NASEO

National Association of State Energy Officials

Accelerating Energy Storage Research, Development, and Demonstration: Policy, Programmatic, and Planning Considerations for States

August 2024

National Association of State Energy Officials

Contents

LIST OF TABLES

LIST OF FIGURES

Cover Image: istockphoto/James Billimore

1. Disclaimer and Acknowledgements

This material is based upon work supported by the U.S. Department of Energy (DOE), Office of Electricity (OE), under award number DE-OE0000924. This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, expressed or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

This report was prepared for the National Association of State Energy Officials (NASEO) by Matthew Hoyt, Jeremie Amsallem, and Cali Clark with Exeter Associates, with support from Kirsten Verclas, Senior Managing Director, NASEO; and Kelsey Jones, Program Director, NASEO. We would like to thank the State Energy Offices for their input and contributions.

NASEO would also like to thank the U.S. Department of Energy, Office of Electricity, for their generous financial support of this initiative, as well as their insights that informed the development and scope of this report.

Image: istockphoto/James Billimore

2. Introduction

The United States faces a complex energy landscape as it transitions toward an electrified, carbon-neutral energy future. This transition presents numerous opportunities for states, including job creation, economic growth, improved public health, enhanced energy security, and energy justice. It also poses challenges related to cost, resiliency, reliability, equitability, and fairness. These challenges are heightened by known and unknown risks and hazards, both natural and man-made. In this evolving energy landscape, energy storage, which encompasses a range of different technologies, has the potential to support the energy transition while mitigating related challenges. Moreover, as energy storage costs decline and use cases expand, its importance to state and federal energy transition, decarbonization, and resilience efforts grows.

State Energy Offices play an important role in advancing the research, development, and demonstration (RD&D) — as well as subsequent deployment — of energy storage technologies by informing the state energy policy actions of governors and legislators, delivering grant and incentive programs, conducting cost-benefit analyses and market assessment studies, preparing state energy storage road maps, engaging with various public and private sector stakeholders, and more. The purpose of this guide is to provide a clear and accessible framework that addresses policy, planning, and programmatic perspectives of energy storage RD&D. The guide also aims to bridge the gap between the technological potential and practical application, assisting State Energy Offices in making better informed decisions about, and implementing effective strategies for, energy storage RD&D that align with their specific energy goals and circumstances.

2.1 Report Scope and Structure

This guide is designed to be a reference for State Energy Offices interested in energy storage RD&D. The primary focus is energy storage RD&D involving utility-scale storage systems (i.e., greater than 1 megawatt [MW] / 1 megawatt-hour [MWh]) supplying energy to meet electricity needs. However, the guide also includes brief discussions of small-scale, customer-sited, and thermal storage to provide a comprehensive view of the energy storage RD&D ecosystem.

This guide begins with a brief overview of the current state of energy storage technologies and applications. Next, the guide examines several prominent barriers and opportunities for energy storage RD&D. The guide then reviews considerations for State Energy Offices related to energy storage RD&D, including common goals and planning approaches, potential partnerships, and implementation strategies. Finally, the guide reviews ways that State Energy Offices can ensure the benefits of energy storage RD&D reach underserved communities. Interspersed throughout are actionable recommendations for future storage RD&D by State Energy Offices and references to successful models adopted to date. The guide also incorporates findings and data from other reports, studies, and relevant resources as endnotes.

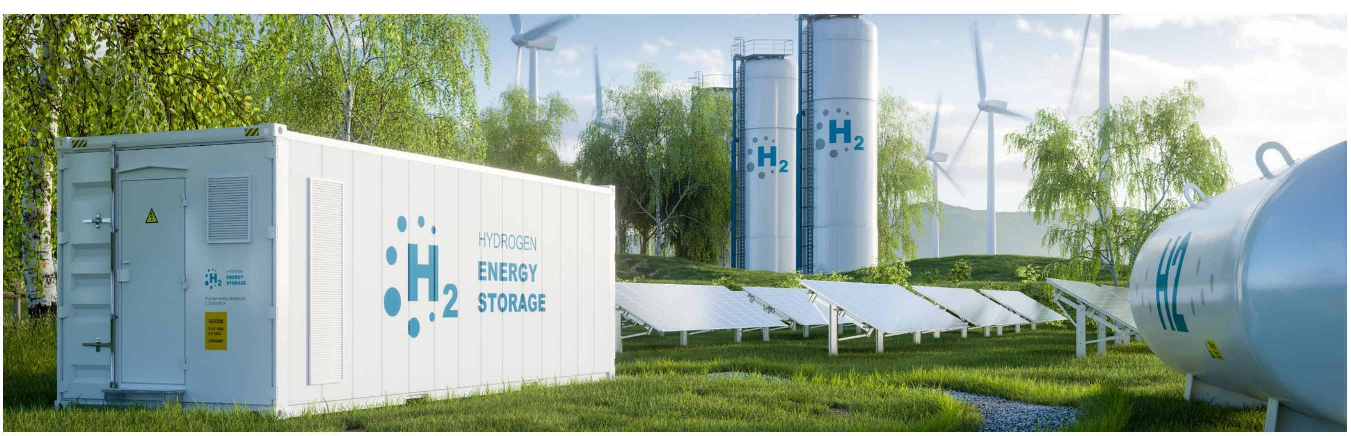

Image: istockphoto/Petmal

3. Overview of Storage and Recent Trends

Individual energy storage technologies can be understood by their potential applications and their resource and performance characteristics. Differences between technologies are among the many factors that influence appropriate energy storage RD&D approaches for State Energy Offices. The following section introduces key energy storage applications, types, performance characteristics, and trends as important background for subsequent discussion.

3.1 Storage Applications

Energy storage RD&D helps State Energy Offices identify new and expanded use cases for energy storage. The use cases that apply, however, vary by state, often depending on regulatory and market conditions, as well as state priorities and needs. The subsequent descriptions showcase a selection of actual and potential applications of energy storage, ranging from large-scale grid support to localized energy solutions.[1]

3.1.1 Reliability / Resiliency

Storage can enhance reliability (i.e., the capacity to meet normal operations) for customers by providing backup power during an outage or interruption. Storage can also mitigate the risk of customer or grid-level outages by buffering against power quality issues when the grid is strained. In some cases, storage is built into a "microgrid" configuration, meaning a self-sufficient electricity grid containing a generation resource (e.g., a solar photovoltaic [PV] system) that can operate on a small scale even if temporarily disconnected from the bulk electric system. Microgrids are increasingly used during emergency response scenarios to ensure continuity of operations at locations providing essential services, such as hospitals, fire stations, and community centers.[1] At the grid level, storage can also enhance resiliency (i.e., the capacity to recover quickly from natural disasters and/or preserve or restore critical infrastructure). Specifically, storage can support orderly and rapid restoration of service during outages as well as provide "black-start" capabilities, meaning firing up a traditional generator without the need for power from the outside the electricity grid.[2]

3.1.2 Ancillary Services

Even in the absence of external interruption, storage can provide services to ensure reliable transmission of electricity and reliable operation of the bulk electric system. These services include frequency and voltage regulation, load following and ramping, black-start, and spinning and non-spinning reserve capacity.[3] These applications each serve specific requirements of electricity provision, such as managing the volatility of electric current and the constant balancing of supply and demand over multiple time frames, from seconds to minutes to hours. Many energy storage systems are recognized for their flexibility and ability to quickly respond to grid demands by switching between charging and discharging states. This instant response is crucial for applications like voltage support and frequency regulation.[4]

1 For general descriptions of energy storage applications, see: Interstate Renewable Energy Council. Charging Ahead: Energy Storage Guide for Policymakers; Stecca, M., Elizondo, L.R. & Soeiro, T.B., *et al.* A Comprehensive Review of the Integration of Battery Energy Storage Systems into Distribution Networks. *IEEE Open Journal of the Industrial Electronics Society* Vol. 1, 46-65 (2020); European Association for Storage of Energy. Segmentation of energy storage applications; and United States Government Accountability Office. Utility-Scale Energy Storage - Technologies and Challenges for an Evolving Grid. March 2023.

3.1.3 Integrating Renewable Energy Resources

Storage can be used to smooth out variableness or absorb excess production from wind, solar, and other intermittent renewable resources. In this way, energy storage can help transform a renewable facility into a “firm” (i.e., more predictable) source of generation by supplying stored power whenever the renewable energy resource experiences an interruption; for instance, when clouds block the sun. It can also minimize the curtailment of renewable energy generation, especially during negative price periods in wholesale markets.[2] Captured renewable energy can be used to offset alternative sources of power at later times.

3.1.4 Arbitrage

Energy storage can release energy that was stored during off-peak periods (i.e., when electricity prices are typically lower) to the grid or end-users during peak periods (i.e., when electricity prices are typically higher). This time shifting, which can range from minutes to months depending on the storage technology, supports efforts to reduce customer or system costs and increase utilization. For example, grid operators dispatch storage energy as a substitute for alternative, higher-cost generation (e.g., natural gas combustion turbine generators) during times of high demand. Alternatively, customers can discharge storage to lower peak demand charges, take advantage of time-of-use or other dynamic rates, participate in demand response programs, and more.[3]

3.1.5 Transmission Avoidance Resource / Infrastructure Deferral

Storage can help avoid or defer costly transmission infrastructure upgrades, especially in areas experiencing load growth or congestion.[5] By discharging during peak demand periods, storage reduces stress on existing transmission lines and reduces energy wasted as heat from congested lines. Storage also potentially defers the need for new lines; strategically locating storage near areas of congestion can relieve bottlenecks and unlock additional capacity on the existing grid. Storage also offers a modular, scalable alternative to traditional infrastructure projects, allowing utilities to better match investments with evolving grid needs.

3.1.6 Supporting Decarbonization and Related Policies

At the state level, energy storage is increasingly recognized as essential for meeting specific decarbonization objectives.[4] As noted above, energy storage indirectly enables higher penetrations of variable renewable resources through its firming, grid support, and infrastructure deferral capabilities. It can also serve as a direct substitute for fossil-fuel resources providing energy, capacity, or ancillary services. For example, storage can meet ramping needs when solar production decreases and demand increases in the early evening, also referred to as the “duck curve.”[6] By displacing more typical ramping resources like natural gas combustion turbines, energy storage can also support air quality and public health objectives so long as stored power is derived from lower-emission sources.

2 In organized wholesale markets, prices may become negative when electricity supply exceeds demand and generators determine that it is more cost-effective to pay buyers to take excess power than it is to curtail production. In some cases, intermittent sources like wind and solar generation may also choose to continue providing service during negative pricing periods in order to capture production-based incentives like the federal Production Tax Credit.

3 For additional discussion of demand flexibility, see: Demand Flexibility and Grid-interactive Efficient Buildings 101.

4 See, for example: States Energy Storage Policy: Best Practices for Decarbonization.

3.2 Types of Energy Storage and Performance Characteristics

Energy storage connected to the electric grid encompasses a variety of technologies, each with unique characteristics and applications. Much of the recent interest in energy storage is due to the rapid cost declines and improved performance of quick-responding, scalable electrochemical storage technologies, in particular, lithium-ion batteries (see discussion below).[5,6] Other storage technologies, however, also play crucial roles in the energy landscape. Figure 1. Common Energy Storage Methods and Select Storage Technologies provides a taxonomy of common energy storage methods and some of the prevalent technologies being used for different energy types.

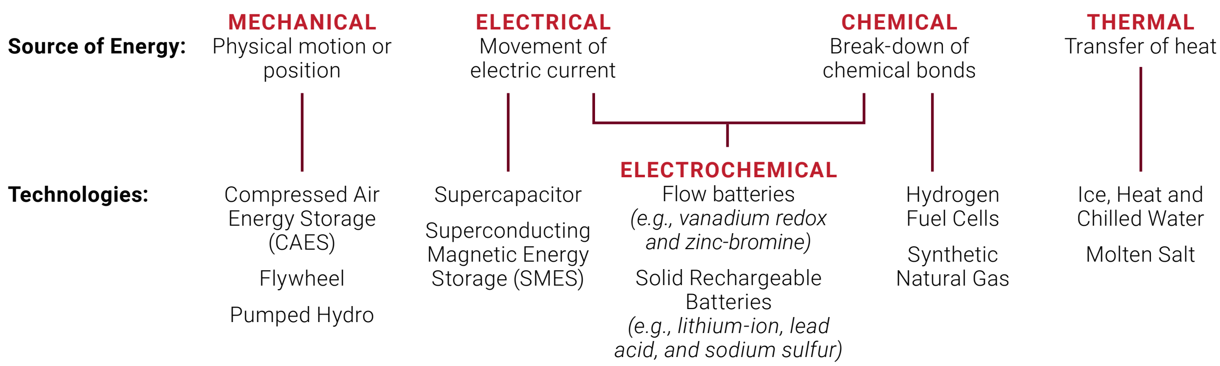

Figure 1. Common Energy Storage Methods and Select Storage Technologies

Source: Adapted from Exeter Associates, Inc. Energy Storage in Maryland: Policy and regulatory options for promoting energy storage and its benefits. 2018.

3.2.1 Mature or Widespread Technologies

The most widespread type of grid-scale storage is mechanical storage, primarily in the form of pumped-storage hydroelectricity (pumped hydro).[7] Pumped hydro accounts for 58% of U.S. energy storage, with a total U.S. capacity of 22.2 gigawatts (GW).[7] These systems are typically capable of storing energy for tens of hours with power capacities up to 1 GW, have lifetimes of 50-60 years or longer,[8] and operational efficiencies between 70-85%.[8] Flywheel Energy Storage (FES or flywheel), another mature technology, supports more abbreviated and smaller-scale energy needs, generally within a duration ranging from seconds to minutes.[9] As of 2023, there were at least five utility-scale flywheel systems in the United States but only 47 MW of total rated power capacity from these systems.[9,10] Flywheel efficiency typically ranges between 85-87%, and units are often used for short-duration ancillary services.[10]

5 Total storage system costs over a lifetime of use include installed costs, system charging, operations and maintenance, extended warranties, financing, taxes, decommissioning, and disposal. Emphasis tends to be placed on the installed costs of storage, i.e., the costs on Day 1, since they are the simplest to track and account for a major portion of the cost of a storage system, thus greatly influencing a project's feasibility. Storage system costs vary widely depending on the technology used, system size, and application.

6 From 2022 to 2023, the levelized cost of lithium-ion battery packs has declined by 14%, the largest drop on record, from $161/kWh to $139/kWh, while deployed energy storage capacity in the United States has increased by 70%, from 7.9 GW to 14.3 GW. Sources: BloombergNEF. Lithium-Ion Battery Pack Prices Hit Record Low of $139/kWh. November 26, 2023; and EIA. Solar and battery storage to make up 81% of new U.S. electric-generating capacity in 2024. February 15, 2024.

7 Pumped hydro works by using low-cost power to pump water from a low-elevation reservoir to a high-elevation reservoir. The water can then be "stored" until power is needed, then released. The downward flow of water spins a hydroelectric turbine that produces electricity.

8 Efficiency, also referred to as Round-trip Efficiency (RTE), is typically calculated as the total percent of energy input (i.e., charge) that can ultimately be recovered during energy output (i.e., discharge). RTE accounts for energy losses depending on the storage method.

9 FES operates by storing kinetic energy in a spinning rotor within a low-friction enclosure. In charging, electric energy is captured by a spinning shaft that moves the rotor. For discharge, electricity is generated by the continued momentum of the charged rotor, which powers the motor-generator as it spins.

10 Note that different data sources list distinct numbers regarding deployment and other resource characteristics. This is due to several factors, including the rapid growth of energy storage deployment, changes in the way developers and utilities deploy storage, the vintage of the tracking database, and differences in how sources identify and record energy storage systems. For example, SNL's Global Energy Storage Database has different numbers than EIA's Form 860 database. This may reflect the fact that the EIA dataset only counts front-of-meter installations over 1 MW, among other things.

Advanced battery energy storage, as mentioned above, represents a rapidly growing sector.[11] These systems offer the flexibility of quick discharge and recharge cycles essential for applications like grid balancing. Currently, lithium-ion batteries are the dominant source of utility-scale battery storage capacity, accounting for over 90% of the U.S. domestic sector as of 2023, according to the National Renewable Energy Laboratory (NREL).[11] Lithium-ion batteries are notable for their high energy density, long cycle life, and high efficiency (typically around 80-95%).[12] These advantages make them ideal for mobile applications like electric vehicles (EVs) and portable electronics, as well as grid-scale energy storage. However, lithium-ion batteries have drawbacks; they can be expensive, have potential safety risks (e.g., fire during thermal runaway),[12] and their production raises concerns about mineral availability and environmental impacts.[13] See below for further discussion of opportunities related to these challenges.

Lead Acid Battery Energy Storage (LABES) is another relatively established electrochemical technology. These batteries have been used for decades, supporting a variety of applications from backup power systems to grid-scale energy storage projects. While they offer lower energy density and shorter life cycles compared to newer battery technologies like lithium-ion, lead-acid batteries are recognized for their proven track record, recyclability, and the ability to deliver high-surge electrical current. Their operational efficiency typically ranges between 80-85%.[14]

Thermal technologies, including ice storage, chilled water storage, and water heaters, are another common and well-established source of energy storage.[13] These units have a long history of providing pre-programmed load-shifting and peak load management services, but can also be used to provide ancillary services and support integration of renewable generation. Operational efficiency varies between 50-90% depending on the thermal application.[15]

3.2.2 Emerging Technologies

Over the past decade, a variety of alternative energy storage technologies have emerged or gained greater prominence, including flow batteries; thermal storage using molten salts, ground heat exchange, phase change materials, and other technologies; and new battery chemistries. These energy storage technologies hold the potential to increase the grid's storage capacity and flexibility, especially if technological advances and price declines continue.

Flow batteries, particularly Redox flow batteries, with their unique design involving separate tanks of electrolytes, have emerged as an alternative to lithium-ion batteries for applications requiring longer-duration energy storage in space-constrained areas.[14] More specifically, the ability of flow batteries to scale-up in capacity independent of their power output increases their flexibility to address a broader range of energy storage needs over varying time frames.[16]

11 All batteries rely on the same basic design and electrochemical process, regardless of size and application. Each battery has three parts: an anode, a cathode, and an electrolyte. The anode and cathode, also known as electrodes, hold opposite charges. When they are connected in an electric circuit, the flow of charge between the anode and cathode causes a chemical reaction in the electrolyte that releases energy.

12 Thermal runaway describes a process by which increasing temperatures result in the release of energy that further increases temperatures, causing uncontrolled acceleration that often results in destructive effects.

13 These technologies work by storing cold or heat and using the sensible or latent heat for later application. For example, ice storage systems create ice during off-peak hours. The stored ice can then be used to cool buildings during peak hours, shifting electricity demand and reducing strain on the grid. Similarly, chilled water storage systems use large tanks to store chilled water produced during off-peak periods. This water is circulated for building cooling during peak hours.

14 Unlike traditional batteries with fixed energy storage, flow batteries store their energy in liquid electrolytes held in external tanks. These electrolytes contain dissolved chemicals that undergo reactions at electrodes within a central cell stack. During discharge, the electrolytes are pumped through the cell stack, where the chemical reactions generate electricity. To recharge a battery, the process is reversed, using electricity to drive the chemical reactions backward. This design allows flow batteries to easily scale their energy storage capacity simply by increasing the size of the electrolyte tanks, making them well-suited for large-scale grid energy storage applications.

Advanced thermal storage technologies have garnered recent attention for their potential to support both industrial heating and extended-duration storage needs.[17] Molten salts already have a long history of use as a transfer and storage medium, especially when coupled with concentrated solar power plants.[15] Their ability to operate at very high temperatures supports collocation of molten salt storage with hard-to-decarbonize, high-heat industrial processes like cement production, steel manufacturing, and chemical processing. Storage using ground heat exchange, meanwhile, has the potential to use stable, below-ground, or underwater temperatures to efficiently store energy over seasonal time horizons. Further, research into improved drilling technologies can potentially expand the suitable geographic areas for these resources.[16] Finally, phase change materials are already well-suited for thermal regulation. These resources can potentially be integrated into additional building and construction applications with further cost declines.[17]

Additional emerging technologies include hydrogen energy storage,[18] iron-air batteries,[19] zinc-based batteries,[20] supercapacitors,[21] solid-state batteries,[22] compressed-air energy storage (CAES),[23] and various gravity-based energy storage configurations. These technologies differ in terms of stage of research, development, deployment, and commercialization. Interest in each of these technologies reflects their potential to address current and/or anticipated limitations with existing energy storage technologies, such as space constraints, safety risks, or availability of component inputs (e.g., minerals). In some cases, emerging technologies are intended to support specific applications, such as identifying lighter, safer (e.g., less flammable), and higher-capacity technologies for EV use or addressing hard-to-decarbonize sectors such as industries that need very high heat for their industrial processes.[24] Similar motivations also underlie efforts to advance the state of the art of more mature technologies.

3.2.3 Performance Characteristics and Trade-offs

Storage devices are often tailored to serve specific customer, grid, or utility needs, either at the selection stage or through the manner in which a system is designed and deployed. For example, pumped hydro and compressed air can last hours to days, aligning with long-duration storage needs. In contrast, many batteries and flywheels are designed for shorter, quick-response applications, ideal for ancillary services. Lithium-ion and lead-acid batteries offer a middle ground, suitable for several hours of energy supply. Increasingly, small behind-the-meter storage systems in homes and businesses are available to be aggregated and controlled as part of "virtual power plants" (VPPs). VPPs can replicate the characteristics of larger resources where market rules allow. Depending on the technology used and project size, energy storage systems can discharge at their full capacity for different durations.

---

15 Molten salt storage involves warming salts and then storing the sensible heat, usually within an insulated container, for later application. Similar sensible heat storage applications are also possible using molten silicon, molten aluminum, or by storing heat in tanks, rock caverns, or concrete.

16 Ground heat exchange, also known as borehole thermal energy storage, applies the natural temperature differences between the surface and subsurface as a medium to store heat or cold, usually in the form of a fluid. Similar heat exchange using bodies of water is called aquifer thermal energy storage.

17 Phase change materials absorb or release latent heat at specific temperatures.

18 Hydrogen energy storage involves a system where electricity is used to produce hydrogen through electrolysis. This hydrogen can then be stored and later reconverted into electricity or used as fuel.

19 Iron-air batteries store energy by oxidizing iron.

20 Zinc-based batteries use zinc and oxygen from the air to store and release energy, providing another avenue for long-duration storage

21 Supercapacitors can store and release energy rapidly, potentially supplementing batteries in applications requiring bursts of power, such as EV acceleration.

22 Solid-state batteries replace the liquid electrolyte in traditional batteries with a solid electrolyte. Recent attention has focused on how solid-state batteries are potentially faster to charge, have a longer lifetime, and are less flammable than lithium-ion batteries for EV purposes.

23 CAES involves the injection and storage of compressed air in underground caverns. Off-peak or excess energy is used to compress air. When power is needed, the compressed air in the storage cavern is heated and expands. The resultant air flow, as it exits the cavern, drives an electric generating turbine. There is only one operational CAES plant in the United States today, a 110-MW capacity plant in Alabama.

24 For general discussion, see: The Renewable Thermal Collaborative; The challenge of decarbonizing heavy industry; and The energy storage space is heating up. Here are some of the technologies making a dent.

Selecting the right energy storage system or class of technologies to support through RD&D involves understanding the specific needs of the proposed applications and how different storage technologies can meet those needs. Key characteristics for State Energy Offices to consider include those listed in Table 1 below. Selecting effective energy storage technology often involves balancing trade-offs between these characteristics. For instance:

- **Pumped Hydro Storage (PHS):** PHS offers long duration, high capacity, and relatively low cost, but has a large footprint and specific geographical requirements. The environmental impact can also be considerable. It is suitable for long-term energy shifting.
- **Lithium-ion batteries:** These batteries boast high energy density, fast response time, and modularity, but can be expensive and have shorter durations than some other technologies. They are well-suited for grid services and integration with renewable energy.
- **Flow batteries:** Flow batteries, such as vanadium Redox flow batteries, offer long duration and a long cycle life, but can have lower energy densities and higher up-front costs. They are promising for applications requiring frequent cycling and long discharge times.

It is important to balance these characteristics with a project's specific needs, budget constraints, and other relevant limitations. Likewise, State Energy Offices should balance similar considerations when evaluating which technologies to explore and support through their policies and programs.

Table 1. Energy Storage Characteristics

Characteristic	Definition	Importance
Capacity	The maximum amount of power a system can deliver at any given time (kilowatt [kW])	Determines ability to meet instantaneous power needs
Duration	How long the system can sustain power output (kilowatt-hour [kWh])	Determines the length of time the system can provide energy
Energy Density	The amount of energy stored per unit volume or mass (e.g., kWh/liter or kWh/kilogram)	Influences space requirements; crucial in space-constrained applications
Efficiency	The ratio of energy output to energy input	Affects system performance and overall cost-effectiveness
Cost	Capital and operating costs, often expressed on a per-unit of power or energy basis ($/kW or $/kWh)	Determines economic viability of the project
Cycle Life	The number of charge/discharge cycles a system can undergo before degradation	Impacts longevity and replacement frequency of the storage system
Response Time	How quickly the system can react to changes in demand or supply	Crucial for applications requiring rapid power injection or absorption
Levelized Cost of Energy (LCOE)	A comprehensive metric of cost over the system's lifetime ($/kWh)	Allows for comparison across technologies, factoring in upfront and ongoing costs
Maturity	The technology's development stage, from emerging to commercially mature	Influences reliability, risk, and availability
Environmental Impact	Considers lifecycle environmental effects, from manufacturing to disposal	Important for ensuring sustainability and minimizing negative environmental externalities
Specific Energy	The amount of energy stored per unit mass (kWh/kg)	Important for weight-sensitive applications, such as electric vehicles
Storage Period	The maximum length of time energy can be stored before significant loss	Crucial for applications with long-term storage needs
Build Time	The time required for construction, installation, and commissioning of a storage system	Impacts project timelines and the ability to address time-sensitive energy needs
Operating Cost	The expenses associated with running and maintaining the storage system	Impacts overall economic viability and competitiveness
Round-Trip Efficiency (RTE)	The percentage of energy input that is retrievable as output after a full charge/discharge cycle	Determines system performance and energy losses
Space	The physical area or space required for the storage system	Impacts the siting suitability and compatibility with existing infrastructure

3.3 Storage Costs and Deployment Trends

The U.S. battery storage sector is experiencing rapid capacity expansion. From 2022 through January 2024, the United States added approximately 6.8 GW of utility-scale battery energy storage to the grid, bringing the total to 15.6 GW. Installed utility-scale battery capacity is anticipated to further increase by as much as 89% by the end of 2024.[18] This increase would bring total U.S. battery capacity above several conventional generation sources, like petroleum liquids, geothermal, and landfill gas, in the same time frame.[19] Looking further out, S&P Global Market Intelligence projects that the United States will bring 95 GW of utility-scale battery storage online by 2035.[20] By comparison, other energy storage technologies have experienced minimal growth since 2022 for reasons associated with geographical constraints, costs, and comparative disadvantage relative to batteries.[21,22]

These deployment trends align with NREL forecasts for lithium-ion battery energy storage system costs. NREL's models predict cost reductions ranging from 16-47% by 2030, relative to 2023 levels, depending on various factors. This could result in lithium-ion battery costs of between $255-$403/kWh in the near term. Longer-term projections are even more optimistic. NREL projects that lithium-ion battery costs could fall by as much as 67% by 2050, potentially reaching levels as low as $159/kWh. This ongoing cost reduction is expected to accelerate the widespread deployment of battery storage.[23] Driving these cost reductions are a variety of actual and anticipated productivity improvements, including those driven by technology, process, and supply chain advancements; economies of scale (i.e., unit cost reductions driven by higher production); and incentives from the federal and state governments.

Figure 2. Comparison of Total Installed Energy Storage System Cost by Technology, 2030 Point Estimates shows DOE forecasts for the 2030 total installed cost of select energy storage technologies in addition to lithium-ion batteries. The chart compares these data along three dimensions:

- **Storage duration:** This axis shows the duration of time that each energy storage technology is capable of discharging stored energy, ranging from two hours to 100 hours.
- **Capacity:** This axis shows the capacity of various energy storage systems, ranging from 1 MW to 1,000 MW.
- **Technology:** The colored symbols represent different energy storage technologies.

Figure 2. Comparison of Total Installed Energy Storage System Cost by Technology, 2030 Point Estimates indicates that the cost of energy storage varies depending on the technology, duration, and capacity, and that certain technologies are expected to be more suitable for shorter, longer, smaller, or larger applications. For example, lithium-ion batteries are expected to continue being the cheapest technology for short-duration storage (up to four hours) and remain more expensive for longer durations. By comparison, vanadium Redox flow batteries are forecast to remain more expensive than lithium-ion batteries for short durations but become more cost-competitive for longer durations. Some technologies are not expected to support specified duration or capacity requirements. For example, DOE does not forecast gravitational storage, which has substantial capital costs, as a potential small-scale resource. State Energy Office RD&D efforts have the potential to advance new applications for certain existing technologies, accelerate efficiency and cost improvements, and spur the development of new technologies that better serve certain capacity and duration needs.

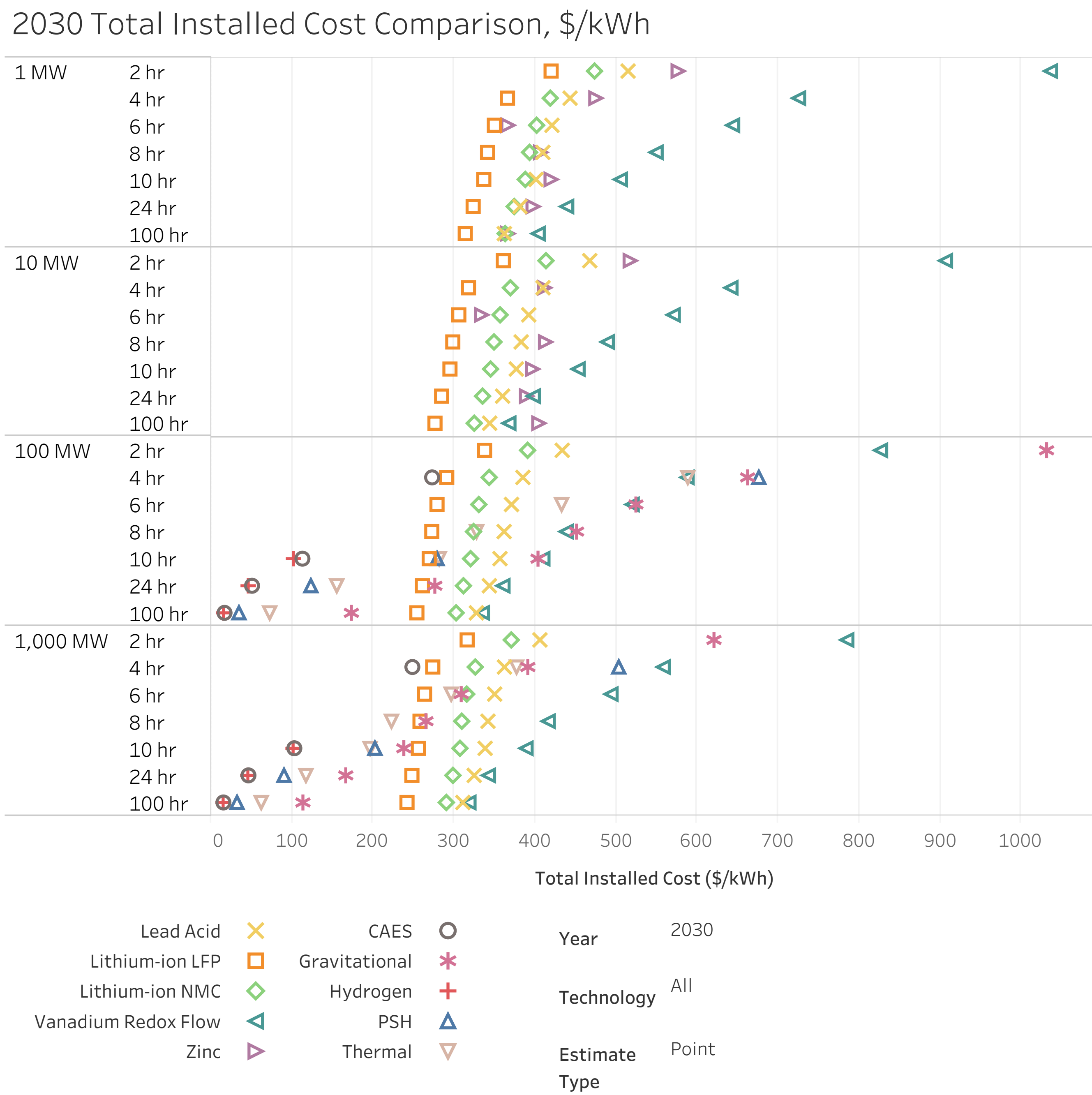

Figure 2. Comparison of Total Installed Energy Storage System Cost by Technology, 2030 Point Estimates

Source: Paul Spitsen and Vince Sprenkle. Energy Storage Cost and Performance Database. Pacific Northwest National Laboratory. 2024.

Notes: Lithium-ion LFP = Lithium-ion lithium iron phosphate; Lithium-ion NMC = Lithium-ion nickel manganese cobalt (NMC) batteries; Lead Acid = Lead-acid batteries; Vanadium Redox Flow = Vanadium Redox flow batteries; Zinc = Zinc-based batteries; PSH = Pumped storage hydropower; CAES = Compressed-air energy storage; Gravitational = Gravity energy storage; Thermal = Thermal energy storage; Hydrogen = Hydrogen energy storage system (bidirectional).

4. Opportunities and Barriers

While market, regulatory, and policy conditions vary by state, some recurring energy storage opportunities and barriers stand out as key considerations for State Energy Offices as they develop or implement RD&D plans, policies, and programs for utility-scale energy storage. Though not an exhaustive list, the following areas warrant consideration during RD&D program development or, in some cases, are ripe for targeted RD&D initiatives.

4.1 Opportunities

4.1.1 Long-Duration Energy Storage

As renewable energy generation capacity continues to grow and traditional baseload power capacity retires, resources capable of storing energy for hours, days, weeks, or even seasons will become increasingly critical to balance supply and demand and stabilize grid operations. The fastest growing energy storage resource, lithium-ion batteries, is less cost-effective when scaled to support grid needs longer than eight hours.[24] Alternative long-duration energy storage resources, like hydrogen storage, CAES, thermal storage, pumped hydro, and flow batteries, are geographically constrained or still in earlier stages of technological development or deployment.[25] As a result, State Energy Office RD&D efforts targeted at advancing long-duration energy storage (LDES) technologies, applications, or capabilities have the potential to catalyze an industry that supports an emerging and essential need.

Several states have already initiated RD&D efforts focused on LDES. For example, the California Energy Commission's (CEC) Long-Duration Energy Storage Program offers direct grants to developers of LDES projects with a focus on demonstrating non-lithium-ion technologies. Notably, the CEC prioritizes proposals that show a clear path to price competitiveness with lithium-ion batteries, the current dominant storage solution.

As another example, the Utah Office of Energy Development is among the partners supporting the Advanced Clean Energy Storage facility in Delta, Utah which, when complete, will deploy 220 MW of alkaline electrolysis and two salt caverns to capture and store excess renewable energy as hydrogen.[25] This novel deployment is intended to catalyze additional initiatives that take advantage of Utah's abundance of natural salt cavern formations. State Energy Offices can prioritize state-funded RD&D or public-private partnerships focused specifically on developing or demonstrating long-duration storage technologies, particularly those suited to their respective state's unique resource mix, geography, and grid characteristics. Other specific LDES research areas include ways to increase energy density, cell size, and other battery features for a variety of electrochemical compositions.[26]

25 For additional information, see: Advanced Clean Energy Storage Hub and Green Hydrogen Project Underway.
26 See: NASEO Virtual Roundtable: State Efforts to Enhance Energy Storage RD&D.

4.1.2 Microgrids and Decentralization of Energy Systems

In response to the increasing frequency and cost of extreme weather events and environmental disasters, there is growing interest on the part of many communities and State Energy Offices to adopt resilience-focused microgrids.[27] That is, microgrids present a pathway to improve resilience by supporting rapid restoration of power and sustainable, independent operation during widescale outages. Microgrids can also create opportunities for localized economic activity and power trading within the microgrid network. State Energy Offices can support adoption of batteries as part of microgrid configurations in these communities. For example, Colorado's Microgrids for Community Resilience (MCR) grant program offers targeted microgrid funding to increase resiliency, particularly for remote and vulnerable communities. The Colorado Energy Office provides programmatic support to facilitate these microgrid projects as well as oversees related Electric Grid Resilience Funds.[26]

4.1.3 Harnessing Home and Mobile Storage for Grid Services

The rise in EV adoption driven by various state and federal policies presents an opportunity to utilize EV batteries for distributed grid services.[27] Similarly, the growing trend of installing energy storage systems in homes and businesses, either to complement renewable energy setups or as backup solutions, enlarges the pool of storage resources potentially available for grid support. State Energy Offices can play a significant role in exploring how these storage resources can be integrated into VPPs or otherwise used to optimize grid performance and resilience.[28] State Energy Offices can also advocate for regulatory changes, paving the way for VPPs where aggregated, smaller-scale energy storage assets contribute more fully to grid management.

California, Puerto Rico, and Hawaiʻi are at the forefront of efforts to engage with distributed storage resources for utility-scale purposes. For example, the CEC's Virtual Power Plant Approaches for Demand Flexibility solictation funds demonstrations of community-based VPPs and innovative energy management systems within commercial buildings, both of which can incorporate storage resources. The aim of this initiative is to integrate additional flexible resources onto the grid.[28]

4.2 Barriers

4.2.1 Ambiguous Storage Classification and Ownership

The resource classification of energy storage (e.g., baseload generation, ancillary resource, load, transmission asset, etc.) determines which rules and regulations apply and which parties, such as utilities or independent developers, can own storage assets. A lack of clarity regarding how a state or market treats storage can, thus, impede investment or preclude certain applications. This challenge is applicable in all markets, but especially prominent in deregulated electricity markets.[29] Here, tension arises between the potential benefits of utility ownership (e.g., leveraging a distribution utility's system expertise to identify optimal siting locations) and the downsides (e.g., utility ownership of storage may stifle third-party innovation or otherwise hinder the participation of non-utility market actors).[30]

State Energy Offices can help develop or support policies and regulations that offer unambiguous rules around ownership and operation. For example, the Maryland Energy Administration was prominently involved in state working groups addressing utility ownership and regulation of front-of-the meter energy storage.[29] These efforts resulted in pilot programs assessing regulatory applications like alternative compensation mechanisms, multi-use project leases, and VPP storage projects.

---

27 For general background, see: Microgrids State Working Group and State Microgrid Policy, Programmatic, and Regulatory Framework.

28 For general discussion of EVs, grid-interactive buildings, or distributed energy resources, see: Electric Vehicles and Alternative Fuels; NASEO-NARUC Grid-Interactive Efficient Buildings Working Group; and Distributed Energy Resources Integration and Compensation Initiative.

29 Deregulation of electricity markets involved separating generation and certain retail services from the delivery (i.e., transmission and distribution) function of local utilities. The generation and retail portions of service were opened up to competition by entities not subject to traditional prudence regulation and regulated returns.

30 See, for example: States Energy Storage Policy: Best Practices for Decarbonization.

4.2.2 Legacy Infrastructure

Outdated infrastructure impedes the implementation and effective utilization of a variety of advanced energy technologies, including storage. For example, outmoded inverters, transformers, and other grid components may not be technically capable of integrating modern energy storage systems with variable outputs. Inadequate grid infrastructure may also have insufficient hosting capacity to support additional loads or bidirectional energy flows associated with energy storage. Further, utilities that have not implemented advanced metering infrastructure (AMI) and other new data and communication technologies may not have the capability to effectively and accurately monitor storage assets and measure their contributions.[30]

State Energy Offices can incorporate storage as part of larger grid modernization plans and address some incompatibilities by sequencing storage improvements after other infrastructure upgrades. For example, New Mexico's Energy, Minerals and Natural Resources Department established a Grid Modernization Advisory Group comprised of industry leaders, researchers, and advocates to identify crucial grid improvements. Their work, particularly the corresponding white papers emphasizing the need for interconnection rule reform, informed the development of a comprehensive Grid Modernization Roadmap. This roadmap outlined an eight-year plan for grid modernization, including recommendations for AMI, energy storage expansion, and interconnection rule optimization.

4.2.3 High Capital and Financing Costs

The relatively high capital cost of various storage technologies hinders their deployment. For example, a typical utility-scale lithium-ion battery project totaling 100 MW with a four-hour duration can have upfront capital costs ranging from around $252-$323/kW-year of storage capacity.[31] In comparison, the installed cost of a natural gas combustion turbine peaker plant typically falls within the range of $115-$221/kW-year of storage capacity.[32] While natural gas peakers may have higher operating costs in the long run, this initial capital cost difference remains a barrier; the substantial up-front investment can discourage developers, utilities, and consumers.

The integration of energy storage into electricity markets also highlights a crucial sensitivity to the cost of capital. Energy storage systems, like many renewable technologies, often exhibit a cost profile characterized by higher initial capital expenditures and lower operating costs. This structure makes them particularly vulnerable to fluctuations in the cost of equity or debt, which are directly influenced by changing interest rates. As interest rates rise, the financing costs associated with these projects increase, potentially impacting their economic viability. Consequently, addressing this sensitivity is necessary for ensuring the successful deployment of energy storage and facilitating a cost-effective transition to a more flexible, reliable grid. State Energy Offices can play a vital role by providing incentives or assurances (e.g., insurance) that reduce both direct and indirect storage cost barriers.

4.2.4 Permitting and Interconnection Barriers

Grid access barriers — namely, permitting issues and interconnection delays — severely impact the deployment of energy storage. In 2022, over 680 GW of energy storage projects were effectively idling in interconnection queues, highlighting the scale of the problem.[33] State Energy Offices can work with their state public utility commissions and utilities to develop clear timelines and processes for reviewing energy storage permits and interconnection requests. State Energy Offices can also support the creation of model permitting or interconnection rules. The New Jersey Board of Public Utilities, for example, has initiated proceedings to modernize interconnection rules and processes for distribution system-level resources including storage.[34] Even in the absence of improvements to these procedures, however, it is still essential that State Energy Offices take these types of delays into consideration when establishing requirements and timelines for energy storage RD&D initiatives.

4.2.5 Limited Revenue Streams

Ensuring adequate compensation for the essential services that energy storage resources provide remains an issue. For example, storage offers benefits like grid stabilization, voltage support, and rapid capacity injection, yet current market designs often fail to fully recognize and compensate for these benefits. Early discussion of this issue is featured prominently in the Massachusetts Department of Energy Resources' (DOER) and the Massachusetts Clean Energy Center (MassCEC) "State of Charge – Massachusetts Energy Storage Initiative Study" ("State of Charge") published in February 2016.[31] These barriers also continue to apply to wholesale markets, and questions persist regarding fair compensation for the comprehensive services that storage provides.[35]

Federal Energy Regulatory Commission (FERC) Orders 841 and 2222 aim to address such challenges on the wholesale market level by facilitating the participation of energy storage and distributed energy resources (DERs), respectively, in regional markets.[36,37] Additionally, revisiting utility-level rate design is crucial to ensure fair compensation for energy storage. This necessitates the development of mechanisms that accurately capture the unique value contributions of energy storage. State Energy Offices can work with legislators and regulators to create markets that acknowledge, quantify, and reward the full range of grid services and the value that storage provides. These market reforms support wider revenue streams for developers, attracting further investment and stimulating increased storage adoption.

4.2.6 Safety and Environmental Concerns

Recent fire incidents in New York and other states have heightened community concerns regarding the safety risks, notably the risk of thermal runaway, associated with battery storage technologies.[32] Additionally, environmental concerns exist regarding mining practices and the disposal of certain battery types, as well as the ecosystem disruption caused by developing certain large-scale resources (e.g., pumped hydro). These types of concerns have a tangible impact on energy storage RD&D, often by slowing down or even halting regulatory approval of certain energy storage deployments.

State Energy Offices can address safety concerns in various ways, including developing or supporting training programs for emergency personnel to handle storage-specific safety challenges and establishing operational or installation standards to mitigate risk. For example, in 2023, the New York State Energy Research and Development Authority (NYSERDA) established an Inter-Agency Fire Safety Working Group to investigate fire incidents and proactively strengthen safety standards for energy storage systems.[38] NYSERDA also makes available training webinars for local governments and stakeholders. Webinar sessions cover crucial topics like fire safety, best practices for first responders, and decommissioning considerations.[39] Energy storage RD&D can also advance the understanding of failure modes and their consequences for different technologies. Related research areas could include battery cell chemistry improvements, optimal safety protocols for high-pressure systems, suppression detection systems, and robust containment infrastructure for materials presenting unique hazards in the event of failure.

State Energy Offices can separately address environmental concerns through initiatives that encourage (or enforce) responsible project siting and lifecycle management. Energy storage RD&D might address this barrier by studying substitutes for certain critical minerals, identifying strategies for hazardous battery waste disposal, or evaluating recycling opportunities.

---

31 See, for example, early discussion of this issue: State of Charge – Massachusetts Energy Storage Initiative Study.
32 See, for example, recent news on the topic: An exploding problem: Fires sparked by lithium-ion batteries are confounding firefighters.

5. Potential Roles of State Energy Offices

State Energy Offices can play multifaceted roles in advancing RD&D of energy storage technologies. State Energy Offices bridge policy and program development, regulatory oversight, and market facilitation. They also work closely with other stakeholders involved in advancing energy storage, support the private sector in deploying energy technologies, and ensure that the benefits of energy storage reach all citizens. The following discussion reviews ways that State Energy Offices can support utility-scale energy storage RD&D as well as some potential goals and strategies for these efforts.

5.1 Partnerships

State Energy Offices often work in concert with a diverse array of stakeholders to shape energy storage policy, regulation, and/or program implementation. Table 2 outlines the different types of external stakeholders, collaborators, and partners that State Energy Offices might engage with as it relates to energy storage. This coordination can be helpful in advancing energy storage RD&D objectives by ensuring adequate consideration of a variety of needs and objectives.

Table 2. Energy Storage RD&D Stakeholders, Collaborators, and Partners for State Energy Offices

Entity	Energy Storage RD&D Role	State Energy Office Partnership
Federal Agencies	DOE sets national energy goals, conducts research, and provides funding for storage initiatives. Other federal agencies (e.g., Dept. of Treasury, Dept. of Homeland Security) oversee specific initiatives (e.g., tax credit guidance, resiliency funding) that have implications for storage projects.	Align state efforts with national goals, tap into federal funding, and leverage federal research and development resources.
Public Utility Commissions (PUCs)	Enact energy storage procurement targets, evaluate utility plans for integrating energy storage, establish rules and regulations supporting grid integration of storage, and approve rates that incentivize storage usage, among other initiatives.	Intervene in and advocate for energy storage policy objectives as part of PUC proceedings.
Other State Agencies	Set policies in areas like economic development, environmental protection, workforce development, and energy justice that directly or indirectly influence storage RD&D.	Close collaboration with these agencies ensures that energy storage initiatives align with broader state goals. Outside state agencies can also serve as a partner and provide resources or financial support.
State Legislators	Create laws that can mandate energy storage targets, incentives, and programs. Their role is legislative, including setting the statutory framework within which State Energy Offices operate.	Oversee the day-to-day management and implementation of legislated energy storage initiatives.
Utilities	Both investor and consumer-owned utilities integrate energy storage onto the grid and manage grid operations. Utilities may also oversee storage as part of economic and reliability planning.	Ensure efficient deployment of storage RD&D resources and promote storage development. This is especially true for consumer-owned utilities outside of PUC oversight.
Private Sector	Energy storage manufacturers, developers, investors, and other commercial entities are involved in creating and deploying energy storage projects. The private sector is a significant driver of innovation and implementation.	Partners for all stages of storage RD&D, especially insofar as state efforts aim to bridge gaps in private sector support or spur private sector activity.
Research Institutions	Universities (public and private), national laboratories, and private sector laboratories (start-ups, corporate labs, contract research) promote technical research related to storage.	Collaborate with research institutions to fund specific projects, align research agendas with state goals, and facilitate technology transfer from academia to industry.
Consumers and Communities	End-users play a crucial role in the adoption and integration of energy storage systems. Their acceptance and participation can drive the deployment and scaling of new technologies.	Engage with consumers and community groups to educate and inform or involve communities in decision-making processes to ensure that projects meet local needs.
Local Governments	Implement zoning and planning regulations, provide permits, and influence local energy policies that influence the development of storage. They often have direct control over local infrastructure and energy planning.	Provide technical and financial support to local governments for implementing energy storage projects, as well as assist in capacity building and strategic planning.

Universities and research labs possess crucial technical knowledge and are often effective partners for State Energy Offices, especially those without extensive in-house resources. The Iowa Energy Office (IEO), for example, collaborates with the University of Iowa and Iowa State University to identify and develop energy storage pilot project opportunities.[33]

State Energy Offices can also leverage utility and other state agency partners to execute storage RD&D. For example, Colorado's MCR program involves the Colorado Department of Local Affairs, Colorado Department of Regulatory Agencies, and Colorado Energy Office. This collaboration enables the Colorado Energy Office to access additional funding, draw from other agencies' expertise on regulatory or policy matters, and build more robust coalitions for projects.[40]

At the federal level, DOE coordinates research, development, demonstration, and deployment of storage technologies through the Energy Storage Grant Challenge (ESGC). The ESGC is co-chaired by the Offices of Electricity (OE) and Energy Efficiency and Renewable Energy (EERE), and includes 12 other offices. Major focal areas include investment and finance; markets and value; and collaboration on thermal, power electronics, and electrochemical technologies.

Engaging early with community leaders, key industries, and representatives can help shape projects and identify localized solutions. The Georgia Environmental Finance Authority's (GEFA) Solar Resiliency Technical Assistance Program exemplifies the importance of proactive community engagement. Rather than predefined storage projects, GEFA provided technical support to conduct detailed techno-economic analysis of solar and storage deployment opportunities specific to each local partner. To enable this sort of evaluation, GEFA also provided pre-assessment funding to help local governments assess their resiliency needs.[41]

Besides the above partners, State Energy Offices can connect with other State Energy Offices in neighboring states that may face similar grid characteristics or storage adoption hurdles. Shared knowledge platforms, such as those provided by NASEO, facilitate exchange of valuable case studies and best practices that translate within a region.

5.2 State Policy

State Energy Office policy involvement can span from the initial conceptualization of policies and provision of related expert guidance to policymakers, all the way to policy implementation and administration. In their policy capacity, as distinct from regulatory activity, State Energy Offices can ensure that energy storage RD&D initiatives are well-designed and effectively managed to meet governor and legislature-directed objectives.

5.2.1 Propagator and Creator

State Energy Offices can be primary drivers in the development of state energy storage policies. This can include outlining information on the opportunities for energy storage in state energy plans or State Energy Security Plans, making policy recommendations to state legislatures or governors, setting state-specific targets for energy storage adoption, and supporting creation (or implementation) of regulatory guidelines that facilitate the integration of energy storage. State Energy Office groundwork for comprehensive energy storage policy can stand alone or be part of broader state efforts that support grid resilience, renewable integration, decarbonization, or other policies. For example, the Connecticut Department of Energy and Environmental Protection (DEEP) releases its "Comprehensive Energy Strategy" report every five years. In the last available edition, DEEP outlined its strategy to increase the development of storage and identified several target applications, such as leveraging EVs as storage assets, using storage to reduce peak demand, and establishing microgrids.[42]

33 For reference, see: Mobile Microgrid for Disaster Recovery.

5.2.2 Policy Implementor

State Energy Offices can be tasked with implementing directives from legislators or governors' offices. Implementation can involve translating high-level mandates into actionable programs for application within a state's energy sector. For example, Maine Legislative Document 528, a bipartisan piece of legislation, tasked the Governor's Energy Office with performing an evaluation of Maine's energy storage market and setting specific targets for energy storage.[43]

Implementation efforts may also include managing pilot programs that test new energy storage solutions, ensuring adherence to established energy storage standards, and systematically tracking whether policy goals are being achieved. By tracking advancements in energy storage technologies, shifts in market dynamics, and the evolving needs of a state's energy system, State Energy Offices ensure the policies remain relevant and responsive. This comprehensive approach helps in fine-tuning strategies and ensuring effective deployment of energy technologies.

5.2.3 Facilitator, Educator, and Decision Supporter

State Energy Offices can provide critical advisory services to stakeholders, including legislators; regulators; investor, municipal, and consumer-owned utilities; private developers; and local governments, as they navigate energy storage policies. In this capacity, State Energy Offices may offer technical assistance, share best practices, and facilitate discussions that guide these entities in aligning their storage efforts with state policies. In some cases, State Energy Offices are responsible for gathering and analyzing data that inform policy decisions related to energy storage. This can include market studies, technology assessments, and cost-benefit analyses (described below) that evaluate the potential impacts and opportunities of energy storage deployment. By preparing these resources, State Energy Offices equip decision-makers with the evidence needed to support storage policy initiatives. State Energy Offices can also support the incorporation of energy storage into broader energy, environmental, and economic goals reflected in state policy. The Iowa Energy Office's Energy Storage Action Plan, for example, is intended to tie potential energy storage initiatives into broader state energy initiatives related to resilience, reliability, and integrating renewable sources, versus making prescriptive policy recommendations.[44]

5.2.4 Participant in Regulatory Proceedings

State Energy Offices often act as intervenors in regulatory proceedings, representing the interests of a state and its citizens and ensuring state policy objectives are adequately considered. In this role, State Energy Offices can contribute to defining how energy storage systems, particularly those connected to the utility grid, are deployed by utilities, compensated by utilities and markets, and regulated on an ongoing basis. For example, the Governor's Office of Energy in Nevada provided background information and recommendations as part of the Public Utility Commission of Nevada's Investigation Regarding Energy Storage Technologies.[45]

State Energy Office efforts can also hold utilities accountable for incorporating technological changes by sharing information about market developments during integrated resource planning and related proceedings. In several states, State Energy Offices also directly initiate rulemaking proceedings intended to develop guidelines for the deployment and utilization of energy storage. For example, California's CEC establishes standards related to minimum performance requirements, interconnection, and resource management of nonresidential energy storage resources.[46]

5.2.5 Common Policy Goals

Acceleration of energy storage deployment is increasingly a priority for State Energy Offices due to storage's ability to support or achieve diverse objectives, as discussed above. Storage RD&D, therefore, is an equally important strategic priority insofar as it can facilitate development of the storage needed to meet each State Energy Office's priorities. Table 3 provides a brief review of several common policy objectives for storage RD&D efforts.

Table 3. Potential Policy Goals for Energy Storage RD&D
Increase Investment and Drive Market Acceleration
▪ **Mitigate liability:** Implement robust risk management strategies, such as standardized liability frameworks, performance parameters, and insurance products, to increase investor confidence and attract capital. ▪ **Reduce time constraints:** Streamline permitting and approval processes to significantly reduce project timelines and costs. ▪ **Create market entry points:** Derive new mechanisms for energy storage to participate in existing competitive and regulated markets to provide the financial incentive for additional investment. ▪ **Improve efficiency or effectiveness:** Promote economies of scale and facilitate experiential learning to accelerate market growth. ▪ **Address uncertainties:** Clarify regulatory frameworks to reduce market uncertainty and attract investment.
Facilitate Technologies Reaching the Market
▪ **Support fundamental research:** Invest in early-stage research targeting breakthroughs in storage materials, chemistries, and system designs to facilitate the development of marketable products. ▪ **Build public-private partnerships:** Leverage partnerships between the public and private sectors to mobilize resources, share risks, and foster market growth. ▪ **Enhance system compatibility:** Develop standards and protocols for the integration of new storage technologies with existing grid infrastructure to enable seamless adoption and operation.
Support Industrial Strategy Objectives
▪ **Stimulate economic activity:** Form regional hubs of energy storage expertise to attract investment and expand the regional tax base. ▪ **Build a workforce:** Develop or recruit a skilled labor pool that can attract new industries and facilitate innovation.
Engage Key Communities
▪ **Support key constituencies:** Reinforce energy equity in underserved communities through targeted incentives and funding mechanisms. ▪ **Connect with stakeholders:** Engage decision-makers and educate community members to foster support and identify (or address) real needs.

5.3 State Roadmaps, Market Assessments, and Plans

Most State Energy Offices are responsible for developing comprehensive state energy plans that lay out the path for a state's energy future, assess supply and demand, provide an overview of the policy landscape, and examine innovative technologies.[34] They also often have responsibility for developing State Energy Security Plans that explore measures for maintaining secure and resilient electric systems. State Energy Security Plans specifically look at hazard mitigation and resilience opportunities such as energy storage and microgrids. In addition, State Energy Offices across the country have developed road maps, market assessments, frameworks, and other documents that specifically look at the role certain energy technologies can play.

When focused on energy storage, these resources address ways to expand and optimize energy storage deployment. (See Appendix A for an illustrative list of reports from State Energy Offices addressing storage in various ways.) State Energy Offices also help integrate energy storage plans into broader state planning efforts and monitor progress toward meeting plan goals, as well as support local entities in developing their own plans. The following sections detail common characteristics of energy storage plans (or the plan development and monitoring process), as well as ways planning extends to the local level.

34 For general resources addressing state energy plans, see: Statewide Comprehensive Energy Plans.

5.3.1 Market, Policy, and Regulatory Overview

These documents often include assessments of current energy storage capacity in a state or region, forecasts of future potential for storage, and detailed descriptions of existing or prospective policy and regulatory conditions affecting storage. Other common elements include a review of existing and prospective storage technologies, assessment of storage revenue streams, and reviews of how energy storage integrates with other state energy initiatives. State Energy Offices conduct research themselves or facilitate collaboration with consultants, utilities, technology developers, and research institutions to gather up-to-date data to develop these overviews. In some cases, an overview is part of a broader techno-economic feasibility analysis.

The Massachusetts DOER's and MassCEC's "State of Charge" report is often cited as a paradigmatic example of how a State Energy Office can comprehensively analyze the potential of energy storage technologies to address a state's energy needs and challenges.[47] This report outlines the market landscape, evaluates specific use cases, and models the benefits of energy storage, including cost savings, grid reliability, and emission reductions. The report also gathers diverse stakeholder perspectives to identify challenges and opportunities, leading to a set of detailed policy and regulatory recommendations aimed at promoting the adoption and integration of energy storage solutions into Massachusetts' energy infrastructure.

5.3.2 Policy and/or Regulatory Guidance

State Energy Offices play a key role in translating the targets outlined in state plans or legislation into actionable guidance for stakeholders. Road maps can provide specific recommendations that empower policymakers to take informed action on storage policy or regulation. They can also serve as a more general resource for legislators and state agencies as they design targeted energy storage actions. Additionally, state road maps can serve as guideposts for investors, project developers, and regulators, aiding their planning and decision-making.

For example, the CEC's "Utility-Scale Renewable Energy Generation Technology Roadmap" serves as a strategic guide for research, development, and demonstration efforts aimed at supporting California's energy targets (as outlined in California Senate Bill 100). This report provides an in-depth evaluation of renewable energy technologies and technology initiatives for nine technology areas. Energy storage systems are one of the areas described, including key barriers to the integration of storage solutions and recommendations of targeted legislative and regulatory initiatives to enhance storage capacity and efficiency. These recommendations are designed to ensure that energy storage can effectively support the integration of renewable sources.[48]

5.3.3 Distinctive Needs and Comparative Advantage Assessment

One way that State Energy Offices can maximize the impact of energy storage policies and RD&D initiatives is by aligning them with the unique strengths and characteristics of their states. Planning exercises, like those described above, provide an important opportunity to identify the distinctive needs and comparative advantage of a region, state, or locality. They also provide a forum for State Energy Offices to recommend additional RD&D that strategically harnesses a state's unique strengths and requirements. Table 4 summarizes some potential needs and advantages a State Energy Office might assess through a state road map, plan, or assessment.

Table 4. Potential Distinctive Needs and Comparative Advantages to Evaluate
Resource Availability and Access
▪ **Geography and topography:** Tailor RD&D to storage technologies that best suit a state's terrain (e.g., pumped hydro storage in mountainous regions or compressed air in underground formations). ▪ **Climate:** Prioritize RD&D that promotes (or requires) storage performance compatible with a state's specific climate conditions (e.g., extreme heat, humidity, or frequent storms). ▪ **Existing infrastructure:** Investigate opportunities to repurpose or more fully utilize existing resources, such as building on a brownfield (e.g., the property of a retired power plant) or integrating into systems with useful byproducts (e.g., heat from local industrial processes).
Laboratories and RD&D Capacity
▪ **Leverage RD&D strengths:** Direct research toward domains where a state already has substantial expertise and facilities (e.g., EV battery RD&D in a state with automotive expertise). ▪ **Explore emerging fields:** Encourage interdisciplinary research that taps into a state's broader scientific competencies (e.g., materials science and alternative battery chemistries).
Workforce and Talent
▪ **Talent pipelines:** Forge partnerships with existing educational institutions to promote or bolster talent pipelines relevant to storage, among other industries (e.g., skilled tradespeople). ▪ **Skills gap analysis:** Collaborate with existing storage companies in a state to identify skill shortages and then develop targeted workforce development programs.

In practice, assessing these factors may lead a state to propose energy storage RD&D targeted at specific technologies or industries. For example, the Iowa Energy Office has a specific interest in long-term storage applications involving renewable hydrogen given the state's prominent and large wind capacity resource, as addressed in IEO's "Renewable Hydrogen in Iowa" report.[49] The "Energy Storage in Maryland" report, prepared by the Maryland Department of Natural Resources' Power Plant Research Program, specifically identifies opportunities to support energy storage RD&D targeting niche, extreme-environment storage technologies that would support the state's large government, aerospace, biotech, and health industries.[50]

5.3.4 Cost-Benefit Analysis

Cost-benefit analysis can complement a State Energy Office's assessment of existing or potential energy storage RD&D initiatives. A robust cost-benefit analysis should encompass the complete array of financial returns associated with storage. This includes direct benefits like revenue from market participation alongside indirect gains such as avoided reliance on peaking plants or displaced transmission assets. For example, in 2019, the Minnesota Department of Commerce Division of Energy Resources conducted an energy storage cost-benefit analysis that found energy storage installed in 2025 could be a cost-effective capacity resource. The analysis also emphasized the importance of strategically locating energy storage in constrained areas to potentially defer transmission and distribution system upgrades.[51]

For states interested in developing similar analyses, resources such as Electric Power Research Institute's StorageVET®,[52] or Pacific Northwest National Laboratory's Energy Storage Evaluation Tool (ESET™)[53] offer frameworks for estimating the value of storage in addressing various use cases. Additionally, modeling frameworks like the Department of Homeland Security's Federal Energy Management Agency's National Benefit-Cost Analysis Toolkit can help State Energy Offices assess the financial value of intangible attributes, like the reliability and resiliency enabled by energy storage investments.[54] These and other resources can streamline the cost-benefit analysis process, particularly for State Energy Offices with limited technical resources.[55]

5.3.5 Stakeholder Engagement

The development of these road maps often involves extensive stakeholder engagement, including collection of feedback from public utilities, private sector participants, and community groups. This participatory approach ensures that plans reflect a wide range of perspectives and address the needs of different stakeholders. State Energy Offices can play a role in facilitating stakeholder and community convenings and focus groups, as well as overseeing stakeholder participation.

For example, developing NYSERDA and the New York State Department of Public Service's "New York's 6 GW Energy Storage Roadmap" involved a comprehensive stakeholder engagement process. Each of the road map's sections includes a subsection with questions for stakeholders. Furthermore, Appendix C of the road map presents a stakeholder survey. To inform road map development, NYSERDA conducted an extensive survey of energy storage developers and installers in the state's most active market segments: residential, retail, and bulk. The survey, along with in-depth engagement sessions with tradespersons, aimed to gather insights on various factors influencing the New York energy storage market. The survey yielded responses from over 50 industry participants, providing valuable input for the road map's recommendations.[56]

Stakeholder engagement initiatives can also emerge as a result of an energy storage roadmap or assessment. For example, following publication of the "Pennsylvania Energy Storage Assessment: Status, Barriers and Opportunities" in April 2021, the Pennsylvania Department of Environmental Protection's Energy Programs Office constituted an Energy Storage Consortium. This Consortium, which includes a wide variety of stakeholders, continues to meet quarterly to discuss various energy storage topics relevant to the assessment.[57]

5.4 Financial Incentives

Financial incentives are a direct mechanism to lower entry barriers and make energy storage solutions more economically viable. State Energy Offices oversee and manage various financial incentives both as a recipient and distributor of state and federal resources.

5.4.1 Recipient

Most typically, State Energy Office funding comes from annual or periodic state budgets, and these budgets can include money earmarked for energy storage RD&D. However, State Energy Offices also often receive funding from federal initiatives. These funds can be designated for developing and demonstrating innovative energy storage technologies and strategies. For instance, the Virgin Islands Energy Office is utilizing U.S. State Energy Program funds to support an energy storage rebate program. The program offers up to $4,000 in rebates for the installation of new residential or commercial grid-interactive battery energy storage systems.[58]

State Energy Offices can also incorporate federal incentives, most especially the investment tax credit but also loan guarantees, into their energy storage RD&D initiatives as a source of cost or risk reduction. For example, Utah's Advanced Clean Energy Storage project will enable the development of clean hydrogen storage using a guarantee from DOE's Loan Programs Office.[59] Table 5 identifies several federal funding opportunities or financial incentives in the IIJA and Inflation Reduction Act (IRA) related to energy storage RD&D that illustrate the types of opportunities available to State Energy Offices.

Table 5. Select Federal Funding Opportunities and Incentives Supporting Energy Storage RD&D in the IIJA and IRA				
Enabling Legislation	**Statute Section**	**Goal**	**Budget**	**Description**
Infrastructure Investment and Jobs Act (2021)	**40207**	Supply Chain Improvement	$2.8 billion	DOE EERE grants to bolster domestic battery supply chain and energy storage manufacturing.
	40334	Pumped Hydropower Demos	$10 million (FY 2022-26)	Demos of >1 GW pumped storage hydropower using intermittent renewables, located on Tribal lands, and serving an organized market.
	41001	General Energy Storage Support	$505 million	$355M for storage demos/pilot grants, and $150M for Long-Duration Energy Storage Pilot Grant Program.
Inflation Reduction Act (2022)	**48E**	Tax Credit for Energy Storage	N/A	Technology-neutral investment tax credit for compliant energy storage projects (operational post-2024).
	22001	Loans for Rural Electrification	$1 billion	Loans/forgivable loans (to FY 2031) for rural renewable energy and energy storage, with interest rates aligned with municipal bonds.

The availability of federal funding and other financial incentives can influence State Energy Office RD&D efforts in several ways beyond simply making resources available. DOE's EERE, for example, identifies cost-competitive LDES as one of its core focus areas, and oversees several related funding and support initiatives.[35] Likewise, DOE's OE co-chairs the Energy Storage Grand Challenge initiative that includes funding programs intended to accelerate LDES RD&D, among other areas.[60] Thus, State Energy Offices might focus on LDES in order to harness DOE resources focused on the topic.

As another example, the new Inflation Reduction Act investment tax credit for energy storage incorporates a base rate/bonus rate structure, where the bonus rate is available for projects that adhere to certain criteria. This provision encourages states to promote projects that are located in designated disadvantaged communities, utilize domestically sourced materials, and more. Further, federal funding typically imposes management and evaluation requirements. State Energy Offices are generally responsible for ensuring their RD&D initiatives comply with these federal mandates, including allocation of appropriate resources to track federally funded programs over time.

5.4.2 Distributor

State Energy Office administered energy storage RD&D incentives can take different forms but generally serve the same function of making energy storage investments more attractive. Prominent incentive types include rebates, loans, and tax incentives, each of which supports various energy storage RD&D applications (see Table 6).

Table 6. Financial Mechanisms by Storage RD&D Resource Characteristics		
Incentive	**Application**	**Suitable Storage Resources**
Grants	Funds initial deployments of early-stage storage resources through direct financial support.	Community-led projects, innovative pilots with potential for scalability, or emerging technologies that require further demonstration to establish cost and performance profiles.
Loans and Loan Guarantees	Direct project financing or backstop financial support that reduces risk exposure.	Larger-scale storage projects, projects with limited or no track record of deployment at scale.
Rebates	Offsets the cost of storage through refunds issued after initial upfront capital expenditure is made.	Smaller-scale storage resources, established technologies with clear net positive cost-benefit.
Tax Credits	Tax relief that is usually realized through the deduction of certain energy storage expenses from taxable income.	Mature storage technologies with established cost structures.

35 See: NASEO Virtual Roundtable: State Efforts to Enhance Energy Storage RD&D.

Grants are the most common financial incentive distributed by State Energy Offices for purposes of supporting energy storage RD&D. Among the chief advantages of grants over other incentive types are their relative ease of administration, and their flexibility in terms of size and requirements. Grants are usually targeted toward the primary beneficiaries of prospective energy storage RD&D and, thus, are direct. For example, the CEC's Electric Program Investment Charge (EPIC) program invests in a broad range of electricity-sector related clean energy research, including storage technologies. The EPIC program has invested in both lithium and non-lithium-based storage technologies. In June 2024, the CEC released a grant funding opportunity through EPIC, Energy Storage Innovations to Support Grid Reliability, that will fund applied research and development and technology demonstration and deployment projects that will advance short- to long-duration stationary energy storage technologies.[61]

State-level tax credits are a fairly novel way to incentivize energy storage. A leading example is Maryland's Energy Storage Income Tax Credit, which provides valuable rebates to residential and commercial property owners who install energy storage systems. Under this program, the Maryland Energy Administration (MEA) can award up to $750,000 in tax credit certificates annually.[62]

5.5 Program Implementation and Execution

State Energy Offices play a pivotal role across the entire lifespan of energy storage incentive and support programs. Effective planning, ongoing management, and data-driven evolution ensure programs survive, succeed, and have long-term impact. These efforts can also ensure programs remain relevant to state policy objectives.

Programs may focus solely on research and development, solely on demonstration, or all three components. Research and development focused programs help originate new storage technologies or applications that serve critical use cases. When looking at demonstration programs, energy storage RD&D initiatives create testing grounds for new technologies and provide valuable data on energy storage system operations and their integration with existing energy systems. Program implementation can also help demonstrate the technical feasibility and value proposition of various energy storage applications in real-world settings. This includes showcasing how storage can address specific grid challenges and optimize system operations. Identified below are key focus areas for different stages of energy storage RD&D program planning and execution.

5.5.1 Program Planning

Framing and guiding the implementation of any program requires strategic inquiries. Table 7 offers a breakdown of select near and long-term considerations for new energy storage RD&D programs, with accompanying questions.

Table 7. Select Questions and Considerations When Identifying Energy Storage RD&D Program Scope
Near-Term
Who is involved, and to what degree? Identify all stakeholders (beneficiaries, program staff, investors, community partners, etc.) and define their specific roles and levels of participation.
What are the goals of the program? Establish clear, measurable, achievable, relevant, and time-bound goals that the program aims to accomplish.
What types of investment/support? Outline the required resources: financial, human capital, time, technology, etc. Be specific about funding sources.
All portions of the state and communities, or just some? Define the geographic and social scope. Will the program impact the entire state, focus on specific regions, or select pilot areas? Will the program serve all communities or specific constituencies?
What is the current state of the program? Conduct a baseline assessment to determine the existing conditions of the program and needs the program seeks to address. Use key metrics and data for benchmarking.
Long-Term
What is the process to ramp up or down? Plan how the program will scale. Consider phases, gradual expansion, and exit strategies for eventual phase-out if applicable.
What are the target market conditions/outcomes? Clearly define desired changes and impacts to be achieved (using indicators) over the long run. Determine whether the program has an open-ended or finite lifespan, or targets a specific condition.
How will progress toward future states be measured? Determine metrics and methods to evaluate and track progress toward long-term outcomes. Consider how to use these data for ongoing program adaptation.

State Energy Offices developing programs may be interested in collecting information from the general public and other key stakeholders to address these and other program scope questions. For example, the Maine Governor's Energy Office released a Request for Information (RFI) soliciting public input regarding the design of a statutorily mandated program to procure up to 200 MW of commercially available, utility-scale energy storage systems connected to transmission and distribution systems.[63] RFIs are an efficient way to collect information and help State Energy Offices shape programs in the early planning phase.

5.5.2 Harmonizing Program Concepts

By actively tracking federal initiatives, State Energy Offices can shape their state-level programs in a complementary manner that fills gaps left unaddressed by existing federal efforts as well as prevents duplicative RD&D. State Energy Offices can also design their programs to demonstrate alignment with federal priorities. This harmonization may help secure federal support, including funding and technical resources, as discussed above.

Similarly, State Energy Offices can accelerate energy storage RD&D by strategically aligning new programs with existing state programs focused on solar and wind deployment, EV integration, or microgrid development. By highlighting the interconnectedness of these technologies and demonstrating how storage enhances or unlocks additional value, State Energy Offices can frame storage as a key enabler. This approach can also reduce policy barriers and streamline the implementation of storage initiatives by leveraging existing program frameworks.

5.5.3 Program Adoption

The basic stages of program adoption are similar for most State Energy Office energy storage RD&D efforts. First, adequate staffing with a clear division of responsibilities facilitates the efficient launch (and eventual operation) of a proposed program. Staffing requirements range from dedicated technical experts who process applications and make funding determinations to supporting personnel who can handle inquiries from funding recipients and manage program administrative tasks.

Second, comprehensive outreach strategies can raise awareness of potential programs among various target audiences, ranging from developers and potential end-users (commercial, industrial, residential) to policymakers and the general public. Outreach efforts can include informational workshops, resources explaining program benefits, and detailed proposal requirement documentation. Third, once a program is active, setting clear, transparent evaluation criteria is integral to the fair and equitable distribution of program support. Prioritizing projects that best align with policy goals, maximize impact, or meet other predefined criteria helps establish a reasoned basis for resource allocation decisions.

5.5.4 Maintenance

Managing an active program typically involves ongoing measurement and evaluation. This can include collecting accurate data on program participation, technology deployment trends, or system performance, depending on the program design. The MassCEC for example, requires quantitative data from private sector recipients of energy storage funding to assess pilot project success, inform regulatory processes, and learn how to scale storage pilots into larger initiatives.[64] Qualitative feedback is also considered; MassCEC conducted over 50 interviews with hundreds of stakeholders as part of the Massachusetts Advancing Commonwealth Energy Storage program assessment.

Having this type of information enables State Energy Offices to track progress toward stated goals and adjust program elements if necessary. Monitoring market shifts, understanding success factors, and identifying any barriers to adoption can also inform ongoing improvements and future program iterations. Energy storage programs may also be designed with a trajectory toward self-sufficiency as the market matures. Gradual, data-informed reduction of incentives, for example, could help mitigate market shock when state support ends.

5.5.5 End-of-Life

While early-stage markets rightly focus on deployment, forward-thinking planning incorporates robust end-of-life (EOL) strategies. Collaboration with technology developers and experts establishes an understanding of recycling pathways or appropriate landfilling practices unique to various energy storage technologies. For example, NYSERDA organized a presentation with Li-Cycle, a leading global lithium-ion battery resource recovery company, and Det Norske Veritas, a technical audit conglomerate, to discuss the economics and environmental considerations of decommissioning energy storage systems.[65] Programs may also include proactive assessment and potential funding mechanisms for site remediation when large-scale storage solutions reach EOL. This minimizes future environmental liabilities for a state and fosters sustainable practices.

5.6 Direct Research and Development

Advancing the state of the art of energy storage can involve a wide variety of research and development efforts, including material science, process innovation, production refinement, and more. With limited exceptions, State Energy Offices do not directly conduct R&D of energy storage technologies. Instead, these activities are left to university, laboratory, and commercial partners. State Energy Offices do, however, enable a broader R&D ecosystem in a variety of ways. First, through policies, incentives, and grid integration efforts, State Energy Offices create a demand-pull that encourages research institutions and private companies to invest in developing new and innovative energy storage technologies.

Second, State Energy Offices can facilitate partnerships and collaborations that pool resources and expertise to tackle complex energy storage R&D challenges. State Energy Offices are potentially well-positioned to track and disseminate learnings from ongoing energy storage RD&D, especially from endeavors supported by state funding. Finally, State Energy Offices can influence R&D priorities through the identification of specific and measurable problems. In this way, a State Energy Office can lay the groundwork for an R&D agenda even if not directly conducting associated R&D.

6. Energy Storage RD&D as part of Energy Justice and Equity Efforts

Integrating energy equity or energy justice considerations into storage RD&D can ensure resources are available to and serve disadvantaged communities, address emergent and longstanding disparities, and create new pathways for community growth. The form that these considerations take can vary by state, as can the communities targeted. In some cases, justice and equity considerations for energy storage fall under broader state initiatives. For example, a state may require that a specified percentage of all funding be allocated to communities comprised of low-income households. Energy storage, however, also offers distinct advantages that make it uniquely suited to support certain communities. Reviewed below are ways that State Energy Offices can develop and design energy storage RD&D to align with an equitable energy transition and/or serve rural, remote, vulnerable, and historically marginalized communities.

6.1 Just Energy Transition and Energy Communities

Just energy transition within the broader context of environmental and energy justice refers to efforts to ensure the benefits and burdens of the energy transition, including adoption of energy storage, are shared fairly.[36] These efforts are typically targeted at "energy communities," meaning communities that have historically depended on fossil fuels as a source of tax revenue, employment, and other local economic activity.[37] Strategies for energy communities also apply to rural, vulnerable, and historically marginalized communities, discussed below. Table 9 identifies the four categories of energy justice, with a brief discussion of how they might apply to energy storage RD&D initiatives conducted by State Energy Offices.

36 Section 5 For general resources addressing equity issues, see: NASEO: Equity.

37 Several interpretations of "energy community" exist within a statutory context. For further discussion, see: What Is An "Energy Community"? Alternative Approaches for Geographically Targeted Energy Policy.

Table 9. Energy Justice Considerations and Energy Storage RD&D Applications			
Justice Type	**Description**	**Applications**	**Goals**
Procedural Justice	Establishing fair processes that involve all energy community stakeholders in the decision-making procedures that affect them.	▪ State Energy Offices can integrate local stakeholders into decision-making through public forums, surveys, workshops, and advisory committees. ▪ State Energy Offices can implement transparent processes for deciding where to locate energy storage projects and how to allocate funding for RD&D, among other decisions.	▪ Ensure that RD&D choices are made openly and with the potential for community input. ▪ Enhance trust, foster local acceptance, and ensure projects directly address just energy transition priorities.[66]
Restorative Justice	Addressing past injustices in ways that repair energy communities to a more equitable state.	▪ Storage RD&D can target technologies that play a direct role in remediation. For example, incentives to pair solar and storage on brownfields can support clean-up and reinvestment that repair areas harmed by legacy pollution.[67] ▪ State Energy Offices can promote RD&D that reduces reliance on fossil fuels and improves local air quality, both of which are crucial for areas with high pollution levels.	▪ Storage RD&D can promote positive outcomes for previously harmed communities through their location.
Recognition Justice	Acknowledging the distinct impacts of policies and programs on different energy communities, and ensuring the knowledge and values of all energy communities are adequately addressed.	▪ State Energy Offices can collaborate with scientists, researchers, and community leaders to assess storage applications. For example, energy storage can emerge as a viable (or even preferrable) substitute for natural gas generation or new transmission lines after accounting for the environmental and societal effects of larger-scale projects, even when storage is more expensive. ▪ State Energy Offices can pursue RD&D projects that also recognize broader community needs. For example, reducing energy cost burdens through building-integrated residential storage, or targeting food deserts for resilient microgrids.	▪ Identify ways that storage solutions better reflect the values and needs of the people being served. ▪ Recognize and address the unique needs of supported communities.
Distributive Justice	Promoting equitable distribution of costs and benefits, including access to new opportunities and compensation for losses, among energy communities.	▪ State Energy Offices can target investment in science, technology, engineering, and math education and skills training within underserved communities. ▪ State Energy Offices can apportion funding in a representative manner (e.g., based on community income) to ensure all communities, including those with fewer resources, have an opportunity to deploy state support. ▪ State Energy Offices can help communities pair storage with community solar, rooftop solar, and other clean energy technologies to make the combined resources more economic as well as enlarge the benefits available from any one resource alone. For example, paired storage and solar may create pathways to energy independence, especially for low-income communities.[68]	▪ Ensure energy communities benefit from investment or other state resources committed to energy storage RD&D. ▪ Create a diverse and well-distributed pipeline of individuals empowered to participate in a growing energy storage sector. ▪ Foster not only direct economic benefit but also greater self-determination for communities traditionally excluded from energy sector decision-making.[69]

States have several resources and tools available to facilitate the assessment and integration of energy justice considerations into energy storage RD&D. NASEO and the Minnesota Department of Commerce Energy Division, for example, published "Designing Equity-Focused Stakeholder Engagement to Inform State Energy Office Programs and Policies" as a guide for State Energy Offices to meaningfully engage with diverse stakeholders, particularly those from marginalized communities.[70] At a national level, the Justice40 Initiative's Memorandums 21-28 and 23-09 implementation guidance offer valuable insights and help align state efforts with national equity goals.[71,72]

State Energy Offices are also increasingly taking a data-driven approach to align projects with broader energy justice goals. For example, California's CalEnviroScreen tool helps the CEC pinpoint areas with socioeconomic disadvantages, high energy burdens, or other distinguishing community characteristics.[73] Connecticut, Delaware, Illinois, Massachusetts, Michigan, New Jersey, New York, Pennsylvania, Virginia, and Washington have similarly designed their own maps.[74] Additionally, federal resources like the Centers for Disease Control and Prevention's social vulnerability maps and the Council on Environmental Quality's Climate and Economic Justice Screening Tool offer State Energy Offices that do not have their own mapping tools the opportunity to freely access data on disadvantaged communities within their states.[75,76]

6.2 Historically Marginalized and Vulnerable Communities

Historically marginalized groups, including low-income, minority, rural, and tribal populations, often bear a disproportionate share of the energy system's burdens. These burdens include higher energy costs, unreliable service, and exposure to pollution from traditional generation sources. Rural communities, in particular, often lack access to reliable energy infrastructure and are dependent on outdated energy sources. Often, marginalized communities are also "vulnerable" communities, meaning they face a heightened risk of harm from climate change, legacy pollution, and the inequities of the existing energy system. Energy storage can play a vital role in protecting these communities by reducing their reliance on polluting energy sources, enhancing the resilience of critical infrastructure, and providing clean energy solutions that alleviate energy burdens and health disparities. State Energy Offices can actively shape and support RD&D to advance storage solutions that directly address the needs of marginalized and vulnerable communities.

The following examples highlight how some State Energy Offices are taking steps to target energy storage RD&D programs to meet marginalized or vulnerable community needs.

- **Iowa:** The IEO championed the development of readily deployable, robust storage systems designed for use in emergency shelters and within communities displaced by severe weather. Iowa's proactive research into storage that supports the operation of critical infrastructure (e.g., water purification) is intended to facilitate smooth transitions for the most climate-vulnerable populations during disruptions and supports the creation of long-term, resilient, sustainable communities.
- **Maryland:** The MEA, as part of the Resilient Maryland program, awards grants to low-income and vulnerable communities. For example, in 2022, MEA awarded $100,000 to the city of Cumberland for a microgrid feasibility study that included a storage component. The proposed project is intended to bolster the resilience of the city's wastewater system and critical emergency services infrastructure. With nearly 24% of the city's population below the poverty line, this community faces significant socioeconomic challenges. Funding for the feasibility study addresses a critical need, especially since the microgrid project would ensure access to clean water and vital services for vulnerable residents if it proceeds.[77]
- **California:** The CEC recently funded the Viejas Band of Kumeyaay Indians to construct a long-duration energy storage project using non-lithium technologies. This initiative focuses on deploying storage to create resilient systems for water purification, foster greater economic security, and avoid alternative energy technologies (e.g., diesel generators) that disrupt traditional ways of life in the Viejas community.[78]
- **Washington:** The Washington State Department of Commerce recently awarded $35.4 million in grants to support 52 planning and 39 installation projects for solar and battery backup systems. One grant to Family Health Centers in Okanogan County, a region prone to wildfires and other natural disasters, will help ensure uninterrupted medical care for vulnerable populations during power outages. This initiative underscores the importance of storage to maintaining critical services during emergencies.[79]
- **Colorado:** The Colorado MCR program is providing grant funding to municipal utilities and rural electric cooperatives to enhance community resilience in the face of power outages and extreme weather events, especially for communities located on isolated feeders.[80]
- **Remote areas:** Ongoing storage projects in states including Maine, Hawai‘i, and Alaska demonstrate how energy storage can optimize remote communities or island microgrids. By increasing energy autonomy, these projects reduce reliance on mainland infrastructure and can increase resilience during disruptive events. For example, the Hawai‘i State Energy Office (HSEO) demonstrates a commitment to addressing these island-specific needs through a partnership with the Kaua'i Island Utility Cooperative to integrate battery storage and advanced grid-forming inverters into two existing solar power plants. This project, which received over $17.9 million from DOE's Grid Resilience and Innovation Partnerships Program, aims to increase dispatchability, reliability, and flexibility within the island's grid. Additionally, the project's novel application of grid-forming technology at this scale has the potential to serve as a replicable model for enhancing island grids and enabling greater decarbonization in other local, regional, and interregional contexts.[81] HSEO considers grid-forming technology deployments to be a priority in proving endgame strategies for grid reliability in scenarios with extremely high penetration of renewables.
- **Wisconsin:** The Office of Energy Innovation at Wisconsin's Public Service Commission has initiated the Grid Resilience Program, funded through the IIJA. This program is designed to bolster the reliability and resilience of Wisconsin's electric grid against extreme weather, wildfires, and natural disasters, with a focus on enhancing service stability in disadvantaged communities including underserved rural communities and tribal areas. To be eligible for these grants, applicants must demonstrate project alignment with specific resilience activities such as weatherization, fire resistance, and the use of DERs.[82]

7. Conclusion: State Energy Offices – Key Drivers of Energy Storage Transformation

State Energy Offices play a pivotal role in executing energy storage RD&D as local, state, and regional entities transition to cleaner, more resilient grids. Successful energy storage RD&D efforts account for various technical, social, economic, and political circumstances, as uniquely applicable to each state and technology. Key lessons for addressing these circumstances, as emphasized throughout this guide, include:

- **Embrace data:** Robust data analysis underpins strategic storage-related policy, investment, and deployment. State Energy Offices can prioritize robust metric measurement and tracking as a way to assess the benefits of energy storage RD&D to stakeholders and ensure optimal deployment of resources.
- **Collaborate broadly:** Forging partnerships among universities, developers, national laboratories, utilities, regulators, and local communities drives progress on RD&D challenges ranging from resolving market participation barriers to mitigating safety concerns. State Energy Offices can work with various partners to apply existing expertise and bring projects to fruition.
- **Remain flexible:** Technological breakthroughs and other changes in market and policy conditions can alter the relative benefits of different storage technologies. State Energy Offices can avoid constraining storage RD&D by remaining technology-neutral and outcome-focused.
- **Consider equity as a cornerstone:** Programs designed with input from and targeted to underserved communities have the potential to redress historical energy inequities. State Energy Offices can champion just energy transition objectives through targeted energy storage programs.

While hurdles remain, energy storage technology and policy have evolved significantly within a short span of time. State Energy Offices have the opportunity to unlock the full potential of these advancements and shape them in accordance with the diverse needs of their respective communities, and many State Energy Offices are already doing just that.

8. Appendix A – Energy Storage Reports

Table 10. Illustrative List of Energy Storage Reports Sponsored or Written by State Energy Offices

State	Reports	Type
California	Assessing the Value of Long-Duration Energy Storage in California (2023)	Impact Assessment
Colorado	The Future of Energy Storage in Colorado (2019)	Market Assessment
Georgia	Solar and Battery Resiliency Best Practices Guide (2022)	Implementation Guide
Iowa	Energy Storage in Iowa (2020); Iowa Energy Plan (2016); Renewable Hydrogen in Iowa (2022)	Market Assessment
Kentucky	Commonwealth of Kentucky Regional Microgrids for Resilience Study (2021)	Impact Assessment
Maine	Maine Energy Storage Market Assessment (2022), Long-Duration Energy Storage (2024)	Market Assessment
Maryland	Energy Storage in Maryland (2018)	Policy and Market Assessment
Massachusetts	State of Charge: Massachusetts Energy Storage Initiative (2016)	Policy and Market Assessment
Michigan	Energy Storage Roadmap for Michigan (2022)	Roadmap
Minnesota	Minnesota Energy Storage Cost-Benefit Analysis (2019)	Market Assessment
Nevada	The Economic Potential for Energy Storage in Nevada (2018)	Market Assessment
New Jersey	Grid Modernization Study (2022)	Roadmap
New York	New York's 6 GW Energy Storage Roadmap: Policy Options for Continued Growth in Energy Storage (2022)	Policy Assessment and Roadmap
North Carolina	Energy Storage Options for North Carolina (2018)	Policy and Market Assessment
Oregon	Oregon Guidebook for Local Energy Resilience (2019)	Implementation Guide
Pennsylvania	Pennsylvania Energy Storage Assessment (2021)	Market Assessment
Vermont	Act 53 Report: A Report to the Vermont General Assembly on the Issue of Deploying Storage on the Vermont Electric Transmission and Distribution System (2017)	Policy and Market Assessment
Virginia	Energy Storage Study (2019)	Market Assessment

9. Endnotes

1 Jones, K., McCurry, W. & Zitelman, K. State Microgrid Policy, Programmatic, and Regulatory Framework. NASEO-NARUC Microgrids State Working Group. August 2023. https://pubs.naruc.org/pub/2649E6EB-D7CE-77DC-2BE3-89D48A713213#:~:text=This%20framework%20provides%20relevant%20background,varying%20strategies%20to%20enable%20microgrids

2 Balducci, P., Mongird, K. & Weimar, M. Understanding the Value of Energy Storage for Power System Reliability and Resilience Applications. *Current Sustainable/Renewable Energy Reports* Vol. 8, 131-137 (2021) https://link.springer.com/article/10.1007/s40518-021-00183-7; USAID and National Renewable Energy Laboratory. Battery Storage for Resilience. *Resilient Energy Platform*. June 2021. https://www.nrel.gov/docs/fy21osti/79850.pdf; and Verclas, K. The Black Box of Blackstart: Electricity Reliability and Interdependency Considerations for State Energy Offices. NASEO. January 7, 2022. https://www.naseo.org/data/sites/1/documents/publications/NASEO_The%20Black%20Box%20of%20Blackstart_FINAL.pdf

3 Electric Power Research Institute, Inc. (EPRI). Ancillary Services in the United States: Technical Requirements, Market Designs and Price Trends. 2019. https://www.epri.com/research/products/000000003002015670

4 Denholm, P., Jorgenson J., & Hummon, M. *et al.* The Value of Energy Storage for Grid Applications. NREL. May 2013. https://www.nrel.gov/docs/fy13osti/58465.pdf

5 Marnell, K., Obi, M., & Bass, R. Transmission-Scale Battery Energy Storage Systems: A Systematic Literature Review. *Energies* 2019, *12*(23), 4603. https://www.mdpi.com/1996-1073/12/23/4603

6 U.S. Energy Information Administration (EIA). As solar capacity grows, duck curves are getting deeper in California. https://www.eia.gov/todayinenergy/detail.php?id=56880; Schmalensee, R. Competitive Energy Storage and the Duck Curve. International Association for Energy Economics. *The Energy Journal* Vol. 43(*2*). 2022. https://journals.sagepub.com/doi/abs/10.5547/01956574.43.2.rsch; Blair, N., Augustine, C. & Cole, W. *et al.* Storage Futures Study - Grid Operational Impacts of Widespread Storage Deployment. NREL. 2022. https://www.nrel.gov/docs/fy22osti/80688.pdf

7 EIA. Preliminary Monthly Electric Generator Inventory (based on Form EIA-860M as a supplement to Form EIA-860). January 2024. https://www.eia.gov/electricity/data/eia860m/

8 University of Michigan, Center for Sustainable Systems. U.S. Grid Energy Storage Factsheet. https://css.umich.edu/publications/factsheets/energy/us-grid-energy-storage-factsheet

9 EIA. Preliminary Monthly Electric Generator Inventory. January 2024. https://www.eia.gov/electricity/data/eia860m/

10 ScienceDirect. Flywheel Energy Storage. https://www.sciencedirect.com/topics/engineering/flywheel-energy-storage

11 Denholm, P., Cole, W. & Blair, N. Moving Beyond 4-Hour Li-Ion Batteries: Challenges and Opportunities for Long(er)-Duration Energy Storage. NREL. September 2023. https://www.nrel.gov/docs/fy23osti/85878.pdf

12 Wittman, R. Side by Side Comparison of Redox Flow and Li-ion Batteries. SNL. June 2021. https://energy.sandia.gov/wp-content/uploads/2021/12/6_Wittman_Reed_SNL_WIPSC_Session5_6-23-21.pdf

13 Heath, G., Ravikumar, D., Hansena, B., & Kupetsa, E. A critical review of the circular economy for lithium-ion batteries and photovoltaic modules – status, challenges, and opportunities. *Journal of the Air & Waste Management Association*, 72(*6*), 478–539. 2022. https://www.nrel.gov/docs/fy22osti/82238.pdf

14 Rand, David and Moseley, Patrick. Energy Storage with Lead-Acid Batteries. ScienceDirect. 2015. https://www.sciencedirect.com/science/article/abs/pii/B9780444626165000139

15 Energy Technology System Analysis Programme and International Renewable Energy Agency. Thermal Energy Storage: Insights for Policy Makers. Technology-Policy Brief E17. 2013. https://iea-etsap.org/E-TechDS/PDF/E17IR%20ThEnergy%20Stor_AH_Jan2013_final_GSOK.pdf

16 Arthur, M. A Look at the Status of Five Energy Storage Technologies. Environmental and Energy Study Institute. August 25, 2020. https://www.eesi.org/articles/view/a-look-at-the-status-of-five-energy-storage-technologies

17 Ma, Z. Economic Long-Duration Electricity Storage by Using Low-Cost Thermal Energy Storage and High-Efficiency Power Cycle (ENDURING). NREL. September 2023 https://www.nrel.gov/docs/fy23osti/84728.pdf; and U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy. Thermal Energy Storage. https://www.energy.gov/eere/buildings/thermal-energy-storage

18 Blair, N., Augustine, C. & Cole, W. *et al.* Storage Futures Study. NREL. 2022. https://www.nrel.gov/docs/fy22osti/80688.pdf; and EIA. Analysis & Predictions. https://www.eia.gov/analysis/projection-data.php

19 EIA. Solar and battery storage to make up 81% of new U.S. electric-generating capacity in 2024. February 15, 2024. https://www.eia.gov/todayinenergy/detail.php?id=61424

20 Lenoir, T. & Marjolin, A. Charging up on battery energy storage 101, US market outlook. S&P Global. April 5, 2023. https://www.spglobal.com/marketintelligence/en/news-insights/research/charging-up-on-battery-energy-storage-101-us-market-outlook

21 EIA. Preliminary Monthly Electric Generator Inventory. January 2024. https://www.eia.gov/electricity/data/eia860m/

22 EIA. Electricity explained: Energy storage for electricity generation. August 2023. https://www.eia.gov/energyexplained/electricity/energy-storage-for-electricity-generation.php

23 Cole, W. & Karmakar, A. Cost Projections for Utility-Scale Battery Storage: 2023 Update. NREL. June 2023. https://www.nrel.gov/docs/fy23osti/85332.pdf

24 Stenson, C. 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

25 Blair, N., Augustine, C. & Cole, W. *et al.* Storage Futures Study. NREL. 2022. https://www.nrel.gov/docs/fy22osti/80688.pdf

26 Colorado Department of Local Affairs. Microgrids for Community Resilience Program. https://dlg.colorado.gov/microgrids

27 Martineau, R. Electric Vehicles Play a Surprising Role in Supporting Grid Resiliency. NREL. October 12, 2023. https://www.nrel.gov/news/program/2023/evs-play-surprising-role-in-supporting-grid-resiliency.html#:~:text=EVs%20can%20absorb%20excess%20power,resilience%20of%20our%20power%20grid.%E2%80%9D

28 California Energy Commission. GFO-23-309 - Virtual Power Plant Approaches for Demand Flexibility (VPP-FLEX). https://www.energy.ca.gov/solicitations/2024-03/gfo-23-309-virtual-power-plant-approaches-demand-flexibility-vpp-flex

29 "Appendix A: PC 44 Memorandum to PPRP on Utility Ownership and Regulation of FOM Storage in Maryland" of the Energy Storage in Maryland. https://dnr.maryland.gov/pprp/Documents/Energy-Storage-In-Maryland.pdf

30 McNamara, W., Passell, H. & Olinsky-Paul, T. States Energy Storage Policy. SNL and CESA. February 2023. https://www.cesa.org/wp-content/uploads/State-Energy-Storage-Policy-Best-Practices-for-Decarbonization.pdf

31 Lazard. 2023 Levelized Cost of Energy+. April 12, 2023. https://www.lazard.com/research-insights/2023-levelized-cost-of-energyplus/

32 Ibid.

33 Lawrence Berkeley National Laboratory, Energy Technologies Area. Queued Up: Characteristics of Power Plants Seeking Transmission Interconnection. 2024. https://emp.lbl.gov/queues

34 State of New Jersey, Notice. In the Matter of Modernizing New Jersey's Interconnection Rules, Processes, and Metrics. January 27, 2023. https://www.nj.gov/bpu/pdf/publicnotice/Notice_Interconnection_ProposedRuleLanguage.pdf

35 Lewis, M. Storage Participation in Wholesale Markets. Morgan Lewis. March 8, 2023. https://www.morganlewis.com/pubs/2023/03/storage-participation-in-wholesale-markets

36 FERC. FERC Order No. 2222: Fact Sheet. https://www.ferc.gov/media/ferc-order-no-2222-fact-sheet

37 FERC. FERC Order No. 841. https://www.ferc.gov/media/order-no-841

38 New York State Energy Research and Development Authority. New York's Inter-Agency Fire Safety Working Group. https://www.nyserda.ny.gov/All-Programs/Energy-Storage-Program/New-York-Inter-Agency-Fire-Safety-Working-Group

39 NYSERDA. Energy Storage Trainings for Local Governments. https://www.nyserda.ny.gov/All-Programs/Clean-Energy-Siting-Resources/Webinar-Series

40 Colorado Department of Local Affairs. Microgrids for Community Resilience Program. https://dlg.colorado.gov/microgrids

41 Georgia Environmental Finance Authority. Solar Resiliency Technical Assistance Program. https://gefa.georgia.gov/solar-resiliency-technical-assistance-program
42 Connecticut Department of Energy and Environmental Protection. Comprehensive Energy Strategy. February 8, 2018. https://portal.ct.gov/-/media/deep/energy/ces/2018comprehensiveenergystrategypdf.pdf
43 State of Maine. An Act To Advance Energy Storage in Maine. June 21, 2021. https://www.mainelegislature.org/legis/bills/getPDF.asp?paper=SP0213&item=3&snum=130
44 Iowa Energy Office. Energy Storage Action Plan. May 2019. https://www.iowaeda.com/UserDocs/IEDA_EneryStorage_2019.pdf
45 Public Utility Commission of Nevada. Docket No. 16-01013. *Investigation Regarding Energy Storage Technologies*.
46 California Energy Commission. Appendix JA12 – Qualification Requirements for Battery Storage. August 2022. https://www.energy.ca.gov/sites/default/files/2022-08/CEC-400-2022-010-AP.pdf#page=225
47 Massachusetts DOER and Massachusetts Clean Energy Center. State of Charge. 2016. https://www.mass.gov/doc/state-of-charge-report/download
48 California Energy Commission. Utility-Scale Renewable Energy Generation Technology Roadmap. Updated September 11, 2020. https://www.energy.ca.gov/publications/2020/utility-scale-renewable-energy-generation-technology-roadmap
49 Johnson, E, & Wilson, G. Renewable Hydrogen in Iowa. Ideal Energy. August 24, 2022. https://www.idealenergysolar.com/wp-content/uploads/2022/10/Renewable-H2-in-Iowa-Second-Edition-Digital.pdf
50 Maryland Power Plant Research Program. Energy Storage in Maryland. 2018. https://dnr.maryland.gov/pprp/Documents/Energy-Storage-In-Maryland.pdf
51 Energy+Environmental Economics. Minnesota Energy Storage Cost-Benefit Analysis. December 31, 2019. https://mn.gov/commerce-stat/pdfs/energy-storage-cost-benefit-study-2020.pdf
52 EPRI. DER-VET™. https://www.der-vet.com/
53 PNNL. ESET™: Model, Optimize and Evaluate Energy Storage Systems. https://eset.pnnl.gov/
54 Federal Emergency Management Agency. Benefit-Cost Analysis. Grants: Tools. https://www.fema.gov/grants/tools/benefit-cost-analysis
55 PNNL. Energy Storage Evaluation Tool. https://eset.pnnl.gov/
56 NYSERDA. Energy Storage Program. https://www.nyserda.ny.gov/All-Programs/Energy-Storage-Program
57 Pennsylvania Department of Environmental Protection. Energy Storage in Pennsylvania. Energy Storage in Pennsylvania. https://www.dep.pa.gov/Business/Energy/OfficeofPollutionPrevention/Pages/Energy-Storage.aspx
58 Virgin Islands Energy Office. VI Battery Energy Storage Program. VIBES. https://energy.vi.gov/vibes/
59 DOE Loan Programs Office. Advanced Clean Energy Storage. https://www.energy.gov/lpo/advanced-clean-energy-storage
60 DOE. Energy Storage Grand Challenge. https://www.energy.gov/energy-storage-grand-challenge/energy-storage-grand-challenge
61 California Energy Commission. GFO-23-317 - Energy Storage Innovations to Support Grid Reliability. https://www.energy.ca.gov/solicitations/2024-06/gfo-23-317-energy-storage-innovations-support-grid-reliability
62 Maryland Energy Administration. Maryland Energy Storage Income Tax Credit - Tax Year 2024. https://energy.maryland.gov/business/Pages/EnergyStorage.aspx
63 Maine Governor's Energy Office. GEO Releases Energy Storage Request for Information. https://mailchi.mp/70feab347335/governors-energy-office-news-and-updates-9423294?e
64 MassCEC. Aggregated Reports and Associated Time Series Data. Advancing Commonwealth Energy Storage. https://www.masscec.com/program/advancing-commonwealth-energy-storage-aces
65 NYSERDA. Decommissioning and End-of-Life Considerations. Energy Storage Trainings for Local Governments. https://www.nyserda.ny.gov/All-Programs/Clean-Energy-Siting-Resources/Webinar-Series
66 Kerby, J., Tarekegne, B. & Hardy, T. *et al.* Energy Justice & Energy Storage. SNL. October 2023. https://www.sandia.gov/app/uploads/sites/82/2023/10/Kerby_Jessica_Equity-Resilience_PR2023.pdf
67 American Clean Power. Redeveloping Brownfields with Solar: Challenges and Opportunities. https://cleanpower.org/resources/redeveloping-brownfields-with-solar-challenges-and-opportunities/
68 DOE. Community Solar Best Practices Guide: Developing Projects with Meaningful Benefits. https://www.energy.gov/communitysolar/community-solar-best-practices-guide-developing-projects-meaningful-benefits
69 DOE, Office of Clean Energy Demonstrations. Long Duration Storage for Everyone, Everywhere Initiative – Workforce Development Listening Session. August 2, 2022. https://www.energy.gov/sites/default/files/2022-08/Workforce%20Development%20Listening%20Session%20-%20Long%20Duration%20Storage%20for%20Everyone%2C%20Everywhere%20Initiative.pdf
70 NASEO. Equity Resources. https://www.naseo.org/issues/equity/resources
71 Executive Office of the President. Office of Management and Budget. Interim Implementation Guidance for the Justice40 Initiative. July 20, 2021. https://www.whitehouse.gov/wp-content/uploads/2021/07/M-21-28.pdf
72 Executive Office of the President. Addendum to the Interim Implementation Guidance for the Justice40 Initiative. January 27, 2023. https://www.whitehouse.gov/wp-content/uploads/2023/01/M-23-09_Signed_CEQ_CPO.pdf
73 California Office of Environmental Health Hazard Assessment. CalEnviroScreen 4.0. May 1, 2023. https://oehha.ca.gov/calenviroscreen/report/calenviroscreen-40
74 NASEO. Equity Resources. https://www.naseo.org/issues/equity/resources
75 Agency for Toxic Substances and Disease Registry. CDC/ATSDR Social Vulnerability Index (SVI). https://www.atsdr.cdc.gov/index.html
76 Council on Environmental Quality. Climate and Economic Justice Screening Tool. https://screeningtool.geoplatform.gov/en/#13.13/-1.0105/-85.81791
77 Maryland Energy Administration. FY22 MEA Resilient Maryland Award List (Both Rounds). https://energy.maryland.gov/business/SiteAssets/Pages/ResilientMaryland/FY22%20MEA%20Resilient%20Maryland%20Award%20List%20(Both%20Rounds).pdf
78 California Energy Commission. California Energy Commission Approves $31 Million for Tribal Long-Duration Energy Storage Project. November 3, 2022. https://www.energy.ca.gov/news/2022-11/california-energy-commission-approves-31-million-tribal-long-duration-energy
79 Washington State Department of Commerce. Commerce awards $35.4 million for solar power with battery back-up systems to bolster community resilience. September 27, 2023. https://www.commerce.wa.gov/news/commerce-awards-35-4-million-for-solar-power-with-battery-back-up-systems-to-bolster-community-resilience/
80 Colorado Department of Local Affairs. Microgrids for Community Resilience Program. https://dlg.colorado.gov/microgrids
81 Hawaiʻi State Energy Office. Hawaiʻi State Energy Office and Kauaʻi Island Utility Cooperative Receive Federal Support for Innovative Technology Demonstration Projects. October 18, 2023. https://energy.hawaii.gov/hawaii-state-energy-office-and-kauai-island-utility-cooperative-receive-federal-support-for-innovative-technology-demonstration-projects/
82 Public Service Commission of Wisconsin. Grid Resilience Program. https://psc.wi.gov/Pages/ServiceType/OEI/GridResilience.aspx

National Association of State Energy Officials

1300 North 17th Street, Suite 1275, Arlington, Virginia 22209 | 703.299.8800 | www.naseo.org