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Battery Energy Storage System Deployment: Local and State Policy Considerations

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EXECUTIVE SUMMARY

The deployment of battery energy storage systems (BESS) is growing throughout the United States, driven by falling prices and the rise in variable renewable resources on the power grid. Utility-scale BESS can enhance grid reliability and balance periods of high renewable energy generation with periods of peak electricity demand. Despite the growth in BESS deployment, many states and localities lack policies for regulating battery storage systems. This report outlines key considerations and recommendations for policymakers preparing for BESS development. States and municipal governments should clarify which entities hold siting authority, develop safety guidance, adopt updated fire codes, build pathways for meaningful community input, and determine how BESS fits within current fiscal policy.

Key Findings

States and municipalities should clarify which entities hold siting authority, develop safety guidance, adopt updated fire codes, build pathways for meaningful community input, and determine how BESS fits within current fiscal policy.

BESS help improve electric reliability and increase grid flexibility as they can charge and discharge rapidly.[19] Further, BESS can provide ancillary services—specifically frequency regulation and voltage support to transmission systems—and can help the grid come back online in the event of a large-scale outage.[20]

To mitigate fire concerns, states and localities should make sure the most recent fire codes are in place, since only newer codes address BESS. Also, ensuring fire departments have the needed resources and first responders receive timely training will protect communities.

Taxes can generate revenue for local governments, while tax breaks and exemptions can also attract developers. The type of exemption will also matter for local governments as hosting BESS poses a significant economic development opportunity.

BACKGROUND

Overview of Storage Technology

Energy storage is not a new phenomenon, given the early history of harnessing power through water wheels and mill ponds, but in recent years, storage has gained increased attention with advancements in battery technologies, along with the growing use of renewables, necessitating a way to store power.[1] While there are multiple types of energy storage technologies, including pumped hydroelectric, compressed air, flywheels, and thermal systems,[2] utility-scale battery storage is currently dominated by lithium-ion technologies which account for well over 90% of the batteries installed in the US.[3] BESS are modular and range in size from a power wall in a garage storing excess generation from rooftop solar to large utility-scale installations.[4] Thus they can be either on the customer side of the meter or interconnected with the transmission and distribution systems.

In addition to lithium-ion batteries, less common battery technologies include flow batteries, lead acid, and sodium-based chemistries.[5] Lithium-ion batteries, first commercialized in 1991, boast a high energy density, quick response time, and high roundtrip efficiency, meaning they can charge and discharge while losing less energy.[6] They effectively provide short-duration storage (between 4–10 hours), but are less cost-effective for longer-duration needs.[7] However, with continued technological innovation, changing grid needs, and the goal of decarbonization, there is a larger role for longer-duration storage going forward.[8] Flow batteries—presently a far less mature technology—could become an effective longer-duration storage solution in the future.[9]

Cost Declines and Growth in Utility-Scale Storage Deployment

Battery price declines, in conjunction with the rise in renewable energy adoption, are driving rapid growth in energy storage systems. In the 2010s, storage costs dropped by almost 90%.[10] While lithium-ion battery pack prices temporarily increased from 2021 to 2022, due to inflation and rising costs of raw materials and battery components, they fell even more between 2022–2023, landing at a record low of $139/kWh.[11] These declines are the result of research and development initiatives and increased manufacturing capacity for the electric vehicle sector, which also relies on lithium-ion batteries and their efforts to become cost-competitive.[12]

BESS deployment has grown rapidly over the past decade, bolstered by cost declines. Between 2014 and 2022, large-scale battery power capacity increased from around 180 MW to over 9,000 MW, making batteries (specifically lithium-ion technologies) the fastest-growing utility-scale storage technology.[13] Between 2020 and 2021, the cumulative power capacity more than tripled,[14] and by the end of 2023, planned and operational utility-scale battery storage power capacity totaled close to 16 GW (16,000 MW).[15] For context regarding energy, battery storage capacity was 22,385 MWh in 2022, and the average U.S. household uses around 10,791 kWh (10.791 MWh) annually.[16] Growth trends are anticipated to continue with another 15 GW expected in 2024. By the end of 2023, around 500 GW of stand-alone storage projects (99% BESS) had applied and started the required studies to connect to the grid, joining the interconnection queue.[17] Specifically, between 2023 and 2027, around 73 GW of large-scale storage projects are looking to connect to the grid, though not all of these will necessarily be built.[18]

Battery Storage: Grid Benefits and Renewable Energy Integration

BESS help improve electric reliability and increase grid flexibility, as they can charge and discharge rapidly.[19] Further, BESS can provide ancillary services, specifically frequency regulation and voltage support, to transmission systems and can help the grid come back online in the event of a large-scale outage.[20]

BESS also help effectively integrate variable renewable energy resources like wind and solar.[21] Intermittent generation from renewables does not always match up with periods of high customer demand, causing challenges in transitioning away from fossil fuels. For example, solar generation is usually highest at midday, and wind power is highest at night and during the spring.[22] As a result, renewable energy peak generation might not sync up with periods of high electricity usage. Storage can help balance periods of high renewable energy generation with customer demand, as BESS can store energy from periods of high renewable energy generation and make it available during peak demand periods.[23] Over 20% of US electricity comes from renewable sources (including wind, solar, hydroelectric, geothermal, and biomass), and it is the fastest-growing energy source in the country, increasing by 42% between 2010 and 2020.[24] Additionally, many states and localities have created greenhouse gas reduction targets to address the climate crisis. According to a 2023 report by Lawrence Berkeley National Laboratory, 29 states and the District of Columbia have renewable portfolio standards (RPS), laws that require that a certain percentage of electricity sold by utilities comes from renewable or alternative clean energy sources, and 15 states have established a 100% clean energy standard (usually in combination with the RPS).[25] BESS can help integrate these renewables and smooth demand, playing an essential role in meeting these targets.

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CONCERNS: SYSTEM SAFETY AND MINING

Fire and Explosion Risk and Mitigation Measures

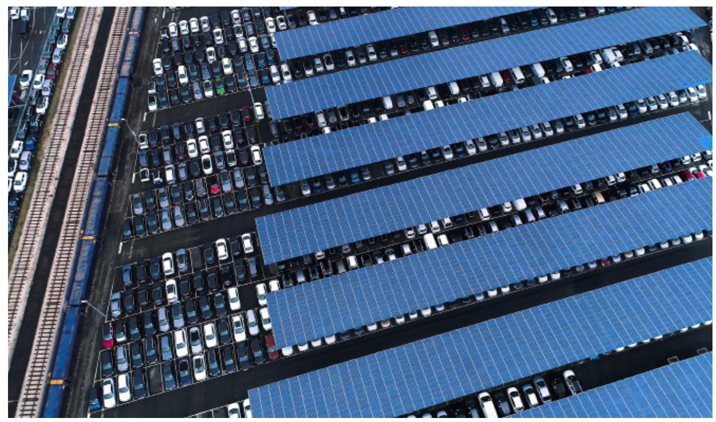
Not uncommon with new technologies, there are some safety concerns with BESS. With the high energy density of lithium-ion batteries, there is a risk of fire and explosion, as they are susceptible to thermal runaway, an irreversible chemical reaction within the battery that can result from overheating, short-circuiting, overcharging, manufacturing defects, and other forms of damage.[26] The heat generated can also cause neighboring cells to enter thermal runaway.[27] When critical temperatures are reached, it can cause the release of flammable gasses and excess energy, sometimes resulting in fires and explosions.[28] To mitigate risk, BESS are equipped with a range of evolving safety technology, including detection technology (e.g., gas, smoke, flame), alarm systems, ventilation systems, and fire suppression systems, to minimize thermal runaway's spreading to multiple cells.[29] They are also usually required to have an emergency operations plan that includes pertinent information about the system for local authorities and first responders.[30] According to a report by Pacific Northwest National Laboratory (PNNL), the fire incidence rate is close to 2.9% for battery energy storage facilities, which is high for energy utilities.[31] Most of the fires occurred at facilities that were less than two years old.[32] With 80% of the utility-scale batteries on the grid installed within the last couple of years, and BESS deployment continuing to grow, the absolute number of fires will likely rise.[33] While some safety emergencies received significant media attention, the rate of incidents has decreased.[34] There is ongoing research to evaluate and mitigate these risks.[25] With rapid growth and advances in technology, batteries today are already safer than ones from just a few years ago, and we can expect future improvements.[36] Policymakers can also actively address safety issues through adopting updated fire codes and developing comprehensive siting and permitting guidance.

Mining Considerations

Battery storage technologies require mined minerals, resulting in upstream environmental and social implications. Beyond lithium, batteries rely on other metals including cobalt, a critical mineral with significant justice concerns related to global mining operations.[37] The United States also relies heavily on global supply chains, as it produces <2% of the raw materials currently used in lithium-ion battery production.[38] Mining also causes environmental degradation. Leveraging storage to displace fossil fuels can lessen pollution burdens on historically disadvantaged communities in the US.[39] However, it is essential that policymakers consider the mining impacts on the environment and disadvantaged communities around the world and invest in recycling initiatives and technologies that are less reliant on minerals that have grave social and environmental impacts.

CONSIDERATIONS AND RECOMMENDATIONS FOR POLICYMAKERS ON UTILITY-SCALE BESS DEPLOYMENT

Despite current and anticipated rapid growth in BESS deployment, state and local policy has not kept pace, with many states and localities lacking specific energy storage siting guidance.[40] Thus in many states, there is an urgent need for guidance and resources to allow for the safe siting and operation of BESS. The deployment of BESS is also being handled in varying ways across the country, with some states giving siting authority to statewide entities and others leaving the decisions to local governments. Policymakers must start by evaluating their state's current renewable energy and storage policies to identify gaps and barriers to BESS deployment. They must also address local community emergency preparedness and consider fire codes, siting and zoning guidance, fiscal policy, and community engagement.



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Assess Current Renewable Energy and Storage Policies Locally and Identify Gaps and Challenges

Policymakers must understand BESS technology and the storage policy landscape in a given state. Some states have policies in place that drive storage development, ranging from the inclusion of storage in renewable portfolio standards or clean energy standards to explicit stand-alone storage mandates.[41] As of November 2023, 12 states had targets for utility-scale storage.[42] New York is currently leading the way with the nation's most aggressive target of 6 GW by 2030.[43] Connecticut and Nevada both have targets of 1,000 MWs by 2030, and Michigan has a target of 2,500 MW, also by 2030.[44] California has met its 1,325 MW target and is now looking to focus on the deployment of longer-duration technologies (8+ hours).[45]

Policymakers need to assess the current policy landscape which dictates whether a state needs mandates, targets, regulatory changes, or other incentive structures to drive storage development.[46] Alternatively, if development is already on the horizon, the focus should be on ensuring safe development and interconnection. It is also essential to understand the role of agencies, like the public utility commission, in determining exact storage targets through updating regulatory processes to account for storage benefits (e.g., how storage is incorporated in utility integrated resource plans), developing storage guidance and pilot programs, and making siting decisions.[47] Another consideration is barriers to deployment related to the independent system operator (ISO) or regional transmission organization (RTO), which range from interconnection delays to improperly valuing storage benefits (e.g., transmission) beyond generation.[48]

Fire Safety: Fire Codes and First Responder Training

To mitigate fire concerns, states and localities should ensure that the most recent fire codes are in place, since only newer codes address BESS. If not already in effect, they should promptly begin the adoption process, as it can take several years.[49] Codes are typically adopted at the state level, even though in some states, localities can adopt codes that are more stringent than the statewide code.[50] To mitigate risks, codes govern BESS design, siting, installation, and operation requirements.[51] The International Code Council (ICC) and National Fire Protection Association (NFPA), non-profit code development organizations that release updated codes roughly every three years, both have chapters on BESS in their current versions.[52] This is a significant change, as the 2015 IFC did not include storage guidance, and the 2018 version has far less extensive storage guidance,[53] demonstrating the importance of adopting the most recent codes.

Furthermore, the communities that host BESS must make sure that their fire departments are adequately resourced and able to respond in the case of an incident. First responders must also receive adequate information and training on energy storage system emergencies. The current version of NFPA 855 mandates first responder training. However, an evaluation conducted by GAO in 2023, including stakeholder interviews, shed light on the reality that local jurisdictions, emergency responders, and even installers do not completely understand hazards unique to BESS and the best ways to address them. Fire safety training is often not available, and the suppression systems are at times inadequate.[54] Ensuring that fire departments have the needed resources and first responders receive timely training will protect communities.

Roles of State and Local Governments: Siting Authority, Storage Guidance Development, and Community Engagement Strategies

Siting authority for utility-scale storage projects can be held at the state or local level. The laws in a given state will dictate which entities are responsible for authorizing projects, providing guidance, engaging the public, and ensuring the codes are in place to allow for the safe operation of BESS. Regardless of whether a state decides to centralize the siting process or leave it to municipalities, which entity holds this decision-making authority should be clear to communities, utilities, and developers.

Placing siting authority with a statewide agency can streamline the storage siting process. However, it can also reduce opportunities for input from impacted communities.[55] For example, California, Connecticut, Vermont, and Michigan, have given a statewide agency siting authority over certain BESS projects, particularly larger-scale projects, instead of leaving all siting decisions

to municipalities.[56] If states are considering centralizing siting authority, policymakers should ensure that the designated statewide agency has the necessary resources and expertise before adoption. Additionally, they should ensure that centralization does not diminish community engagement opportunities.

Even in states where siting authority is left to local governments, the state still has an important role to play in helping municipalities prepare for BESS. States can create standardized guidance for municipalities and make sure that they have adequate resources to site BESS safely. For example, the New York State Energy Research and Development Authority (NYSERDA) has developed robust BESS siting guidance for local governments. Their guidebook provides detailed instructions for localities considering BESS and includes a model law and permit.[57] Other states should consider developing guidance that helps local governments safely site BESS.

If not preempted by state law, municipal zoning ordinances are another way localities can better integrate

BESS development and address community impacts. Local governments can also use setbacks and screening requirements to lessen the noise and visual impacts of BESS.[58] For example, while the NFPA requires that BESS be 10 feet from other buildings and lot lines,[59] governments can require larger buffers for BESS in their zoning ordinances. Most communities, however, have not yet considered BESS in their zoning. A PNNL survey specifically targeting energy storage technologies identified only 12 county or municipal ordinances in the United States with regulations specifically addressing energy storage technologies.[60] This demonstrates that this is an area where rapid growth is needed.

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Community engagement is an essential aspect of the considerations outlined above. Whether siting decisions are made at the state or local level, the authorizing entity must ensure robust and accessible opportunities for community engagement. For localities to safely and successfully host BESS, advancing a transition to clean energy, communities must be involved in the siting process, receive financial benefits, and have adequate safety mitigation measures. Without meaningful public engagement in siting, states and localities risk slowing down the BESS deployment process.[61] To meaningfully include communities in the BESS siting decision-making process, policymakers must create robust pathways to continually invite the public into the process from the outset and build trust with communities, especially those disproportionately impacted by the energy system.[62]

This will require governments to allocate resources to work with practitioners who specialize in community engagement.[63]

Taxation and Fiscal Policy

A large part of the current conversation around taxes and energy storage relates to federal tax cuts to drive storage development, but another important component is how state and local property, sales, and use taxes are applied to BESS. Taxes can generate revenue for local governments, while tax breaks and exemptions can also attract developers. The type of exemption will also matter for local governments, as hosting BESS poses a significant economic development opportunity. For example, if it includes a payment in lieu of taxes (PILOT) beyond just an exemption, host communities will see more revenue.[64] Striking a balance between ensuring community benefits and incentivizing BESS development is a key consideration for state and local governments.[65]

Many states have tax breaks for alternative generation facilities, largely wind and solar,[66] but it is often unclear how BESS fits within many of these definitions.[67] Some states do not treat BESS as a "generation" resource or include it in their definition of renewable resources, leaving it outside of certain renewable energy policies, unless it is co-located with another form of generation (e.g., solar). According to the Solar Energy Industries Association, around 36 states offer some level of property tax exemption for solar energy, and 25 states offer sales tax exemptions.[68] Policymakers must clarify where BESS fits in their locality's tax code and guarantee compensation for communities.

SUMMARY OF POLICY RECOMMENDATIONS

Battery storage is a new and changing landscape in many respects, but as the technology continues to evolve, there are principles and recommendations states and local governments can follow when siting BESS. The following recommendations are based on the best available information at this time and address the key considerations for policymakers outlined above:

- **Assess state targets and context:** Policymakers should first assess current state renewable energy and specific storage targets, utility IRP guidance and RTO policies, and market barriers to renewables to understand what resources communities need and on what timeline.

- **Update fire codes:** States and municipalities (if relevant) should quickly adopt the most recent version of relevant fire codes (e.g., NFPA 855) and subsequent versions as they are released.
- **Build fire safety capacity:** Policymakers should monitor emerging best practices around fire safety and ensure that localities have the capacity and resources to address BESS emergencies. This includes, but is not limited to, adequate emergency responder training, adequate safety training for local fire departments, a comprehensive emergency response plan for BESS, and a nearby fire department with sufficient equipment.
- **Determine siting authority:** Policymakers need to determine and clarify what entity holds siting authority, whether at the state or local level, and then ensure the designated entity has adequate resources to make informed decisions, engage the public (focusing on host communities and historically marginalized populations), and address community concerns. If not preempted by state law, local governments (or localities) should update zoning ordinances to include BESS guidance that aligns with siting guidance and community input.
- **Review and update tax code:** States and/or localities with authority should evaluate how fiscal policy impacts BESS, with an emphasis on reviewing and updating their tax code. States must ensure that host communities see financial benefits.

ENDNOTES

1. International Code Council, Inc., "Energy Storage Systems: Based on the IBC, IFC, IRC and NEC," 2022, 1-2, https://www.iccsafe.org/wp-content/uploads/Energy-Storage-Systems-Book_FINAL.pdf.
2. International Code Council, Inc., "Energy Storage Systems," 13-19.
3. PNNL, "Types of Batteries," Pacific Northwest National Laboratory (PNNL), accessed May 16, 2024, https://www.pnnl.gov/explainer-articles/types-batteries; "Form EIA-860 Detailed Data with Previous Form Data (EIA-860A/860B)," accessed May 10, 2024, https://www.eia.gov/electricity/data/eia860/.
4. Jeremy Twitchell, Devyn Powell, and Matthew Paiss, "Energy Storage in Local Zoning Ordinances," October 1, 2023, 2, 4, https://doi.org/10.2172/2204502.
5. Matthew D. Paiss et al., "Study of Codes & Standards for Energy Storage Systems: A Report to Congress," Pacific Northwest National Laboratory (PNNL), Richland, WA (United States), March 1, 2022, 2, https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-32789.pdf?__hstc=249664665.5deb355fa38549dd4c66494b6fce975d.1718743343001.1718743343001.1718743343001.1&__hssc=249664665.2.1718743343001&__hsfp=3523199817; International Code Council, Inc., "Energy Storage Systems," 19; U.S. Government Accountability Office, "Utility-Scale Energy Storage: Technologies and Challenges for an Evolving Grid," (GAO-23-105583), March 30, 2023, 18, 22-23, https://www.gao.gov/products/gao-23-105583.
6. U.S. Government Accountability Office, "Utility-Scale Energy Storage," 9, 24–25.
7. U.S. Government Accountability Office, "Utility-Scale Energy Storage," 24, 26.
8. Courtney Stenson, "Long-Duration Energy Storage: The Time Is Now," Pacific Northwest National Laboratory (PNNL), May 25, 2023, https://www.pnnl.gov/news-media/long-duration-energy-storage-time-now; Jeremy Twitchell, Kyle DeSomber, and Dhruv Bhatnagar, "Defining Long Duration Energy Storage," Journal of Energy Storage 60 (April 1, 2023): 105787, https://doi.org/10.1016/j.est.2022.105787.
9. U.S. Government Accountability Office, "Utility-Scale Energy Storage," 27-29, 37.
10. Chernyakhovskiy et al., "USAID Energy Storage Decision Guide for Policymakers" (National Renewable Energy Laboratory, July 1, 2021), vii, https://www.nrel.gov/docs/fy21osti/78815.pdf (citing "Battery Pack Prices Cited Below $100/kWh for the First Time in 2020, While Market Average Sits at $137/kWh," BloombergNEF, BloombergNEF (blog), December 16, 2020, https://about.bnef.com/blog/battery-pack-prices-cited-below-100-kwh-for-the-first-time-in-2020-while-market-average-sits-at-137-kwh/.
11. Evelina Stoikou, "Battery Prices Are Falling Again as Raw Material Costs Drop," Bloomberg, November 26, 2023, https://www.bloomberg.com/news/articles/2023-11-26/battery-prices-are-falling-again-as-raw-material-costs-drop; "Lithium-Ion Battery Pack Prices Hit Record Low of $139/kWh," BloombergNEF (blog), November 26, 2023, https://about.bnef.com/blog/lithium-ion-battery-pack-prices-hit-record-low-of-139-kwh/; "Lithium-Ion Battery Pack Prices Rise for First Time to an Average of $151/kWh," BloombergNEF (blog), December 6, 2022, https://about.bnef.com/blog/lithium-ion-battery-pack-prices-rise-for-first-time-to-an-average-of-151-kwh/.
12. Chernyakhovskiy et al., "Energy Storage Decision Guide," vii; Mariko Geronimo Aydin and Cevat Onur Aydin, "California Public Utilities Commission Energy Storage Procurement Study" (Lumen Energy Strategy, LLC. Prepared for the California Public Utilities Commission, May 31, 2023), 21 https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/energy-storage/2023-05-31_lumen_energy-storage-procurement-study-report.pdf.
13. U.S. Government Accountability Office, "Utility-Scale Energy Storage," 22; "Battery Storage in the United States: An Update on Market Trends," U.S. Energy Information Administration, July 24, 2023, https://www.eia.gov/analysis/studies/electricity/batterystorage/; "Form EIA-860 Detailed Data with Previous Form Data (EIA-860A/860B)," accessed May 10, 2024, https://www.eia.gov/electricity/data/eia860/.
14. "Battery Storage in the United States: An Update on Market Trends," U.S. Energy Information Administration, July 24, 2023, https://www.eia.gov/analysis/studies/electricity/batterystorage/.
15. Katherine Antonio and Alex Mey, "U.S. Battery Storage Capacity Expected to Nearly Double in 2024," U.S. Energy Information Administration, accessed March 8, 2024, https://www.eia.gov/todayinenergy/detail.php?id=61202.
16. "Battery Storage in the United States: An Update on Market Trends," U.S. Energy Information Administration, July 24, 2023, https://www.eia.gov/analysis/studies/electricity/batterystorage/; "Frequently Asked Questions (FAQs)," U.S. Energy Information Administration, accessed June 16, 2024, https://www.eia.gov/tools/faqs/faq.php.
17. Joseph Rand et al., "Queued Up: 2024 Edition: Characteristics of Power Plants Seeking Transmission Interconnection As of the End of 2023" (Lawrence Berkeley National Laboratory, April 2024), https://eta-publications.lbl.gov/sites/default/files/queued_up_2024_edition_r2.pdf.
18. Paiss et al., "Study of Codes & Standards," 1.
19. Thomas Bowen, Ilya Chernyakhovskiy, and Paul Denholm, "Grid-Scale Battery Storage: Frequently Asked Questions" (National Renewable Energy Laboratory, September 2019), https://www.nrel.gov/docs/fy19osti/74426.pdf.

20. Thomas Bowen, Ilya Chernyakhovskiy, and Paul Denholm, "Grid-Scale Battery Storage"; The Cadmus Group, "Solar + Storage: A Guide for Local Governments" (SolSmart, June 25, 2019), 2-4, https://solsmart.org/wp-content/uploads/imported-files/SolSmart_SolarPlusStorage_Guide_06-25-2019.pdf; Renewables Grid Initiative, "Energy Storage: Perspectives from California and Europe" (California ISO, October 2019), 7-8, https://www.caiso.com/Documents/EnergyStorage-PerspectivesFromCalifornia-Europe.pdf.

21. The Cadmus Group, "Solar + Storage, 2;" Renewables Grid Initiative, "Energy Storage," 7.

22. "Solar Integration: Solar Energy and Storage Basics," Energy.gov, accessed June 16, 2024, https://www.energy.gov/eere/solar/solar-integration-solar-energy-and-storage-basics; "Wind Generation Seasonal Patterns Vary across the United States," U.S. Energy Information Administration, February 25, 2015, https://www.eia.gov/todayinenergy/detail.php?id=20112; "As Solar Capacity Grows, Duck Curves Are Getting Deeper in California," U.S. Energy Information Administration (EIA), June 21, 2023, https://www.eia.gov/todayinenergy/detail.php?id=56880; Dan Tong et al., "Geophysical Constraints on the Reliability of Solar and Wind Power Worldwide," Nature Communications 12, no. 1 (October 22, 2021): 6146, https://doi.org/10.1038/s41467-021-26355-z.

23. Thomas Bowen et al., "Grid-Scale Battery Storage," 2; The Cadmus Group, "Solar + Storage," 2.

24. "Renewable Energy," U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy, accessed May 11, 2024, https://www.energy.gov/eere/renewable-energy; "Renewable Energy," Center for Climate and Energy Solutions, Center for Climate and Energy Solutions, accessed May 11, 2024, https://www.c2es.org/content/renewable-energy/.

25. Galen L. Barbose, "U.S. State Renewables Portfolio & Clean Electricity Standards: 2023 Status Update" (Lawrence Berkeley National Laboratory, June 2023), https://emp.lbl.gov/publications/us-state-renewables-portfolio-clean.

26. International Code Council, Inc., "Energy Storage Systems," 12, 35-36; U.S. Government Accountability Office, "Utility-Scale Energy Storage," 25; Jeremy Twitchell, Devyn Powell, and Matthew Paiss, "Energy Storage in Local Zoning Ordinances" (Pacific Northwest National Laboratory, October 1, 2023), https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-34462.pdf; "PNNL Invention Reduces Risk of Battery Explosions."

27. International Code Council, Inc., "Energy Storage Systems," 36.

28. International Code Council, Inc., "Energy Storage Systems," 35; U.S. Government Accountability Office, "Utility-Scale Energy Storage," 25; Twitchell, Powell, and Paiss, "Local Zoning Ordinances," 4; "PNNL Invention Reduces Risk of Battery Explosions."

29. International Code Council, Inc., "Energy Storage Systems," 35; U.S. Government Accountability Office, "Utility-Scale Energy Storage," 25; "PNNL Invention Reduces Risk of Battery Explosions."

30. International Code Council, Inc., "Energy Storage Systems," 50.

31. Twitchell, Powell, and Paiss, "Local Zoning Ordinances," 4.

32. Twitchell, Powell, and Paiss, "Local Zoning Ordinances," 5.

33. Twitchell, Powell, and Paiss, "Local Zoning Ordinances," 5.

34. Twitchell, Powell, and Paiss, "Local Zoning Ordinances, 4-5"; EPRI, TWAICE, and PNNL, "Insights from EPRI's Battery Energy Storage Systems (BESS) Failure Incident Database: Analysis of Failure Root Cause" (EPRI, 2024), https://www.epri.com/research/products/000000003002030360.

35. Paiss et al., "Expert Panel: Code-Compliant Fire and Explosion Protection," https://www.youtube.com/watch?v=vyR6R4Q3v28.

36. International Code Council, Inc., "Energy Storage Systems," 35.

37. Jeremy Richardson, "How to Ensure Energy Storage Policies Are Equitable" (Union of Concerned Scientists, November 2019), https://www.ucsusa.org/sites/default/files/2019-11/Ensure-Energy-Storage-Policies-Equitable-Brief.pdf.

38. Margaret Mann, Vicky Putsche, and Benjamin Shrager, "Grid Energy Storage: Supply Chain Deep Dive Assessment" (U.S. Department of Energy, February 24, 2022), 17, https://www.energy.gov/sites/default/files/2022-02/Energy%20Storage%20Supply%20Chain%20Report%20-%20final.pdf.

39. Bethel Tarekegne et al., "Analysis of Energy Justice and Equity Impacts from Replacing Peaker Plants with Energy Storage" (2022 IEEE Electrical Energy Storage Application and Technologies Conference (EESAT), Austin, TX, USA: IEEE, 2022), https://doi.org/10.1109/EESAT55007.2022.9998034.

40. Twitchell, Powell, and Paiss, "Local Zoning Ordinances," 14-17.

41. "Energy Storage Policy Database," Pacific Northwest National Laboratory, accessed May 13, 2024, https://energystorage.pnnl.gov/

regulatoryactivities.asp.

42. California, Connecticut, Illinois, Maine, Maryland, Massachusetts, Michigan, Nevada, New Jersey, New York, Oregon and Virginia, PNNL Storage Policy Database; Tony Lenoir and Aude Marjolin, "Charging up on Battery Energy Storage 101, US Market Outlook," S&P Global Market Intelligence, April 5, 2023, https://www.spglobal.com/marketintelligence/en/news-insights/research/charging-up-on-battery-energy-storage-101-us-market-outlook; Andy Colthorpe, "Michigan's New 2.5GW Energy Storage Target Sets Pace for US Midwest Clean Energy Transition," Energy-Storage.News, November 29, 2023, https://www.energy-storage.news/michigans-new-2-5gw-energy-storage-target-sets-pace-for-us-midwest-clean-energy-transition/; Ryan Kennedy, "Maryland Passes Energy Storage Target of 3 GW in 10 Years," Pv Magazine USA, April 11, 2023, https://pv-magazine-usa.com/2023/04/11/maryland-passes-energy-storage-target-of-3-gw-in-10-years/.

43. Jason Plautz, "As States Ramp up Storage Targets, Policy Maneuvering Becomes Key," Utility Dive, February 8, 2022, https://www.utilitydive.com/news/as-states-ramp-up-storage-targets-policy-maneuvering-becomes-key/618218/; Colthorpe, "Michigan's 2.5GW Target Sets Pace for US Midwest Clean Energy Transition."

44. Plautz, "As States Ramp up Storage Targets, Policy Maneuvering Becomes Key"; Colthorpe, "Michigan's 2.5GW Target."

45. Will McNamara, Howard Passell, and Todd Olinsky-Paul, "States Energy Storage Policy: Best Practices for Decarbonization" (Sandia National Laboratories and Clean Energy States Alliances, February 2023), https://www.cesa.org/wp-content/uploads/State-Energy-Storage-Policy-Best-Practices-for-Decarbonization.pdf.

46. Jeremy Twitchell, "A Review of State-Level Policies on Electrical Energy Storage," Current Sustainable/Renewable Energy Reports 6, no. 2 (June 1, 2019): 35–41, https://doi.org/10.1007/s40518-019-00128-1.

47. Twitchell, "Review of State-Level Policies"; Plautz, "Policy Maneuvering Becomes Key."

48. Joseph Rand et al., "Queued Up: 2024 Edition: Characteristics of Power Plants Seeking Transmission Interconnection As of the End of 2023" (Lawrence Berkeley National Laboratory, April 2024), https://eta-publications.lbl.gov/sites/default/files/queued_up_2024_edition_r2.pdf; Jeff St. John, "'Enormous Step' for Energy Storage as Court Upholds FERC Order 841, Opening Wholesale Markets," Greentech Media, July 10, 2020, https://www.greentechmedia.com/articles/read/court-upholds-ferc-order-841-opening-wholesale-markets-to-energy-storage; John D Wilson et al., "Generator Interconnection Scorecard: Ranking Interconnection Outcomes and Processes of the Seven U.S. Regional Transmission System Operators" (Advanced Energy United, February 2024), https://gridstrategiesllc.com/wp-content/uploads/2024/03/AEI-2024-Generation-Interconnection-Scorecard.pdf.

49. Twitchell, Powell, and Paiss, "Local Zoning Ordinances," 8.

50. Twitchell, Powell, and Paiss, "Local Zoning Ordinances," 8.

51. Twitchell, Powell, and Paiss, "Local Zoning Ordinances," 6-7.

52. Paiss et al., "Study of Codes & Standards"; Twitchell, Powell, and Paiss, "Local Zoning Ordinances".

53. "Energy Systems," 2018 International Fire Code § 1206 (2017), https://codes.iccsafe.org/content/IFC2018/chapter-12-energy-systems#IFC2018_Pt03_Ch12_Sec1206.

54. U.S. Government Accountability Office, "Utility-Scale Energy Storage," 43-44.

55. National Academy of Sciences, *Accelerating Decarbonization in the United States: Technology, Policy, and Societal Dimensions* (The National Academies Press, 2023), 214, https://doi.org/10.17226/25931; Anushree Chaudhuri and Lawrence Susskind, "Shifting to State Preemption: The Implications of New Renewable Energy Siting Frameworks in the U.S.," Clinic Research Report (MIT Renewable Energy Clinic, January 29, 2024), https://renewable-energy.mit.edu/blog/research-report-state-preemption.

56. Pacific Northwest National Laboratory, "State Siting Authority of Energy Storage Facilities" (Pacific Northwest National Laboratory, July 2022), https://www.pnnl.gov/sites/default/files/media/file/State%20Siting%20of%20Energy%20Storage%20-%20Memo%20-%20Jul22.pdf; "Renewable Energy and Energy Storage Facility Siting," Michigan Public Service Commission, accessed May 13, 2024, https://www.michigan.gov/mpsc/commission/workgroups/2023-energy-legislation/renewable-energy-and-energy-storage-facility-siting.

57. NYSERDA, "New York State Battery Energy Storage System Guidebook" (New York State Energy Research and Development Authority, December 2020), https://www.nyserda.ny.gov/All-Programs/Clean-Energy-Siting-Resources/Battery-Energy-Storage-Guidebook.

58. Jeremy Twitchell, "Overview of Battery Energy Storage Systems (BESS)," https://s3.documentcloud.org/documents/23865610/1-twitchell_overview-of-battery-energy-storage-systems_wa-workshop.pdf.

59. "Standard for the Installation of Stationary Energy Storage Systems," NFPA 855 § 9.5.2.6.1 (2023), https://link.nfpa.org/free-access/publications/855/2023.

60. Twitchell, Powell, and Paiss, “Local Zoning Ordinances,” 16.

61. National Academy of Sciences, *Accelerating Decarbonization*, 214.

62. National Academy of Sciences, *Accelerating Decarbonization*, 198, 213.

63. National Academy of Sciences, *Accelerating Decarbonization*, 217.

64. Eli Gold, “Solar Energy Property Taxation,” Renewable Energy Policy Initiative (Center for Local, State, and Urban Policy at the University of Michigan’s Gerald R. Ford School of Public Policy, June 2021), https://closup.umich.edu/research/solar-energy-property-taxation; Catherine Collins and Anju Chopra, “Property Tax Incentives for Renewable Energy: Pervasive Yet Idiosyncratic” (Tax Analysts, October 21, 2013), https://gwipp.gwu.edu/sites/g/files/zaxdzs6111/files/downloads/Property%20Tax%20Incentives%20for%20Renewable%20Energy%20October%202013.pdf.

65. Eli Gold, “Solar Energy Property Taxation”; Catherine Collins and Anju Chopra, “Property Tax Incentives for Renewable Energy.”

66. “Property Tax Status of Alternative Energy Systems,” 307–0210 Oregon Revised Statutes §, accessed May 13, 2024, https://secure.sos.state.or.us/oard/viewSingleRule.action?ruleVrsnRsn=18197.

67. Parvin Van Enger, Amy Frees, and Jennifar Hill, “SALT and Battery: Taxes on Energy Storage | Tax Notes” (Tax Notes, July 31, 2023), https://www.taxnotes.com/special-reports/energy-taxation/salt-and-battery-taxes-energy-storage/2023/07/27/7gzwj.

68. “Solar Tax Exemptions,” Solar Energy Industries Association, accessed May 17, 2024, https://www.seia.org/initiatives/solar-tax-exemptions.