

Building a Resilient Power Future with Battery Energy Storage Systems



Introduction

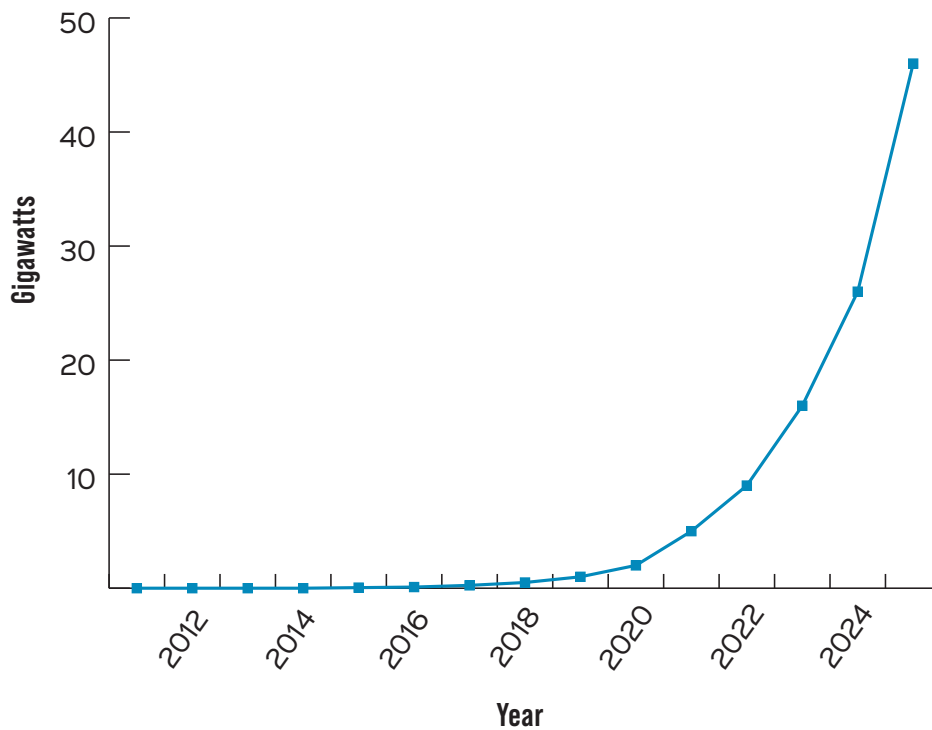
Battery energy storage systems (BESS) are transforming the ways in which electricity and the grid are managed. By storing energy for on-demand use, the systems stabilize the grid, maximize renewable energy integration, and offer quick responses to power disruptions.

The U.S. is witnessing a dramatic surge in BESS capacity. In 2023, 11.9 gigawatts (GW) of capacity was added, representing a 55% increase. In 2024

this jumped another 66% to more than 26 GW. This represents a five-fold expansion within just four years.^{1,2}

BESS can help capture electricity generated by wind and solar resources for later use, improving grid reliability and resiliency. The rapid expansion of BESS has led to an increasing number of state and local governments tasked with regulating the technology.

Figure 1. Cumulative U.S. utility-scale battery power capacity (2011-2025)³



Driven by falling costs and technological advances, the massive increase in BESS capacity has made these systems a key tool for stabilizing grid frequency by rapidly balancing supply and demand.

1 Jacobo, Jonathan Touriño, and JP Casey. "US Deployed 11.9 GW of BESS in 2024, 18.2 GW of Grid-Scale Additions Expected in 2025." Energy Storage News, Feb. 26, 2025, energy-storage.news/us-deployed-11-9gw-of-bess-in-2024-18-2gw-of-grid-scale-additions-expected-in-2025. Accessed November 2025.

2 "U.S. Battery Capacity Increased 66% in 2024." U.S. Energy Information Administration, March 12, 2025, eia.gov/todayinenergy/detail.php?id=647store05. Accessed November 2025.

3 Ibid.

Basics of battery energy storage systems

- BESS is a series of electro-chemical devices that collect and store excess electrical energy, produced from the grid or generating facility, to provide energy or grid services for later use.⁴
- Due to steep decreases in prices, lithium-ion batteries are used in the vast majority of grid-scale storage systems.⁵
- BESS play a crucial role in stabilizing the electrical grid and improving the reliability and power delivery through several factors.
 - » The primary use of BESS in the U.S. is to provide such grid service functions as frequency regulation on transmission lines to exactly match electricity supply with demand.⁶
 - » A growing use of BESS is long-term storage of utility-scale energy generation from wind and solar. This is done by storing excess energy produced, and releasing it as demand rises above generation, also known as electricity shifting. The need for “peaker plants,” power plants built to meet peak electricity demand is reduced, which in turn lowers overall electricity costs and eases the strain on the grid infrastructure.⁷
- The size of systems can range from small, residential units to large, grid-scale installations. Systems can be co-located with electric generation, like wind and solar.
 - » *Example: the Lansing Battery Storage project in Allamakee County, Iowa, which has a completion date of December 2026, is designed to have 150 megawatts (MW) of BESS.⁸ Alternatively, Decorah, Iowa, operates a smaller, 2.5 MW battery storage project designed to absorb excess customer-generated rooftop energy.⁹*



The Cedar Rapids Community Solar garden at Deer Run¹⁰

Location: Cedar Rapids, Iowa
Size: 5MW, 10MWh (Community-scale)
Commissioned: January 2022
Number of Battery Containers: 6
Number of Battery racks in each container: 6



Grant County solar project¹¹

Location: Potosi, Wisconsin
Size: 100 MW, 400MWh (Utility-Scale)
Commissioned: July 2025
Number of Battery Containers: 128
Number of Battery racks in each container: 5

4 Bowen, Thomas, et al. “Grid-Scale Battery Storage.” National Renewable Energy Laboratory, September 2019, docs.nrel.gov/docs/fy19osti/74426.pdf. Accessed November 2025.

5 Ibid.

6 Ibid.

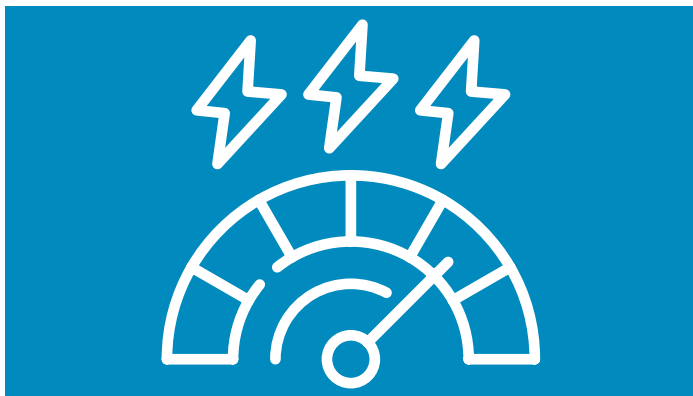
7 Ibid.

8 “Lansing Battery Energy Storage System.” Alliant Energy, 2025, alliantenergy.com/our-energy/energy-storage/lansing. Accessed November 2025.

9 Bunge, Mike. “Decorah Battery Project Goes Online, Called a ‘Model’ for America.” KIMT3 News, Dec. 2, 2021, kimt.com/news/iowa/decorah-battery-project-goes-online-called-a-model-for-america/article_444517a1-fc5e-58cc-ad1a-d9f281e8d212.html. Accessed November 2025.

10 Photo of Cedar Rapids Community Solar garden, provided by Alliant Energy, December 2025.

11 Photo of Grant County solar site, provided by Alliant Energy, December 2025.



Safety considerations and standards

- The primary safety issue lithium-ion batteries may encounter is thermal runaway, a condition where a battery cell located within a BESS overheats and leads to fires. While battery fires tend to be high-profile events, they are relatively rare when compared to the number of installations.
 - » *Example: The Electric Power Research Institute (EPRI) maintains a database of fires involving grid-connected BESS from media reporting sources. EPRI's database identified 14 incidents in the U.S. in 2023 with 491 large, utility-scale projects for a fire incidence rate of 2.9 percent.¹⁶ There has not been a single loss of life in the U.S. due to a BESS fire.¹⁷*
- To limit the potential for thermal runaway, developers of BESS are advised, or in some cases, required to follow specific standards such as UL 9540 and National Fire Protection Association (NFPA) 855.
- UL 9540 is the comprehensive, product safety standard for BESS to ensure the system is designed and built to minimize safety hazards, including the risks associated with thermal runaway.¹⁸
 - » The key purpose of this standard is to ensure all components work together safely and the system is designed to contain potential failures and prevent them from spreading.
 - » The standard requires system operators to monitor battery cells, detect anomalies like overheating or overcharging, and take appropriate actions to prevent thermal runaway.

System size and operation duration

- The duration of BESS operation depends on the system's size, specifically its energy capacity measured in megawatt-hours (MWh) and power rating measured in MW.¹²
 - » Systems designed primarily for grid services typically provide power for one to two hours, while systems designed for electricity shifting can provide power for four to eight hours at maximum capacity.¹³
 - » *Example: A 100 MW Battery Energy Storage System at maximum power can provide approximately 400 MWh of energy, for about 83,300 homes for four hours.¹⁴*
- The lifetime of the batteries is measured in cycles, which is the number of times the battery is fully charged and discharged, and in years.
 - » Modern lithium-ion batteries can last for 4,000 to 6,000 cycles and have an expected life-span of 10 years, with some batteries to last much longer.¹⁵

12 Linga, Vikram. "Duration of Utility-Scale Batteries Depends on How They're Used." U.S. Energy Information Administration, March 25, 2022, eia.gov/todayinenergy/detail.php?id=51798. Accessed November 2025.

13 Ibid.

14 "Use of Energy Explained, Energy Use in Homes." U.S. Energy Information Administration, Dec. 18, 2023, heia.gov/energyexplained/use-of-energy/electricity-use-in-homes.php. Accessed November 2025.

15 "Load Cycles and Useful Life in BESS." Pebblex Energy, Oct. 31, 2023, bepebblex.com/en/cycles-charge-useful-life-bess. Accessed November 2025.

16 Srinivasan, Lakshmi, et al. "Insights from EPRI's Battery Energy Storage Systems (BESS) Failure Incident Database." Electric Power Research Institute, May 2024, sandovalcountynm.gov/wp-content/uploads/2024/12/InsightsfromEPRI_sBatteryEnergyStorageSystems_BESS_FailureIncidentDatabase_AnalysisofFailureRootCause.pdf. Accessed November 2025.

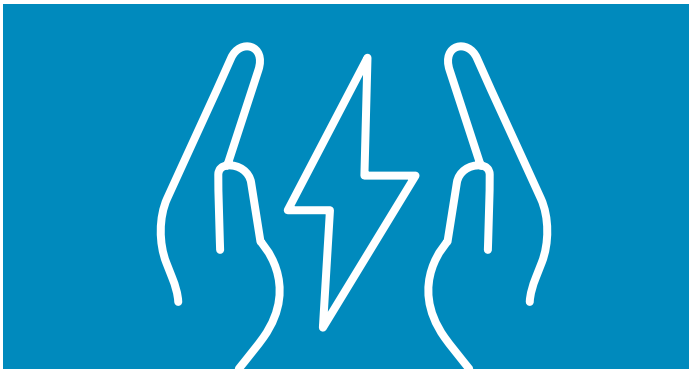
17 "Fact: No Deaths Have Resulted from Energy Storage Facilities in the United States." Advanced Power Alliance, Nov. 20, 2024, poweralliance.org/2024/11/20/fact-no-deaths-have-resulted-from-energy-storage-facilities-in-the-united-states. Accessed November 2025.

18 "Enhancing Energy Storage System Safety: Evolving Large-Scale Fire Test Methods and Regulatory Demands." Underwriters Laboratories Solutions, 2025, delivery-p133222-e1298791.adobe.com/adobe/assets/urn:aaid:aem:df221993-67aa-4d67-8660-20bdab933b75/original/as/Largescalefirewhitepaper.pdf. Accessed November 2025.



Safety considerations and standards, continued

- The NFPA 855, Standard for the Installation of Stationary Energy Storage Systems, focuses on installation to reduce the overall risks presented by thermal runaway. NFPA 855 requires any BESS device over 20 kilowatt-hours (kWh) to be certified to standards laid out in UL 9540 and UL 9540A.
 - » The standard outlines proper clearance and separation from other structures and mandatory requirements, and explains key safety features such as a hazard mitigation analysis, an emergency response plan, and details of all safety systems.
 - » Additionally, the standard requires proper battery management systems to monitor temperature, voltage, and state of charge.
 - » UL 9540A is a test where thermal runaway is intentionally created to guide design features to contain battery failures.
- The NFPA 855 standard has been adopted statewide in Washington, Michigan, Indiana, New York, Massachusetts, Maryland, and Connecticut. It is being considered in Texas, California, Colorado, Iowa, Illinois, and Virginia.¹⁹



Considerations for battery energy storage system ordinances

Local decision makers may be tasked with enacting ordinances to regulate the siting and permitting of BESS. Some key topics that should be considered include definitions, siting and zoning standards, safety and emergency plans, and decommissioning.

Definitions^{20,21}

- Ordinances should define “battery energy storage system” and other key terms so the type of battery system and its regulated use are clearly defined and applied consistently.

Siting standards^{22,23,24}

- Setback distances may vary depending on system size or zone (for example, setbacks may differ between systems in residential vs. industrial zones). A common setback is 50 to 150 feet from property lines. Additionally, NFPA 855 includes setbacks and buffer requirements.
- Decision makers may choose to vary requirements based on system size or tier.
- Site design such as noise, visual impact, fencing, lighting, and signage may be addressed.

Zoning districts and permitted use²⁵

- Ordinances should define the districts where BESS are permitted or conditional, and where BESS are primary or accessory uses that can be co-located with electric generation, like wind and solar, or near substations.

19 “Battery Energy Storage: Commitment to Safety and Reliability.” American Clean Power, 2025, cleanpower.org/wp-content/uploads/gateway/2025/03/ACP_BatteryEnergyStorageCommitmenttoSafety_FactSheet_0306-1.pdf. Accessed November 2025.

20 Ross, Brian, and Monika Vadali. “Zoning Practice: Battery Energy Storage Systems.” American Planning Association, March 2024, planning-org-uploaded-media.s3.amazonaws.com/publication/download_pdf/Zoning-Practice-2024-03.pdf. Accessed November 2025.

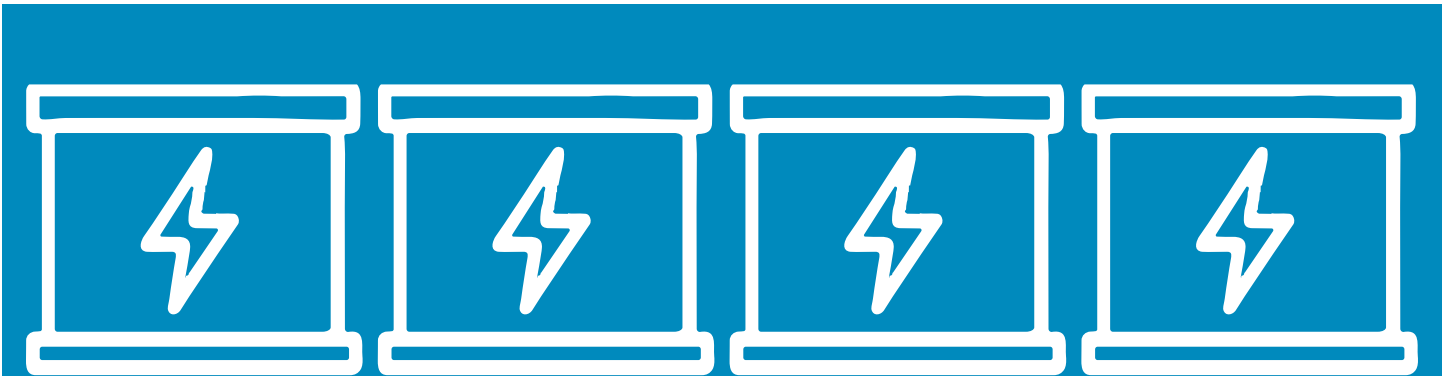
21 Powell, Devyn W., and Jeremy B. Twitchell. “An Overview of Local Zoning Ordinances for Battery Energy Storage Systems.” Pacific Northwest National Laboratory, Oct. 9, 2023, sandia.gov/app/uploads/sites/82/2023/10/Powell_Devyn_Policy_PR2023.pdf. Accessed November 2025.

22 Ibid.

23 “Model Ordinance: Utility-Scale Battery Energy Storage Systems.” American Clean Power, cleanpower.org/wp-content/uploads/gateway/2024/06/BESS-Model-Ordinance.pdf. Accessed November 2025.

24 Ross, Brian, and Monika Vadali. “Zoning Practice: Battery Energy Storage Systems.” American Planning Association, March 2024, planning-org-uploaded-media.s3.amazonaws.com/publication/download_pdf/Zoning-Practice-2024-03.pdf. Accessed November 2025.

25 Ibid.



Considerations for battery energy storage system ordinances, continued

Emergency and safety^{26,27}

- Officials are advised to require compliance with the most recent version of NFPA 855, which provides the most up-to-date comprehensive requirements for the design, installation, and operation of BESS to minimize fire and other hazards.
- Emergency response plan: A detailed plan as part of the BESS permit application process may include items such as:
 - » Requiring BESS owners to provide training to local fire departments in the event of thermal runaway;
 - » Facility layout and access points for emergency responders;
 - » Procedures for responding to various emergencies, such as emergency shutdown procedures; or
 - » Contact information for project operators, including a 24-hour emergency number.

Decommissioning²⁸

- Decision makers should include provisions for decommissioning of projects, which include standards for site restoration and a plan for financial surety.

26 “Model Ordinance: Utility-Scale Battery Energy Storage Systems.” American Clean Power, cleanpower.org/wp-content/uploads/gateway/2024/06/BESS-Model-Ordinance.pdf. Accessed November 2025.

27 Bowen, Thomas, et al. “Grid-Scale Battery Storage.” National Energy Renewable Laboratory, September 2019, docs.nrel.gov/docs/fy19osti/74426.pdf. Accessed November 2025.

28 “Model Ordinance: Utility-Scale Battery Energy Storage Systems.” American Clean Power, cleanpower.org/wp-content/uploads/gateway/2024/06/BESS-Model-Ordinance.pdf. Accessed November 2025.