SAFETY COLLABORATIVE

ENERGY STORAGE SYSTEM SAFETY

Development and Adoption of Codes and Standards

Energy, environmental, and economic challenges are spurring more widespread consideration and use of energy storage systems (ESSs), which in turn are driving increased development of new energy storage technologies (ESTs). Both of these factors are increasing the focus on ensuring that public health, safety, and welfare are not adversely affected; something that has been addressed for many years through codes, standards, and regulations (CSR). CSRs provide requirements that, if followed, can foster ESS safety whether electrical, mechanical, or thermal regardless of the range of ESS applications, energy capacities, physical sizes, location, or number installed at any given site. The degree to which CSRs are updated to fully address ESS safety (e.g., electrical shock, fire, explosion, egress, and protecting an installation from natural or manmade disasters) or access by unauthorized persons and the success in adopting those CSRs significantly affects how fast ESS growth can occur while minimizing the probability of safety-related incidents.

Understanding CSR Development and Deployment

The development of codes, standards, and related documents in the U.S. and their adoption as laws, rules, regulations, and related requirements can be challenging to understand, as can the activities associated with documenting and verifying compliance with what is adopted. This document is intended to facilitate a more uniform understanding of how safety-related CSRs are developed and adopted. A second document in this series addresses documenting and verifying compliance with CSR (e.g., conformity assessment). Such understanding can foster improved communications among ESS stakeholders, and the collaboration needed to realize more timely acceptance and approval of safe ESTs through appropriate CSRs.

Development of CSR Requirements

In the U.S, requirements (criteria) are generally developed by voluntary sector standards development organizations (SDOs) that involve all stakeholders, including potential adopters of those documents. However, the requirements sometimes are developed directly by an adopting entity such as a state or local government or a utility. Voluntary sector standards and model codes available for adoption in the U.S. cover a wide range of safety-related issues; EST types and applications are two of many issues of our built environment.

A number of SDOs are involved in the development of documents that directly or indirectly address EST safety. The documents can be standards or model codes (generally in normative enforceable requirements), but they can also include guidelines that include informative criteria (not enforceable). SDOs may develop and publish one or more documents, which can vary in scope and applicability to an energy storage installation, and generally revise them on a regular basis. Some U.S. standards and model codes are listed in Table 1, beginning with micro applicability (e.g., EST components) and proceeding to overarching or macro applicability (e.g., a fire code that covers all aspects of the built environment). While these documents are separate and distinct, they can also refer to each other, generally from the macro level down. Collectively they represent a body of work that serves as a benchmark for what is considered safe.

Once published, standards and model codes are available for adoption throughout the U.S. and in other countries. They are also regularly updated to reflect ongoing research results, technology development, and experience gained from existing technology applications. The availability of these documents eliminates the need for those who want to address ESS safety to separately and in parallel conduct their own "home grown" development, revision, updating, and enhancement process on an ongoing basis.

TABLE 1. U.S. Standards and model codes addressing energy storage technology safety.

Energy Storage System Components	• **IEEE P1679.1** Guide for the Characterization and Evaluation of Lithium-Based Batteries in Stationary Applications • **IEEE P1679.2** Guide for the Characterization and Evaluation of Sodium-Beta Batteries in Stationary Applications • **IEEE P1679.3** Guide for the Characterization and Evaluation of Flow Batteries in Stationary Applications • **UL 1973** Batteries for Use in Light Electric Rail and Stationary Applications • **UL 1974** Evaluation for Repurposing Batteries • **UL 810A** Electrochemical Capacitors
Complete Energy Storage Systems	• **UL 9540** Energy Storage Systems and Equipment • **ASME TES-1** Safety Standard for Thermal Energy Storage Systems
Installation of Energy Storage Systems	• **NFPA 855** Standard for the Installation of Stationary Energy Storage Systems • **NECA 416** Recommended Practice for Installing Stored Energy Systems • **FM Global Property Loss Prevention Data Sheet # 5-33** Electrical Energy Storage Systems
Safety of the Built Environment	• **NFPA 1** Fire Code • **NFPA 70-** National Electrical Code [NEC] • **IFC** International Fire Code • **IRC** International Residential Code • **DNVGL-RP-0043** Safety, Operation and Performance of Grid-connected Energy Storage Systems • **IEEE C2** National Electric Safety Code [NESC]

Adoption and Application of Codes and Standards in the U.S.

Adoption involves a formal decision by anyone to rely on or require, implement, and comply with a standard or model code. These documents can be adopted through a number of governmental vehicles at the federal, state, local, territorial, or Native American tribal levels, via utility requirements, and through private sector mechanisms such as insurance policies, contracts, incentive programs, or professional licensing requirements. Adoption makes compliance with the adopted standards or model codes, developed in the voluntary sector, mandatory.

The mandatory nature of adoption can include a situation in which compliance is required without exception or it can be conditional, such as qualifying for a grant or governmental program. The adoption process is not unique to ESS; what is adopted to address ESS safety is a component of a larger set of requirements that cover a broader range of health, safety, and welfare goals associated with the built environment, of which EST is a part. Of interest are requirements in CSRs that can require the application and use of ESTs (to be covered in a future ES3 brief).

Adoption of a standard or model code almost always is "date certain" meaning a specific edition is adopted rather than the document being adopted in perpetuity. Hence, each time a new edition of a standard or model code is published that new edition must be specifically adopted.

The federal government, through its legislative or executive branches, can be given preemptive authority over state, local, or territorial government and/or private sector interests to adopt and require compliance with standards and model codes. However, Native American Tribes have sole authority to govern their tribal property, and when addressing the safety of the built environment on their property they generally adopt standards and model codes developed in the private sector. State, local, and territorial governments can develop, adopt, and/or enforce laws, rules, and regulations, as can utilities and private sector entities such as insurance carriers, lenders, and investors/ property developers.

When state government adopts requirements they can be preemptive such that local governments would have no authority to adopt different requirements, or in some cases would have authority to add to (but not take from) what the state has adopted. When the state does not have preemptive authority, the local government is free to adopt what they deem appropriate (through applicable governmental processes) to protect the safety of their citizens. Note that state preemptive authority may cover all subjects or only certain ones (e.g., all codes and standards, or only electrical/plumbing issues, or maybe only state-owned/funded construction).

Federal agencies that own and/or lease property have the authority to adopt and enforce rules and regulations covering the built environment under their control. Each agency is responsible for the buildings it owns and the private sector buildings it leases and occupies. This is also the case at the state or local level with respect to facilities owned, leased, or in some way funded by state or local government.

Adopting entities (legislative or regulatory) may not necessarily adopt the most recent standards or model codes or, upon adoption, may include amendments that can either strengthen or update the requirements or weaken them. Engagement in this process at the state and local levels can foster more timely adoption of current standards or model codes. Because state and local governmental adoptions generally occur on a 3-year or more cycle (similar to development of standards and model codes), it is equally important to recognize state and local schedules associated with, and opportunities for, adoption. Coupling this with a 3-year cycle for development of standards and model codes means that what is adopted can be at least 3 years outdated from what is considered current. Note these adoption schedules are not specifically directed at EST, but rather at all CSRs being adopted and applied to address the built environment within the authority of the adopting entity.

Other adoption mechanisms, whose timing is not as structured, are also relevant. Utilities adopt standards and model codes to govern the acceptability of ESTs and their installation on the grid side of the meter or possibly for an EST they own and operate on public or private property on the customer side of the meter. The utility is able to undertake adoption at any time. This is also the case for insurance carriers and owners/developers looking to update specifications or other criteria they place on those they insure or who do design and construction work for them.

Once adopted, compliance with the provisions of the model codes, standards, guidelines, and other requirements that have been adopted must be ensured. This is accomplished through conformity assessment. Conformity assessment includes documenting compliance with the adopted CSR and then validating that the CSR criteria have been satisfied. This ensures that the expected outcomes as memorialized in the CSR are achieved and, on that basis, the safety-related performance of an ESS can be trusted. See the companion document "Fostering the Safety of Energy Storage Systems through Codes and Standards – Conformity Assessment" for more information on that topic.

TABLE 2. Avenues for CSR Adoption in the U.S.

- Legislative or regulatory action by a governmental entity (federal, state, local, territorial, Indian Tribe) as a mandatory requirement in all cases or as a condition for program participation or funding.
- Action by a utility as controlled by a Public Utility Commission and acting as the authority having jurisdiction for their systems on the grid side of the meter or being involved with or connecting to an ESS on the customer side of the meter.
- A requirement by an insurance carrier as a condition of insurance coverage or some graduation in insurance rates.
- A condition for licensing (e.g., a state contractor licensing board that adopts and applies particular technical requirements and compliance with those as a condition for licensure).
- By reference in building specifications issued by a building owner/developer or financial institution that is underwriting a project.
- By anyone considering the application and use of energy storage that, in the absence of any other means of adoption, elects to apply model codes or standards to their project for marketing, stewardship, or other reasons (e.g., self-adoption).

Conclusion

As with all prior and future technologies used in the built environment, EST can provide value but it can also adversely affect public safety. In the absence of criteria to document and validate safety and an infrastructure to develop, adopt, and apply the criteria, it is impossible to uniformly and confidently determine what is and is not safe and ensure that safety on an ongoing basis. In addition, while some people involved in EST development and deployment "do the right thing", others do not thereby adversely affecting safety to the point where EST could be precluded from the market.

The unique public-private collaboration in the U.S. for developing standards and model codes and then adopting them establishes a basis for what is and is not safe. This system grew out of the way the U.S. was established giving certain authorities to the three branches of the federal government and other authorities to state, local, territorial, and tribal governments. The system also recognizes the ability and authority of private sector interests and businesses to establish and adopt additional requirements, thereby going above and beyond minimally acceptable criteria. Once the criteria are established and adopted, a conformity assessment system that involves all stakeholders is also in place to ensure compliance with those criteria.

While providing for public safety, the U.S. system can also present challenges to EST development and deployment. Because standards and model codes cannot anticipate new technology, it takes time to conduct the necessary research upon which to base new criteria for those documents. It takes time to adopt those revised documents once they are developed and to ensure those involved in ensuring compliance are familiar with them. There are no ways to "short cut" this process and guarantee a comparable degree of safety. But working together, those involved in the U.S. system have the ability to facilitate the acceptance of new technology, such as EST while ensuring the public safety.

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Sandia National Laboratories

Contact Information

For more information about this document and/or ES Safety Collaborative activities, contact:

David M. Rosewater
Energy Storage Systems Analyst & Researcher
Sandia National Laboratories
P.O. Box 5800 MS 1108
Albuquerque, NM 87185-1108
Phone: 505-844-3722
Email: dmrose@sandia.gov

Pacific Northwest NATIONAL LABORATORY

Contact Information

For more information about this document and/or ES Safety Collaborative activities, contact:

David R. Conover
Energy Tech & Market Adoption
Pacific Northwest National Laboratory
P.O. Box 999, MSIN K6-05
Richland, WA 99352
Phone: 703-444-2175
Email: david.conover@pnnl.gov

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