PNNL-34462

Energy Storage in Local Zoning Ordinances

October 2023

Jeremy B Twitchell
Devyn W Powell
Matthew D Paiss

Prepared for the U.S. Department of Energy
under Contract DE-AC05-76RL01830

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Executive Summary

Increasing policy support and declining prices for battery energy storage systems (BESS) are driving rapid growth in the installation of these systems in the United States and around the world. Because a BESS is modular in nature and has limited infrastructure requirements, it has the potential to placed on infill developments in close proximity to existing uses, which creates the potential for conflict. As the use of BESS grows, local planning and zoning staff are increasingly being asked to determine where the systems can be built and how their impacts on surrounding uses can be mitigated. While a large-scale BESS offers significant electric grid and societal benefits, it can also pose safety, visual, auditory, and environmental impacts on the community in which it is located. While these are material impacts, current safety codes for energy storage systems and land use frameworks provide planners with the necessary tools and processes to mitigate those impacts and ensure that their communities safely receive the benefits of energy storage systems. This report provides an overview of BESS from a land use perspective and describes their implications for zoning and project permitting. It concludes with an analysis of current energy storage zoning standards adopted by local jurisdictions in the U.S. Its intent is to objectively inform land use decisions for energy storage projects by equipping planning officials with relevant information about these technologies and knowledge of what questions to ask during review processes, so that energy storage projects can move forward in ways that will benefit electric systems while not unduly affecting host communities.

Acknowledgments

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Acronyms and Abbreviations

BESS	Battery Energy Storage System
dB	Decibel
EIA	Energy Information Administration
IFC	International Fire Code
IRA	Inflation Reduction Act
MW	Megawatt
NFPA	National Fire Protection Association
SDO	Standards-developing Organization

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1.0 Introduction and Background

Numerous U.S. states have adopted aggressive energy decarbonization targets in recent years; 16 states and territories have enacted binding legislation requiring all of their electricity to either be 100 percent clean or fully offset by clean energy, while another seven states have aspirational, non-binding goals for an electric supply that is either fully decarbonized or fully offset by clean energy. Another 25 states and territories have clean energy requirements of varying levels, including some of those that have aspirational goals for a fully decarbonized grid (Clean Energy States Alliance 2023; National Conference of State Legislators 2023).

Because the output of non-emitting energy resources like wind and solar is variable, integrating them into the electric grid while maintaining reliable service presents a challenge. In response, many states have also implemented policies to encourage or require energy storage investments as a means of harnessing renewable energy and matching it to customer demands. To date, 10 states have adopted legislation or executive actions requiring electric utilities to install certain amounts of energy storage, and many states have also established financial incentives and other policies designed to encourage the use of energy storage to make the electric grid more flexible (PNNL 2022).

Electric utilities have also increased their investments in energy storage in recent years, in many cases independently of any state policy. For example, about 24 percent of all battery energy storage in the U.S. has been installed in Texas, which has no energy storage incentives or policies in place (EIA 2023).

These state and utility efforts have been reinforced by recent federal legislation that provided incentives to reduce the costs of manufacturing and purchasing energy storage. The Infrastructure Investment and Jobs Act of 2021 provided $200 million in federal funding for battery manufacturing facilities in the U.S., while the Inflation Reduction Act (IRA) of 2022 created tax incentives for both battery manufacturers and battery purchasers. The credits for the purchase of energy storage depend on the size and characteristics of the system, and can range from 6 to 70 percent.

While the intent of the IRA is to reduce the cost of manufacturing, purchasing and installing a BESS, the increased demand coupled with lingering supply chain challenges from the pandemic caused a temporary increase in BESS costs in recent years. However, analysts project that the pending increases in U.S. battery manufacturing capacity will cause BESS costs to stabilize by 2024 (BloombergNEF 2022).

The confluence of these factors—changing grid needs, supportive policies, and declining costs—has dramatically accelerated the growth of the battery energy storage industry in recent years. Figure 1 illustrates the cumulative amount of battery energy storage added to the U.S. electric grid since 2020 and projected installation rates for the near future.

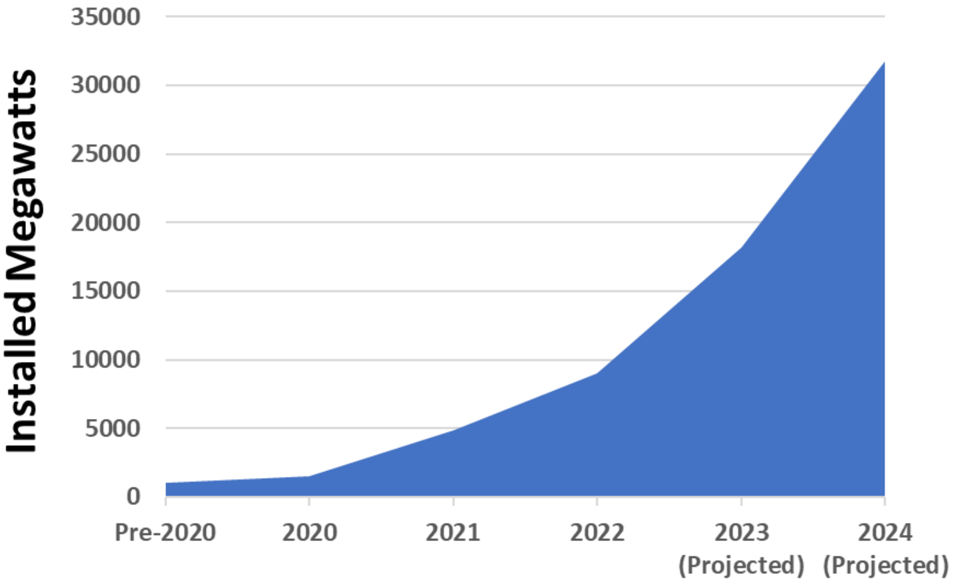

Figure 1: Existing and Projected U.S. Battery Energy Storage System Installations, 2016-2023

As Figure 1 illustrates, battery energy storage is in a period of rapid growth. At the end of 2020, there were about 1,500 megawatts (MW) of battery energy storage installed on the U.S. grid. That number more than tripled in 2021, nearly doubled in 2022, and is expected to double again in 2023 (EIA). Based on contracts expected to be completed by the end of the year, there will be more than 18,000 MW of battery storage on the grid—an 18-fold increase in four years. And contracts are already in place for more than 13,000 more MW in 2024 (EIA).

As a point of reference, the average residential utility customer uses an average of 1.2 kilowatts (kW) at any given point in time, so 1 MW of energy storage would support about 833 residential customers. How long a battery will support those customers depends on their exact usage and the total amount of energy in the battery. Most systems being installed today are rated for 4 hours, so a 1 MW BESS would support 833 customers for about 4 hours under normal usage.

Batteries are a unique class of energy system infrastructure. Because the basic unit is a small cell or pouch, a BESS is modular in nature and can be configured in virtually any size. Additionally, a BESS has relatively limited infrastructure requirements, needing just a concrete pad to sit on and a connection to the electric grid. These two factors—modularity and limited infrastructure needs—mean that a BESS can be built virtually anywhere, including in close proximity to existing commercial and residential uses.

These factors create a unique challenge for planning and zoning officials at local jurisdictional levels, who are frequently tasked with deciding where energy storage assets may be sited and how their impacts on the community may be mitigated. And because BESS is a new technology with a unique risk profile, planners may lack the necessary information and familiarity to respond to proposed battery systems in their jurisdiction. In some places, the resulting uncertainty and extensive review processes are resulting in developers withdrawing projects (Smith 2022). In other places, it has led local planners to ban energy storage projects outright (Colthorpe 2022; Merzbach 2022; Ryan 2022).

Energy storage technologies hold significant value for the electric grid and are a critical factor in decarbonization efforts. But the interactions between a BESS and its host community are complex and require local planning and zoning officials to consider unique operational and safety needs when evaluating a proposed energy storage project (Gerow, Gerrard and Dernbach 2021). This report defines the potential community impacts of an energy storage project in terms relevant to a local planner and provides real-world examples of how communities have addressed those impacts. Its intention is to objectively inform planners as they develop the conditions and ordinances necessary to ensure the safe and acceptable operation of energy storage projects within their communities.

Section 2 describes the safety standards that govern energy storage systems, Section 3 provides an overview of other potential community impacts of a BESS, and Section 4 summarizes existing local zoning ordinances in the U.S. for energy storage systems.

2.0 Safety Considerations

While there are many energy storage technologies, virtually all energy storage systems installed on the electric grid in the last few years and most of those expected to be installed in coming years are lithium-ion batteries. Lithium-ion batteries have become the dominant technology because they offer high energy density at a cost competitive price. This makes them the ideal solution for electric vehicles and consumer electronics, where space and weight are constrained. It also facilitated the development of a global supply chain that has driven down costs and made lithium-ion batteries the most readily available and affordable source of energy storage for electric grid applications as well.

Lithium-ion systems are also modular in nature, in that they are based on a single cell or a small pouch, which can be aggregated and configured in many different ways and system sizes. Therefore, a lithium-ion battery installation may be a large, utility-scale investment consisting of many interlinked systems covering several acres, or a small system hanging in the garage of a home, or anything in between. Planning and zoning officials may see applications for projects that vary widely in their size and potential impacts. Because electrical substations are the hubs of a utility's system, many energy storage developers may seek to build near a substation so that they can provide support and benefits across a wider area of the utility's system. But planners may also see applications for battery systems sited near or on the premises of a large customer or for distributed networks of smaller batteries spread throughout a utility's system, in addition to the growth of small residential and commercial systems installed by individual utility customers.

And while the energy density of lithium-ion batteries is one of the technology's key benefits, it is also its greatest risk. Because lithium-ion batteries store large amounts of energy within a relatively small space coupled with having a flammable electrolyte, they have the potential to become unstable and enter thermal runaway—a state in which the chemical reactions within the battery release excess energy and gases that cause battery failure and fires.

While battery fires tend to be high-profile events, they are relatively rare when compared to the number of installations. The Electric Power Research Institute (EPRI) maintains a database of fires involving grid-connected BESS from media reporting sources. It does not include battery fires in vehicles or consumer mobility products and contains an incomplete record of fires in systems that were owned and installed by individual customers. But the database does contain a thorough accounting of fires involving the type of large, grid-connected BESS that would be subject to review and approval by local planners.

EPRI's database identifies 14 such incidents in the U.S. (EPRI 2023).[1] To place that number in context, there were 491 large, utility-scale projects in the U.S. as of April 2023, for a fire incidence rate of about 2.9 percent. No BESS fire in the U.S. has resulted in loss of life, and many of the affected facilities were able to resume operation.

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[1] The EPRI database identifies 12 total battery fires in the U.S. The other four involved smaller, privately owned and installed BESS. Eleven of the fires involved lithium-ion batteries and one involved a lead acid battery.

For further context, the average age of the BESS that caught fire was about 18 months, and as indicated in Figure 1, more than 80 percent of the large-scale batteries on the U.S. grid have been installed within the last two years. It is therefore possible that the rate of BESS fires could increase in the coming years. But as discussed in the box to the right and will be further discussed below, lessons learned from BESS fires have guided changes in safety codes that are intended to reduce the impact from future incidence of fires.

Battery fires release toxic gases and may potentially spread to other community infrastructure. And because batteries contain both chemicals and electrical energy, traditional firefighting techniques such as dousing the fire with water may have limited success. Battery failures represent a material risk that planners must address when considering a proposed battery project, but there is a significant body of work in battery safety on which they may rely. A full review of the numerous codes and standards governing energy storage systems is beyond the scope of this report, but has been done elsewhere (Vartanian, Paiss, Viswanathan, Kolln, and Reed 2021).

Case Study: Surprise, AZ

The most prominent BESS fire in the U.S. happened in April 2019 in Surprise, AZ, when a 2-MW BESS housed within a structure caught fire and exploded.

The explosion occurred several hours after the fire was reported, when firefighters opened the door to inspect the facility and the introduction of oxygen caused the flammable gases trapped in the container to ignite. Several firefighters were severely injured.

In response to this event, current codes require explosion control systems for BESS. Many BESS developers have also moved to cabinet-based systems, which have limited internal spaces where gases may accumulate and do not allow entrance by first responders.

Adoption and enforcement of these codes and standards is generally done at the state level, which means that many local planners may have limited or no authority to enforce them. However, a working knowledge of these codes and standards can serve planners in developing an understanding of industry best practices for the safe installation and operation of energy storage systems. The objective of this section is to equip local planning and zoning officials with a knowledge of key codes and standards affecting energy storage safety so that they know what questions to ask and what conditions to impose or negotiate to mitigate the risks.

2.1 Safety Codes and Standards

This section provides an overview of the safety criteria applicable in the procurement, design, commissioning and emergency response to a BESS incident. There are well-defined codes and standards governing stationary energy storage systems to guide these steps. Figure 2 illustrates how various codes & standards apply to specific components of a battery storage system and how they all relate to one another.

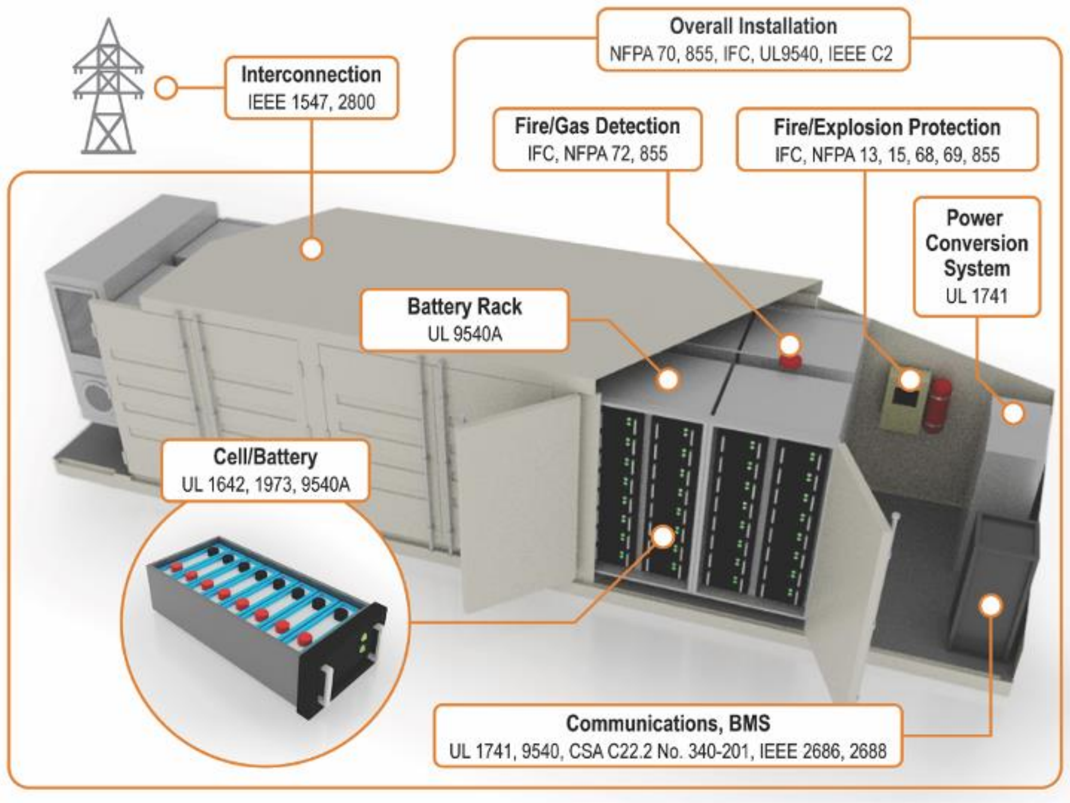

Figure 2: Overview of Codes and Standards for Battery Energy Storage Systems

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 the National Fire Protection Association (NFPA) and the International Fire Code (IFC) for codes. 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; that report is publicly available (Paiss et al 2022).

Typically, a code is a document that guides installation requirements, while a standard is a document that describes the safety requirements of a product and how to perform certification testing. In the energy storage 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.” UL 9540 is the key product safety standard for energy storage systems, and ESS listed to this standard is a requirement in both the IFC and NFPA 855. This standard addresses the compatibility of all components and systems, functional safety, enclosures, ventilation and cooling, communications, and fire safety. In addition to the requirement for listing to UL 9540, there are requirements for fire testing to UL 9540A. In a UL

9540A test, thermal runaway is intentionally created so that test administrators can understand how the cell performs under failure and observe how fires spread through the unit. This is used to help design fire safety features and establish safe distances between units to limit propagation should a failure occur. A system that is UL 9540 certified, therefore, is a system designed to contain battery failures and prevent them from spreading to adjacent units while ensuring against explosions.

The high-profile fire of a grid-scale battery at a Tesla facility in Australia in July 2021 illustrates the importance of UL 9540 compliance. When one of the project’s 212 units caught fire, proper spacing largely contained the failure to the unit where it originated. Even though winds were high that day—nearly three times the wind speed assumed in the 9540A test—the fire only caused minor damage to one neighboring unit, and the rest of the large project was unaffected (Blum et al 2022). This was further demonstrated during a failure in a similar system in Monterey County, CA in Sept 2022, where damage was contained to the unit of origin. Two other fire incidents at outdoor energy storage systems in 2023 followed this pattern as well.

This point of failures being contained to the unit of origin is critical in both system design and assessing the project’s overall risk profile. The risk of a fire incident at a battery storage project does not increase with project size; the two are decoupled in a well-designed system that prevents a fire in one unit from spreading to neighboring units. Regardless of project size, the fundamental question in assessing a project’s risk is what happens if a single unit fails, rather than what happens if every unit fails at once. In determining the risk to neighboring properties, it is recommended that siting consider prevailing winds where projects are located less than 150 feet from occupied structures, with the knowledge that weather conditions and incident specifics will guide any emergency response by the fire service. In general, it is the distance to the closest BESS enclosure more than the total number of BESS on a site that should guide the siting considerations from a fire safety perspective.

In addition to the requirements in the National Electrical Code (NFPA 70) addressing installation requirements, the adopted fire code in a local jurisdiction provides additional guidance for safe installations. For federally owned facilities, the NFPA codes are often enforced, with NFPA 855 as the guiding document for stationary energy storage systems. For states that follow the International Fire Code (IFC), there is language similar to NFPA 855. NFPA 855 includes criteria for the system design, installation, commissioning, repair/replacements, explosion control, and decommissioning. While the standard has technology-specific sections, it was initially created to address the unique risks that lithium-ion chemistries represent. It is expected that future editions of the IFC will reference NFPA 855 for ESS requirements.

Much of NFPA 855 deals with technical details that are beyond the scope of planning and zoning, and direct enforcement of the standard is beyond the jurisdiction of many local planning agencies. However, many of NFPA 855’s requirements are relevant to zoning considerations, and familiarity with the standard can provide a blueprint for knowing what questions to ask about a project and what conditions to impose or negotiate. Some of the requirements in NFPA that have direct relevance to local zoning officials include:

- An emergency response plan and training for local emergency responders (Section 4.3)
- Use of UL 9540-listed equipment (Section 4.6)
- Fire control and suppression systems (Section 4.9)

- A decommissioning plan for removing and disposing of the system at the end of its useful life (Section 8.1)
- Detailed site/facility construction requirements (Sections 9.3 through 9.5)
- Explosion control (Section 9.6)

NFPA 855 can be accessed and reviewed for free by anyone who registers on the NFPA's website (www.nfpa.org/855). In addition to the standards identified above, NFPA 855 also contains Appendix B: Battery Energy Storage System Hazards. While not a part of the standard, Appendix B can be a valuable reference for local planners and first responders to understand the safety risks associated with battery storage and strategies for addressing them.

2.2 First Responder Training and Protection

Outreach to local fire officials is an important phase of project development and should begin early in project planning. This will identify local amendments to adopted codes as well as determine training requirements for the responding agencies. Early inclusion of local fire officials can also help identify any potential barriers to permitting of projects.

On the training side, NFPA 855 has requirements that training of operations staff as well as emergency responders be provided by the system owner or operator. Typically, this training will include high-level awareness training of battery safety, operations, and response guidance that will be used to create guidelines often known as Standard Operation Procedures or SOP's.

Common recommendations for Lithium-ion ESS are increasingly including allowing a battery located outdoors to be allowed to burn if on fire, with attention paid to protecting nearby exposure structures or other ESS. These recommendations inform the siting of ESS as well as emergency response training.

2.3 Implications for Local Planners

NFPA and IFC codes are updated on a 3-year cycle to include new information and requirements. In the case of energy storage codes, this is particularly relevant as lessons learned from system failures and technological innovations are integrated into new versions of the code. But because adoption of code updates is a state-level process in most states, and because a code update can be costly and time-consuming, it may take years for a state to complete one.

Some states allow local jurisdictions to adopt codes that exceed those adopted at the state levels, while others prohibit it. In either case, understanding these standards and knowing what questions to ask can ensure safe installation and operation of BESS projects in their jurisdiction, regardless of what version of the code is in force. Many developers will likely be willing to voluntarily abide by industry best practices, even if not legally required in the jurisdiction; asking the right questions can increase local comfort with the project and facilitate voluntary agreements. Example questions that planners can ask include:

- Is this system listed to UL 9540?
- Have local fire officials been briefed on the project?

- What training would be necessary for first responders?
- What explosion control equipment will the project employ?
- What maintenance and repair plans are in place?

3.0 Other Zoning Implications

Safety is frequently the most pressing concern expressed in local zoning proceedings for energy storage projects, and justifiably so. But there are several other potential community impacts that local planners may be asked by their constituents to address. This section will briefly discuss four other types of community impacts: sound, odor and emissions, visual, and environmental. It will also illustrate how planners are mitigating these impacts, drawing on case studies from various jurisdictions that have dealt with siting large energy storage projects.

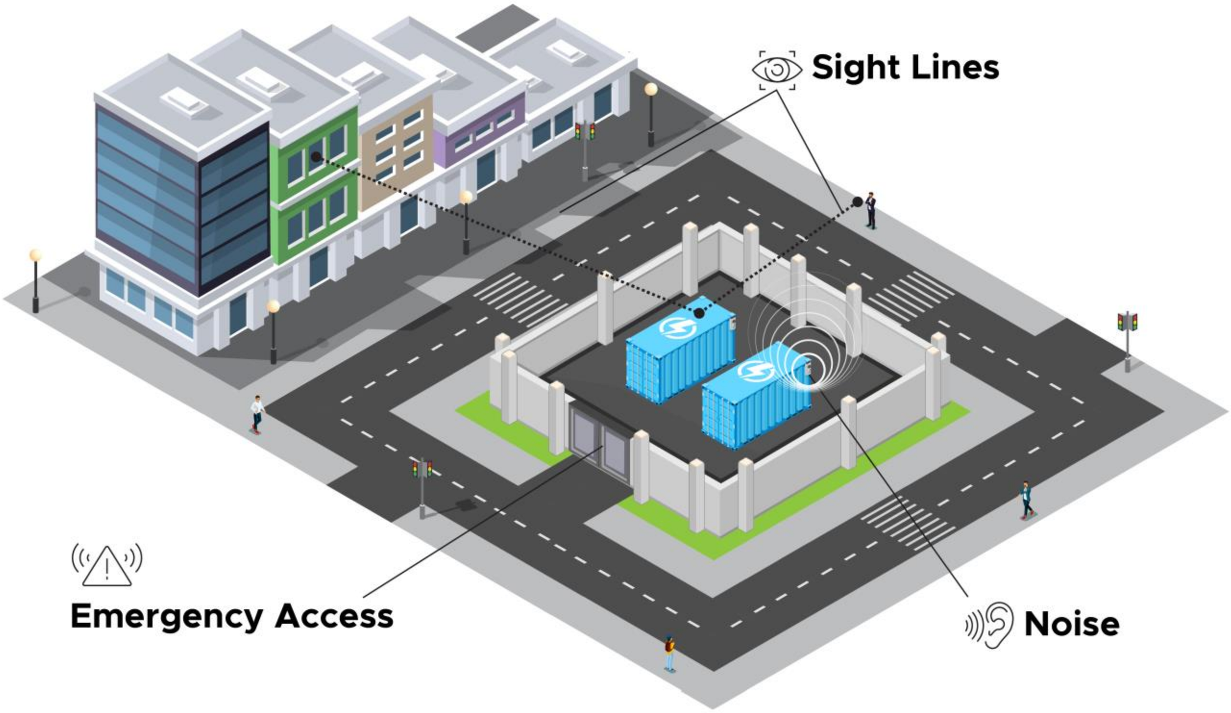

Figure 3: Potential Community Impacts of Energy Storage Projects

Before proceeding, it is important to note that every project will be different. Due to the wide range of battery providers, component manufacturers, and project configurations, no two projects will have the same impacts profile. Each project will need to be considered based on its specific components and configuration to properly identify and mitigate its impacts. This section is meant as a guide to help planners identify the specific aspects of an energy storage project that could cause community impacts, give some indication of the potential size of those impacts, and document how different jurisdictions have addressed those impacts. The case studies in this section are presented for illustrative purposes and are not intended as an endorsement or recommendation of any particular approach.

3.1 Visual Impacts

Because a lithium-ion battery project is ultimately an aggregation of many individual cells and racks, there is flexibility in how that project is packaged. Many energy storage developers have settled on a containerized solution, in which systems are built on a modular basis in a shipping container or other container manufactured by the developer. These systems generally range between about 8 and 12 feet in height.

Alternatively, some battery storage projects have been assembled within a structure, in some cases a repurposed industrial facility and in others in a building constructed specifically for the storage project. The Moss Landing Energy Storage Facility in California is an example of a storage project housed in a repurposed industrial building, while the Salem Smart Power Center in Oregon is an example of a storage project housed in a newly constructed building.

While housing energy storage within a structure can serve to screen the project from surrounding uses, it generally increases project costs because of the expenses of constructing the building, engineering the project to fit within the building, and the increased cooling requirements for the larger interior space. Due to the cost reductions and engineering efficiencies that can be achieved through standardized containers, most projects will likely opt for a containerized approach and local planners may find it appropriate to screen those containers from surrounding uses.

Section 70 of the NFPA requires all large electrical installations, like energy storage systems, to have a perimeter fence of at least 7 feet to prevent unauthorized access to the facility. This requirement creates an inherent screen for all large energy storage systems, though some jurisdictions have increased the perimeter fence requirements to 8 feet or more, depending on the site characteristics.

Some jurisdictions, however, have determined that large perimeter walls may be an eyesore of their own, and have added more layers of screening. When planners in Ripley, NY raised concerns about the large perimeter fence around a solar and storage facility, the developer proposed to meet the town’s objectives by strategically siting trees at certain points around the perimeter to provide an additional, natural layer of screening from certain angles (ConnectGen 2021). In St. James County, VA, planners required vegetated buffers ranging from 20 feet to 60 feet wide when issuing a use permit for a battery storage system in their jurisdiction (St. James County Community Development 2022).

In more heavily urbanized areas where options for setbacks and screening may be more limited, some utilities and local jurisdictions have opted for more creative approaches like commissioning murals to be painted on the exterior of energy storage projects to help them blend in with the community. In Chicago, utility Commonwealth Edison hired local artists to paint the history of their neighborhood on the side of energy storage systems that are part of the Bronzeville Microgrid (Commonwealth Edison 2020).

3.2 Auditory Impacts

A battery storage system has three sources of noise:

- The inverter, which converts the direct current electricity stored in the battery to the alternating current electricity used on the electric grid (and vice versa);
- The transformer, which increases the voltage of the electricity stored in the batteries to the level used on the utility’s transmission or distribution system; and
- The ventilation and cooling system, which maintains a safe operational temperature for the batteries.

Several jurisdictions that have permitted a large energy storage system have required an impact study that included, among other things, sound impacts. Those studies have generally concluded that individual inverters, transformers, and ventilation systems generally have sound levels between 60 and 80 decibels (dB) when measured at close distance (Burns & McDonnell 2019; Louden 2015; Hodgson 2022; Plus Power 2019). 60 dB corresponds to a normal conversation and 80 dB corresponds to the noise level inside a car (Britannica 2022).

The ultimate noise level experienced by neighboring property owners will depend on three factors: the number of noise-producing components in the project (which increases the noise level), the distance between those components and the property line, and physical screening (which both decrease the noise level). One study found that when the collective impact of all inverters, transformers, and ventilation systems in a project is studied, the noise level would be 101 dB at the source, but an unscreened buffer of 400 feet between the nearest component and the property line reduced that level to 59 dB at the property line (Burns & McDonnell 2019). In another analysis for a similarly sized battery storage project, the analysis determined that a buffer of 125 feet coupled with an 8-foot perimeter fence and natural screening provided by large trees would reduce the noise level at the property line to about 55 dB (Plus power 2019).

Noise standards will vary by jurisdiction and the specific zone in which a storage project is located. Where a project has the potential to cause noise pollution for surrounding property owners, local planning and zoning officials may consider requiring a noise study to identify the noise impacts and then requiring setbacks and/or screening to mitigate those impacts.

3.3 Odor Impacts

During normal operations, a lithium-ion system does not emit gases and has no odor impacts on neighboring property owners. During a battery fire, the system will emit hydrogen, carbon monoxide, carbon dioxide, and various hydrocarbon gases such as methane and propane (Baird, Archibald, Marr, and Ezekoye 2019). While they are all odorless, these gases can create risk of fire and explosion if allowed to accumulate in an enclosed space. As the fire spreads, toxic fluorine-based gases may be released as plastics and other incidental equipment burn (Larsson, Andersson, Blomqvist, and Mellander 2017). As explained in Section 2, it was the buildup of flammable gases in a sealed battery room that caused an explosive deflagration event in Surprise, AZ in 2019 that injured several fighters (Hill 2020).

The implication for planning and zoning officials is to be aware of the risk for off-gassing and to ask storage developers about what systems will be in place to limit the buildup of flammable gases. It may also be appropriate to have a plan for directing neighboring property owners to evacuate or shelter in place in the event of a fire to avoid exposure to the gas.

In some instances of BESS fires, evacuation or shelter-in-place orders have been issued to nearby property owners as a precautionary measure. Where air quality monitoring has been performed after a battery fire, no harmful levels of emissions have been detected (Percha 2021; Copitch 2022).

3.4 Environmental Impacts

The global environmental impacts of energy storage systems associated with their manufacture, operation and decommissioning are an active area of research, with dozens of reports and papers addressing the topic in recent years (Hiremath, Derendorf, and Vogt 2015; Pellow et al 2020). Planners and zoning officials, however, are more likely to be concerned with the local environmental impacts arising from the construction and operation of battery storage projects, which is a much less active area of inquiry. Impacts on watersheds have been a particular topic of discussion in local storage proceedings around the country.

Because lithium-ion battery cells and pouches are designed to be self-contained, a lithium-ion BESS will only leak in a failure state. In fact, battery leakage is an early indicator of failure (Lu et al 2020). During normal operations, therefore, a lithium-ion BESS will not leak chemicals that could contaminate local watersheds.. Another emerging energy storage technology, flow batteries, use large tanks of liquid to store energy that pose a different risk profile for leaks. Several early projects using this technology had leakage issues, so local planners may want to ensure that flow battery projects are designed to manage this risk. A flow battery will also be engineered with primary and secondary containment systems to ensure that any leaks do not escape the system's envelope.

The primary risk of local environmental contamination associated with battery storage systems is the use of water in fire suppression. The water will bind with the chemicals released during the fire and carry them into drainage systems, where they could contaminate watersheds. This risk supports an emerging consensus in the firefighting community, outlined above, that water suppression should be used sparingly on battery fires for exposure protection. If the local fire department prefers to use water in its response plan, then planners may want to require a severable storm drain connection to ensure that contaminated water cannot leave the site.

4.0 Survey of Energy Storage in Local Zoning Ordinances

Local planning and zoning officials can benefit from seeing how other jurisdictions have addressed the unique question of battery energy storage siting, as this both illustrates available alternatives and demonstrates their viability.

To identify where battery storage zoning ordinances have been developed, the research team reviewed data from EIA Form 860M, which provides an inventory of all utility-scale electric generation and storage resources in the U.S. and is updated on a monthly basis. Data from the July 2021 report were used for this analysis, which listed energy storage systems of 4.9 MW or more in 97 cities and counties whose zoning ordinances are publicly searchable in the Municode database. Those ordinances were searched for any reference to batteries or energy storage, yielding 28 results. The search was then repeated for all local codes in the Municode database, which contained local ordinances for more than 3,300 other jurisdictions at the time, yielding another 31 results.

In all, the survey identified 42 municipalities and 17 counties with zoning, building code, fire code, permitting, local tax, or sustainability ordinances regulating energy storage to some degree. In addition, 55 municipal or county codes also include local adoption of updated standard fire or building codes that include standards for energy storage. This is not a mutually exclusive count; some areas that have specific storage considerations in their ordinances have also adopted a storage-inclusive code. Overall, relatively few cities and counties appear to currently have zoning ordinances that directly govern energy storage, underscoring the value of guidance for local planners.

4.1 State-level Variations in Local Siting and Zoning Authority

Rules determining which level of government holds overall zoning authority varies by state. Most states follow a similar general framework: municipal governments have the authority to zone land within their incorporated boundaries, and county governments may develop zoning ordinances for unincorporated county land. In the six New England states, New Jersey, and Pennsylvania, no land is unincorporated, and municipalities or townships have zoning authority over all land within their boundaries. Three states – Texas, Oklahoma, and Alabama – restrict counties' ability to zone unincorporated land, meaning that unincorporated county land in those states is largely not zoned (Lo 2019).

In Texas, the Texas Local Government Code prohibits counties from regulating, among other stipulations, the use of any building or property, or the size and number of buildings on any property. Certain counties have been granted permission from the state to enact ordinances in response to specific issues, but counties in general may not enact zoning ordinances (Phillips 2002). Oklahoma grants some ability to counties to zone unincorporated land and enables county boards to form collaborative planning commissions alongside governments of incorporated municipalities. However, most counties in Oklahoma do not have zoning ordinances for unincorporated land (Sweeney 2018). Alabama similarly does not grant counties broad powers to zone unincorporated land.

While Oklahoma and Alabama only have one utility-scale battery storage system each, Texas was home to 62 utility-scale battery projects totaling 2,306 MW as of April 2023, including several of the country's largest utility-scale battery storage systems (EIA 2023). Eight of the state's nine largest storage projects are located on unincorporated county land. There are several likely reasons why Texas has attracted recent investment in so many large-scale storage projects, including ERCOT commitments to encourage and remove barriers to energy storage integration following the Texas freeze of 2021 (Jones 2022). The lack of zoning and permitting requirements and abundant space on unincorporated county land in Texas may also offer incentives for project developers.

4.2 Overview and Categorization of Storage in Local Zoning Ordinances

The presence of energy storage language in local zoning ordinances can be divided into four categories: ordinances written to regulate solar generation that also include energy storage; local adoption of fire or building codes that include standards for energy storage systems; ordinances that are specifically targeted at energy storage technologies; and ordinances that encourage or incent storage adoption.

Table 1 summarizes these different categories, how widely they have been adopted by municipalities across the country, and specific examples of each category.

Table 1: Energy Storage in Local Zoning Ordinances

Description	Number of ordinances found	Examples
Ordinances written to regulate solar installations that also include storage. These ordinances generally only regulate storage systems when co-located with solar generation, and generally apply all solar PV regulations to storage components.	37	• *Plumsted, New Jersey* requires all equipment for a solar energy system, "including ... structures for batteries or storage cells" to "be completely enclosed by a minimum 12 foot high fence," and prohibits all systems from being located in a "front, side, or rear yard setback." *(Township of Plumsted, NJ Code § 15-5.21)* • *Boulder, Colorado*'s zoning ordinances define a "solar energy system" as "a system ... which may include an energy storage facility," and then defines permitting requirements and zoning districts eligible for installation of these systems. *(Boulder County Land Use Code Article 18, 18-199)*
Local adoption of fire or building codes that include standards for energy storage systems. County and municipalities have adopted fire and/or building codes that include explicit safety, labeling, and siting guidance for energy storage, such as the 2018 IFC, 2020 NEC, or NFPA 855.	12	• *Yarmouth, Maine* has locally adopted NFPA 855, "Standard for the Installation of Stationary Energy Storage," into its municipal fire and safety code. *(Town of Yarmouth, Maine Code Chapter 319: Fire Prevention and Life Safety Ordinance, 2021)* • *Daly City, California* amended the California Fire Code, which already includes some regulations for energy storage, to specify that means for disconnection must be included with ungrounded conductors connected to energy storage systems. *(City of Daly City, Municipal Code 15.24.130 - Article 706.7)*
Ordinances specifically targeted at energy storage technologies. These regulations include labeling standards, permitting requirements, setbacks, height standards, and visibility requirements. These ordinances may contain standards like those in standard fire or building codes and may be adopted in addition to these codes to add additional guidance. Alternatively, they may be adopted by local governments unable to exceed state code requirements.	12	• *King George County, Virginia* requires battery energy storage facilities to have access to water, provide access to the county fire department, have decommissioning plans, be labeled with NFPA 704 placards, and to not be visible from “any adjacent street, use or building.” *(King George County, Virginia Code of Ordinances § 4.19)* • *Madison, Maine* requires battery storage systems to be enclosed by a minimum eight-foot fence with a locking gate and feature a visible sign to warn of potential voltage hazards. *(Town of Madison, Maine Code of Ordinances § 484-41)*
Ordinances that incent or encourage energy storage development. Some municipal ordinances protect the right to install energy storage systems or use local building codes to add incentives for storage.	5	• *Lancaster, California* ensures that all residents and businesses are “permitted to construct and operate stand-alone electric energy systems,” including “fuel cell systems [and] battery systems.” *(City of Lancaster, California, Ordinance No. 1067)* • *Wilton Manors, Florida*’s “Green Building Design Option” system, written into its code of ordinances, requires new buildings to earn a minimum number of green building “points,” and allows on-site solar and storage systems to contribute to their total. *(Wilton Manors, Florida Code of Ordinances § 170-050).*

Each of these approaches has advantages and disadvantages. As Table 1 shows, the most commonly utilized approach to storage in local zoning ordinances has been to add energy storage to ordinances that were primarily crafted to regulate solar installations. Including energy storage in a new or existing zoning ordinance targeted at solar may be the fastest, least-resistance approach to placing some form of local oversight for energy storage projects on the book. These ordinances may also provide a means of addressing some of the community impacts of energy storage, such as sound and visual impacts.

However, as described above, energy storage technologies have unique risks that will likely fall outside of the scope of a solar-focused ordinance. Ensuring that storage systems installed in a jurisdiction have met applicable technical standards and that first responders are prepared to deal with an emergency are objectives that are unlikely to be satisfied by inserting energy storage into solar zoning ordinances.

Some local jurisdictions may have the authority to adopt national and international codes at the local level; this study identified 12 localities that have done so. While this approach provides the security of applying best industry safety practices to local energy storage projects, it is likely not viable for most jurisdictions. Fire and electrical code adoption are state-driven processes, and many states prohibit county and municipal bodies from exceeding state-adopted codes. Even where local officials have the authority to exceed state standards, their jurisdictions may become financially liable for any incremental requirements. This may present a significant financial risk, particularly for smaller localities.

Another 12 jurisdictions identified in this study have adopted ordinances that are specifically targeted at energy storage technologies, but do not include formal adoption of national or international fire or electrical codes. This approach presents a middle ground for local officials to address many of the potential impacts of energy storage developments, particularly for those that cannot implement current fire and electric codes. As the examples in the table show, these ordinances may address emergency response by requiring access to water at the facility, or may focus on visual and sound impacts by requiring projects to be screened from neighboring properties.

Finally, the study identified five jurisdictions that have taken some form of proactive step to encourage or incent local energy storage development, such as establishing a right for property owners to install it. While these policies may be a vehicle for aligning local zoning decisions with local, regional, or state energy policies and goals, they must be paired with more detailed ordinances if the potential community impacts of the desired energy storage investments are to be mitigated.

5.0 Summary

Energy storage technologies offer significant potential to make the electric grid more clean, flexible, and reliable. The rapidly accelerating investment in storage technologies by utilities, independent developers, and individual customers can deliver far-reaching benefits to all electric customers, and the development of a lithium-ion battery supply chain has rapidly driven down the cost of those investments. However, those same customers face unique risks when battery energy storage technologies are installed in their communities, and local planning and zoning officials face the momentous challenge of understanding and mitigating those risks in a rapidly developing and changing environment. As with any electrical device, batteries can and will occasionally fail. The goal for BESS is to isolate failures to the unit of origin with as minimal negative impact to the environment and population as possible.

Fortunately, local officials have tools at their disposal. Multiple codes and standards have been adopted at the national and international levels to guide safe installation and operation of battery energy storage technologies, and those codes are regularly updated as lessons are learned from a growing operational history for the technology. While implementation of those codes and standards will be beyond the authority of many local planning and zoning officials, a working knowledge of those codes and standards can help planners know what questions to ask during the review process to ensure peaceful coexistence between energy storage projects and the communities that host them.

By identifying the potential risks of battery energy storage and how those risks have been addressed in fire and electric codes as well as local zoning ordinances from around the country, this work may be useful to local planning and zoning officials who are tasked with responding to a proposed battery storage project in their jurisdiction in crafting project conditions and zoning ordinances that will enable the growth of these beneficial technologies while mitigating their risks to local residents.

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