and egress, incident response instructions and location of system controls	
---	--

Means provided to contain any system leakage or spills associated with ESS operation or effluents associated with any incident response	
---	--

ESS Installation – Commissioning

An ESS commissioning plan is developed and implemented and a report is available for the AHJ	
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6.0 Reference Materials

Overview of Development and Deployment of CSRs Affecting ESS Safety, PNNL 23578, June 2014

Energy Storage System Overview and Addressing System Safety, PNNL-SA-108235, March 6, 2015

Inventory of Safety-Related Codes and Standards for Energy Storage Systems, PNNL-23618, September 2014

DOE/EPRI 2013 Electricity Storage Handbook in Collaboration with NRECA, July. 2013,
<http://www.sandia.gov/ess/publication...D2013-5131.pdf>

Appendix A

Overview of CSR Development, Adoption, and Compliance Verification

Appendix A

Overview of CSR Development, Adoption, and Compliance Verification¹

A.1 How CSRs are Developed and Adopted

Codes, standards, and regulations (CSR) are the body of criteria or provisions that, when adopted by anyone or any entity through laws, regulations, specifications, licensing criteria, contracts, and a number of other adoption vehicles, must be satisfied to design, construct, commission, rehabilitate, operate, maintain, repair, and demolish components of the built environment such as buildings, facilities, products, systems, and equipment therein. The provisions in CSRs affect the acceptability of energy storage technology on the utility and customer side of the meter and the time and resources necessary to bring such technology to market as well as the eventual cost of the technology installation. They create opportunities for the development and use of new technology to address new and emerging issues where proponents of the technology are proactive in conducting needed safety-related research and recommending enhancements to CSRs.

An historical review of CSRs in the United States indicates that requirements memorialized in them have been developed and deployed to address natural or manmade disasters (e.g., building fires, hurricanes, seismic events), new and emerging issues (e.g., indoor air quality, radon, accessibility for the disabled), and to provide a basis for the application of new technology (e.g., plastic pipe, engineered lumber, non-CFC based refrigerants). One historical example is the need for electrical safety codes coincident with the introduction of electrical lighting in the late 1800s. Figure A.1 provides a high-level general overview of the CSR development and deployment process in the United States.

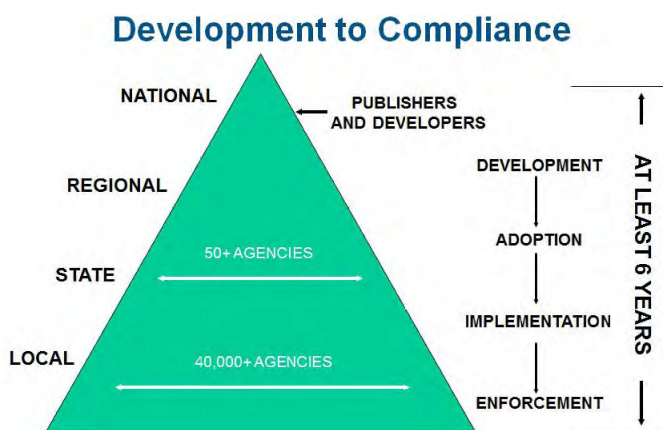


Figure A.1. Development to Compliance

¹ Derived from *Overview of Development and Deployment of Codes, Standards, and Regulations Affecting Energy Storage System Safety in the United States*, August 2014, PNNL-23578, which can be reviewed at http://www.energy.gov/sites/prod/files/2014/10/f18/Overview%20of%20Development%20and%20Deployment%20of%20Codes%2C%20Standards%20and%20Regulations%20Affecting%20ESS%20Safety%20in%20the%20US%20August%202014_1.pdf for additional information on this topic.

The basis for most CSR requirements in the United States are model codes and standards developed and published by organizations in the private sector. These documents exist separately to address a specific purpose and scope provided in each model code or standard. Collectively, they are part of a comprehensive set of laws, rules and regulations covering all aspects of the built environment that are required to be satisfied because they have been adopted. There are a myriad of standards, each of which cover building-related issues and properties and the construction and installation of products, materials, components, etc. Beyond standards, there are building, mechanical, fire, electrical, plumbing, accessibility, energy-efficiency, and other model codes that reference those standards as appropriate on an individual basis and then collectively those model codes address the built environment (e.g., all buildings and facilities and their component parts).

Considering ESS safety from a ground-up perspective, standards will apply to the smallest parts of the system (e.g., wires, relays, switches, etc.) to address their design, construction, and safety features to serve their intended purpose. Subsequently, standards for components of the ESS (cells/modules, inverters, management systems, etc.) that rely on those other standards would be relevant for the resultant assembly of those ‘parts’ to ensure that the components individually and collectively safely serve the intended purpose; safety determined based on how they perform against relevant safety-related metrics. Beyond the assembly of components to create an ESS, the focus evolves to how the ESS is integrated into the built environment, whether at a utility site, connected to a wind farm and the grid, or in, on, or adjacent to a building or facility on public or private property. In looking at that integration of the ESS with a site and associated buildings and facilities, the standards for the ESS itself and its components will be referenced, but necessary criteria also will be provided to ensure the safety of the ESS in relation to its environment (e.g., fire department access, fire alarms and suppression, clearances to combustibles, ventilation of and egress from spaces where the ESS is located, etc.). This situation (i.e., components, systems and then system installations) means that a number of different CSRs will apply and will have been developed under the auspices of a number of different entities. Fortunately, the processes for development of standards and model codes are generally the same.

Voluntary sector standards development organizations (SDOs) exist in the United States as private-sector entities with the mission of developing and publishing standards and model codes to address specific issues, technologies, and design/construction solutions. The documents developed are generally focused on specific areas or issues and impact stakeholders who want to deploy technology. Two important issues to recognize about the process that each SDO employs is that development occurs on a particular schedule and each SDO organizes and manages the process. Provisions in the documents published by the SDO are not developed by the SDO but, instead, are developed by all interested and affected parties under a process provided and administered by the SDO. Whether acting alone or as the ESS ‘industry,’ any revisions to existing CSRs will have to account for SDO schedules and deadlines and be initiated by someone other than the staff of the SDO. Those revisions will have to be developed, supported with safety-related research and other documentation, and fostered through the process by the proponent of the revision. Ideally, that proponent will be the ESS industry taking a proactive role, as opposed to reacting to what others outside the ESS industry may feel is needed to address ESS safety. In the case of new CSRs, the same is true, but the schedule is driven in part by the time it takes to develop a draft document and work it through the SDO process. For new standards or model codes, it would be advantageous for the ESS industry to develop a pre-standard, protocol, or guideline that can address any immediate need for safety-related criteria and also serve as a first draft of a standard or model code.

The standards development process in general is depicted in Figure A.2, and model code development process for the International Code Council is depicted in Figure A.3; however, each SDO has a unique process. Many of those processes are intended to satisfy the American National Standards Institute’s (ANSI) essential requirements for standards development.

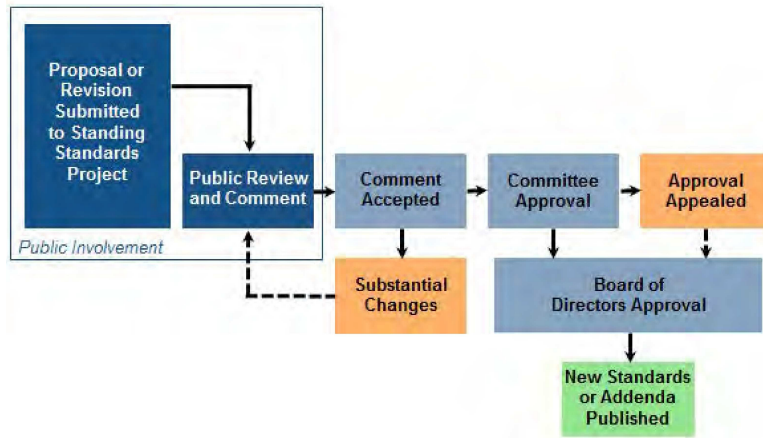


Figure A.2. Typical Standards Development Process in the United States

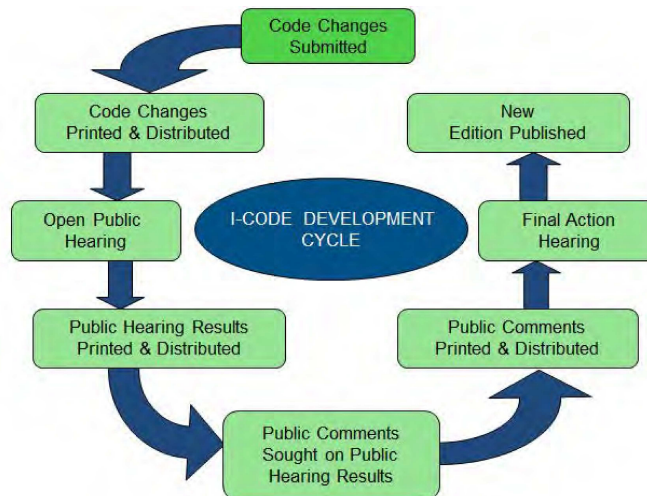


Figure A.3. ICC Codes Development Process

When applying a process meeting the ANSI essential requirements, it is important to determine if an applicable standard or model code already exists and can be revised or if a new document is needed because no applicable standard or model code exists. In either case, a committee of balanced interests is generally formed to oversee the revision of an existing document or development of a new document. Any interested and affected party can be considered for participation on these development committees and can also submit proposed revisions to any of the existing documents. In the case of a new standard, a new committee will be established to develop a draft document for consideration; however, that process is streamlined if, as previously noted, those requesting the development of the standard have a draft (e.g., guideline, protocol, bench standard or pre-standard, etc.) upon which to base their initial standards development work.

All proposed revisions are considered by the committee responsible for revision of the document, and those voted for approval by the committee are made available for public review. Any interested party can submit comments, and the comments must be considered by the committee. The commenter is advised of the disposition of his/her proposal and has an opportunity to work with the committee to find an acceptable compromise or if an acceptable outcome is not realized then remain unresolved. If this process results in significant changes to the original proposal or draft document that was sent out for public review, those changes or if extensive enough, the entire document must be submitted for additional public review and comment. When all or a vast majority of commenters are satisfied, the standard can be considered for approval. Commenters with unresolved issues can appeal a decision to approve the standard. If an appeal is successful, the standard must return for additional revision and public review. In some instances, the proposed changes are heard in open public hearings, where the committee votes a recommended disposition on each change. Those changes are published for public review and comment, and additional comments can be submitted. After changes and additional comments are considered at a second public hearing, the final vote occurs on each change by federal, state, or local government representatives. Regardless of the details associated with each SDO process, all processes designed to apply the ANSI essential requirements that are employed by SDOs are intended to ensure balance, transparency, and consensus on the outcome associated with each document. Collaboration among proponents of energy storage and affected stakeholders when going into and engaging in this process is advantageous because, ideally, it will already represent a consensus.

A regulatory body (federal, state, or local government; Public Utility Commission, Indian Tribe, etc.) can also develop their own requirements instead of adopting the output from the SDOs. In this case development and adoption are concurrent as opposed to development in the voluntary sector and the adoption of the results by these same legislative bodies or regulatory agencies. These entities also include utilities that own or operate grid-side ESSs. Ideally, what is developed in the voluntary sector meets the needs of all adopters from a technical, administrative, and time standpoint, thus eliminating the need for each adopter to develop its own unique criteria. That said, they do retain authority to develop and adopt measures they feel are appropriate for their needs. Federal agencies, however, are strongly encouraged through an Office of Management and Budget Circular A119 to participate in voluntary sector standards development and adopt the resultant standards as opposed to developing their own unique criteria.

A.2 How CSRs are Deployed and Compliance Verified?

Deployment of CSRs is what happens after model codes and standards are developed by voluntary sector SDOs and published. As public and private entities consider the content of model codes and standards, deployment involves the processes associated with the adoption of these model codes and standards as laws, rules, regulations or guidance. Deployment also includes how compliance with the adopted codes and standards is documented and verified.

Adoption of model codes and standards can be made by any person or entity, public (e.g., federal, state, or local governments; governmental agencies; or tribal governments) or private (e.g., corporation, insurance carrier, utility, or person). A public entity may adopt model codes and standards through the legislative process as a law or through the administrative process as a rule or regulation or vehicle as a condition for participation in a government program. A private entity may adopt model codes and standards through contracting mechanisms or as a basis for membership in a professional group. Other familiar forms through which model codes and standards may be adopted include contractual

specifications (including through requests for proposals), tariffs of public utilities, or safety codes (including building and fire codes). Adoption of model codes and standards help ensure that these requirements developed in the voluntary sector, (or directly developed by the adopting entity from ‘scratch’ or as amended model codes and standards) are enforceable. While federal, state, and local government and other adopting entities have the authority to develop CSRs, most adopt those developed in the voluntary sector with amendments, additions, and deletions, as required, to address any specific needs of those entities that were not addressed. For instance, while the U.S. Department of Defense adopts the ICC International Building Code (IBC) as a component of its Unified Facility Criteria, provisions on blast safety are added to augment the IBC criteria. Reliance on the output from voluntary sector SDOs was not always the case as many adopting entities developed their own unique provisions. Even into the late 20th century, some states and major cities did not adopt model codes developed in the voluntary sector to govern building design and construction but, instead, maintained their own unique criteria developed through state or local processes.

The federal government does not generally have the authority to mandate the adoption of legislation and regulations by state or local governments. Nonetheless, the federal government can employ ‘soft’ influence on state and local governments, including conditioning federal funding on adoption of certain standards. When the federal government exercises its market power—for example, in building or leasing buildings—or when it has preemptive authority (i.e., federal authority that is superior to and preempts state and local laws that are in conflict with federal law or attempt to regulate something that is wholly regulated by the federal government), it may directly require federally adopted CSRs. In other circumstances, state and local regulations will apply to the built environment, which would include an ESS installation. For an ESS located on the grid side of the meter, equipment and buildings owned or operated by the utility are covered by what is adopted by the utility.

When adopted by a governmental entity through legislative or regulatory action, the model codes and standards become binding legal authority for the jurisdiction over which the governmental entity exercises authority. Governmental agencies take on responsibility for the implementation and enforcement (e.g., conformity assessment) of the adopted CSR. When adopted by private entities (including utilities, insurance or corporate entities) through tariffs, policies, specifications, contracts or other legal documents, what is adopted may apply in addition to the codes and standards adopted by governmental entities or may provide a legal obligation where no laws or regulations have been adopted or the government lacks the authority to adopt. The power to implement and enforce what is adopted rests with the entity that adopts the CSR, but much of the work for documenting and maintaining compliance with the CSR shifts to the private sector. Documenting compliance with what is adopted rests with various private-sector entities—manufacturers, builders, designers, product specifiers, contractors, building owners, utilities, and others—involved in the design, construction, operation, use and demolition or decommissioning of what is regulated. Task of verifying compliance rests with adopting authorities or their designated agents (e.g., approved third parties or in some cases peer review) and is performed based on an assessment of the documentation provided, including inspections, against what has been adopted.

With respect to ESSs, responsibilities would shift to the manufacturer of system components for documenting component compliance; the system manufacturer for documenting system compliance; and a builder, engineer or record, or contractor responsible for documenting the system installation is compliant. After an ESS installation is approved, those engaged in its operation and maintenance would also be responsible for compliance with any applicable CSRs, including those applicable to the repair,

alteration, relocation, or renovation of an existing ESS. Those verifying compliance (e.g., the authority having jurisdiction enforcing the adopted CSR) would include government agencies, utilities, insurance carriers, and others who adopted the CSR and made them applicable to the ESS components, system, system installation, and operation and maintenance of the system.

Demonstrating compliance is generally the burden of the building or technology installation owner or developer, those who will be acting on behalf of these responsible entities—including the architect, engineer, builder, contractor, and others involved in design and construction— will likely be tasked with documenting compliance on their behalf. These entities rely on the manufacturer of the products, materials, systems or equipment to be used to provide sufficient documentation to that makes the case that what is installed complies with the adopted CSR. All of these activities are included under the broader term ‘conformity assessment.’ This includes testing, certification, quality assurance, calculations, simulation, and other activities, all of which are intended to document the degree to which the applicable CSRs are satisfied. In turn, the documentation is presented to the approving authority that will use it to validate compliance with the CSR in the design stage and then will engage in various inspections during the construction stage as well as through commissioning during operation and use and even decommissioning (e.g., retirement and recycling or disposal of the system or system components).

Generically, conformity assessment is the process of verifying that required actions are done correctly so the results are reliable and expected outcomes are likely to be achieved. It involves determining what information is required, what metrics should be used with the identified information, the basis for measuring and reporting outcomes, inspection and review by qualified entities, and quality control. Unless adopting entities that enforce CSRs assume responsibility for these tasks, they will rely on the work of others to verify performance.

Uniform codes and standards are part of everyday life and exist for many reasons, ranging from efficiency to safety. In the manufacturing and services industries, there are procedures and criteria used to set standards, metrics used to track compliance with targeted standards, and minimum acceptance levels that are used to test and evaluate results. For example, standards prescribe the temperature at which food should be stored and cooked, the efficiency and reliability ratings for a water heater, and the base professional knowledge required of an insurance salesperson. Conformity assessment embodies the process of identifying attributes to be evaluated, and comparing these attributes to an accepted set of values or qualifications and continuing to measure performance over time to ensure compliance with a standard; such compliance then memorializing that the desired outcomes such as safety are achieved. Using gasoline as an example, conformity assessment means identifying the importance of having gasoline with a uniform and sufficiently high octane, establishing testing procedures to measure uniformity and octane values, setting metrics for certain classes of gasoline, and performing ongoing inspections to confirm the uniformity and level of octane is ‘as advertised.’ Generally, as applied to an ESS, the identified attribute to be evaluated is the successful, safe, and efficient deployment, use, and decommissioning of an ESS, which requires that standards for the ESS and its components within the built environment are documented and verified against an adopted CSR, metrics are established to ensure compliance, and the resultant installation is monitored from commissioning, operating, maintenance, repair, refurbishing and eventually to decommissioning, in a safe manner as per the adopted CSR. To carry out a conformity assessment for an ESS, all aspects of the ESS throughout its life cycle should be considered. For example, planning for education of first responders to deal with an emergency at an ESS site is as much a part of conformity assessment as verifying the C-rate of a battery.

A.3 Who is Involved?

Anyone involved in the design, construction, installation, sale, purchase, or use of a product or service can be involved. Those on the supply side may have to meet certain requirements (e.g., codes, standards, regulations, protocols, etc.; basically what is adopted) and those on the demand side have an interest in knowing what was supposed to be satisfied actually happens. For ESSs, the following entities would likely be involved in conformity assessment when focused on the safety and performance aspects of the system.

- Manufacturers of systems or components associated with the system (i.e., testing to make sure systems/components comply with standards for safety, testing to determine performance and quality control of production, etc.).
- Accredited third-party testing laboratories (i.e., nationally recognized testing laboratories) that conduct testing and issue reports of findings (e.g., pass/fail or results for specific metrics).
- Entities that accredit third-party testing laboratories to applicable standards. Accredited third-party certification agencies that conduct factory inspections to validate that continued production of the system or system components conforms to the details and specifications of the system or system component that was tested and upon which compliance with the standard or the presentation of specific metrics is based.
- Entities that accredit third-party certification agencies to applicable standards.
- Designers, installers, contractors, utilities, building owners/developers, and others involved in the planning and execution of the installation of an ESS that, in their particular activities associated with the installation, are required in some way to comply with CSRs associated with the installation.
- Insurance carriers, accredited third-party inspection agencies, registered design professionals, code officials, fire officials, electrical inspectors, utilities, and others involved in assessing the planned installation satisfies CSRs associated with the installation and assessing the actual installation and any required commissioning to validate that what was constructed satisfies the approved plans and specifications.

Appendix B

Overview of Conformity Assessment for Energy Storage System Products and Components and Installation of the System

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B.1 Conformity-Assessment Overview

Conformity assessment embodies how the attributes of something are determined; comparing them to any requirements applicable to those attributes and then the conduct of an ongoing process to ensure that compliance with those requirements is ensured over time. This would be done for energy storage systems (ESS) and their component parts by verifying that continued production as to the design and construction of the ESS system or component parts is identical to the component or system that has been tested and found to comply with a particular standard. The ability to state, with certainty, that an ESS system or component parts meets the provisions of one or more applicable safety standards supports the timely acceptance of safe ESS systems and components. Where this is not accomplished, then a basis for acceptance of the ESS system or component parts must be developed as a basis for communication between proponents of an ESS and the authority having jurisdiction (AHJ).

B.2 Standards for ESS Components

The fundamental basis for the evaluation of an ESS with respect to safety is the design and construction of the components that comprise the system (e.g., battery, inverter, controls, etc.). Standards for ESS components are intended to provide safety-related metrics that are considered important to evaluate and to assess how the component performs in relation to those metrics. The designer of the component designs and constructs the component to ensure the ESS performs acceptably in relation to the safety metrics described in a safety standard applicable to the component and subjects the component to testing required by the standard. If the component satisfied the provisions of the standard and related design criteria and performance metrics, then the component would be considered to be in compliance with the standard. Such testing would be conducted by an accredited testing laboratory. Through third-party certification programs, ongoing production of the component would be inspected to ensure that subsequent production is identical to that of the component that was tested and found to comply with the standard. In addition, those certification programs also would review and assess the administrative and quality control aspects associated with the manufacturer of the component. Standards covering ESS components and the associated conformity-assessment activities to document and validate compliance would be of primary relevance to component manufacturers in deploying the component. Manufacturers of complete ESS ‘products’ or those that assembled an ESS onsite from various components would benefit when using components that comply with relevant standards because the products would be easier to accept and deploy. AHJs then have an easier time approving ESS installations when the components are validated as complying with applicable standards. Note that the standards covered in Chapter 3 for an entire ESS ‘product’ could concurrently address the acceptability of the components to the degree that such standards addressed the safety of the individual components in the ESS.

Appendix C provides a listing of standards applicable to components of ESS. Included are standards that clearly apply, may apply, or while not directly applicable to ESS components may offer some insight or examples that could be applied in the future to ESSs. The title and designation of the standard and summary of the scope are provided along with initial comments relating to further consideration of the standard in addressing ESS safety. Although the focus of this document is U.S. codes, standards, and/or regulations (CSR) of some international standards are included because they were presented in presentations during the U.S. Department of Energy Safety Workshop in February 2014.

B.3 Standards for an Entire ESS

The fundamental basis for the evaluation of an ESS technology with respect to safety is the design and construction of the components that comprise the system (e.g., battery, inverter, controls, etc.). Standards for ESS components, as covered in Chapter 3 and listed in Appendix C, are intended to provide criteria for the design and construction of the component and safety-related performance metrics that are considered important to evaluate during testing. Considering an ESS as an assembly of components, a standard for a complete ‘product’ is likely to refer to various components and component standards within the ESS standard and then simply tie them together. One approach to assessing the safety of the ESS ‘product’ is to confirm that the components meet relevant component standards and then assess the acceptability of their assembly as an ESS. Another is to consider the ESS ‘product’ as a black box, consider how the entire ESS would function as an assembly of components, and evaluate the ESS ‘product’ against an appropriate standard covering that assembly. If the ESS ‘product’ satisfied the provisions of the standard and related design criteria and performance metrics, then the components of the ESS would be considered to be in compliance with the standard. Through third-party certification programs, ongoing production of the ESS ‘product’ would be inspected to ensure that subsequent production is identical to the ESS that was tested and found to comply with the standard. In addition, those certification programs would also review and assess the administrative and quality control aspects associated with the manufacturer of the component. When an ESS standard addresses the performance of one or more components within the requirements in the standard, then the safety of those components is evaluated as a result of testing of the entire ESS.

Standards covering an ESS as a complete product and the associated conformity-assessment activities to document and validate compliance would be of primary relevance to manufacturers producing an entire ESS “product,” although ESS component manufacturers would want to be familiar with those standards to ensure their components comply with these standards when used in the ESS. Those that assemble a complete ESS ‘product’ onsite from various components would likely have to document compliance on the basis of that standard and, as such, would benefit when using components that complied with relevant component safety standards. In addition, those assembling the product onsite may also be more likely to have installation-related codes and standards address the assembly of those components. Utilities, building regulatory agency staff, and others engaged in validating compliance would have an easier time approving ESS installations when the ESS ‘product’ is validated as complying with applicable standards. In the absence of such standards and until they are developed, it is more likely that approval of an ESS ‘product,’ whether prepackaged or assembled onsite from various components, would have to be pursued on a case-by-case basis involving the applicable parties involved in documenting and validating safety of the ESS.

Appendix D provides a listing of standards applicable to entire ESS. Included are any and all standards that clearly apply, may apply, or while not directly applicable to an ESS may offer some insight or examples that could be applied in the future to ESSs. The title and designation of the standard and summary of the scope are provided along with initial comments relating to further consideration of the standard in addressing ESS safety. Although the focus of this document is CSRs in the United States, some international standards are included because they were used in presentations during the Department of Energy Safety Workshop in February 2014.

B.4 What if an ESS or ESS Component is not Tested, Listed, or Certified?

The discussions in this section cover three available methods that can be used to document the safety of an ESS and, on that basis, seek approval for the ESS under current CSRs that may not specifically address the safety of a proposed ESS installation. While AHJs ultimately retain the authority to perform the activities described in each method, they generally rely on information provided by accredited third parties. Note that utilities are more likely to conduct this work themselves for ESS installations they will own and operate than are federal, state, or local agencies who are the AHJs associated with the permitting and approval of ESS installations on the customer side of the meter.

B.4.1 Method 1: Unlisted ESS Components or Entire Systems

The acceptability of the ESS ‘product’ or components of an ESS, where there are no applicable or available standards, can be secured through the application and use of National Fire Protection Association (NFPA) 791 covered in Chapter 3. This standard provides a methodology for evaluating and accepting unlabeled electrical equipment (e.g., untested and labeled¹ as meeting available and applicable standards) for compliance with the intended safety associated with nationally recognized standards and other requirements imposed by the AHJ. Where an ESS component or ESS ‘product’ is tested and labeled as meeting applicable nationally recognized standards, which are generally adopted by reference as part of CSR that would apply to an ESS installation, then that associated labeling speaks to the acceptability of the ESS or ESS component. Where not labeled, because of a choice by the manufacturer or because standards do not yet exist upon which to assess the safety of the ESS component of ESS ‘product,’ the provisions of NFPA 791 provide guidance to technology proponents in documenting the acceptability of what is proposed and to AHJs in evaluating what is proposed and considering if and how it should be approved. It is important to note that the application of NFPA 791 would likely be different for each ESS manufacturer and for those seeking to install the ESS as well as each AHJ. As such, while providing a basis for approval, the application and use of NFPA 791 is more likely to be unique for each ESS and each ESS installation. While providing a short term means to foster deployment of ESS, the availability of specific CSRs covering the ESS and ESS installation would eliminate the need to apply NFPA 791.

¹ The term “labeled” in the National Electrical Code, is defined as equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the authority having jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

B.4.2 Method 2: Alternative Methods and Materials

Until the provisions in CSR “catch up” to specifically address ESS installations, there is little concrete guidance for ESS manufacturers or users seeking approval of an ESS installation or for AHJs to use in assessing the safety of the installation. Alternative methods and materials provisions in CSR provide a path to documenting or verifying compliance with existing CSR on the basis that what is proposed, while not specifically addressed in the CSR, is no more hazardous nor less safe than something that is specifically covered in the CSR. Where an ESS component or entire ESS is unlisted, the application of NFPA 791 as discussed above should be considered and will be helpful in documenting the safety of the ESS components and ESS ‘product.’ The provisions associated with alternative methods and materials, while applicable to an ESS component or entire ESS, are more apt to be applied in securing approval for the intended installation of the ESS, even if it is listed. This is because, whether listed or unlisted, CSR also cover how the installation of an ESS in relation to its surroundings is deemed to be safe.

Each entity that has adopted and enforces CSR that contain the above type of provision then provides an avenue for approval of an ESS installation on the basis of equivalent performance. The burden of proving equivalent performance (e.g., no more hazardous or nor less safe than something specifically provided in the CSR) is with the technology proponent (manufacturer or entity wishing to use the technology). Unless the approval authority can provide details of what information they require to document equivalent performance, the technology proponent will generally have to review the existing CSR being used, which can tend to be prescriptive in nature, as the equivalency metric as well as other research related to ESS safety and develop the rationale and documentation of equivalency themselves. While what is developed by the ESS proponent may be acceptable to one approval authority, it may not be acceptable to others. As a result, the application of this path to documenting the safety of an ESS before updated and more appropriate CSR are available can differ from one approval authority to the next. Clearly having examples of how other ESS installations have been approved, as covered in Chapter 4.0, can serve to augment the available documentation. This is something each ESS manufacturer might undertake in an effort to standardize documenting the safety of their ESS and its intended installations until CSRs are available that provides the needed criteria upon which to approve an ESS installation. Where the manufacturer of the ESS chooses not to pursue activities to document the safety of their ESS, then that responsibility may fall on those specifying or installing the ESS. Faced with having to take on that responsibility, specifiers or installers of an ESS could choose to forgo that ESS application and use or select a system from a manufacturer that has addressed this issue.

In most instances, the AHJ enforcing the CSR will not conduct an assessment of equivalency if what is proposed does not satisfy their CSR requirements but instead rely on the technology proponent (i.e., the permit applicant) to provide the necessary documentation. In this case, the documentation is provided using the provisions in the current CSR as a metric. This can also be accomplished by a third party on the basis of failure modes and effects analysis or other methodology that is focused on the safety-related aspects of an ESS regardless of what may or may not be in CSR. Either way, there are multiple AHJs whose application of the CSR they have adopted can and will vary. While the ESS proponent can develop their own documentation and customize it for each particular ESS installation and AHJ, the use of an accredited third party can simplify the approval process.

B.4.3 Method 3: Third-Party Safety Documentation

Involvement of an accredited third party in assessing an ESS or ESS installation is relevant to the two paths identified above. Outside those two paths, a third-party independent assessment of ESS safety can be considered and would include their identification of the issues that would need to be addressed, the documentation needed that the ESS proponent would have to supply, and the preparation of a report of findings that documented the acceptability of the ESS supported by failure modes and effects analysis of FMEA (as noted this analysis could also focus on equivalency with the current CSR). An FMEA will provide a logical assessment and documentation of safety outside the specifics in any CSR.

Where a third party is assessing safety based on equivalency with current CSRs, they may include the criteria to be used in their assessment in an acceptance criteria document, pre-standard, protocol, or guideline that serves as a surrogate for CSR that may not be approved and published and that address the technology. Accredited third-party agencies will perform such assessments and issue reports of findings that can be provided to AHJs to document ESS safety and used to secure ESS installation approvals until CSR are revised to specifically address ESS technology. When the specific criteria needed to address ESS safety exist in the CSR then more traditional means of testing and listing the ESS and its components and evaluation of an ESS installation can be applied in documenting and validating ESS safety.

Because some ESS installations may be unique and not readily assessed as discussed above, third parties can also be employed to assess the acceptability of a specific ESS technology installation onsite and as installed. Those third parties would have to be accredited as field evaluation bureaus (FEBs) in order for the information they provide to be acceptable to AHJs because they are in essence doing what the AHJ is authorized to do in approving an ESS installation. For instance, FEBs can be assessed and accredited by the International Accreditation Service to conduct evaluations of electrical equipment based on the International Accreditation Service Accreditation Criteria for Field Evaluation of Unlisted Electrical Equipment (AC354). The request for these types of evaluations usually comes from a building department, code enforcement official, fire marshal or similar regulatory body and is primarily to determine compliance with applicable codes or standards of innovative, one-of-a-kind, limited production, used or modified products that are not listed or labeled under a full testing, listing or certification program. Such an evaluation process may be completed at the point of manufacture, interim points of distribution, in the evaluating organization's facilities, in situ or a combination of the above. Similar programs exist to support utilities in assessing grid-side technologies. In the United States, those include the Canadian Standards Association, UL, LLC, Factory Mutual, Intertek Testing Services, ETL and in Canada include the Electrical Safety Authority field evaluation, Canadian Standards Association (CSA), Entela, Intertek Testing Services, the Quality Auditing Institute, and UL of Canada. Information on third parties that have been ANSI accredited can be found at <https://www.ansica.org/wwwversion2/o.../Portfolio.asp>.

Organizations meeting International Accreditation Service FEB accreditation requirements also meet the requirements of the Recommended Competency Guidelines for Third-Party Field Evaluation Bodies and the Recommended Practice and Procedure for Unlabeled Electrical Equipment Evaluation. These guidelines and recommended practices have been developed by the American Council for Electrical Safety and, as such, these bodies could also be used by ESS proponents to secure necessary ESS technology and installation approvals.

Most governmental authorities provide information on the means and methods for securing approvals on a performance equivalency basis. For instance, details were found for the following jurisdictions by searching on “alternative methods and materials.”

- Laguna Beach City, CA <http://lagunabeachcity.net/civicax/f...px?BlobID=5505>
- Berkeley, CA <http://www.cityofberkeley.info/uploa...nstruction.pdf>
- Bellevue, WA <http://www.ci.bellevue.wa.us/pdf/Dev...ematerials.pdf>
- Orange County, CA http://www.ocfa.org/_uploads/pdf/guidea01.pdf
- Reedy Creek, FL <http://www.rcid.org/Portals/0/Docume...ls-Methods.pdf>
- Clark County, NV http://www.clarkcountynv.gov/Depts/d.../Form_1003.pdf

In summary, a path to securing ESS technology and installation approvals does exist in CSRs. That path can bridge the gap until CSRs are updated to provide specific criteria for ESS components, ESS ‘products,’ and ESS installations. That said the implementation of this path is up to the entity responsible for documenting CSR compliance (e.g., component manufacturer, ESS manufacturer, ESS installer, etc.) based on what AHJs coving the envisioned ESS installations require of that documentation as supporting ESS safety and CSR compliance. As such, there is a possibility that each entity using these paths may choose to evaluate equivalent performance on a different basis.

Increased uniformity in assessment and approval of ESS technology can be facilitated through the use of accredited third parties who would issue reports of findings of equivalency and acceptability for consideration by AHJs responsible for approving ESS installations. To facilitate the uniformity and acceptability of those reports of findings, the development of acceptance criteria or a protocol could be undertaken. Such a document would essentially mirror or contain criteria that most AHJs would develop on their own and use as a basis for approval under a performance equivalency based compliance path. In using these provisions, the ESS proponent then has guidance in preparing documentation of CSR compliance (on the basis of equivalent performance) as does an accredited third party in reviewing that documentation and issuing a report of findings as to verification of compliance. That report of findings can then be used by any AHJ in considering the approval of an ESS and conducting the necessary inspections to validate compliance with their CSR. The basis is that the report of findings documents equivalent safety and performance to outcomes derived from compliance with the current CSR, and that the ESS is installed in accordance with those findings.

Organizations and entities that would develop such criteria and issue such reports include the following:

- Federal, state or local AHJs in the enforcement of their CSR using this alternative path to compliance verification.
- Registered design professionals who are licensed to practice in states where an ESS installation is proposed.
- Manufacturers and ESS proponents (although this would be considered first-party self-certification and not generally accepted by AHJs).
- Third-party accredited testing and certification agencies.

Note that those acceptance criteria or protocols can form the basis for revisions to existing CSR or development of new CSR.

It also is important to separate the manner in which utilities would engage in approval of ESS installations on the basis of safety-related performance for ESS installations on the grid side of the meter. The utility can follow the performance equivalency path above and rely on information documenting the acceptance of the ESS on the basis of equivalent performance to the specific CSR. Where the utility does not adopt those CSR or is not inclined to recognize information provided by third-party agencies, the utility may act as the AHJ and conduct specific safety testing themselves, develop their own acceptance criteria and undertake any other activities they feel are needed to detail a basis for ESS safety and validate that a proposed ESS complies with what the utility has adopted. For instance, as reported above, one utility required the conduct of destructive testing to validate that the batteries being supplied would not “runaway” if an incident were to occur.

Ideally, the proponents of ESS technology can agree on the criteria upon which an ESS is considered safe in conjunction with AHJs on both sides of the meter, thereby fostering uniformity and more timely and less complicated review and approval of ESS installations in both the short term to assess ESS safety on the basis of performance equivalency and the long term in formulating new and revising existing CSR.

B.5 CSRs for Installation of an ESS

Appendix E provides a listing of CSRs applicable to the installation of an ESS or that may have specific criteria for some ESS technologies, may currently being revised to provide criteria for others and may currently or even in their next edition be silent on some ESS technologies as well as how to address some safety-related issues. Included in the listing of CSRs are any and all that clearly apply, may apply, or while not directly applicable to ESSs may offer some insight or examples that could be applied in the future to ESS installations. The title and designation of the standard and summary of the scope are provided.

The CSRs covered in Appendix E are relevant to the installation of an ESS ‘product’ or matched assembly of components that has been approved as outlined in Chapter 3.0 and further elaborated on in Appendices C and D. Installation provisions simply cover where and how the ESS interacts with its environment to ensure the surrounding environment is not adversely affected by an incident associated with the ESS and, in turn, that the ESS is not adversely affected by a natural or manmade incident associated with the surrounding environment. Where the ESS has not been approved as covered in Chapter 3.0 and instead is an assembly of ESS components onsite, then the provisions of Chapter 4.0 will have a greater impact on the ESS because they will address the acceptability of how those components are aggregated as an ESS onsite. In other words, the CSR in Chapter 3.0, Appendices C and D, and their application as discussed in Appendix B will assume much of what would be covered in Chapter 3.0 had the ESS been a completed ‘product’ that arrived at the site compliant with standards applicable to the ESS ‘product.’

The CSRs discussed in Chapter 3.0 and Appendices C and D cover directly or indirectly the following issues. If specifics are not provided in the CSRs, these issues are intended to be addressed pursuant to the purpose and scope of those CSRs. The lack of specific provisions is likely due to the typical time lag between technology development/deployment and updating of CSRs.

Key to a review of the CSR and identification of relevant criteria is a determination of the ESS technology being applied, the size/capacity of the ESS, its location on the site and relationship to the utility grid, the occupancy and use of the building(s) associated with the site if any (e.g. residential, office, industrial, etc.), and its interaction with other systems onsite such as solar systems. With this information, as provided for in Chapter 5.0, and knowledge of the CSR that are applicable to the installation based on its geographic location, the criteria applicable to relevant safety issues can be determined.

Before doing that, it is recommended that a hazard mitigation analysis be considered if the ESS technology is not tested and listed as covered in Chapter 3.0 or is of a size/capacity and type that is commensurate with what can best be described as a formidable ESS installation. As systems become more formidable or are not tested and listed, it is more likely that the acceptability of the ESS installation will not be able to be readily documented or verified using the criteria in current CSRs.

Note that the repair, rehabilitation, renovation, or addition to an existing ESS installation will also be covered by CSRs. Where changes are made to the ESS technology, those changes will have to be deemed safe and accepted in addition to the installation of the resultant ESS using current CSRs. As such, the following information should also be considered relevant to existing installations that undergo any change in the ESS or its installation.

B.5.1 Siting

The acceptability of the siting of the ESS, as installed in relation to the surrounding environment, must be determined. This includes but is not limited to features associated with the property on which it is located as well as its proximity to any buildings or structures on the property. In addition as covered below where installed in or on a building there will be additional considerations. Beyond the acceptability of the location of the ESS, the acceptability of the foundation, protection from the elements (e.g. seismic, rain, snow, ice, wind, floods, wildfires, etc.) must be addressed. A means of access to and egress from the ESS will also need to be provided, most notably access for first responders. Clearance to combustible materials and other hazards on the site must also be considered as well as clearances between any intakes or exhausts associated with the ESS and/or the buildings, structures or systems proximate to the ESS.

Where located outdoors and not protected, the ESS will have to be determined acceptable for installation in the anticipated outdoor environment. When located on a rooftop, access to the ESS will have to be provided (e.g. service walkways) and clearances to edges of the roof or other rooftop construction will have to be addressed. In addition the type of construction associated with the rooftop may determine the acceptability of the rooftop for an ESS installation as may the height of the rooftop above grade. When installed on the interior of a building or structure, there will be a number of requirements related to access and egress, ventilation and exhaust, and separation of the ESS from other portions of the building.

B.5.2 Interconnection with Other Systems

Interconnection of an ESS with other systems (electrical, gas, ventilation, communications, central control systems, fire detection, etc.) will be covered in CSR and will likely be generally addressed in the same manner as other energy-related technologies. A disconnecting means for the ESS will likely need to be provided as well.

B.5.3 Ventilation, Thermal Management and Exhaust

Depending on the system type and location, the system and/or the area surrounding the system may require ventilation and exhaust air and possibly a thermal management system. Those systems would be installed in accordance with adopted CSRs and would not likely be much different than if those systems were serving other systems or equipment, although a separate system from other such systems onsite may be required for the ESS. Where the ESS is tested and listed and comes in an enclosure, this issue will already be addressed as a part of that process; however, depending on the location of the ESS and its enclosure, these issues may still need to be addressed to ensure the ventilation and exhaust air associated with the enclosure will not be adversely affected because of the manner in which the ESS is installed.

B.5.4 Fire Protection

The system will require fire protection in the form of smoke detection, fire detection, and/or fire-suppression systems. Where the ESS is tested and listed and comes in an enclosure, this issue will already be addressed as part of that process. However, depending on the location of the ESS, additional criteria may apply to ensure those systems are properly interconnected on the site. The type of fire-suppression system, if any, required will be dictated by the type of ESS, its size/capacity, and its location. CSRs may provide specific information for a particular ESS or may not have been updated to provide the needed specifics. Where the latter is the case, the hazard mitigation analysis previously covered should provide a basis for documenting what fire protection systems will support a safe ESS installation.

In addition to fire detection and protection, fire containment will need to be addressed where an ESS is installed inside a building or structure to ensure, based on the type of construction separating the ESS installation area from other parts of a building or structure, that fire and smoke will be contained in the area of origin. Smoke removal systems may also be required based on location and ESS type.

Consideration must also be given to the containment of any fluids that may leak from an ESS and/or may be as a result of firefighting activities. The type of ESS and its size/capacity and location will also determine how this issue is addressed in CSR.

All ESS installations will need signage adjacent to the ESS and any means of access to areas where an ESS is installed. Signage should satisfy CSR requirements and address the type of system(s); battery technology, if applicable; and capacity of each system in kWh, location, and purpose of all manual controls and emergency shutoff devices, the amount and type of any corrosive liquids or hazardous chemicals associated with the ESS, and the type of any fire-suppression systems provided. Also, instructions for first responders for addressing fire and smoke control should be available adjacent the access point to the ESS installation.

Appendix C

Standards Related to Energy Storage System Components

Appendix C

Standards Related to Energy Storage System Components

Standard	Scope Summary
ATIS 06000330:2008 Valve-Regulated Lead Acid (VRLA) Batteries Used in the Telecommunications Environment	Covers VRLA batteries, used as a reserve energy source that supports DC-powered telecommunications load equipment. Defines the proper operational use, storage conditions and test criteria initial and lifetime for VRLA cells (modules). Intended to be used to establish initial physical and performance characteristics of VRLA cells or modules, performance expectations throughout their lifetime and operations conditions for appropriate use and guidance for designers of these cells or modules.
CENELEC Workshop Agreement (CWA) 50611 Flow batteries – Guidance on the specification, installation and operation, April 2013	The CWA provides guidance on the specification, installation and operation of flow batteries. It facilitates the pre-commercial phase when flow batteries need to be compared with other flow batteries or other electrical storage devices. It provides guidance to conformity assessment bodies to benchmark flow battery conformity with existing directives and other regulations.
EN 50272-2 Safety Requirements for Secondary batteries and battery installations – Part 2 stationary batteries	The standard applies to a 1500 VDC limit, protection against electricity, gas emission and electrolyte. It is limited to lead-acid and nickel technologies in applications for telecom, photovoltaic (PV), uninterruptable power supply (UPS), emergency lighting, power station, stationary engine starting.
FM Global Property Loss Prevention Data Sheet 5-31 Cables and Bus Bars, December 2004	This data sheet covers electrical protection and fire protection for cables and bus bars and discusses aluminum conductors, describing methods of connecting, splicing and terminating to prevent excessive heating that could result in arcing and fire.
IEC 60622 Secondary cells and batteries containing alkaline or other non-acid electrolytes – Sealed nickel-cadmium prismatic rechargeable single cells	The standard specifies marking, tests and requirements for sealed nickel-cadmium prismatic secondary single cells.
IEC 60623 Secondary cells and batteries containing alkaline or other non-acid electrolytes – Vented nickel-cadmium prismatic rechargeable single cells	The standard specifies marking, designation, dimensions, tests and requirements for vented nickel-cadmium prismatic secondary single cells.
IEC 60896-11 Stationary lead-acid batteries, Part 11: Vented types – General requirements and methods of tests	This part of IEC 60896 is applicable to lead-acid cells and batteries which are designed for service in fixed locations and which are permanently connected to the load and to the DC power supply. Part 11 of the standard is applicable to vented types only. The object of this standard is to specify general requirements and main characteristics with corresponding test methods associated with all types and construction modes of lead-acid stationary batteries, excluding valve-regulated types.

Standard	Scope Summary
IEC 60896-21 Stationary lead-acid batteries, Part 21: Valve-regulated types – Methods of test	Applies to all stationary lead-acid cells and monobloc batteries of the valve-regulated type for float charge applications (i.e., permanently connected to a load and to a DC power supply), in a static location and incorporated into stationary equipment or installed in battery rooms for use in telecom, UPS, utility switching, emergency power or similar applications. The objective is to specify test methods for all types and construction of valve-regulated stationary lead-acid cells and monobloc batteries used in standby power applications. This part of IEC 60896 does not apply to lead-acid cells and monobloc batteries used for vehicle engine starting applications (IEC 60095 series), solar PV energy systems (IEC 61427) or general purpose applications (IEC 61056 series).
IEC 60896-22 Stationary lead-acid batteries, Part 22: Valve-regulated types – Requirements	Applies to all stationary lead-acid cells and monobloc batteries of valve-regulated type for float charge applications, (i.e., permanently connected to load and DC power supply), in a static location and incorporated into stationary equipment or installed in battery rooms for use in telecom, UPS, utility switching, emergency power or similar applications. The objective of this part of IEC 60896 is to assist in understanding the purpose of each test contained within IEC 60896-21 and provide guidance on a suitable requirement in the battery meeting the needs of a particular industry application and operational condition. This standard is used in conjunction with common test methods described in IEC 60896-21 and is associated with all types and construction of valve-regulated stationary lead-acid cells and monoblocs used in standby power applications. This part of IEC 60896 does not apply to lead-acid cells and batteries used for vehicle engine starting applications (IEC 60095 series), solar PV applications (IEC 61427), or general purpose applications (IEC 61056 series).
IEC 61427-1 Secondary cells and batteries for photovoltaic energy systems (PVES) – General requirements and methods of test	This international standard provides general information about secondary batteries used in PVES and the typical methods of test used for the verification of battery performance. This standard does not include specific information relating to battery sizing, method of charge or PVES design. NOTE: This standard is applicable to lead-acid and nickel-cadmium cells and batteries. This standard will be amended to include other electrochemical systems when they become available.
IEC 61951-1 Ed 4 Portable sealed rechargeable single cells – Part 1: Nickel- cadmium	Specifies marking, designation, dimensions, tests and performance requirements for portable sealed nickel-cadmium small prismatic, cylindrical and button rechargeable single cells, suitable for use in any orientation.
IEC 61951-2 Ed 3 Portable sealed rechargeable single cells - Part 2: Nickel-metal hydride	Specifies marking, designation, dimensions, tests and performance requirements for portable sealed nickel-metal hydride, small prismatic, cylindrical and button rechargeable single cells, suitable for use in any orientation. This third edition cancels and replaces the second edition published in 2003 of which it constitutes a technical revision.

Standard	Scope Summary
IEC 61960 Ed 3 Secondary lithium cells and batteries for portable applications	Specifies performance tests, designations, markings, dimensions and other requirements for secondary lithium single cells and batteries for portable applications. The objective of this standard is to provide the purchasers and users of secondary lithium cells and batteries with a set of criteria with which they can judge the performance of secondary lithium cells and batteries offered by various manufacturers.
IEC 62133-1 Ed 2 Secondary cells and batteries containing alkaline and other non-acid electrolytes - Safety requirements for portable sealed secondary cells, and for batteries made from them, for use in portable applications – Part 1: Nickel systems	This standard and standard 62133-2 below are in development and are categorized in: Aerospace electric equipment and systems, Electrical and electronic equipment. These standards address safety of the respective battery chemistries for portable applications.
IEC 62133-2 Ed 2 2 Secondary cells and batteries containing alkaline and other non-acid electrolytes – Safety requirements for portable sealed secondary cells, and for batteries made from them, for use in portable applications – Part 2: Lithium systems	See above entry for Standard 62133-1.
IEC 62259 Secondary cells and batteries containing alkaline or other non-acid electrolytes – Nickel-cadmium prismatic secondary single cells with partial gas recombination	The standard specifies marking, designation, dimensions, tests and requirements for vented nickel-cadmium prismatic secondary single cells where special provisions have been made in order to have partial or, under very specific conditions, full gas recombination.
IEC 62485-2 Safety requirements for secondary batteries and battery installations – Part 2: Stationary batteries	This part of the IEC 62485 applies to stationary secondary batteries and battery installations with a maximum voltage of DC 1 500 V (nominal) and describes the principal measures for protections against hazards generated from electricity, gas emission, and electrolyte.
IEC CD 62619 Secondary cells and batteries containing alkaline or other non-acid electrolytes. Safety requirements for secondary lithium cells and batteries, for use in industrial applications.	The standard provides requirements on safety aspects associated with the erection, use, inspection, maintenance and disposal of cells and batteries for stationary applications and motive (other than on-road vehicle). Under development moving toward the committee draft voting stage. Includes safety requirements for lithium-ion cells for stationary and off-road motive applications and some battery requirements (evaluation of battery and battery management system [BMS] combination). Not a system standard, as it covers only battery and BMS interaction. Regional regulations such as EU directives (light vehicle, electromagnetic compatibility [EMC]) Japan S Mark (SBA S1101).
IEC CDV 62620 Secondary cells and batteries containing alkaline or other non-acid electrolytes – Secondary lithium cells and batteries for use in industrial applications	The standard specifies marking, designation, dimensions, tests and requirements for large format lithium-ion secondary single cells and batteries used in Industrial Applications including Stationary applications.
IEC 62620 Ed 1 Large format secondary lithium cells and batteries for use in industrial applications	The standard covers product and test specifications for all secondary cells and batteries of sealed and vented designs containing alkaline or other non-acid electrolytes.

Standard	Scope Summary
IEC 62675 Ed 1 Sealed Ni-MH prismatic rechargeable single cells for industrial applications	The standard covers secondary cells and batteries containing alkaline or other non-acid electrolytes - Sealed nickel-metal hydride prismatic rechargeable single cells for industrial applications.
IEC/TR 62914 Ed 1 Experimental procedure for the forced internal short-circuit test (Supplemental information to IEC 62133 Ed 2.0)	This technical report is in development is categorized in: Acid secondary, Alkaline secondary, Cells & batteries, Copper products.
IEEE C37.90.1-2002 Standard Surge Withstand Capability Tests for Relays and Relay Systems Associated with Electric Power Apparatus	The standard covers two types of design tests for relays and relay systems that relate to the immunity of this equipment to repetitive electrical transients are specified. Test generator characteristics, test waveforms, selection of equipment terminals on which tests are to be conducted, test procedures, criteria for acceptance, and documentation of test results are described. This standard has been harmonized with IEC standards where consensus could be reached.
IEEE C57.12.00-2010 Standard for General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers	The standard provides electrical and mechanical requirements for liquid-immersed distribution and power transformers, and autotransformers and regulating transformers; single- and polyphase, with voltages of 601 V or higher in the highest voltage winding, are set forth. It is basis for the establishment of performance, and limited electrical and mechanical interchangeability requirements of equipment are described, and for assistance in the proper selection of such equipment. The requirements in the standard apply to all liquid-immersed distribution, power, and regulating transformers except the following: instrument transformers, step voltage and induction voltage regulators, arc furnace transformers, rectifier transformers, specialty transformers, grounding transformers, mobile transformers, and mine transformers.
IEEE C57.13-1993 Standard Requirements for Instrument Transformers	The standard covers electrical, dimensional, and mechanical characteristics, taking into consideration certain safety features, for current and inductively coupled voltage transformers of types generally used in the measurement of electricity and the control of equipment associated with the generation, transmission, and distribution of alternating current. The aim is to provide a basis for performance, interchangeability, and safety of equipment covered and to assist in the proper selection of such equipment. Accuracy classes for metering service are provided. The test code covers measurement and calculation of ratio and phase angle, demagnetization, impedance and excitation measurements, polarity determination, resistance measurements, short-time characteristics, temperature rise tests, dielectric tests, and measurement of open-circuit voltage of current transformers.

Standard	Scope Summary
IEEE C62.22-2009 Guide for the Application of Metal-Oxide Surge Arresters for Alternating-Current Systems	The guide covers the application of metal-oxide surge arresters to safeguard electric power equipment, with a nominal operating voltage 1000 V and above, against the hazards of abnormally high-voltage surges of various origins. It also provides information on the characteristics of metal-oxide surge arresters and the protection of substation equipment, distribution systems, overhead lines, and large electrical machines.
IEEE 484 Recommended Practice for Installation Design and Installation of Vented Lead Acid Batteries for Stationary Applications	The recommended practice document provides recommended design practices and procedures for storage, location, mounting, ventilation, instrumentation, preassembly, assembly, and charging of vented lead acid batteries. Required safety practices are also included. This document is applicable to full-float stationary applications where a battery charger normally maintains the battery fully charged and provides DC loads.
IEEE 1361 Guide for Election, Charging, Test, and Evaluation of Lead-Acid Batteries Used in Stand-Alone PV Systems	The guide was written to provide a relevant PV battery test procedure that can be used to evaluate battery performance and identify appropriate PV battery charging requirements. The document contains a tutorial on lead-acid battery technology, battery charging characteristics, and a laboratory test procedure to evaluate charge parameters and battery performance.
IEEE 1660 Guide for Application and Management of Stationary Batteries Used in Cycling Service	The guide is intended to provide assistance to users of stationary battery systems in determining appropriate battery management strategies that may be applied by addressing the primary similarities and differences in battery design and operation for standby versus cycling applications.
IEEE 1661 Guide for Test and Evaluation of Lead-Acid Batteries Used in PV Hybrid Power Systems	The guide was written to provide a PV hybrid power system battery test procedure that can be used to assist in evaluating battery capacity, and appropriate PV battery charging requirements.
Telcordia GR-3020-CORE Nickel-cadmium batteries in the outside plant	The document addresses the safety and performance issues of NiCad batteries intended for use as backup power systems in telecommunications outside the plant. NiCad batteries have a longer service and shelf life than lead-acid batteries and an inherent ruggedness to withstand harsh environments. The document includes electrical, chemical, environmental, physical design and quality and reliability requirements as well as a section on documentation and testing requirements and auxiliary charging devices.

Standard	Scope Summary
<p>Telcordia GR-3150-CORE Generic requirements for secondary non-aqueous lithium batteries</p>	<p>The document presents general requirements that Telcordia and participating industry representatives view as applicable to large format non-aqueous rechargeable lithium batteries to replace or interoperate with conventional batteries (i.e., lead-acid, nickel-based); function seamlessly with DC power plants; and provide reliable backup power to load equipment in a network environment of a typical telecommunications service provider. Lithium batteries compliant with criteria in this document are recommended for deployment outside the plant at locations such as controlled environmental vaults, electronic equipment enclosures, huts and in uncontrolled structures such as cabinets. This standard addresses lithium batteries comprised of non-aqueous liquid or polymerized electrolytes that provide ionic conductivity between lithiated positive active material electrically separated from metallic lithium or lithiated negative active material. This document covers lithium batteries shipped disassembled (full assembly requires the series or parallel connections of cells or modules and a connection to an external BMS) or fully assembled (as 48 V systems with an integrated electronic management system).</p>
<p>Telcordia GR-4228-CORE VRLA battery string certification levels based on requirements for safety and performance</p>	<p>The document provides a 3-level system of VRLA String Safety and Performance Criteria based on Telcordia generic requirements documents. The VRLA string criteria levels are defined as follows:</p> <ul style="list-style-type: none"> • Level 1, Safety and Minimal Operability – minimum acceptable level of compliance needed to preclude hazards and degradation of the network facility and hazards to personnel, and needed to ensure battery operability at the installation time in controlled environments. • Level 2, Limited Operability – minimum acceptable level of compliance needed to provide limited assurance of battery operability under controlled environment conditions. • Level 3, Full Operability – minimum acceptable level of compliance needed to ensure battery operability throughout its expected life under the range of acceptable environmental conditions.
<p>UL 489 Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures</p>	<p>1.1 This standard covers molded-case circuit breakers, circuit-breaker and ground-fault circuit interrupters, fused circuit breakers and accessory high-fault protectors. These circuit breakers are specifically intended to provide service entrance, feeder and branch circuit protection in accordance with the National Installation Codes in Annex B, Ref. 1. This standard covers instantaneous-trip circuit breakers (circuit interrupters) specifically intended as part of a combination motor controller in accordance with the National Installation Codes in Annex B, Ref. 1.</p> <p>1.2 This standard covers molded-case and fused molded-case switches.</p>

Standard	Scope Summary
	<p>1.3 This standard covers devices rated at 600 V or less and 6000 amps or less.</p> <p>1.4 The devices referenced in 1.1 and 1.2 are intended for installation in an overall enclosure or as parts of other devices such as panelboards. The acceptability of the combination will be determined when the complete product is investigated.</p> <p>1.5 This standard covers circuit-breaker enclosures and accessory devices intended for use with the devices described in 1.1 and 1.2.</p> <p>1.6 This standard does not cover low-voltage power circuit breakers covered in Annex B, Ref. 3 and Ref. 4 or supplementary protectors covered in Annex B, Ref. 5.</p> <p>1.7 This standard contains supplements covering the requirements for molded-case circuit breakers for: a) Marine Use; b) Naval Use; c) Uninterruptible Power Supply Use; d) Classified Circuit Breakers; and e) Software in Programmable Components.</p>
<p>UL 810A Electrochemical Capacitors</p>	<p>1.1 These requirements cover electrochemical capacitors for use in equipment such as electronic products, uninterruptible power supplies, emergency lighting, engine starting, and power equipment. These energy storage capacitors, also known as electric double-layer capacitors, ultracapacitors, double-layer capacitors or supercapacitors, consist of either individual capacitors or multiple series and/or parallel connected capacitors with or without associated circuitry.</p> <p>1.2 These requirements do not cover electrochemical capacitors for use in hazardous (Classified) locations.</p>
<p>UL 1642 Lithium Batteries</p>	<p>1.1 These requirements cover primary (nonrechargeable) and secondary (rechargeable) lithium batteries for use as power sources in products. These batteries contain metallic lithium, lithium alloy or lithium-ion and may consist of a single electrochemical cell or two or more cells connected in series, parallel, or both that convert chemical energy into electrical energy by an irreversible or reversible chemical reaction.</p> <p>1.2 These requirements cover lithium batteries intended for use in technician-replaceable or user-replaceable applications.</p> <p>1.3 These requirements are intended to reduce the risk of fire or explosion when lithium batteries are used in a product. The final acceptability of these batteries is dependent on their use in a complete product that complies with the requirements applicable to such product.</p> <p>1.4 These requirements are also intended to reduce the risk of injury to persons due to fire or explosion when user-replaceable lithium batteries are removed from a product and discarded.</p> <p>1.5 These requirements cover technician-replaceable lithium batteries that contain 5.0 g (0.18 oz.) or less of metallic lithium. A battery containing more than 5.0 g</p>

Standard	Scope Summary
	<p>(0.18 oz.) of lithium is judged on the basis of compliance with the requirements in this standard as applicable and further test to determine whether the battery is acceptable for its intended uses.</p> <p>1.6 These requirements cover user-replaceable lithium batteries that contain 4.0 g (0.13 oz.) or less of metallic lithium with not more than 1.0 g (0.04 oz.) of metallic lithium in each electrochemical cell. A battery containing more than 4.0 g (0.13 oz.) or a cell containing more than 1.0 g (0.04 oz.) lithium may require further examination and test to determine whether the cells or batteries are acceptable for their intended uses.</p> <p>1.7 These requirements do not cover the toxicity risk that may result from the ingestion of a lithium battery or its contents, or the risk of injury to persons that may occur if a battery is cut open to provide access to the metallic lithium.</p>
<p>UL 1973 Batteries for Use in Light Electric Rail and Stationary Applications</p>	<p>Safety standard for stationary batteries for energy storage applications, non-chemistry specific and includes electrochemical capacitor systems or hybrid electrochemical capacitor and battery systems. Includes requirements for unique technologies such as flow batteries and sodium beta (i.e., sodium sulfur and sodium nickel chloride). Includes construction requirements, tests and production tests. Also includes requirements for cells used in these systems such as lithium-ion, nickel, lead-acid and includes sodium beta and flow battery requirements.</p>
<p>UL 2580-ULC S8250 Batteries for use in Electric Vehicles</p>	<p>1.1 These requirements cover electrical energy storage assemblies such as battery packs and combination electrochemical capacitor assemblies and modules that make up these assemblies for use in electric-powered vehicles as defined in this standard.</p> <p>1.2 This standard evaluates electrical energy storage assembly's ability to safely withstand simulated abuse conditions and prevents any exposure of persons to hazards from the abuse. This standard evaluates electric energy storage assembly and modules based on manufacturer's specified charge and discharge parameters at specified temperatures. It does not evaluate assembly's interaction with other control systems within the vehicle.</p> <p>1.3 This standard does not evaluate performance or reliability of devices.</p> <p>1.4 This standard does not include requirements for the evaluation of batteries for light electric vehicles such as electrical assist bicycles, wheel chairs, electric scooters and similar devices as defined in the Standard for Batteries for Use in Light Electric Vehicle Applications, UL 2271/ULC-S2271.</p>

Appendix D

Standards Related to the Entire Energy Storage System

Appendix D

Standards Related to the Entire Energy Storage System

Standard	Scope Summary
<p>ANSI C84.1 Electric Power Systems and Equipment— Voltage Ratings (60 Hertz)</p>	<p>This standard establishes nominal voltage ratings and operating tolerances for 60-hertz electric power systems above 100 volts. It also makes recommendations to other standardizing groups with respect to voltage ratings for equipment used on power systems and for utilization devices connected to such systems.</p> <p>This standard includes preferred voltage ratings up to and including 1200 kV maximum system voltage, as defined in the standard.</p> <p>In defining maximum system voltage, voltage transients and temporary overvoltages caused by abnormal system conditions such as faults, load rejection, and the like are excluded. However, voltage transients and temporary overvoltages may affect equipment operating performance and are considered in equipment application.</p> <p>The purposes of this standard are to:</p> <p>1) Promote a better understanding of the voltages associated with power systems and utilization equipment to achieve overall practical and economical design and operation; 2) Establish uniform nomenclature in the field of voltages; 3) Promote standardization of nominal system voltages and ranges of voltage variations for operating systems; 4) Promote standardization of equipment voltage ratings and tolerances; 5) Promote coordination of relationships between system and equipment voltage ratings and tolerances; 6) Provide a guide for future development and design of equipment to achieve the best possible conformance with the needs of the users; and 7) Provide a guide, with respect to choice of voltages, for new power system undertakings and for changes in older ones.</p>
<p>American Society of Mechanical Engineers (ASME) TES-1 - Safety Guideline for Molten Salt Thermal Energy Storage Systems</p>	<p>In June 2015, the ASME Council on Standards and Certification approved the creation of a new Standards Committee on Safety Standards for Thermal Energy Storage Systems (TES). The TES Standards Committee, which will report to the Board on Safety Codes and Standards, is envisioned to develop and maintain safety guidelines and standards covering the design, construction, testing, maintenance, and operation of thermal energy storage systems for the life cycle of the equipment. The proposed initial standard to be developed will provide requirements and recommendations to address the process safety considerations for Nitrate Molten Salt systems of concentrated solar power plants. ASME is regularly soliciting subject matter experts and affected stakeholders to help support these efforts. A first draft of the standard has been completed and is undergoing review and refinement by the TESSC.</p>

Standard	Scope Summary
AWEA 9.1-2009 Small Wind Turbine Performance and Safety Standard	<p>This standard was created by the small wind turbine industry, scientists, state officials, and consumers to provide consumers with realistic and comparable performance ratings and assurance the small wind turbine products certified to this standard are engineered to meet standards for safety and operation. The goal is to provide consumers with confidence in the quality of small wind turbine products meeting this standard and an improved basis for comparing competing product performance. This performance and safety standard provides a method for evaluation of wind turbine systems in terms of safety, reliability, power performance, and acoustic characteristics. This standard for small wind turbines is derived largely from existing international wind turbine standards developed under the auspices of the International Electrotechnical Commission (IEC). Specific departures from the IEC standards are provided to account for technical differences between large and small wind turbines, to streamline their use, and to present their results in a more consumer-friendly manner.</p>
CA PUC Tariff Rule 21	<p>Third parties must use certified equipment (both behind the meter and on the distribution grid) when attempting to interconnect new components to the grid. Certified equipment is equipment that has passed through rigorous certification testing procedures done by Nationally Recognized Testing Laboratories (NRTLs); UL is one such example. NRTLs create testing procedures for equipment that verify equipment functionality and safety to pre-set testing standards created by nationally recognized engineering groups such as IEEE. Certified equipment is tested against set standards so that the performance of the component under various conditions is predictable and certain. Predictability and certainty in relation to grid component reactions to various grid events enables responses to these events, by first responders and other interested parties, routinized, predictable and safe. Therefore, by requiring certified equipment in the interconnection process, new equipment will be expected to perform in certain, predictable ways under various grid conditions and events. Predictability also enables safety measures and routines to be created and executed.</p>
CA PUC Tariff Rule 21, Section L	<p>Testing procedures and criteria for “certifying” generators or inverters is provided. The testing procedures listed in the rule rely heavily on those described in UL, IEEE, and International Electrotechnical Commission (IEC) documents – most notably, UL 1741 testing procedures and IEEE 1547 Standard for Interconnecting Distribution Resources with Electric Power Systems. Section L describes the test procedures and requirements for equipment used for the Interconnection of Generating Facilities to Distribution Provider’s Distribution or Transmission System. Included are Type Testing, Production Testing, Commissioning Testing, and Periodic Testing. Equipment tested and approved (i.e., “Listed”) by an accredited NRTL meets both Type Testing and Production Testing requirements described in Rule 21 and is considered to be certified equipment for the purposes of interconnecting with the distribution or transmission system. Non-certified equipment will</p>

Standard	Scope Summary
	be required to provide information on some or all of the tests described in the rule and even then there is no guarantee that a utility will approve the non-certified equipment for use on the grid.
ICC IBC - International Building Code	<p>The <i>International Building Code</i> (IBC) is the foundation of the complete Family of International Codes®. It is an essential tool to preserve public health and safety that provides safeguards from hazards associated with the built environment. It addresses design and installation of innovative materials that meet or exceed public health and safety goals.</p> <p>Internationally, code officials recognize the need for a modern, up-to-date fire code addressing conditions hazardous to life and property from fire, explosion, handling or use of hazardous materials and the use and occupancy of buildings and premises.</p>
ICC IFC - International Fire Code	<p>The International Fire Code, in this 2015 edition, is designed to meet these needs through model code regulations that safeguard the public health and safety in all communities, large and small. This comprehensive fire code establishes minimum regulations for fire prevention and fire protection systems using prescriptive and performance-related provisions. It is founded on broad-based principles that make possible the use of new materials and new system designs. This 2015 edition is fully compatible with the Family of International Codes.</p>
ICC IMC - International Mechanical Code	<p>ICC uses the acronym to refer to ICC's model codes, standards, services and resources related to plumbing, mechanical, fuel gas, and swimming pools/spas topics. Originally, PMG stood for Plumbing Mechanical and Fuel Gas. But with the release of the International Swimming Pool and Spa Code (ISPSC) in 2012, it has expanded to include pools and spas.</p> <p>ICC's model PMG codes include the IPC, IMC, IFGC and ISPSC.</p>
ICC IRC - International Residential Code	<p>Internationally, code officials recognize the need for a modern, up-to-date residential code addressing the design and construction of one- and two-family dwellings and townhouses not more than three stories above grade. The International Residential Code is designed to meet these needs through model code regulations that safeguard the public health and safety in all communities, large and small. This comprehensive, stand-alone residential code establishes minimum regulations for one- and two-family dwellings and townhouses using prescriptive provisions. It is founded on broad-based principles that make possible the use of new materials and new building designs. This 2015 edition is fully compatible with the Family of International Codes.</p>
IEC 60812 Analysis Techniques for System Reliability - Procedure for Failure Mode and Effects Analysis (FE/ULMA)	<p>The standard describes FMEA and failure mode, effects and criticality analysis (FMECA), and gives guidance as to how they may be applied to achieve various objectives by providing the procedural steps necessary to perform an analysis; identifying appropriate terms, assumptions, criticality measures, failure modes; defining basic principles; and providing examples of necessary worksheets or other tabular forms. All the general qualitative considerations presented for FMEA will apply to FMECA, as latter is an extension of the other.</p>

Standard	Scope Summary
IEC 60950-1 (2013) Information technology equipment - Safety - Part 1: General requirements	The standard is applicable to mains- or battery-powered information technology equipment, including electrical business equipment and associated equipment, with a RATED VOLTAGE not exceeding 600 V. Also applicable are components and subassemblies intended for incorporation in information technology equipment. It is not expected that such components and subassemblies comply with every aspect of the standard, provided that the complete information technology equipment, incorporating such components and subassemblies, does comply.
IEC 61025 Fault Tree Analysis (FTA)	The standard describes fault tree analysis and provides guidance on its application as follows: definition of basic principles: describing and explaining associated mathematical modeling and explaining FTA relationships to other reliability modeling techniques; description of the steps involved in performing the FTA; identification of appropriate assumptions, events and failure modes; identification and description of commonly used symbols.
IEC 61508 Functional Safety of Electrical/Electronic/ Programmable Electronic Safety-related	The standard is intended to be a basic functional safety standard applicable to all kinds of industry. It defines functional safety as: “part of the overall safety relating to the equipment under control and its control system, which depends on the correct functioning of the E/E/PE safety-related systems, other technology safety-related systems and external risk reduction facilities.”
IEC 62040-1 Ed1 Uninterruptible power systems (UPS) – Part 1: General and safety requirements for UPS used in operator access areas	This standard specifically applies to UPS with an electrical energy storage device in the DC link. It is used with IEC 60950-1, referred to in this standard as reference document (RD). It is applicable to UPS that are movable, stationary, fixed or for building-in, for use in low-voltage distribution systems and intended to be installed in any operator accessible area or in restricted access locations as applicable. It specifies requirements to ensure safety for the operator and layman who may come into contact with the equipment and, where specifically stated, for the service person.
IEC 62040-1 Ed2 Uninterruptible power systems (UPS) – Part 2: General and safety requirements for UPS installed in restricted access locations	The standard addresses the EMC conformity assessment of categories C1, C2 and C3 products as defined in this part of IEC 62040, before placing them on the market. The requirements have been selected to ensure an adequate level of EMC for UPS at public and industrial locations.
IEC 62257-9-5 Recommendations for Small Renewable Energy and Hybrid Systems for Rural Electrification – Protection Against Electrical Hazards	The document applies to stand-alone rechargeable electric lighting appliances or kits that can be installed by a typical user without employing a technician. This technical specification presents a quality assurance framework that includes product specifications a framework for interpreting test results test methods and standardized specifications sheets templates for communicating test results.

Standard	Scope Summary
IEC 62257-9-1 Recommendations for small renewable energy and hybrid systems for rural electrification – Micropower systems	The standard applies to a micropower plant which is the electric energy generation subsystem associated with a decentralized rural electrification system. It provides general requirements for the design, erection and operation of micropower plants and general requirements to ensure the safety of persons and property. The plants covered by this specification are low-voltage AC, three- or single-phase, with rated capacity less than or equal to 100 kVA.
IEC 62257-9-2 Recommendations for small renewable energy and hybrid systems for rural electrification – Microgrids	The standard specifies the general requirements for the design and the implementation of microgrids used in decentralized rural electrification to ensure the safety of persons and property and their satisfactory operation according to the scheduled use.
IEC 62897 Stationary Energy Storage Systems with Lithium Batteries – Safety Requirements (under development)	This part of the standard specifies general safety requirements for stationary energy storages with lithium batteries. The purpose of the requirements of this standard is to ensure that hazards to the operator/user and the surrounding area are reduced to a tolerable level. Requirements for protection against particular types of hazards: electric shock or burn, mechanical hazards, spread of fire from the equipment, excessive temperature, effects of fluids and fluid pressure, liberated gases, explosion, chemical hazards (e.g., electrolyte).
IEC 62932-2-1 Flow Battery Systems For Stationary Applications – Part 2-1: Performance, general requirements and methods of test	This part of the IEC 62932 series specifies general information relating to the requirements and typical methods of test for flow battery system.
IEC 62932-2-2 Flow Battery Systems For Stationary Applications – Part 2-2: Safety requirements	This part of IEC 62932-2-2 applies to Flow Battery Systems for stationary use and its installations with a maximum voltage of DC 1 500 V (nominal) in compliance with IEC 62932-1.
IEC 62933 EES systems – Terminology	This regulation will define terms applicable to the electrical energy storage systems
IEC 62934 Unit parameters and testing methods of EES systems	The scope is to define Unit parameters and Testing methods to assure the system capability and performance of electrical ESS.
IEC 62936 Environmental issues of EES systems	This new work item proposal deals with general environmental requirements, specific environmental requirements of EES systems. The general environmental requirements include the normative documents for the harmful material of system, recycling of system and greenhouse effects. The specific environmental requirements of EES systems only need the normative documents from several aspects such as electrical, mechanical, surrounding conditions, etc.
IEC ESS Standards (in development or review; some of these may have scope summaries)	IEC CDV 62619 (li-Ion industrial cell and battery safety) - CDV out for review and done by SC 21A IEC NP 62485-5 (Stationary li-ion battery system safety) - NWIP out for review and done by TC 21 IEC FDIS 61427-2: Secondary cells and batteries On-grid PV applications) - FDIS balloted

Standard	Scope Summary
	<p>IEC CD 62932-1, (Flow battery terminology) - CD will be out for review in 2015 and done by TC21/JWG7 of TC s21 and 105</p> <p>IEC CD 62932-2-1 (Flow battery general requirements & method of test) - CD will be out for review in 2015 and done by TC21/JWG7 of TC s21 and 105</p> <p>IEC CD 62932-2-2 (Flow battery safety) - CD will be out for review in 2015 and done by TC21/JWG7 of TC s21 and 105</p> <p><i>CDs Under Development and Due Out Q4 of 2015</i></p> <p><i>IEC 62933 (EESS Terminology Standard) – 9/15</i></p> <p><i>IEC 62934 (EESS Performance Standard) – 12/15</i></p> <p><i>IEC 62935 (EESS Installation Standard) – 10/15</i></p> <p><i>IEC 62936 (EESS Environment Technical Specification) – 12/15</i></p> <p><i>IEC 62937 (EESS Safety Technical Specification) – 12/15</i></p> <p><i>Note: These activities occur through IEC TC 120 and U.S. input to that process is through a U.S. Technical Advisory Group to TC 120 that is organized under the auspices of NEMA.</i></p>
IEEE C2 - National Electrical Safety Code	<p>This Code covers basic provisions for safeguarding of persons from hazards arising from the installation, operation, or maintenance of 1) conductors and equipment in electric supply stations, and 2) overhead and underground electric supply and communication lines. It also includes work rules for the construction, maintenance, and operation of electric supply and communication lines and equipment. The standard is applicable to the systems and equipment operated by utilities, or similar systems and equipment, of an industrial establishment or complex under the control of qualified persons. This standard consists of the introduction, definitions, grounding rules, list of referenced and bibliographic documents, and Parts 1, 2, 3, and 4 of the 2012 Edition of the National Electrical Safety Code.</p>
IEC NP 62937 Safety considerations related to the installation of grid integrated EES Systems	<p>The scope of this NWIP is to prepare normative documents on safety dealing with: 1) main risks related to couples of use cases and associated technologies; 2) technical contents and results to be included in the safety report and auditing framework; 3) list of main features to be validated by testing; 4) scale at which the storage system must be tested; and 5) recommendations to prevent or mitigate accidental effect.</p>
IEEE 485 Lead-Acid Batteries for Stationary Applications	<p>This standard details methods for defining the DC loads and for sizing a lead-acid battery to supply those loads in full-float operation.</p>
IEEE 1375 Guide for the Protection of Stationary Battery Systems	<p>This guidance provides for the protection of stationary battery systems, which include the battery and DC components to and including the first protective device downstream of battery terminals. Recommendations are not intended to set requirements; rather, they present options to the battery system designer concerning the types of protection available.</p>
IEEE 1491 Guide for Selection and Use of BMS in Stationary Applications	<p>The document discusses operational parameters that may be observed by battery monitoring equipment used in stationary applications and the relative value of such observations. Although a list of commercially available systems is not given, a means for establishing specifications for the desired parameters to be monitored is provided.</p>

Standard	Scope Summary
IEEE 1679 Recommended Practice for the Characterization and Evaluation of Emerging Energy Storage Technologies in Stationary Applications	Standard covers recommended information for an objective evaluation of emerging energy storage technology by a potential user of any stationary application. Storage technologies are those that provide a means for the reversible storage of electrical energy (i.e., device receives electrical energy and can discharge electrical energy later). The storage medium may be electrochemical (e.g., batteries), kinetic (e.g., flywheels), electrostatic (e.g., electric double-layer capacitors [EDLCs]), thermal or other medium. Devices recharged by non-electrical means such as fuel cells are beyond the scope of this document.
ISO 9000 Series Quality Management	The ISO 9000 family addresses various aspects of quality management and contains some of ISO's best known standards. The standards provide guidance and tools for companies and organizations who want to ensure that their products and services consistently meet customer's requirements, and that quality is consistently improved. Standards in the ISO 9000 family include: ISO 9001:2008 - sets out the requirements of a quality management system ISO 9000:2005 - covers basic concepts and language ISO 9004:2009 - focuses on how to make a quality management system more efficient and effective ISO 19011:2011 - sets out guidance on internal and external audits of quality management systems.
NFPA 1 Fire Code	Fire Code, advances fire and life safety for the public and first responders as well as property protection by providing a comprehensive, integrated approach to fire code regulation and hazard management. It addresses all the bases with extracts from and references to more than 130 NFPA® codes and standards including such industry benchmarks as NFPA 101, NFPA 54, NFPA 58, NFPA 30, NFPA 13, NFPA 25, and NFPA 72.
NFPA 101 Life Safety Code	The Life Safety Code is the most widely used source for strategies to protect people based on building construction, protection, and occupancy features that minimize the effects of fire and related hazards. Unique in the field, it is the only document that covers life safety in both new and existing structures.
NFPA 110 - Standard for Emergency and Standby Power	This standard covers performance requirements for emergency and standby power systems providing an alternate source of electrical power in buildings and facilities in the event that the normal electrical power source fails. Systems include power sources, transfer equipment, controls, supervisory equipment, and accessory equipment needed to supply electrical power to the selected circuits. NFPA 110 presents installation, maintenance, operation, and testing requirements as they pertain to the performance of the emergency or standby power supply system (EPSS) up to the load terminals of the transfer switch. Specific topics include definitions of the classification of EPSS; energy sources, converters, inverters, and accessories; transfer switches and protection; installation and environmental considerations; and

Standard	Scope Summary
<p>NFPA 111-2013 Standard on Stored Electrical Energy Emergency and Standby Power Systems</p>	<p>routine maintenance and operational testing.</p> <p>Readiness of emergency power is a key consideration in safeguarding building occupants in the event of a disruption of the normal utility supply. NFPA 111 covers performance requirements for stored electric energy systems providing an alternate source of electrical power in buildings and facilities during interruption of the normal power source.</p> <p>Requirements in NFPA 111 address:</p> <ul style="list-style-type: none"> Power sources Transfer equipment Controls Supervisory equipment Accessory equipment that are needed to supply electrical power to selected circuits Installation, maintenance, operation, and testing requirements as they pertain to the performance of the stored emergency power supply system.
<p>NFPA 791-2014 Recommended Practice and Procedures for Unlabeled Electrical Equipment Evaluation</p> <p>NFPA 1620 - Standard for Pre-Incident</p>	<p>NFPA 791 covers recommended procedures for evaluating unlabeled electrical equipment for compliance with nationally recognized standards. Criteria provide guidance to third-party field evaluation bodies (FEBs) on how to perform evaluations of unlabeled electrical equipment in a consistent and reliable manner, thus assisting regulating authorities who make product and related installation approval decisions and facilitating acceptance of the results. Specific areas covered include pre-site preparation, construction inspection, electrical testing, and reporting, and documentation.</p> <p>This standard provides criteria for developing pre-incident plans to help responders effectively manage emergencies so as to maximize protection for occupants, responding personnel, property, and the environment. Comprehensive guidance covers the pre-incident planning process, physical and site considerations, occupant considerations, water supplies and fire protection systems, special hazards, emergency operations, and pre-incident plan testing and maintenance. Annexes contain case histories and information addressing special or unique characteristics of specific occupancy classifications, as well as sample forms for pre-incident planning.</p>
<p>NFPA 5000 - Building Construction and Safety Code</p>	<p>This code provides requirements for that construction, protection, and occupancy features necessary to safeguard life, health, property, and public welfare and minimize injuries. Design criteria regulate and control the permitting; design; construction, alteration, and repair; quality of materials; equipment and systems; use and occupancy; demolition; location; and maintenance of all types of buildings and structures. Separate chapters address issues specific to individual occupancy types, structural features, building materials, and building systems. A performance-based option is also included.</p>

Standard	Scope Summary
PGMA Safety Standard for Portable Generators (under development)	Scope – Clear definition of what is/is not covered by the standard (e.g., power, voltage, and other criteria). Includes criteria for the following: Guarding of moving parts (i.e., mechanical hazards) Enclosing “live” parts (electrical shock hazard) Sharp edges Corrosion resistance Endurance (after a defined period of operation, ensure that product still conforms to standard) Environmental tests (e.g., temperature, humidity, rain, etc.) Mechanical strength (e.g., drop test or impact test) Grounding and bonding Spacing’s (typically, creepage and clearance distances) Abnormal operation (operation outside the scope of specifications (e.g., high/low voltage or overload) – Product does not need to operate properly but must not create a hazard Temperature test – Product operated and temperatures taken at various points for safety to personnel (accessible points) and within limits for insulation use Electrical strength (dielectric test) Labeling requirements Operator manual requirements
Telcordia GR-63 Issue Number 04	This generic requirements document (GR) presents minimum spatial and environmental criteria for all new telecommunications equipment used in Central Offices and other environmentally controlled telephone equipment spaces. These criteria were developed jointly by Telcordia and industry representatives. They are applicable to switching and transport systems, associated Cable Distribution Systems, Distributing and Interconnecting Frames, power equipment, operations support systems, and Cable Entrance Facilities. Compliance with these requirements may increase network robustness, simplify equipment installation, and promote the economic planning, engineering and operation of equipment spaces. Issue 4 of GR-63 includes the following updated information: Criteria for equipment-cooling air-inlet and exhaust locations are revised and clarified. Operating temperature test conditions are now a function of the equipment-cooling air-inlet location. A detailed heat dissipation calculation procedure is provided for frame and shelf-level equipment. Fire resistance test methods are updated to address specific service provider requirements. Unpackaged shock-testing levels for field-replaceable units and smaller chassis are more closely aligned with other standards and the expected levels encountered during installation. The Office Vibration test now includes an option for a random vibration method that is aligned with other standards.

Standard	Scope Summary
<p>UL 924 Emergency Lighting and Power Equipment</p>	<p>1.1 This Standard applies to emergency lighting and power equipment for use in unclassified locations and intended for connection to branch circuits 600 V or less. Intended to supply illumination, power or both automatically to critical areas and equipment in the event of failure of normal supply in accordance with NEC Article 700 or 701, NFPA 70, Life Safety Code, NFPA 101, Fire Code, NFPA 1, International Building Code (IBC) and International Fire Code (IFC).</p> <p>1.2 Examples of equipment from 1.1 include Exit Signs, Emergency Luminaires, Unit Equipment, Central Station Battery Banks, Inverters, Automatic Battery Charging and Control Equipment, Automatic Load Control Relays and Derangement Signal Equipment.</p> <p>1.3 This Standard also applies to auxiliary lighting and power equipment for use in unclassified locations. Auxiliary equipment has not been investigated to determine compliance with the performance requirements of Article 700 or 701 of the NEC, NFPA 70, the Life Safety Code, NFPA 101, or the IBC. Such equipment includes luminaires with an integral battery backup power supply, illuminated directional signs, battery assemblies, and related devices.</p> <p>1.4 This Standard does not include requirements for equipment covered by other Standards, such as Luminaires, UL 1598; Uninterruptible Power Systems, UL 1778; Luminous Egress Path Marking Systems, UL 1994; Transfer Switch Equipment, UL 1008; Electric Signs, UL 48</p>
<p>UL 1741 Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources</p>	<p>1.1 These requirements cover inverters, converters, charge controllers, and interconnection system equipment (ISE) intended for use in stand-alone (not grid-connected) or utility-interactive (grid-connected) power systems. Utility-interactive inverters, converters, and ISE are intended to be operated in parallel with an electric power system (EPS) to supply power to common loads.</p> <p>1.2 For utility-interactive equipment, these requirements are intended to supplement and be used in conjunction with the Standard for Interconnecting Distributed Resources With Electric Power Systems, IEEE 1547, and the Standard for Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems, IEEE 1547.1.</p> <p>1.3 These requirements cover AC modules that combine flat-plate PV modules and inverters to provide AC output power for stand-alone use or utility-interaction, and power systems that combine other alternative energy sources with inverters, converters, charge controllers and ISE in system-specific combinations.</p> <p>1.4 These requirements also cover power systems that combine independent power sources with inverters, converters, charge controllers, and ISE in system-specific combinations.</p> <p>1.5 The products covered by these requirements are intended to be installed in accordance with the NEC, NFPA 70.</p>

Standard	Scope Summary
<p>UL 1778 Uninterruptable Power Sources</p>	<p>1.1 Scope Replace this clause of the RD with the following:</p> <p>1.1.1 Equipment covered by this standard This Standard applies to UPS, whose primary function for this Standard is to ensure continuity of an alternating power source. The UPS may also serve to improve the quality of the power source by keeping it within specified characteristics. This Standard is applicable to movable, stationary, fixed, and built-in UPS for distribution systems up to 600 V AC. This equipment is designed to be installed in accordance with the Canadian Electrical Code, Part I, Canadian Standards Association (CSA) C22.1, or the National Electrical Code, ANSI/NFPA 70, and, unless otherwise identified, the Standard for the Protection of Electronic Computer Data-Processing Equipment, ANSI/NFPA 75. This Standard specifies requirements intended to ensure safety for the operator and where specifically stated for SERVICE PERSONNEL. This Standard is intended to reduce the risk of fire, electric shock, or injury to persons from installed equipment, both as a single unit or as a system of interconnected units, subject to installing, operating, and maintaining equipment in the manner prescribed by the manufacturer.</p> <p>1.1.2 Additional requirements In addition to the requirements in this Standard, a UPS is to comply with the UPS-relevant requirements of Information Technology Equipment Safety - Part 1: General Requirements, CAN/CSA-C22.2 No. 60950-1/UL 60950-1, first edition, (RD), as applicable for the country where the product will be used. Wherever there is a conflict between requirements of this document and the RD, requirements of this Standard will prevail. Engine-driven DC power generators intended to provide backup power for the battery supply circuit of UPS units are investigated for compliance with the requirements of the Standard for Stationary Engine-Generator Assemblies, UL 2200, and the CSA Standard for Motors and Generators, C22.2 No. 100. UPS that employ hospital grade components identified by the markings “Hospital Only,” “Hospital Grade,” or a green dot on the body of the component, or otherwise implying suitability for medical use are evaluated to the requirements of this Standard and Medical Electrical Equipment, Part 1: General Requirements for Safety, CAN/CSA-C22.2 No. 601.1/UL 60601-1.</p> <p>1.1.3 Exclusions These requirements do not cover UPS units for use as emergency systems or as legally required standby systems, described in Articles 700 and 701, respectively, of the National Electrical Code, ANSI/NFPA 70, and Section 46 of the Canadian Electrical Code, Part I, CSA C22.1. Where considered appropriate, revision of requirements will be proposed and adopted in conformance with the methods employed for development, revision, and implementation of this Standard. NOTE 1: For equipment subject to transient overvoltages exceeding those for Category II according to IEC 60664, additional protection might be necessary. Such additional protection may be located in the mains supply to the equipment or in the equipment as an integral design feature. NOTE 2: Where the</p>

Standard	Scope Summary
UL 2021 Fixed and Location-Dedicated Electric Room Heaters	<p>additional protection is an integral part of the equipment insulation requirements, CREEPAGE DISTANCES and CLEARANCE distances from the mains through to the load side of the additional protection may be judged as Category III or IV as required. All insulation requirements, CREEPAGE DISTANCES, and CLEARANCE distances on the load side of the additional protection may be judged as Category I or II as required.</p> <p>This Standard does not cover all types of UPS but may be a guide for such equipment. Requirements additional to those specified in this Standard are in some cases necessary for specific applications; e.g., equipment intended for operation exposed to extremes of temperature; excessive dust, moisture or vibration; flammable gases; corrosive or explosive atmospheres; and UPS equipment based on rotary machinery.</p> <p>I.1 These requirements cover fixed and location-dedicated electric room heating equipment rated 600 V or less to be employed in ordinary locations in accordance with the NEC, ANSI/NFPA 70.</p> <p>1.2 These requirements do not cover movable heaters, wall- or ceiling-hung heaters, baseboard heaters, duct heaters, central-heating furnaces, fan-coil units, panel- or cable-type radiant-heating equipment, electric boilers, or any other electric heating equipment or appliances covered in or as a part of separate, individual requirements.</p>
UL 6141 Wind Turbine Converters and Interconnection Systems Equipment	<p>1 Scope</p> <p>1.1 These requirements cover Wind Turbine Converter (WTC) products and assemblies. Some of the features and functions of these products include but are not limited to, generation of real and reactive power in parallel with the EPS (electric utility grid) supplying power in a stand-alone operational mode, multiple mode operation, and bidirectional power flow operation with the EPS.</p> <p>1.2 These requirements address WTC products and assemblies intended for installation in accordance with their ratings, installation instructions, the NEC, ANSI/NFPA 70, and applicable utility and model building codes.</p> <p>1.3 These requirements also address wind turbine utility interconnection systems equipment that performs utility interconnection protection functions for paralleling wind turbines with the EPS.</p>
UL 6142 Small Wind Turbines	<p>1 Scope</p> <p>1.1 These requirements cover small wind turbine systems (WT) and electrical subassemblies. With respect to this standard, small WT are considered to be wind turbines where a user or service person cannot or is not intended to enter the turbine to operate it or perform maintenance. These units are intended for use in stand-alone (not grid-connected) or utility-interactive applications. Utility-interactive, grid-tied WT are operated in parallel with an EPS to supply power to common loads.</p> <p>1.2 The WT power, control and protection systems are evaluated only to the extent that they function within the manufacturer's specified limits and response times. These control and protection</p>

Standard	Scope Summary
	<p>functions are evaluated with respect to risk of electric shock and fire. It is intended that the electrical subassemblies that address power transfer control and protection functions evaluated per this document are to be coordinated with the mechanical and structural limitations specified in AWEA 9.1, Small Wind Turbine Performance and Safety Standard, the IEC 61400 series documents, or Germanischer Lloyd: Guideline for the Certification of Wind Turbines documents.</p> <p>1.3 These requirements do not cover: a) WT generating systems intended for off-shore installation; b) WT generating systems intended for hazardous locations; c) Mechanical or structural integrity of the WT system or subassemblies; d) Verification that manufacturer-defined controls and protection limits maintain the WT system within its safe mechanical and structural limits; e) Mechanical loading of ladders, hoist supports, elevator mounting means, scaffolding, personnel tie offs, or other personnel load-bearing functional parts.</p> <p>1.4 The wind turbine products covered by these requirements are intended to be installed according to the NEC, ANSI/NFPA 70.</p> <p>1.5 The evaluation of products to this standard includes evaluation of all features and functions incorporated in or available for the turbine or referred to in the documentation provided with the turbine, if these features or functions can affect compliance of the product with this standard.</p> <p>1.6 Turbines where a user or service person is intended or required to enter the turbine to operate or perform maintenance on the turbine are considered to be large wind turbine systems and are covered in the Outline of Investigation for Wind Turbine Generating Systems, UL 6140.</p> <p>1.7 These requirements cover WT rated 1500 Vac or less.</p>
<p>UL 9540 Outline for Investigation for Safety for Energy Storage Systems and Equipment</p>	<p>These requirements cover ESS that are intended to store energy from power or other sources and provide electrical or other types of energy to loads or power conversion equipment. The ESS may include equipment for charging, discharging, control, protection, communication, controlling the system environment, fuel or other fluid movement and containment, etc. The system may contain other ancillary equipment related to the functioning of the ESS. These are intended for use in utility-interactive applications in compliance with IEEE 1547 and IEEE 1547.1 or other applications intended to provide grid support functionality. These systems may be stand-alone to provide energy for local loads, or in parallel with an EPS, electric utility grid or applications that perform multiple operational modes.</p>

Standard	Scope Summary
<p>UL 9741, Outline of Investigation for Bidirectional Electric Vehicle (EV) Charging System Equipment</p>	<p>These requirements cover bidirectional electric vehicle charging equipment that charge electric vehicles from an electric power system and also include functionality to export power from the electric vehicle to an electric power system. When commanded, the bidirectional charging equipment exports electric power from the EV stored energy supply to the EPS to supply power to common loads. For utility-interactive equipment, these requirements are intended to supplement and be used in conjunction with the Standard for Interconnecting Distributed Resources With EPS, IEEE 1547, and the Standard for Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems, IEEE 1547.1.</p>
<p>UL 62109-2, Safety of power converters for use in photovoltaic power systems – Part 2: Particular requirements for inverters.</p>	<p>These requirements cover bidirectional EV charging equipment that charge EVs from an electric power system and also include functionality to export power from the EV to an electric power system. When commanded, the bidirectional charging equipment exports electric power from the EV stored energy supply to the EPS to supply power to common loads. For utility-interactive equipment, these requirements are intended to supplement and be used in conjunction with the Standard for Interconnecting Distributed Resources With EPS, IEEE 1547, and the Standard for Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems, IEEE 1547.1.</p>

Appendix E

Standards Related to the Installation of Energy Storage Systems

Appendix E

Standards Related to the Installation of ESSs

Standard	Scope Summary
AS 2676-1983 Installation and Maintenance of Batteries in Buildings	The standard sets out the requirements for the installation and maintenance in buildings of stationary batteries having a stored capacity exceeding 1 kWh, or a floating voltage of 115 V but not exceeding 650 V. Applies to both battery rooms and battery cabinets. Safety requirements are included particularly in relation to the ventilation requirements to ensure an explosive atmosphere does not arise. Commissioning, inspection and maintenance of stationary batteries are also covered.
AS/NZS 3000-2007 Electrical Installations	The standard sets out requirements for the design, construction and verification of electrical installations, including the selection and installation of electrical equipment forming part of such electrical installations. These requirements are intended to protect persons, livestock, and property from electric shock, fire and physical injury hazards that may arise from an electrical installation that is used with reasonable care and with due regard to the intended purpose of the electrical installation. In addition, guidance is provided so that the electrical installation will function correctly for the purpose intended.
AS 3011.2-1992 Electrical installations - Secondary batteries installed in buildings - Sealed cells	Specifies requirements for the installation of sealed secondary batteries permanently installed in buildings.
AS 4777.1-2005 Grid connection of energy systems via Inverters	This Standard specifies the electrical installation requirements for inverter energy systems and grid protection devices with ratings up to 10 kVA for single-phase units, or up to 30 kVA for three-phase units, for the injection of electric power through an electrical installation to the electricity distribution network. NOTES: 1 Although this Standard does not apply to larger systems, similar principles can be used for the installation of such systems. 2 This Standard does not cover detailed installation requirements for the energy source(s) and its associated wiring.
EN 61000-6 Electromagnetic Compatibility (EMC)	There are various sub standards (6-1, 6.-2, etc.) that apply to EMC. Information from IEC 61000-

Standard	Scope Summary
	<p>6-1 covers EMC immunity requirements for electrical and electronic apparatus intended for use in residential, commercial and light industrial environments. Immunity requirements in the frequency range 0 Hz to 400 GHz are covered. No tests need to be performed at frequencies where no requirements are specified. This generic EMC immunity standard is applicable if no relevant dedicated product or product-family EMC immunity standard exists. This standard applies to apparatus intended to be directly connected to a low-voltage public mains network or connected to a dedicated DC source which is intended to interface between the apparatus and the low-voltage public mains network. This standard also applies to apparatus which is battery operated or is powered by a non-public, but non-industrial, low-voltage power distribution system if this apparatus is intended to be used in the locations described below. The environments encompassed by this standard are residential, commercial and light industrial locations, both indoor and outdoor. Though not comprehensive, the following list gives an indication of locations included:</p> <ul style="list-style-type: none"> • Residential properties (e.g., houses, apartments, etc.) • Retail outlets (e.g., shops, supermarkets, etc.) • Business premises (e.g., offices, banks, etc.) • Areas of public entertainment (e.g., cinemas, public bars, dance halls, etc.) • Outdoor locations (e.g., gas stations, amusement and car parks, sports centers, etc.) • Light industrial locations (e.g., workshops, laboratories, service centers, etc.) <p>Locations characterized by being supplied directly at low voltage from the public mains network are considered to be residential, commercial, or light industrial. The object of this standard is to define the immunity test requirements for apparatus specified in the scope in relation to continuous and transient conducted and radiated disturbances including electrostatic discharges. The immunity requirements have been selected to ensure an adequate level of immunity for apparatus at residential, commercial and light-industrial locations. The levels do not, however, cover extreme cases, which may occur at any location but with a very low probability of occurrence. Not all disturbance phenomena have been included for testing purposes in this standard; only those considered as relevant for the equipment covered. These test requirements represent essential electromagnetic compatibility</p>

Standard	Scope Summary
	immunity requirements.
EPA Emergency Planning and Community Right-to-Know Act (EPCRA)	The EPCRA of 1986 were created to help communities plan for emergencies involving hazardous substances. EPCRA requires hazardous chemical emergency planning by federal, state and local governments, Indian tribes, and industry. It also requires industry to report on the storage, use and releases of hazardous chemicals to federal, state, and local governments.
TITLE 47 USC Telecommunication Chapter I--Federal Communications Commission PART 15 Radio Frequency Devices Subpart B Unintentional Radiators Sec. 15.109 Radiated emission limits	Sets radiated emissions limits.
FM Global Property Loss Prevention Data Sheet 5-10 Protective Grounding for Electric Power Systems and Equipment, January 2011	The document describes the various methods used for grounding electrical systems and the non-current carrying metal parts of electrical wiring systems and equipment and also discusses the advantages and disadvantages of the different grounding methods, and the means employed to safeguard property from arc damage and fire.
FM Global Property Loss Prevention Data Sheet 5-1 Lightening and Surge Protection for Electrical Systems, April 2012	The document describes modern procedures and practices for protecting industrial power distribution systems and associated equipment from damage caused by over voltages due to lightning, switching, or a system abnormality.
FM Global Property Loss Prevention Data Sheet 5-19 Switchgear and Circuit Breakers, January 2006	The document describes switchgear as a general term covering switching, interrupting, control, metering, protective, and regulating devices and assemblies of these devices with their associated interconnections, accessories, and supporting structures and provides for the basic operation, protection, inspection, maintenance, and testing of various types of switchgear used in applications of at least 600V.

Standard	Scope Summary
FM Global Property Loss Prevention Data Sheet 5-23 Emergency and Standby Power Systems, October 2012	The document describes describe the types, operation, and protection of emergency and standby power systems, and provides guidelines for their application. Recommendations are included for the arrangement and protection of fuel supplies feeding emergency and standby power systems.
IAPMO Uniform Mechanical Code	<p>The Uniform Mechanical Code established minimum requirements and standards for the protection of the public health, safety and welfare. 101.3 Scope. The provisions of this code shall apply to the addition to or erection, installation, alteration, repair, relocation, replacement, use, or maintenance of heating, ventilating, cooling, refrigeration systems; incinerators; or other miscellaneous heat-producing appliances within this jurisdiction.</p> <p>The Uniform Mechanical Code addresses the design, construction, installation, quality of materials, location, operation, and maintenance or use of heating, ventilating, cooling, and refrigeration systems; heat-producing appliances, fuel-gas piping systems, and fuel-gas appliances to maintain the desired environmental conditions in a space.</p>
IAPMO Uniform Plumbing Code	<p>The Uniform Plumbing Code establishes minimum requirements and standards for the protection of the public health, safety and welfare. 101.2 Scope. The provisions of this code shall apply to the erection, installation, alteration, repair, relocation, replacement, addition to, use, or maintenance of plumbing systems within this jurisdiction. The Uniform Plumbing Code covers potable water, building supply, and distribution pipes; all plumbing fixtures and traps; all drainage and vent pipes; and all building drains, and building sewers, including their respective joints and connections, devices, receptors, and appurtenances within the property lines of the premises and shall include potable water piping, potable water treating or using equipment, medical gas and medical vacuum systems, liquid and fuel-gas piping, and water heaters and vents for same.</p>
IAPMO Uniform Solar and Hydronics Code	<p>The Uniform Solar Energy and Hydronics Code established minimum requirements and standards for the protection of public health, safety and welfare for application to the erection, installation, alteration, repair, relocation, replacement, addition to, use or maintenance of solar energy systems, including but not limited to equipment and appliances intended to utilize solar</p>

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	energy for space heating or cooling; water heating; swimming pool heating or process heating; and solar PV systems. The code includes systems where equipment and components collect, convey, store and convert the sun's energy for a purpose, including but not limited to service water, pool water and space heating and cooling as well as electrical service.
<p>IEC 62935 Planning and Installation of Electrical Energy Storage Systems</p>	<p>This work item proposal deals with the planning and installation of EES systems and should be elaborated in close cooperation with unit parameter and testing aspects. The intention is to give guidance for planning and installation of EES systems and to provide standards and other deliverables which can be used by power system planners, system integrators and commissioning staff. This activity was initiated by IEC TC 120 under PNW 120-33. The rationale for the proposed activity in this area was that the introduction of the ESS as components of the grid (utility grid, commercial or industrial grid, residential grid) may require implementing safety measures regarding the urbanization levels of areas in which they are installed. The potential risks for these systems must be studied in relation to the technologies used and their locations. The scope of this NWIP is to prepare normative documents on safety dealing with main risks related to the couples of use cases and associated technologies, technical contents and results to be included in the safety report and auditing framework, list of main features to be validated by testing, scale at which the storage system must be tested, recommendations to prevent or mitigate accidental effect.</p>
<p>IEC New Work Item Proposal (NWIP) 21/823/NP – Flow Battery Technologies – Safety</p> <p>IEC ESS Standards (in development or review; some of these may have scope summaries)</p>	<p>This activity is in the working stage to become an IEC standard and will complement the existing CWA: Flow batteries - Guidance on the specification, installation and operation.</p> <ul style="list-style-type: none"> • IEC CDV 62619 (li-Ion industrial cell and battery safety) - CDV out for review and done by SC 21A • IEC NP 62485-5 (Stationary li-ion battery system safety) - NWIP out for review and done by TC 21 • IEC FDIS 61427-2: Secondary cells and batteries On-grid PV applications) - FDIS balloted • IEC CD 62932-1, (Flow battery terminology) - CD will be out for review in 2015 and done by TC21/JWG7 of TC s21 and 105 • IEC CD 62932-2-1 (Flow battery general

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	<p>requirements & method of test) - CD will be out for review in 2015 and done by TC21/JWG7 of TC s21 and 105</p> <ul style="list-style-type: none"> • IEC CD 62932-2-2 (Flow battery safety) - CD will be out for review in 2015 and done by TC21/JWG7 of TC s21 and 105 <ul style="list-style-type: none"> - <i>CDs Under Development and Due Out Q4 of 2015</i> <ul style="list-style-type: none"> ○ IEC 62933 (EESS Terminology Standard) – 9/15 ○ IEC 62934 (EESS Performance Standard) – 12/15 ○ IEC 62935 (EESS Installation Standard) – 10/15 ○ IEC 62936 (EESS Environment Technical Specification) – 12/15 ○ IEC 62937 (EESS Safety Technical Specification) – 12/15 <p><i>Note: These activities occur through IEC TC 120 and U.S. input to that process is through a U.S. Technical Advisory Group to TC 120 that is organized under the auspices of NEMA.</i></p>
<p>ICES-003 Issue 5 August 2012 Spectrum Management and Telecommunications Interference-Causing Equipment Standard</p>	<p>1. Scope – This Interference-Causing Equipment Standard–003 (ICES-003) sets out the technical requirements relative to radio noise generated by Information Technology Equipment (ITE).</p> <p>2. Purpose and Applications – 2.1 ITE is defined as devices or systems that use digital techniques for purposes such as data processing and computation. ITE is any unintentional radiator (device or system) that generates and/or uses timing signals or pulses having a rate of at least 9 kHz and employs digital techniques for purposes such as computation, display, data processing and storage, and control. ITE is designated Category II Equipment, meaning that a Technical Acceptability Certificate or equipment certification is not required. ITE that is subject to ICES-003 is approved through Self-Declaration of Compliance by the manufacturer, importer or distributor of ITE, which will ensure compliance with all technical requirements prescribed by ICES-003 and the results compiled into a test report. That report shall clearly state which test method was used to determine compliance. The methods of measurement are set out in the standards incorporated by reference in ICES-003 specified in Section 3.</p>

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<p>IEEE 519-1992 Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems</p>	<p>The guide applies to all types of static power converters used in industrial and commercial power systems. The problems involved in the harmonic control and reactive power compensation of such converters are addressed, and an application guide is provided. Limits of disturbances to the AC power distribution system that affect other equipment and communications are recommended.</p>
<p>IEEE 1145-1999 Recommended Practice for Installation and Maintenance of Nickel-Cadmium Batteries for Photovoltaic (PV) Systems</p>	<p>The document provides safety precautions, installation design considerations, and procedures for receiving, storing, commissioning, and maintaining pocket- and fiber-plate nickel-cadmium storage batteries for PV power systems. Disposal and recycling recommendations are also discussed. This recommended practice applies to all PV power systems, regardless of size or application that contain nickel-cadmium battery storage subsystems.</p>
<p>IEEE 1187-2013 Recommended Practice for Installation Design and Installation of Valve-Regulated Lead-Acid Batteries for Stationary Applications</p>	<p>The document provides guidance for the installation and installation design of VRLA batteries. This recommended practice is intended for all standby stationary installations. However, specific applications, such as emergency lighting units and semi-portable equipment, may have other appropriate practices and are beyond the scope of this recommended practice. Alternative energy applications are not covered.</p>
<p>IEEE P2030.2.1 Working Group (WG), Guide for Design, Operation, Maintenance of Battery Energy Storage Systems, both Stationary and Mobile, and Applications Integrated with Electric Power Systems (SASB/SCC21/WGBESS) IEEE P2030.3</p> <p>Standard for Test Procedures for Electric Energy Storage Equipment and Systems for Electric Power Systems Applications</p>	<p>The document provides alternative approaches and practices for design, operation, maintenance, integration and interoperability, including distributed resources interconnection, of stationary or mobile battery energy storage systems (BESS) with the EPS at customer facilities, electricity distribution facilities or bulk transmission electricity facilities. This document addresses BESS and applications conformance to the IEEE 1547 series. Requirements for distributed resources interconnection, implementing IEEE 2030 smart grid interoperability reference model guidance, and builds upon the IEEE 1547, IEEE 2030, and relevant IEEE PV standards and IEEE standards for batteries.</p> <p>This standard is intended to be used by BESS designers, operators, system integrators, and equipment manufacturers. It provides an introduction of engineering concerns of BESS, identifies key technical parameters, engineering approaches and application practices requirements of BESS, and its operation and maintenance. It</p>

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	<p>addresses not only electric power concerns but also the directly related communications and information technology concerns for BESS and applications integrated with EPSes. Implementation of this guide will assist in the standardization of BESS applications. Standardized test procedures are necessary to establish and verify compliance with those requirements. These test procedures need to provide both repeatable results, at independent test locations, and have flexibility to accommodate the variety of storage technologies and applications. This standard establishes test procedures for electric energy storage equipment and systems for EPS applications. It is recognized that electric energy storage equipment or systems can be a single device providing all required functions or an assembly of components, each having limited functions. Components having limited functions shall be tested for those functions in accordance with this standard. Conformance may be established through combination of type, production, and commissioning tests. Additionally, requirements on installation evaluation and periodic tests are included in this standard.</p>
<p>ICC International Building Code (IBC)</p>	<p>The provisions of this code shall apply to the construction, alteration, relocation, enlargement, replacement, repair, equipment, use and occupancy, location, maintenance, removal and demolition of every building or structure or any appurtenances connected or attached to such buildings or structures. Exception: Detached one- and two-family dwellings and multiple single-family dwellings (townhouses) not more than three stories above grade plane in height with a separate means of egress and their accessory structures shall comply with the International Residential Code.</p>

Standard	Scope Summary
ICC International Fire Code (IFC)	<p>This code establishes regulations affecting or relating to structures, processes, premises and safeguards regarding:</p> <ol style="list-style-type: none"> 1. The hazard of fire and explosion arising from the storage, handling or use of structures, materials or devices 2. Conditions hazardous to life, property or public welfare in the occupancy of structures or premises 3. Fire hazards in the structure or on the premises from occupancy or operation 4. Matters related to the construction, extension, repair, alteration or removal of fire-suppression or alarm systems 5. Conditions affecting the safety of fire fighters and emergency responders during emergency operations.
ICC International Mechanical Code (IMC)	<p>The IMC regulates the design, installation, maintenance, <i>alteration</i> and inspection of mechanical systems that are permanently installed and utilized to provide control of environmental conditions and related processes within buildings. It also regulates those mechanical systems, system components, <i>equipment</i> and appliances specifically addressed herein. The installation of fuel-gas distribution piping and <i>equipment</i>, fuel gas-fired appliances and fuel gas-fired <i>appliance</i> venting systems shall be regulated by the <i>International Fuel Gas Code</i>.</p> <p>Exception: Detached one- and two-family dwellings and multiple single-family dwellings (townhouses) not more than three stories high with separate means of egress and their accessory structures shall comply with the <i>International Residential Code</i>.</p>
ICC International Plumbing Code (IPC)	<p>The IPC applies to the erection, installation, alteration, repairs, relocation, replacement, and addition to, use or maintenance of plumbing systems within this jurisdiction. This code shall also regulate nonflammable medical gas, inhalation anesthetic, vacuum piping, nonmedical oxygen systems and sanitary and condensate vacuum collection systems. The installation of fuel-gas distribution piping and equipment, fuel-gas-fired water heaters and water heater venting systems shall be regulated by the <i>International Fuel Gas Code</i>.</p> <p>Exception: Detached one- and two-family dwellings and multiple single-family dwellings</p>

Standard	Scope Summary
	(townhouses) not more than three stories high with separate means of egress and their accessory structures shall comply with the <i>International Residential Code</i> .
ICC International Wildland Urban-Interface Code	<p>The provisions of the IWUCI apply to the construction, alteration, movement, repair, maintenance and use of any building, structure or premises within the <i>wildland urban-interface areas</i> in this jurisdiction.</p> <p>Buildings or conditions in existence at the time of the adoption of this code are allowed to have their use or occupancy continued, if such condition, use or occupancy was legal at the time of the adoption of this code, provided such continued use does not constitute a distinct danger to life or property.</p> <p>Buildings or structures moved into or within the jurisdiction shall comply with the provisions of this code for new buildings or structures.</p>
IEEE 80 Guide for Safety in AC Substation Grounding	<p>The guide covers outdoor ac substations, either conventional or gas-insulated. Distribution, transmission, and generating plant substations are also included. With proper caution, the methods described herein are also applicable to indoor portions of such substations, or to substations that are wholly indoors. No attempt is made to cover the grounding problems peculiar to DC substations. A quantitative analysis of the effects of lightning surges is also beyond the scope of this guide.</p>
IEEE 100 The Authoritative Dictionary of IEEE Standards Terms Seventh Edition	
IEEE 693 Recommended Practice for Seismic Design of Substations	<p>The document provides seismic design recommendations for substations, including qualification of each equipment type. Design recommendations consist of seismic criteria, qualification methods and levels, structural capacities, performance requirements for equipment operation, installation methods, and documentation.</p>
IEEE 937 Recommended Practice for Installation and Maintenance of Lead-Acid Batteries for PV Systems	<p>The standard covers design considerations and procedures for storage, location, mounting, ventilation, assembly, and maintenance of lead-acid secondary batteries for PV power systems are provided. Safety precautions and instrumentation considerations are also included. Even though general recommended practices are covered, battery manufacturers may provide specific instructions for battery installation and maintenance.</p>

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<p>IEEE 979 Guide for Substation Fire Protection</p>	<p>The original guide (1994) was developed to identify substation fire protection practices that generally have been accepted by industry. The new edition includes changes in industry practices for substation fire protection. New clauses on fire hazard assessment and pre-fire planning have been added. The purpose of the original guide (1994) was to give design guidance, fire hazard assessment, and pre-fire planning in the area of fire protection to substation engineers. Existing fire protection standards, guides, and so on that may aid in the design of specific substations or substation components are listed in Annex F. the new edition revision updates that guidance.</p>
<p>IEEE 1184 Guide for Batteries for Uninterruptible Power Supply Systems</p>	<p>The guide discusses various battery systems so that the user can make informed decisions on selection, installation design, installation, maintenance, and testing of stationary standby batteries used in UPS systems.</p>
<p>IEEE/ASHRAE 1635-2012 Guide for the Ventilation and Thermal Management of Batteries for Stationary Applications</p>	<p>The document discusses vented lead acid, VRLA, and NiCad stationary battery installations and is intended to serve as a bridge between the electrical designer and the heating, ventilation, and air-conditioning designer. Ventilation of stationary battery installations is critical to maximize battery life while minimizing the hazards associated with hydrogen production. This guide describes battery operating modes and the hazards associated with each. It provides the heating, ventilation, and air-conditioning designer with the information to provide a cost-effective ventilation solution.</p>
<p>IEEE 1547 Standard for Interconnecting Distributed Resources with Electric Power Systems</p>	<p>The standard establishes criteria and requirements for interconnection of distributed resources with EPS. It provides a uniform standard for interconnection of distributed resources with electric power systems. It also provides requirements relevant to the performance, operation, testing, safety considerations, and maintenance of the interconnection.</p> <p>The U.S. Federal Energy Policy Act of 2005 calls for state commissions to consider certain standards for electric utilities. Under Section 1254 of the Act: “Interconnection services shall be offered based upon the standards developed by the Institute of Electrical and Electronics Engineers: IEEE Standard 1547 for Interconnecting Distributed Resources with Electric Power Systems, as they may be amended from time to time.”</p>

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	IEEE 1547 was first published in 2003, reaffirmed in 2008, and Amendment 1 published in 2014 as an outgrowth of the IEEE-hosted SCC21 May 2012 Workshop. More than 80 industry participants collaborated in the IEEE-hosted SCC21 December 2013 workshop, and recommended a revised title, scope, and purpose to launch an IEEE SCC21 project and working group to complete a full revision of the IEEE 1547 standard before 2018, but preferably sooner.
IEEE C2-2012 - 2012 National Electrical Safety Code (NEC)	This Code covers basic provisions for safeguarding of persons from hazards arising from the installation, operation, or maintenance of conductors and equipment in electric supply stations and overhead and underground electric supply and communication lines. It also includes work rules for the construction, maintenance, and operation of electric supply and communication lines and equipment. The standard is applicable to the systems and equipment operated by utilities, or similar systems and equipment, of an industrial establishment or complex under the control of qualified persons. This standard consists of the introduction, definitions, grounding rules, list of referenced and bibliographic documents, and Parts 1, 2, 3, and 4 of the 2012 Edition of the NEC.
NFPA 1 - Fire Code	Fire Code, advances fire and life safety for the public and first responders as well as property protection by providing a comprehensive, integrated approach to fire code regulation and hazard management. It addresses all the bases with extracts from and references to more than 130 NFPA® codes and standards including such industry benchmarks as NFPA 101, NFPA 54, NFPA 58, NFPA 30, NFPA 13, NFPA 25, and NFPA 72.
NFPA 2 - Hydrogen Safety Code	This code provides fundamental safeguards for the generation, installation, storage, piping, use, and handling of hydrogen in compressed gas (GH2) form or cryogenic liquid (LH2) form. Provisions apply to the production, storage, transfer, and use of hydrogen in all occupancies and on all premises. NFPA 2 includes fundamental requirements for hydrogen in both gaseous and liquid phases and contains additional use-specific categories, such as vehicle fueling facilities, systems for fuel cell power and generation, applications involving combustion processes and special atmospheres, and operations in the laboratory.

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<p>NFPA 11 - Standard for Low-, Medium-, and High-Expansion Foam Systems for Fire Protection</p>	<p>This standard covers the design, installation, operation, testing, and maintenance of low-, medium-, and high-expansion foam systems for fire protection. Criteria apply to fixed, semi-fixed, or portable systems for interior and exterior hazards. General requirements include system components and system types, specifications and plan installation, testing and acceptance, and maintenance. Separate chapters address specific issues associated with low-expansion system design, medium- and high-expansion systems, compressed air foam systems, and low-expansion foam systems for marine applications.</p>
<p>NFPA 13 - Standard for the Installation of Sprinkler Systems</p>	<p>The industry benchmark for design and installation of automatic fire sprinkler systems, NFPA 13 addresses sprinkler system design approaches, system installation, and component options to prevent fire deaths and property loss. Comprehensive requirements include sprinkler system design, installation, and acceptance testing; hanging and bracing systems; underground piping; and seismic protection in line with SEI/ASCE 7. NFPA 13 also includes provisions for special storage arrangements.</p>
<p>NFPA 15-2012 Standard for Water Spray Fixed Systems for Fire Protection</p>	<p>The standard helps ensure effective fire control, extinguishment, prevention, or exposure protection through requirements for the design, installation, and system acceptance testing of water spray fixed systems for fire protection. It also contains requirements for the periodic testing and maintenance of ultra-high-speed water spray fixed systems.</p>
<p>NFPA 16 - Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems</p>	<p>This standard contains minimum requirements for the design, installation, and maintenance of foam-water sprinkler and spray systems that use low-expansion foam. Criteria cover general requirements, system components, water supplies, system design and installation, acceptance test, and inspection, testing, and maintenance. Systems are to be designed with the required density for either foam or water application as the controlling factor, depending on the design purpose.</p>
<p>NFPA 55 - Compressed Gases and Cryogenic Fluids</p>	<p>NFPA 55 facilitates protection from physiological, over-pressurization, explosive, and flammability hazards associated with compressed gases and cryogenic fluids. Criteria provide fundamental safeguards for the installation, storage, use, and handling of compressed gases and cryogenic fluids in portable and stationary cylinders, containers, and tanks in all occupancy types.</p>

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<p>NFPA 70-2014 National Electrical Code (NEC)</p>	<p>NEC is the benchmark for safe electrical design, installation and inspection to protect people and property from electrical hazards. The NEC addresses the installation of electrical conductors, equipment and raceways; signaling and communications conductors, equipment and raceways; and optical fiber cables and raceways in commercial, residential and industrial occupancies. Article 480 provides electrical installation requirements for all stationary installations of electrical storage batteries (photo). For batteries in PV systems, additional requirements of Art 690, Part VIII apply. But covering a battery system from square one to end of life requires far more knowledge than what is in Art 480 (see sidebar: Beyond Article 480). 2014 NEC includes a subsection on battery and cell terminations.</p> <p>Not all 50 states have adopted the 2014 edition. Some states have adopted the 2008 or 2011. The 2017 NEC is likely to replace references to ESS installation in Article 480 and has proposed a new Article 706 Energy Storage Systems that consider the application of electrochemical energy storage along with other types of energy storage that are referenced in other Articles within the code (e.g., PV, Wind, etc.)</p>
<p>NFPA 70E-2012 Standard for Electrical Safety in the Workplace</p>	<p>NFPA 70E requirements for safe work practices to protect personnel by reducing exposure to major electrical hazards. Originally developed at Occupational Safety and Health Administration (OSHA)'s request, NFPA 70E helps companies and employees avoid workplace injuries and fatalities due to shock, electrocution, arc flash and arc blast, and assists in complying with OSHA 1910 Subpart S and OSHA 1926 Subpart K.</p>
<p>NFPA 72 - National Fire Alarm and Signaling Code</p>	<p>NFPA 72 provides the latest safety provisions to meet society's changing fire detection, signaling, and emergency communications demands. In addition to the core focus on fire alarm systems, the code includes requirements for mass notification systems used for weather emergencies; terrorist events; biological, chemical, and nuclear emergencies; and other threats. Rules cover the application, installation, location, performance, inspection, testing, and maintenance of fire alarm systems, supervising station alarm systems, public emergency alarm reporting systems, fire warning equipment and emergency communications systems, and their components. Provisions are expressed in prescriptive requirements with performance-based design methods and risk</p>

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	analysis requirements provided and essential for the proper design and integration of mass notification systems.
NFPA 91 - Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Particulate	This standard provides technical requirements for exhaust systems that will protect lives and property from fires and explosions and minimize damage in the event that such fires and explosions occur. Provisions cover design, construction, installation, operation, testing, and maintenance of exhaust systems for air conveying of vapors, gases, mists, and noncombustible particulate solids except as modified or amplified by other applicable NFPA standards. Specific topics include corrosive materials, air-moving devices, air separation devices, ignition sources, and fire protection.
NFPA 92 - Standard for Smoke Control	This standard protects life and reduces property loss by establishing requirements for the design, installation, and testing of smoke control systems used to mitigate the impact of smoke from fire. Provisions apply to both new and retrofitted smoke containment and smoke management systems and cover topics including basic physics of smoke movement in indoor spaces, methods of smoke control, supporting data and technology, building equipment and controls, design fundamentals, calculations, stairwell pressurization systems, component and acceptance testing, and documentation.
NFPA 101 Life Safety Code	The Life Safety Code is the most widely used source for strategies to protect people based on building construction, protection, and occupancy features that minimize the effects of fire and related hazards. Unique in the field, it is the only document that covers life safety in both new and existing structures.
NFPA 400-2013 Hazardous Materials Code	NFPA 400 consolidates fundamental safeguards for the storage, use, and handling of hazardous materials in all occupancies and facilities. The Code does not apply to storage or use of hazardous materials for individual use on the premises of one- and two-family dwellings. The Code's fire and life safety requirements are applicable to a wide range of substances including but not limited to ammonium nitrate solids and liquids, corrosive solids and liquids, flammable solids, organic peroxide formulations, oxidizers, pyrophoric solids and liquids, toxic and highly toxic solids and liquids, unstable (reactive) solids and liquids, water-reactive solids and liquids. Compressed gases and cryogenic fluids are included within the context of NFPA 55.

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NFPA 472 - Standard for Competence of Responders to Hazardous Materials/Weapons of Mass Destruction Incidents	This standard shall identify the minimum levels of competence required by responders to emergencies involving hazardous materials/weapons of mass destruction. The purpose of this standard shall be to specify minimum competencies required for those who respond to hazardous materials/ weapons of mass destruction incidents and necessary for a risk-based response to these incidents.
NFPA 550-2012 Guide to the Fire Safety Concepts Tree	The guide describes the structure, application and limitations of the Fire Safety Concepts Tree, which provides an overall structure with which to analyze the potential impact of fire safety strategies. NFPA 550 examines the interrelation of fire safety features and their effect on achieving specific fire safety goals and objectives. It identifies tools to help fire safety practitioners communicate fire safety and protection concepts and can be used to assist with the analysis of codes or standards, facilitate the development of performance-based designs, provide an overall structure with which to analyze potential fire safety strategy impacts and identify gaps and redundancies in the strategies.
NFPA 704-2012 Standard System for the Identification of the Hazards of Materials for Emergency Response NFPA 730 - Guide for Premises Security	<p>The standard provides criteria for assessing the health, flammability instability and related hazards presented by short-term, acute exposure to a material under conditions of fire, spill or similar emergencies. A number rating system of 0-4 is provided to rate each of the four hazards on a placard and provides emergency responders with information to determine immediate actions in an emergency. Tables in the standard provide criteria for the ratings and placard specifications such as letter size and arrangement of numbers and colors.</p> <p>This guide describes construction, protection, occupancy features, and practices intended to reduce security vulnerabilities to life and property. Provisions cover security planning, administrative controls, security perimeters, crime prevention through environmental design, security systems, and accessory property. In addition, individual chapters present specific requirements for educational facilities; health care; lodging, multi-dwelling unit buildings, restaurants, shopping centers, retail establishments, office buildings, and industrial facilities.</p>

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<p>NFPA 731 - Standard for the Installation of Electronic Premises Security Systems</p> <p>NFPA 750 - Standard on Water Mist Fire Protection Systems</p>	<p>This standard provides requirements for the application, location, installation, performance, testing, and maintenance of electronic premises security systems and their components. Provisions define the means of signal initiation, transmission, notification, and annunciation; the levels of performance; and reliability. NFPA 731 also presents information necessary to modify or upgrade an existing system to meet the requirements of a particular application. Chapters cover fundamentals; intrusion detection systems; electronic access control systems, video surveillance systems; holdup, duress, and ambush systems; monitoring stations; testing and inspections, and asset protection systems.</p> <p>This standard protects life and property from fire through the standardization of design, installation, maintenance, and testing requirements for water mist fire-suppression systems. Provisions relate to system components and hardware, system types, installation, design objectives and fire test protocols, design calculations, water supplies and atomizing media, plans and documentation, acceptance criteria, maintenance considerations, and marine systems.</p>
<p>NFPA 790-2012 Standard for Competency of Third-Party Field Evaluation Bodies</p>	<p>Installed electrical equipment that has not been previously certified, listed, recognized, or classified undergoes a “field evaluation” to ensure compliance. The standard provides qualifications and competencies for third parties performing field evaluations and specifies how they are to be completed. Provisions cover FEB application for recognition; FEB organization; FEB personnel; appeals, complaints, and disputes; application for evaluation; preparation for evaluation; evaluation; evaluation report; decision to issue an FEB statement of conformity; use of FEB statement of conformity; and test and measuring equipment.</p>
<p>NFPA 850-2010 Recommended Practice for Fire Protection for Electric Generating Plants and High-Voltage DC Converter Stations</p>	<p>The document outlines fire safety recommendations for gas, oil, coal, and alternative fuel electric generating plants, including high-voltage DC converter stations and combustion turbine units used for electric generation. Fire prevention and fire protection recommendations advance the safety of construction and operating personnel, physical integrity of plant components, and the continuity of plant operations. Specific criteria provided include combustion turbines and internal combustion engines, alternative fuels, wind turbine generating facilities, solar thermal power</p>

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	<p>public welfare and minimize injuries. Design criteria regulate and control the permitting; design; construction, alteration, and repair; quality of materials; equipment and systems; use and occupancy; demolition; location; and maintenance of all types of buildings and structures. Separate chapters address issues specific to individual occupancy types, structural features, building materials, and building systems. A performance-based option is also included.</p>
<p>The NFPA Foundation (CSR related activity)</p>	<p>The NFPA Foundation is conducting a multi-phase research program to develop guidance for the protection of lithium-ion batteries in storage (it is not clear if this is applicable to those used in energy storage applications or simply the storage of those batteries while awaiting sale or distribution or both). The first two phases of this project, a hazard assessment and a large-scale flammability characterization, were completed in 2013. The latter program provided good information on the performance of cartoned small format batteries in storage, and indications are that a practical sprinkler protection solution, similar to that used for other common stored commodities will be effective. To confirm this finding, a third and final phase of the test program – a validation phase is required. This will consist of large-scale testing (between 8 and 24 pallet loads) to ensure that the sprinkler system proposed will be effective in controlling the fire hazard.</p>
<p>IEC TC 120 PNW 120-31 Planning and Installation of Electrical Energy Storage Systems – Standard Technical Specification (proposed work item)</p>	<p>The intention of this activity is to give guidance for planning and installation of EES systems and to provide standards and other deliverables which can be used by power system planers, system integrators and commissioning staff.</p>
<p>IEC 60529 Degrees of protection provided by enclosures</p>	<p>The standard applies to the classification of degrees of protection provided by enclosures for electrical equipment with a rated voltage not exceeding 72.5 kV. The object of the standard is to give</p> <p>a) Definitions for degrees of protection provided by enclosures of electrical equipment as regards:</p> <ul style="list-style-type: none"> • protection of persons against access to hazardous parts inside the enclosure; • protection of the equipment inside the enclosure against ingress of solid foreign objects; • protection of the equipment inside the enclosure against harmful effects due to the

Standard	Scope Summary
	<p>ingress of water.</p> <p>b) Designations for these degrees of protection.</p> <p>c) Requirements for each designation.</p> <p>d) Tests to be performed to verify that the enclosure meets the requirements of this standard. It will remain the responsibility of individual technical committees to decide on the extent and manner in which, the classification is used in their standards and to define “enclosure” as it applies to their equipment. However, it is recommended that for a given classification the tests do not differ from those specified in this standard. If necessary, complementary requirements may be included in the relevant product standard. A guide for the details to be specified in relevant product standards is given in Annex B.</p> <p>For a particular type of equipment, a technical committee may specify different requirements provided that at least the same level of safety is ensured. This standard deals only with enclosures that are in all other respects suitable for their intended use as specified in the relevant product standard and which from the point of view of materials and workmanship ensure that the claimed degrees of protection are maintained under the normal conditions of use.</p> <p>This standard is also applicable to empty enclosures provided that the general test requirements are met and that the selected degree of protection is suitable for the type of equipment to be protected.</p> <p>Measures to protect both the enclosure and the equipment inside the enclosure against external influences or conditions such as mechanical impacts, corrosion, corrosive solvents (e.g., cutting liquids), fungus, vermin, solar radiation, icing, moisture (e.g., produced by condensation), explosive atmospheres and the protection against contact with hazardous moving parts external to the enclosure (such as fans), are matters for the relevant product standard to be protected.</p>
<p>IEC 62485-1 Ed 1 Safety requirements for secondary batteries and battery installations – Part 1 General safety information</p>	
<p>IEC 62485-2 Safety requirements for secondary batteries and battery installations. Part 2: Stationary batteries.</p>	<p>This part of the IEC 62485 applies to stationary secondary batteries and battery installations with a maximum voltage of DC 1 500 V (nominal) and describes the principal measures for protections against hazards generated from: electricity, gas emission, and electrolyte. This international</p>

Standard	Scope Summary
	standard provides requirements on safety aspects associated with the erection, use, inspection, maintenance and disposal.
IEC 62485-3 Ed 1 Safety requirements for secondary batteries and battery installations – Part 3 traction batteries	This part of IEC 62485 applies to secondary batteries and battery installations used for electric vehicles (e.g., in electric industrial trucks, including lift trucks, tow trucks, cleaning machines, automatic guided vehicles), battery-powered locomotives, electric vehicles (e.g., goods vehicles, golf carts, bicycles, wheelchairs) and does not cover the design of such vehicles. The standard covers lead dioxide-lead (lead-acid), nickel oxide-cadmium, nickel-oxide-metal hydride and other alkaline secondary batteries. Safety aspects of secondary lithium batteries in such applications will be covered in their own appropriate standards. The nominal voltages are limited to 1000 V AC and 1500 V DC, respectively, and describe the principal measures for protection against hazards generally from electricity, gas emission and electrolyte. It provides requirements on safety aspects associated with the installation, use, inspection, maintenance and disposal of batteries.
IEC 62485-4 Ed 1 Safety requirements for secondary batteries and battery installations – Part 4: VRLA batteries for use in portable appliances	
IEC 61434:1996-10-03 Edition 1.0 Secondary cells and batteries containing alkaline or other non-acid electrolytes – Guide to designation of current in alkaline secondary cell and battery standards	Applies to secondary cells and batteries containing alkaline or other non-acid electrolytes. It proposes a mathematically correct method of current designation which shall be used in future secondary cell and battery standards.
IEC/TS 61438:1996-11-28 Edition 1.0 Possible safety and health hazards in the use of alkaline secondary cells and batteries – Guide to equipment manufacturers and users	The document outlines the fundamental conditions necessary for the creation of each hazard. It includes identification and characterization of the possible hazards inherent in the application, use, and abuse of nickel-cadmium cells and batteries. It also includes examples for appliance design which minimizes these hazards. It also presents some typical but non-exhaustive examples of misuse that may precipitate or actions which mitigate the hazard.
UL 96A, Installation Requirements for Lightning Protection Systems	The document is intended to assist code authorities, designers, and installers to develop, and install a complete lightning protection system that can withstand the tremendous power of a lightning strike. Depending on the type, a strike can exceed 300,000 amps, over one gigavolts (1 billion volts) and with temperatures as high as 36,000°F., or about three times hotter than the sun's surface. This guide does not have information on protection of equipment inside a building.

Standard	Scope Summary
	<p>Dissipation of a lightning strike requires correct system design, installation in accordance with UL 96A, NFPA 780, and all listed components correctly installed and connected to earth. And common bonded to the building electrical system in accordance with Article 230, 250, 280, 800 and 810, of the NEC. This installation guide covers definitions and installations used on virtually all types of structures designed and built today. The installation must be designed to protect the entire structure not just a small portion or section of the structure.</p>

