Pacific Northwest NATIONAL LABORATORY

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Study of Codes and Standards for Stationary Energy Storage Systems

A Report to Congress

March 2022

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Ryan J Franks
Christopher G. Searles
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Michael Ropp
Vincent Sprenkle

U.S. DEPARTMENT OF ENERGY

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Pacific Northwest National Laboratory
Richland, Washington 99354

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Acronyms and Abbreviations

AHJ	Authority Having Jurisdiction
BESS	Battery Energy Storage Systems
CSA	Canadian Standards Association
DER	Distributed Energy Resource
DR	Distributed Resource
EIA	Energy Information Administration
EPS	Electric Power System
ESS	Energy Storage System
EV	Electric Vehicle
IBC	International Building Code
ICC	International Code Council
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IFC	International Fire Code
IRC	International Residential Code
MW	Megawatt
NFPA	National Fire Protection Association
SAE	Society of Automotive Engineers
SDO	Standards Developing Organization
UL	Underwriters Laboratories
UPS	Uninterruptable Power Supply
U.S.	United States

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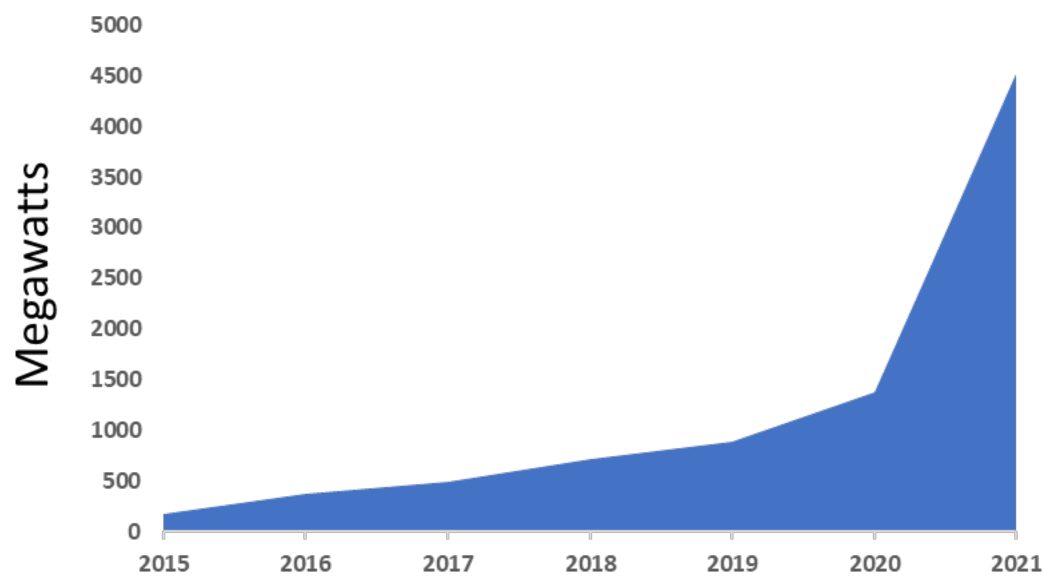
1.0 Introduction

The Infrastructure Investment and Jobs Act (H.R. 3684, 2021) directed the Secretary of Energy to prepare a report identifying the existing codes and standards for energy storage technologies. The stated goals for the report are to enhance the safe development of energy storage systems by identifying codes that require updating and facilitation of greater conformity in codes across different types and usages of energy storage technologies. This paper will focus on the specific codes and standards for stationary energy storage systems (ESS).

This requirement comes at a timely moment in the ongoing evolution of the U.S. electric grid. As states, utilities, and electric consumers adopt aggressive goals for reducing emissions from the electric sector, they are increasingly turning to energy storage technologies as a means of managing the variability associated with non-emitting energy resources, such as wind and solar. Driven by many factors, such as state policies that mandate or facilitate energy storage development, federal policies that enable the participation of storage resources in energy markets, and falling technology prices, energy storage installations have rapidly increased in the United States in recent years, as shown in Figure 1.



Energy Information Administration

Figure 1. Cumulative Installed Utility-Scale Battery Energy Storage, U.S.

As Figure 1 shows, 2021 saw a remarkable increase in the deployment of battery energy storage in the U.S. Twice as much utility-scale battery energy storage was installed in 2021 alone—3,145 megawatts (MW)—than was installed in all previous years combined (1,372 MW) (EIA 2022). This pace is expected to continue accelerating, as utilities have reported to the Energy Information Administration (EIA) that they are already contracted to install more than 6,100 MW of utility-scale energy storage in 2022 (EIA 2022). Furthermore, a review of interconnection queues from around the country found that more than 73 gigawatts of large-scale energy storage projects are trying to connect to the grid between 2023 and 2027 (Rand et al. 2021). While not all those planned projects will be built, these numbers are indicative of the interest in utility-scale energy storage and its rapid growth on the electric grid.

In addition to these large, utility-scale storage projects, individual customers are also installing energy storage at an increasing rate to manage their energy costs. The market for customer-sited energy storage in 2021 is projected to be the largest ever when final installation data is available, accounting for several hundred additional MW (Wood Mackenzie & ESA 2021).

As this report will detail, there are many codes and standards that affect the construction, installation, and usage of energy storage technologies.

The remainder of this section will briefly discuss the safety risks associated with battery storage technologies and why codes and standards are needed. Section 2 will summarize the key codes and standards affecting the design and installation of battery energy storage technologies. Section 3 will provide an overview of code development cycles and why codes are continuously updated. Finally, Section 4 addresses the crucial role that states play in adopting codes and the challenges that frequently prevent states from keeping up with code development cycles.

1.1 Battery Characteristics Create Risk

Lithium-ion battery technologies represent the overwhelming majority of recently installed energy storage in the United States and likely will continue to do so for the foreseeable future given rapidly decreasing cost and cycle-life (Mongird et al. 2020). Among commercially available types of energy storage, lithium-ion batteries are also the most energy-dense, which means that they can store more electrical energy in a smaller space relative to other technologies.

This energy density gives lithium-ion batteries the flexibility to provide service as a large, utility-scale asset; as the power source for a vehicle; or as a small device hanging in a home's garage and is a major reason for the technology's success. However, with current technologies, the same energetic chemical reactions that create that energy density also pose risks if they are not safely managed. In a 2018 report, the U.S. Consumer Product Safety Commission identified more than 25,000 incidents of lithium-ion batteries overheating or combusting between 2012 and 2017 (Lee 2018). In the last decade, there have also been fires at seven grid-scale battery facilities in the United States and dozens of other incidents internationally (EPRI 2022). Two recent incidents in California have resulted in 400 MW being removed from the grid for extended periods, raising concerns from regulators over safety and reliability (Colthorpe 2022; Vistra 2021).

While these incidents are relatively rare when considering the millions of lithium-ion batteries thorough out the built environment, they represent a material risk to health and property. It is reasonable to extrapolate that, with the monumental growth expected, failures occasionally will occur, as well. To manage and minimize those risks, electric safety professionals have developed a wide range of codes and standards related to battery energy storage: testing criteria to ensure the safety of different chemistries under different uses, design requirements to achieve durable and reliable system assembly, and interconnection standards to achieve 1) interoperability between power system components and 2) maximization of positive impacts and minimization of negative impacts of ESS on the larger power system.

2.0 Battery Storage Codes and Standards Walkthrough

Figure 2 provides a visual interpretation of a few key published standards and model codes for stationary energy storage systems in relation to the components, system, or installation level. The following sections provide a breakdown by the standards development organization (SDO), document name, and brief description of scope. The list is not all encompassing, and a more thorough compilation is provided in a quarterly report produced by the Energy Storage Safety Collaborative led by Pacific Northwest National Laboratory and Sandia National Labs. To subscribe to the ES Safety Collaborative and receive the quarterly reports visit https://public.govdelivery.com/accounts/USDOESNLEC/signup/30707.

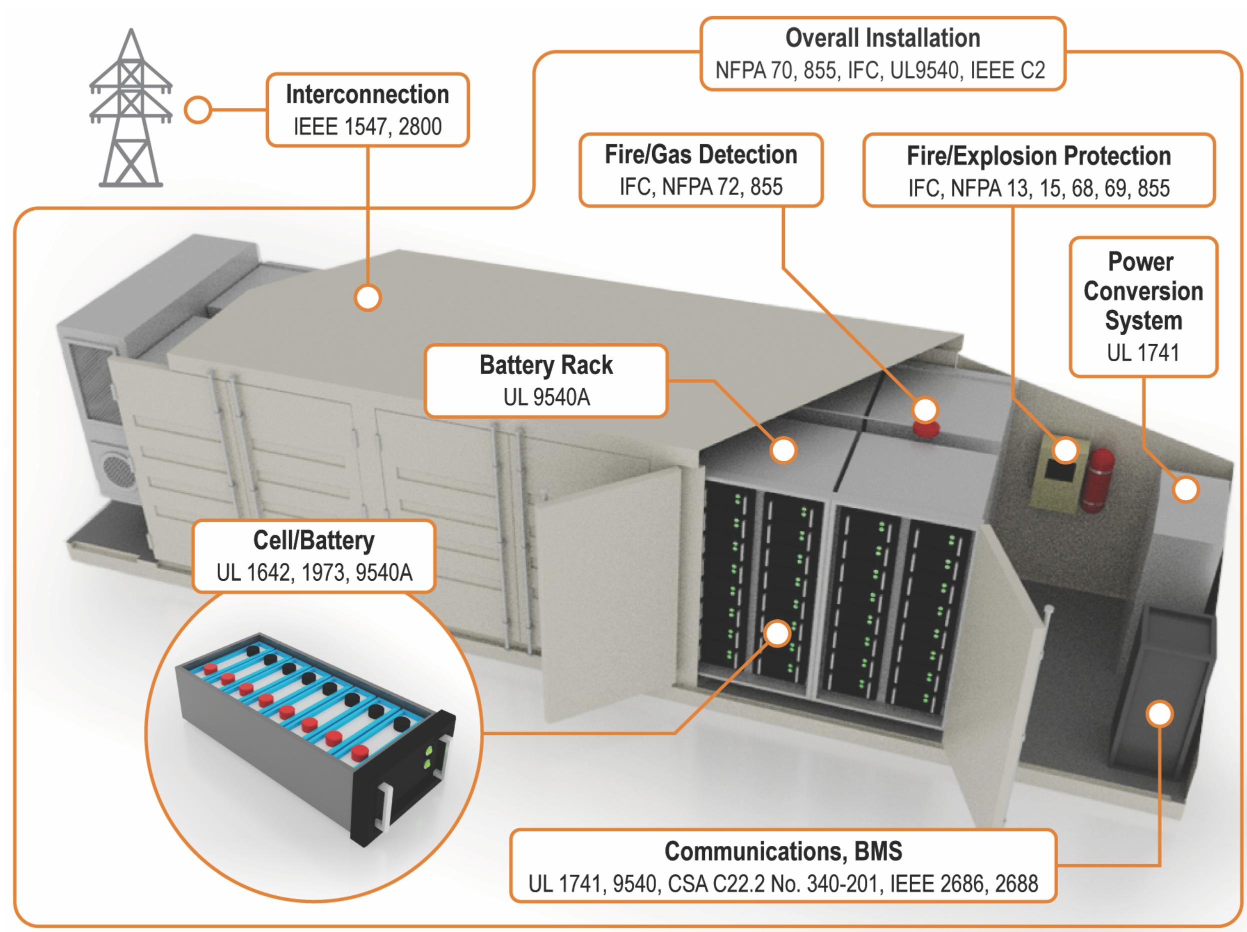


Figure 2. ESS C&S Diagram

2.1 Component Level

Beginning at the smallest level, the items in Table 1 represent the primary codes or standards for the individual components of an ESS and the SDO responsible for maintaining the document.

Table 1. Component Level Codes and Standards

SDO	Standard	Title	Electrical Energy Storage (ESS) Relevance
CSA Group	CSA C22.2 No. 340-20xx	CSA C22.2 No. 340-20xx Battery Management Systems	A new standard that will apply to the design, performance, and safety of battery management systems. It includes use in several application areas, including stationary batteries installed in local energy storage, smart grids and auxiliary power systems, as well as mobile batteries used in electric vehicles (EVs), rail transport, and aeronautics.
IEEE Advancing Technology for Humanity	IEEE 1679.1-2017	IEEE 1679.1: Guide for the Characterization and Evaluation of Lithium-Based Batteries in Stationary Applications	Defines a range of technologies for lithium-based batteries, including their construction, aging mechanisms, and failure modes, as well as pointing to existing safety standards and regulatory requirements.
IEEE Advancing Technology for Humanity	IEEE 1679.2-2018	IEEE 1679.2: Guide for the Characterization and Evaluation of Sodium-Beta Batteries in Stationary Applications	Defines the range of technologies for sodium-beta batteries, including their construction, aging mechanisms, and failure modes, as well as pointing to existing safety standards and existing regulatory requirements. This guide focuses on sodium-nickel chloride and sodium-sulfur batteries.
MESA	MESA-Verifying ESS/SunSpec	MESA – Verifying ESS Device Compliance with the SunSpec Modbus Communication Standard Using the MESA Profile	Specifies standardized communication between components within the ESS. And identifies tools that can be used to verify compliance with MESA-Device specification by using the SunSpec Modbus communications standard.
UL	UL 1642	UL 1642: Lithium Batteries	Covers the use of lithium batteries (both primary and rechargeable) used in technician-replaceable or user-replaceable applications with the purpose of reducing the risk of fire or explosion.
UL	UL 1741	UL 1741: Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources	Covers requirements for inverters, converters, charge controllers, and interconnection system equipment intended for use in both off-grid and grid-connected environments.

SDO	Standard	Title	Electrical Energy Storage (ESS) Relevance
	UL 1973	ANSI/CAN/UL 1973: Standard for Batteries for Use in Stationary, Vehicle Auxiliary Power and Light Electric Rail (LER) Applications	Covers requirements for battery systems for use in energy storage systems for stationary applications such as photovoltaic, wind turbine storage, or uninterruptible power supply UPS. It also covers battery systems for use in light rail and stationary rail applications, such as rail substations.
	UL 1974	ANSI/CAN/UL 1974: Evaluation for Repurposing Batteries	Covers the sorting and grading process of battery packs, modules, and cells, as well as electrochemical capacitors that were originally configured and used for other purposes, such as EV propulsion, and now intended for a repurposed use application, such as for use in stationary energy storage systems and other applications. This standard excludes the process for remanufactured batteries.

2.2 Battery System Level

Moving up, the items in Table 2 represent a few key codes or standards for an entire battery or other energy storage system.

Table 2. Battery System Level Codes and Standards

SDO	Standard	Title	ESS Relevance
	ASME TES-1	TES-1: Safety Standard for Thermal Energy Storage Systems	Provides safety-related criteria for molten salt thermal energy storage systems.
	ASME TES-2	TES-2: Safety Standard for Thermal Energy Storage Systems, Requirements for Phase Change, Solid and Other Thermal Energy Storage Systems	Provides guidance on the design, construction, testing, maintenance, and operation of thermal energy storage systems, including but not limited to phase change materials and solid-state energy storage media, giving manufacturers, owners, users, and others concerned with or responsible for its application by prescribing necessary safety requirements.
	UL 9540	ANSI/CAN/UL 9540: Energy Storage Systems and Equipment	Product safety standard for an Underwriters Laboratories (UL) listing of an energy storage system.
	UL 9540A	UL 9540A: Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems (BESS)	Named a “Large-Scale Fire Test,” this multi-level test method evaluates the fire characteristics of a battery energy storage system that undergoes thermal runaway. The data generated can be used to determine the fire and explosion protection required for an installation of that battery energy storage system.

2.3 Installation and Application Level

The items in Table 3 identify the codes or standards covering how or where an ESS can be installed.

Table 3. Installation and Application Level Codes and Standards

SDO	Standard	Title	ESS Relevance
CSA Group	CSA C22.1-21	C22.1-21 Canadian Electrical Code, Part I (25th edition), Safety Standard for Electrical Installations	In many respects, this is the Canadian equivalent of the U.S. National Electrical Code (NFPA [National Fire Protection Association] 70). Section 64 now incorporates energy storage requirements for the installation and maintenance of renewable energy, energy production and ESSs.
NFPA	NFPA 855	NFPA 855: Standard for the Installation of Stationary Energy Storage Systems	Stipulates requirements to ensure the safety of ESSs, including new and emerging technologies. Bedrock standard to assist authorities having jurisdiction (AHJ) in determining if an ESS has minimized safety risks with that particular installation.
ICC International Code Council	ICC IBC	International Building Code 2021	2021 International Building Code (IBC) now addresses “ESS in dedicated use buildings” as moderate-hazard factory industrial, Group F-1 buildings; separation and protection requirements have been removed since they are covered by Section 1207 of the International Fire Code (IFC); Section 3115 (new) covers intermodal shipping containers that are repurposed for use as buildings or structures but includes an exemption for stationary storage battery that comply with Chapter 12 of the IFC. Reference is also made for ventilation of ESSs.
ICC International Code Council	ICC IFC	International Fire Code 2021	Chapter 12 of the IFC covers energy systems. Section 1207 within that chapter covers electrical ESSs. The International Code Council (ICC) code development process associated with the 2021 IFC has been completed, and the new edition has been available since December 2021. During the process, the provisions of the 2018 IFC related to ESS were enhanced to be consistent with the needs of industry and with NFPA 855.
ICC International Code Council	ICC IRC	International Residential Code 2021	Chapter 3 R328 lays out requirements for the installation, spacing, locations, energy ratings limitations, and ventilation, as well as EV issues for ESSs to be located in one- and two-family dwellings. Some of these provisions are recent additions to 2018 version. Section 1207 of the IFC deals with ESS installations exceeding the limits published in R328.5. These provisions are outside the energy efficiency provisions within Chapter 11 – Energy Efficiency, where all other provisions regarding energy are addressed.

SDO	Standard	Title	ESS Relevance
IEEE Advancing Technology for Humanity	IEEE 1679-2020	IEEE 1679-2020: IEEE Recommended Practice for the Characterization and Evaluation of Energy Storage Technologies in Stationary Applications	Provides a framework for manufacturers to characterize their emerging or alternative energy storage technology and for prospective users to make an informed evaluation on the suitability of that technology to meet their needs.
IEEE Advancing Technology for Humanity	IEEE C2-17	IEEE C2-17, National Electric Safety Code (NESC)	Governing electric utility standard that covers electrical safety for utility systems and equipment. The 2023 edition will add provisions for ESSs installed within an electric utility.
NFPA	NFPA 1	NFPA 1: Fire Code	Adopted in 19 states as one of the key NFPA safety codes working at an overarching level for fire prevention and remedial action. Correlates with NFPA 855, specifying requirements related to the installation of ESSs, recognizing both established battery technologies and newer emerging energy storage technologies.
NFPA	NFPA 70	NFPA 70: National Electrical Code (NEC)	Adopted in all 50 states, considered the benchmark for safe electrical design, installation, and inspection to protect both people and property from electrical hazards. Article 706 applies to ESSs, while Article 480 remains applicable to batteries as used in standard stationary backup power applications.

In addition, the international standards in Table 4 are important to consider, especially for enabling a U.S. export market for ESS at the Installation and Application Level.

Table 4. International Codes and Standards

SDO	Standard	Title/Description	ESS Relevance
IEC	IEC 62933-2-1, 2-2	Electric Energy Storage (EES) Systems – Part 2: Unit parameters and testing methods	Part 2-1 provides requirements characterizing ESS. Part 2-2 provides additional requirements in for characterizing ESS in use cases.
IEC	IEC 62933-3-1, 3-2, 3-3	Electrical Energy Storage (EES) Systems – Part 3: Planning and performance assessment of electrical energy storage systems	Part 3-1 provides requirements for developing ESS. Part 3-2 provides additional requirements in power-intensive and renewable energy applications. Part 3-3 provides additional requirements for energy intensive and backup power applications.

SDO	Standard	Title/Description	ESS Relevance
IEC	IEC 62933-4-1, 4-2, 4-3, 4-4	Electric Energy Storage (EES) Systems – Part 41: Guidance on environmental issues	Part 4-1 provides requirements on environmental issues related to ESS. Part 4-2 provides additional requirements related to battery failure. Part 4-3 provides additional requirements related to local environment and location.
IEC	IEC 62933-5-1, 5-2, 5-3, 5-4	Electrical Energy Storage (EES) Systems – Part 5: Safety considerations for grid-integrated EES systems	Part 5-1 provides requirements for safety in ESS. Part 5-2 provides additional requirements for electrochemical-based systems. Part 5-2 provides additional requirements for non-anticipation modifications including partial replacement, changing application, relocation, and the loading of reused batteries. Part 5-4 provides additional requirements related to lithium-ion battery-based systems.

2.4 Interconnection Requirements

Two key families of standards govern the interconnection requirements of energy storage systems to power systems, as illustrated in Figure 3.

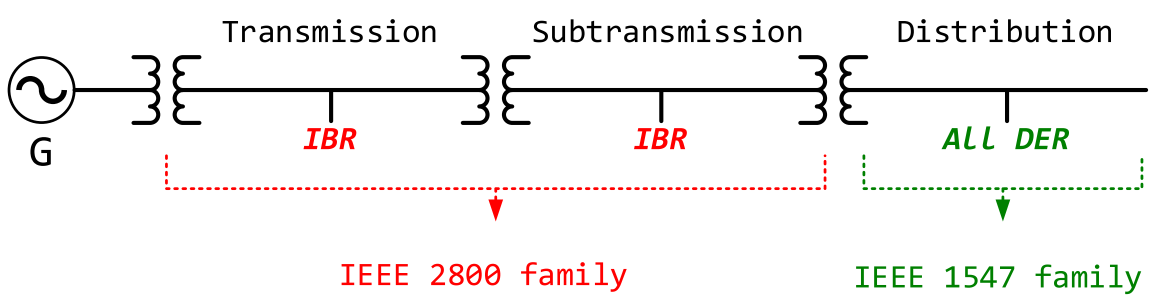


Figure 3. Representation of the Range of Applicability of the Two Main Families of IEEE Interconnection Standards

For energy storage systems interconnected at the distribution level, the IEEE 1547™ family of standards applies, as listed in Table 5 below. The base standard of this family is IEEE Std 1547-2018™, which lays out the interconnection requirements. IEEE Std 1547.1-2020™ gives the requirements for the tests needed to verify compliance with IEEE Std 1547-2018™. Another 1547-family standard that is particularly relevant to energy storage is IEEE Std P1547.9, which, as of this writing, is nearing the end of the balloting process and is expected to be published in 2022. IEEE Std P1547.9 is a guide for the application of IEEE Std 1547-2018™ and IEEE Std 1547.1-2020™ to distribution-connected energy storage systems.

For energy storage systems interconnected at the transmission or sub-transmission levels via a power electronic (inverter) interface, the IEEE 2800™ family of interconnection standards will apply.

The base standard of this family is IEEE Std 2800-2022, which defines the interconnection requirements for all inverter-based resources[3] connected at the transmission and sub-transmission levels. As of this writing, IEEE Std 2800-2022™ has been approved for publication in 2022. Standards P2800.1 and P2800.2 will then spell out the testing requirements to demonstrate compliance with P2800.

Table 5. Interconnection Standards

SDO	Standard	Title	ESS Relevance
IEEE	IEEE 2800-2020	Standard for Interconnection and Interoperability of Inverter-Based Resources Interconnecting with Associated Transmission Systems	Standard sets interconnection, performance, capability, and interoperability requirements for all inverter-interfaced systems (including ESS) connected to transmission and sub-transmission systems.
IEEE	IEEE 1547-2018	Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces	Standard for interconnection of DER with EPS. DER, as defined in IEEE 1547, includes ESSs capable of exchanging real power (kilowatts, megawatts) with the local distribution utility grid. IEEE 1547 also defines the performance requirements that are the basis for UL 1741 listing.
IEEE	IEEE 1547.2-2008	Guide for IEEE Standard 1547-IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems	Provides technical background and application details to support applying the basic requirements of IEEE [Institute of Electrical and Electronics Engineers] 1547-2003. This is done by characterizing various forms of distributed resource (DR) technologies and their associated interconnection issues. The IEEE 1547 series of standards is cited in the Federal Energy Policy Act of 2005.
IEEE	IEEE 1547.3-2022	Guide for Cybersecurity of Distributed Energy Resources Interconnected with Electric Power Systems	Facilitates the interoperability of DR and helps DR project stakeholders implement monitoring, information exchange, and control to support the technical and business operations of DR and transactions among the stakeholders. Document being updated to provide guidelines for Cybersecurity of Distributed Energy Resources (DER) interconnection with Electric Power Systems (EPS).
IEEE	IEEE 1547.9-2022	Guide for Interconnection of Energy Storage Distributed Energy Resources with Electric Power Systems	Guide provides information on and examples of how to apply IEEE Standard 1547 with associated EPS interfaces that result in interconnection of energy storage DER, including those connected to EPS capable of bidirectional real power exchange with the EPS.

[3] In this context, the term "inverter" includes bidirectional power converters used with energy storage.

3.0 The Codes and Standards Formulation Process

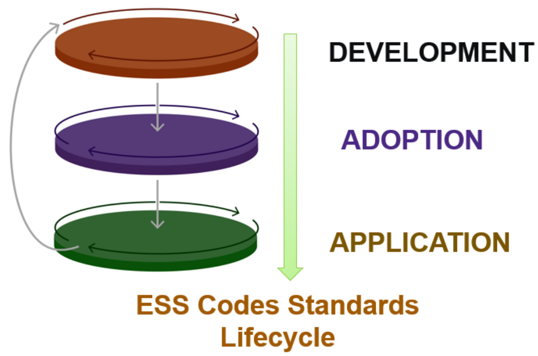


Figure 4. C&S Lifecycle

Having effective codes and standards is a three-stage process, beginning with the development stage, followed by adoption, and finally, consistent application by all stakeholders (Figure 4). Compliance requirements for products belong in two classifications: voluntary requirements and mandatory. Voluntary requirements typically evolve as *de facto* requirements from best practices, standard contracting requirements, or minimum usability or interoperability requirements. Mandatory requirements are those that are set by law or regulation and are enforced by the adoption or reference of the code/standard.

In the United States, codes and standards are primarily written by standards developing organizations (SDOs). Examples of SDOs include UL and IEEE for standards and NFPA and the ICC for codes.

SDOs write standards in balanced committees formed of stakeholders from manufacturers, users, testing agencies, consumers or customers, and other interested categories. The intent of writing these requirements is to set minimum levels for safety, usability, and interoperability; and to create common terminology and testing procedures.

Typically, a code is a document that tells you primarily *what* to do, while a standard is a document that tells you *how* to do something and how to perform certification testing. In the energy storage system industry, an example of this code and standard relationship is the NFPA 1 Fire Code requiring that energy storage systems of certain sizes and in certain environments be “tested and listed.” This code then references standard UL 9540, “Standard for Safety of Energy Storage Systems and Equipment.” As an ancillary point, an accredited testing laboratory, such as UL, the Canadian Standards Association (CSA), Technischer Uberwachungsverein (TUV), or others then perform testing to the standard and provide a test report and certification that a product complies with the standard.

In some situations, compliance directly with standards can be mandated. For instance, when the Occupational Health and Safety Administration or the Consumer Product Safety Commission adopts a standard into regulation, compliance is mandatory.

Occupational Health and Safety Administration has adopted various battery and energy storage standards recently, for instance, compliance to UL 1973, “Standard for Batteries for Use in Stationary, Vehicle Auxiliary Power and Light Rail Applications” for batteries in some worker contexts.

In some contexts, for energy storage systems, compliance regulations take the form of a state adopting a code, which then references and requires testing and listing or adherence to a standard. Some cities, counties, and special administrative districts (e.g., school or sewer districts) also adopt locally amended codes for their environments. When a state does not uniformly adopt a code year, then interpretation of national code and how to enforce it is left to local jurisdictions.

Codes are typically revised on a three-year cycle, while standards are revised periodically according to a schedule set by the SDO (e.g., when a number of changes are collected or an urgent action is needed to address changes in technology or the marketplace). However, states and local administrative bodies may only adopt the next edition of model codes into regulation or law on a periodic schedule. Figure 5 below clearly identifies the highly inconsistent adoption of the IFC across the US.

Energy storage systems continue to be a rapidly evolving industry. Thus, the key to safe and up-to-date compliance requirements involves the adoption and application of codes and standards in addition to the development or writing of codes and standards. More explicitly, to assure safety and commercial viability the best practice is for the most recent codes and standards to be adopted by states for local enforcement.

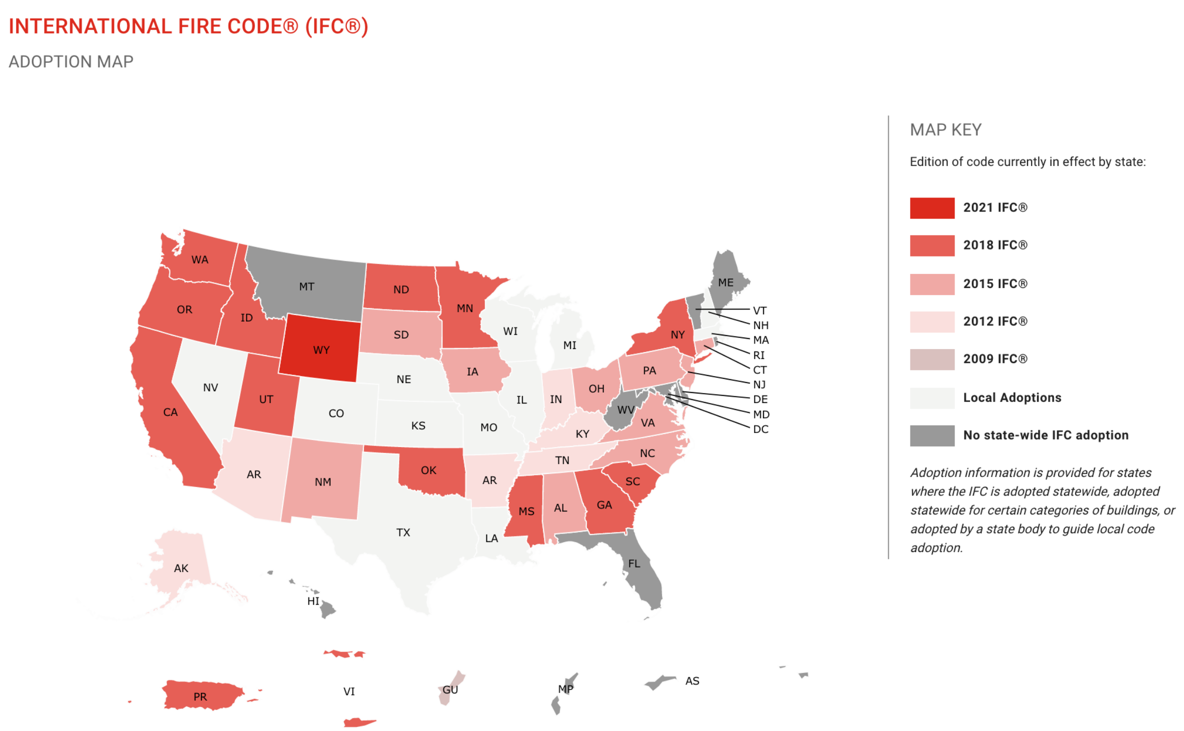


Figure 5. IFC Adoption Map (Credit: International Code Council)

4.0 State Impacts and Considerations

4.1 The Intersection of Codes and Standards with Other Disciplines

Codes and safety standards are developed by a broad selection of stakeholders, but when it comes to the physical deployment of battery energy storage, several non-engineering disciplines are involved. Each of these entities plays an important role in the practical realization of energy storage projects. Although they are not directly involved in the development or adoption of safety codes and standards, a working knowledge of those codes and standards can help those entities contribute to the safe deployment and operation of energy storage technologies through the processes that they manage. This section will briefly discuss some of those entities and how their work affects and is affected by codes and standards.

4.1.1 Energy Regulators

State energy regulators at public utility commissions (or equivalent) are charged with reviewing and approving utility investments. Depending on the state's regulatory structure, state regulators may have jurisdiction over all utility investments or only over those connected to the distribution system. Because their authorizing statutes generally direct them to act in the public interest, regulators have latitude in approving utility proposals and may be able to negotiate or impose reasonable safety conditions on projects.

As was discussed in Section 3, once codes and standards have been developed, they must be adopted on a state-by-state basis. Because of the timing of code update cycles and the complexity of state adoption processes, a state may fall behind on a given standard by one or more cycles. If a state is still following an obsolete standard that no longer represents best safety practices, regulators may be able to negotiate or impose conditions that would require a utility to follow best available practices that exceed the state's current code requirements.

Quasi-judicial proceedings, such as rate cases, provide a venue for regulatory staff and other stakeholders to negotiate reasonable safety conditions with the utility for commission review. Less formal proceedings, such as plan reviews or approval of utility requests for proposal documents, also may provide an opportunity for regulators to attach safety conditions to future procurements of battery energy storage. Having a working knowledge of safety codes and standards at the institutional level would also enable regulatory staff to ask informed questions of the utility and provide effective guidance of the commission's expectations for battery energy storage safety during their ongoing interactions with utilities in various proceedings.

Regulators can also be an effective voice in advocating for a state to adopt current codes and standards. Their unique perspective on the safe operation of the electric grid and the importance of consumer protection qualify them to provide objective and trusted input into state code adoption processes.

4.1.2 State Energy Facility Siting Agencies

Many states have an independent body that is tasked with reviewing and approving the proposed sites and designs of large-scale energy generation facilities. Once a facility has been sited, siting agencies oversee its construction and activation to ensure compliance with state laws and regulations. The authorizing statutes and processes vary by state, and whether energy storage facilities (which store, but do not generate electricity) are under the jurisdiction of these siting agencies is an open question in some states (Faulkner 2019).

Whether energy storage facilities are subject to oversight by a siting agency is determined by state legislatures. Requiring that oversight can be beneficial to the state in ensuring that storage facilities are designed according to codes and standards adopted in the state or imposed by regulators, and that construction of the facility meets those codes and standards.

Regardless of whether stand-alone energy storage is included in a siting agency's jurisdiction, the agency will likely have to oversee generation projects that include a storage component, as new renewable generation facilities are increasingly being paired with energy storage (Rand et al. 2021). Having a working knowledge of safety codes and standards for battery energy storage will enable siting professionals to conduct an informed review of the battery component of hybrid generation facilities and ensure that design specifications meet relevant requirements and that the facilities are constructed according to specifications.

4.1.3 Local Zoning Officials

Once a site is selected for an energy storage facility, it likely will be subject to review and approval by local zoning officials at the municipal or county level. As discussed in the previous subsection, many states have not clarified whether energy storage facilities are under the jurisdiction of state siting agencies. Therefore, the local zoning review may be done in parallel with the state siting agency to ensure compliance with local zoning ordinances, or it may be the only siting review done for the facility.

In either case, local zoning officials will be responsible for determining whether the ESS facility is an appropriate use for the proposed site and whether any conditional approvals, such as screening or setbacks, will be needed to limit the energy storage system impact on neighboring properties. Their review will also likely include consideration of potential emergencies and securing access and necessary training for emergency personnel who would respond to an incident at the facility.

A working knowledge of safety codes and standards for energy storage is crucial in these duties. Although local zoning officials likely will not have the authority to impose above-code requirements if state codes are outdated, knowing the best practices embodied in current code versions will enable them to ask informed questions and explore options for addressing gaps, including voluntary agreements with the developer to go above state code requirements.

Developing an understanding of the risks associated with energy storage will also enable local zoning officials to address, on a case-by-case basis, how those risks will be mitigated and what conditions may be necessary to protect neighboring property owners.

4.1.4 State Legislative Bodies

Policy developments related to energy storage have intensified and diversified in recent years, as the federal government and states identify additional roles for energy storage technologies in meeting energy goals. These policies come in many forms, such as mandates, financial incentives, and new regulations, but they share a common goal of facilitating the deployment of energy storage on the electric grid. In recent years, several states have enacted sweeping energy storage legislation that implements multiple energy storage policies at once (PNNL 2022).

Knowledge of codes and standards can help legislators and policymakers take more holistic approaches to energy storage policy development by including measures that ensure the best available safety and interconnection practices are used in the state. States generally require cost-benefit analyses and extensive public hearings before adopting a code update. While these steps ensure that the impacts of the code are given a fair hearing and are fully considered, they can also erect a barrier that impedes code adoption. Absent a clear directive for the state to update its codes and funding for the necessary analyses and proceedings, a state may fall behind in the code adoption cycle and be reliant on obsolete practices.

State legislators can remedy these issues by providing clear guidance for relevant state agencies to prioritize code adoption and the necessary resources to support the state's established processes. They may also play a role in the adoption of updated codes and standards or in revising and simplifying code adoption processes. Through these approaches, legislators and policymakers can establish a culture of safety in the state from the top down, creating mechanisms to ensure that the safe installation and usage of energy storage are given equal weight as policy goals designed to encourage energy storage adoption.

4.1.5 State and Local Fire Officials

Fire officials act as crucial stakeholders in the deployment of energy storage assets of all sizes. As fire officials bear liability in ensuring that risks have been identified and properly mitigated, ensuring that emergency responders will have ready access to large commercial and utility-scale projects is a necessary step in the local approvals process. For smaller, customer-sited assets, the comfort level of fire officials with different products will be a governing factor in whether and where those products will be eligible for use in their respective jurisdictions.

Having an in-depth knowledge of codes and standards gives fire officials the ability to issue permits without additional delays for education. Rather than being seen as unreasonable actors placing barriers against the deployment of storage, fire officials can point to codes and standards as an objective foundation to support their position and illustrate the deficiencies that they have identified.

Fire officials are also uniquely situated as the most credible source of information and objective advocacy for a state to update its codes and standards. Having a knowledge of current practice and the specific risks created when a state fails to update its codes can be an effective driver for a state to remedy those deficiencies.

5.0 Summary

The Infrastructure Investment and Jobs Act (H.R. 3684, 2021) directed the Secretary of Energy to prepare a report identifying the existing codes and standards for energy storage technologies. This report addresses a section of this request and serves to enhance the safe development of energy storage systems by identifying codes that require updating and facilitation of greater conformity in codes across different types and usages of energy storage technologies.

This report identifies the safety risks associated with stationary battery storage technologies and why codes and standards are needed, summarizes the key codes and standards affecting the design and installation of battery energy storage technologies, provides an overview of code development cycles and why codes are continuously updated and addresses the crucial role that states play in adopting codes and the challenges that frequently prevent states from keeping up with code development cycles.

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Pacific Northwest National Laboratory

902 Battelle Boulevard
P.O. Box 999
Richland, WA 99354
1-888-375-PNNL (7665)

www.pnnl.gov