NARUC
National Association of Regulatory Utility Commissioners

# Energy Storage Primer: Foundational Information and Approaches to Deployment


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# I. About this Primer

This paper is an educational resource to help readers understand the fundamental technologies, market trends, and regulatory frameworks associated with energy storage in the United States. It provides essential context on the energy storage market, ownership options, grid services, valuation, compensation, policy, and incentive mechanisms that states utilize to accelerate storage deployment. The primer is intended to assist utility commissioners and commission staff who are new to energy storage build an understanding of the basics of energy storage in a regulatory context.

# II. Introduction to Energy Storage

An energy storage system (ESS) uses electricity (or some other energy source, such as solar-thermal energy or gravity) to charge an energy storage system or device, which is discharged to supply (or displace) electricity when needed. ESSs can provide a variety of services to support electric power grids. In some cases, ESSs may be paired or co-located with other generation resources to improve the economic efficiency of one or both systems.[1]

See the NARUC Storage Resource Library for a list of resources divided into key topic areas to enable further learning on energy storage challenges, potential solutions, and technologies. Topics include policy analysis, planning, regulatory, technology, siting, safety, state examples, and use cases.

There are five types of ESSs in commercial use in the United States:[2]

1. **Batteries** (electro-chemical): Similar to common rechargeable batteries but on a larger scale, batteries can store electricity until it is needed and then release it at desired levels and quality. These systems can use lithium-ion, sodium-ion, lithium-sulfur, lithium-metal, or other chemistries.[3] Most of the growth in storage this decade has been from battery energy storage systems (BESS).

2. **Pumped-storage hydroelectric**: Electricity is used to pump water up to a reservoir where it is stored. The water is released from the reservoir when generation is needed and it flows through a turbine to generate electricity.[4] Prior to 2024, pumped storage was the largest storage resource in the U.S. and remains the second largest source of storage.[5]

3. **Thermal energy storage**: Electricity can be used to produce and store thermal energy. For example, electricity can be used to produce chilled water or ice during times of low demand or surplus and later used for cooling during periods of peak electricity consumption.[6]

1 EIA: "Electricity explained: Energy storage for electricity generation." U.S. Energy Information Administration. 2022. Updated August 2023. https://www.eia.gov/energyexplained/electricity/energy-storage-for-electricity-generation.php.

2 EPA: "Electricity Storage." August 4, 2025. https://www.epa.gov/energy/electricity-storage.

3 EIA: "Electricity explained: Energy storage for electricity generation." U.S. Energy Information Administration. 2022. Updated August 2023.

4 ibid

5 SPS Global: Garrett Hering and Susan Dil, "'Boom Time': US Battery Storage Sector Bullish After Another Record Year," S&P Global Market Intelligence, March 12, 2026, https://www.spglobal.com/market-intelligence/en/news-insights/articles/2026/3/boom-time-us-battery-storage-sector-bullish-after-another-record-year-99542996.

6 EIA: "Electricity explained: Energy storage for electricity generation." U.S. Energy Information Administration. 2022. Updated August 2023.

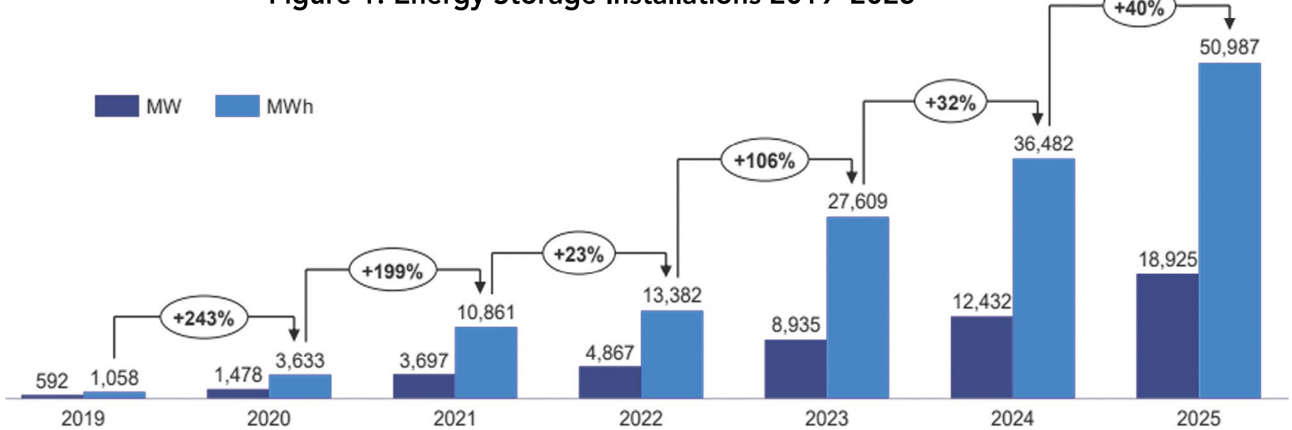
4. **Compressed-air storage**: Electricity is used to compress air up to approximately 1,000 pounds per square inch and store it, often in underground caverns. When electricity demand is high, the pressurized air is released to generate electricity through an expansion turbine generator.[7]

5. **Flywheels**: Electricity is used to accelerate a flywheel (a type of rotor) through which the energy is conserved as kinetic rotational energy. When the energy is needed later, the spinning force of the flywheel is used to turn a generator. Some flywheels use magnetic bearings, operate in a vacuum to reduce drag, and can attain rotational speeds up to 60,000 revolutions per minute.[8]

# III. Market Statistics

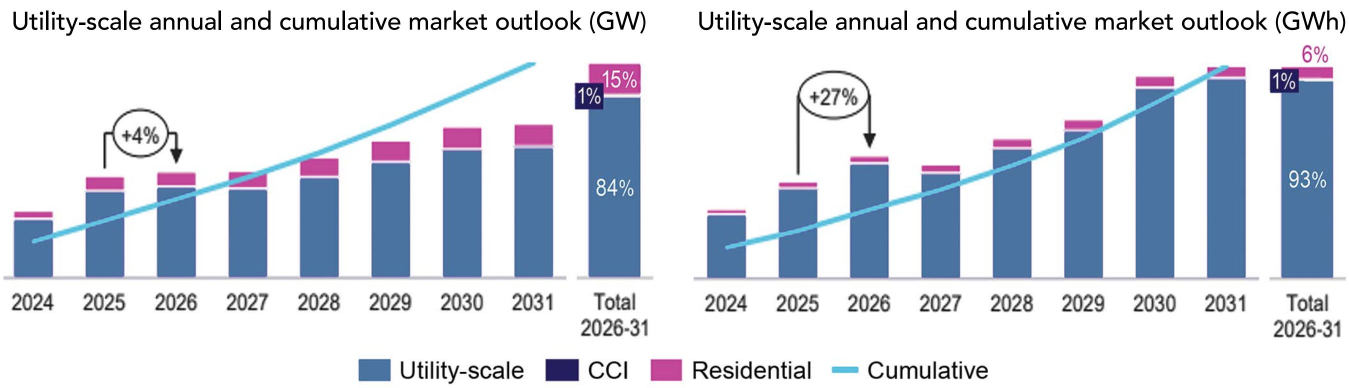
Since 2019, energy storage has been growing significantly in the United States as a power resource (see **Figure 1**).

**Figure 1. Energy Storage Installations 2019–2025**




Gigawatt hours (GWh) of installed storage grew by 27 percent between 2025 and 2026 (see **Figure 2**). The US is projected to add roughly 500 GWh of storage from 2026 to 2031, a 250 percent increase compared to 2020–2025.[9]

**Figure 2. Energy Storage Growth Projections**[10]




7 ibid

8 ibid

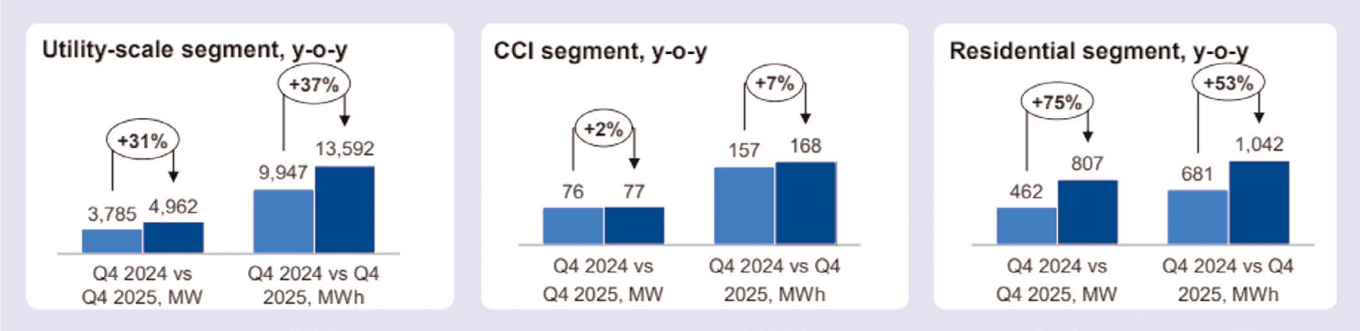
9 Wood Mackenzie/American Clean Power Association: "U.S. Energy Storage Monitor Q1 2026 and 2025 Year in Review." Wood Mackenzie/American Clean Power Association. March 2026. https://www.woodmac.com/reports/power-markets-us-energy-storage-monitor-q1-2026-and-2025-year-in-review-150449846/.

10 ibid

Q4 2025 also set a new quarterly record with 5.8 GW / 14.8 GWh deployed,[11] representing 12.8% of the total 45 GW operational in the U.S. today.[12] Batteries are by far the fastest growing energy storage technology, followed by pumped hydro. Installed battery storage is expected to triple in the next few years.[13]

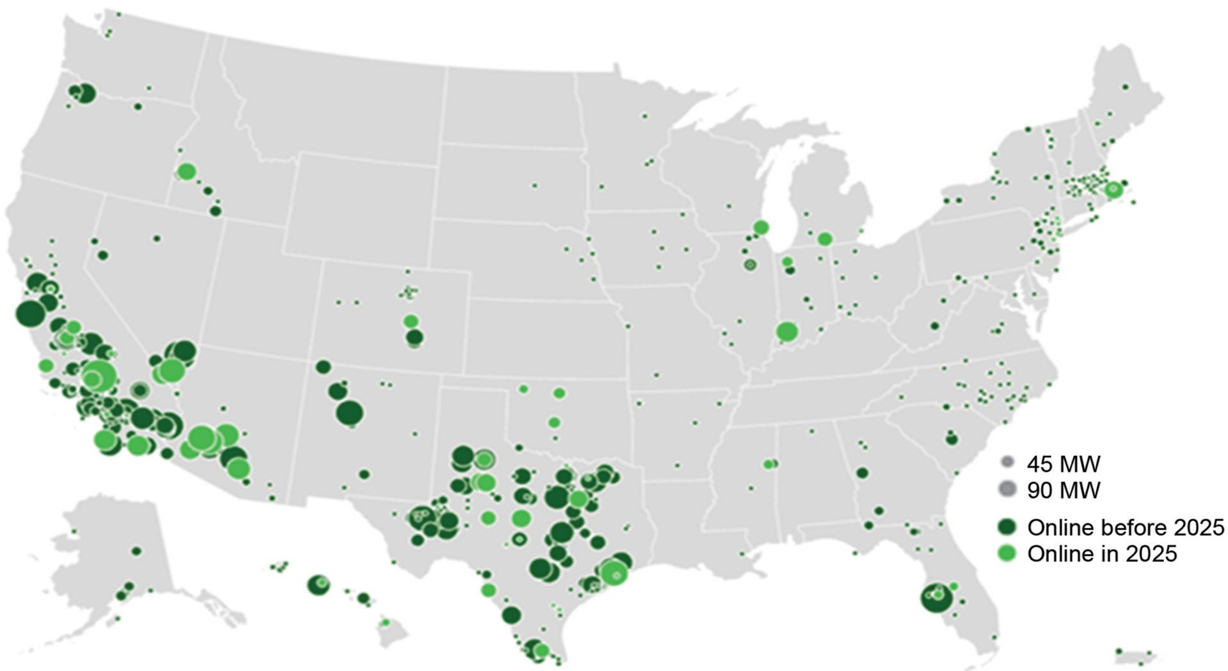
See **Figure 3** for capacity additions by owner type: utility, commercial and industrial, or residential. Utility-owned storage represents the majority of capacity, but fewer overall projects (978 utility-scale battery projects in the U.S. with 137 GWh of total energy storage capacity). Customer-sited (distributed) storage accounts for nearly 500,000 distributed storage installations that represent about 83 GWh of total energy storage capacity.

**Figure 3. Energy Storage Deployment by Ownership Model**[14]




California and Texas lead the U.S. in installed battery storage capacity by state, though many states have energy storage installations (see **Figure 4**).[15]

**Figure 4. Geography of Utility-Scale Energy Storage as of March 2025**[16]




11 Ibid

12 ACP. "Clean Energy Storage Facts." ACP. Accessed May 19, 2026. https://cleanpower.org/facts/clean-energy-storage/.

13 EEI. "Energy Storage Update." Edison Electric Institute Legal & Clean Energy Policy. May 2025. https://www.eei.org/-/media/Project/EEI/Documents/Issues-and-Policy/Energy-Storage/Energy-Storage-Status-Update.pdf.

14 Wood Mackenzie/American Clean Power Association: "U.S. Energy Storage Monitor Q1 2026 and 2025 Year in Review." Wood Mackenzie/American Clean Power Association. March 2026.

15 EEI. "Energy Storage Update." Edison Electric Institute Legal & Clean Energy Policy. May 2025.

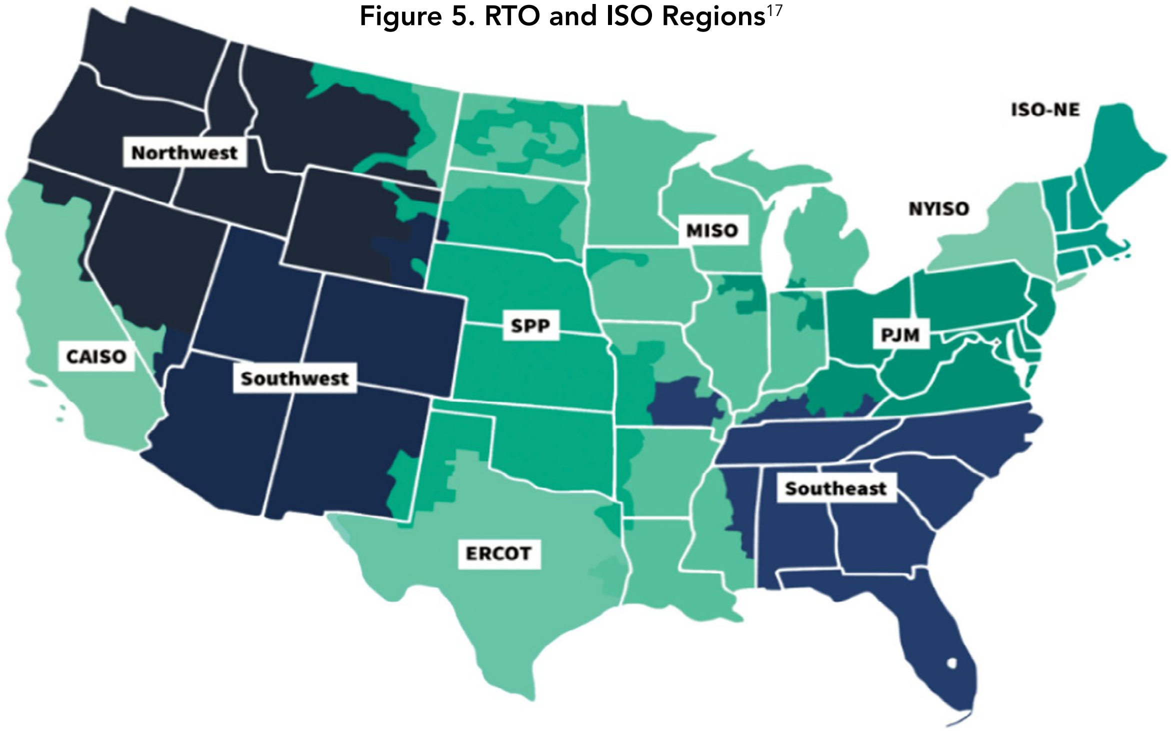
16 ACP. "Clean Power Quarterly Market Report Q1 2025 (Public)." ACP. Accessed May 19, 2026. https://cleanpower.org/resources/clean-power-quarterly-market-report-q1-2025-public/.

# IV. Market Context and Ownership Options

## A. Market Context

In the U.S., Regional Transmission Organizations (RTOs) and Independent System Operators (ISOs) manage wholesale electricity markets in and among various states. **See Figure 5** for a map of RTOs and ISOs.

**Figure 5. RTO and ISO Regions**[17]




Regardless of its location within or outside a regional market (RTO/ISO), a utility can either be vertically integrated—own generation, transmission, and distribution infrastructure—or restructured and not own generation infrastructure. See **Figure 6** for a map of vertically integrated and restructured states.[18]

In restructured areas, a utility is not allowed to own generation infrastructure and in most cases is also not allowed to own utility-scale storage. In some states, restructured (distribution-only) utilities have been allowed to own distribution-connected 'front of the meter' (FOTM) and/or customer-sited 'behind the meter' (BTM) storage to meet various grid, customer, and policy goals.

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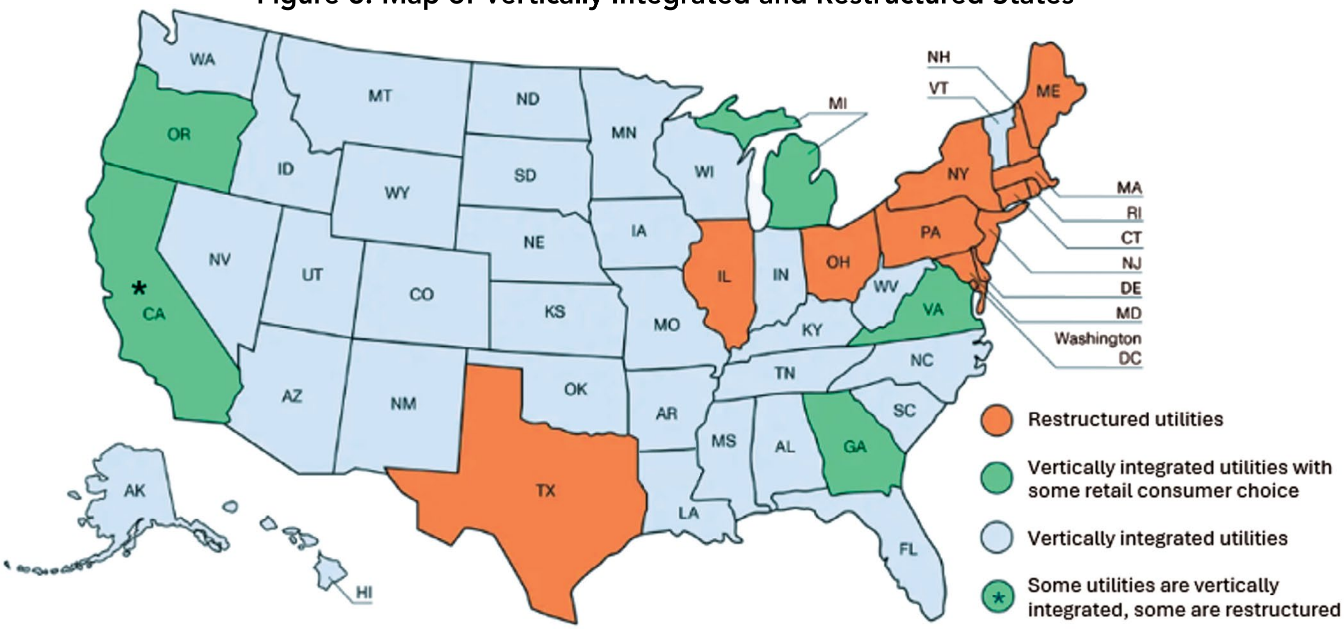
17 FERC. "Electric Power Markets." March 27, 2025. https://www.ferc.gov/electric-power-markets.

18 In Maryland, a restructured state, there is an exception in statute for utilities to own generation. Public Utilities Article § 7-510(c)(6)) states "In order to meet long-term, anticipated demand in the State for standard offer service and other electricity supply, the Commission may require or allow an investor-owned electric company to construct, acquire, or lease, and operate, its own generating facilities, and transmission facilities necessary to interconnect the generating facilities with the electric grid, subject to appropriate cost recovery."

**Figure 6. Map of Vertically Integrated and Restructured States**[19]




## B. Ownership Options

Energy storage ownership is shaped largely by a state's market status (restructured vs vertically integrated) and the scale of the technology deployed. Ownership plays a critical role in how storage assets are financed, operated, and integrated into the grid. Ownership models for each of the three groups of scaled energy storage are discussed below.

1. **Large-scale storage** is owned by utilities or developers (independent power producers). In vertically integrated states, utility-owned and utility-contracted storage are the dominant ownership types. In contrast, merchant-owned storage is the dominant ownership type in restructured markets.

2. **Storage portfolios** could be a combination of utility-owned and customer-owned. States that allow utility ownership of energy storage can combine small, distributed, customer-owned storage assets with larger utility-owned storage systems.[20] Additionally, some states require utilities to procure storage capacity from installations of different sizes or located on different areas of the grid.[21]

3. **Distributed storage** can be FTM or BTM and owned by utilities, customers, or third-party developers. BTM utility-owned distributed storage may require a customer lease payment instead of a large up-front investment. In exchange, the utility controls the batteries' operations.[22] The system can also support the home's electric load during grid outages. As an alternative to utility ownership, some BTM distributed battery programs rely on customer-owned batteries or leasing from a third party. Some states have adopted performance-based utility programs whereby third-party ownership with leasing or power purchase agreements[23,24] allows developers/aggregators to lease batteries to customers and contract these leased batteries into these programs.

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19 CNET. "You Can Choose Your Electricity Provider in These States With Deregulated Markets." Accessed May 19, 2026. https://www.cnet.com/home/energy-and-utilities/energy-deregulation/.

20 Olinsky-Paul, Todd and Olivia Tym. "Energy Storage Program Design for Peak Demand Reduction." Clean Energy Group/Clean Energy States Alliance. December 2024. https://www.cleanegroup.org/publication/energy-storage-program-design-for-peak-demand-reduction/.

21 ibid

22 McNamara, Will. "Policy 'Deep Dives': Net Metering and BTM Ownership Models." Sandia National Laboratories. November 2022. https://www.sandia.gov/app/uploads/sites/273/2022/11/DOEE_McNamara_Session-3_Dives.pdf

23 ibid

24 ibid

# V. Grid Services

Utility-scale battery energy storage systems are installed to provide energy capacity and grid services, while distributed energy storage systems can be aggregated to provide grid services to the bulk power system, distribution system, or customers (referred to as aggregated DER or ADER). This section describes the services that energy storage is capable of providing to the electric grid. ADER grid services are defined as the specific, distinguishable benefits that an intentional use of many individual distributed energy resources (DERs) can provide to maintain a reliable and stable electric grid. See **Table 1** for a full list of grid services that energy storage can provide. A U.S. Department of Energy (DOE) 2023 report, Bulk Power, Distribution and Grid Edge Service Definitions, describes three categories of services that are necessary to maintain a reliable electric grid, most of which BESS can be configured to provide:[25]

1. **Bulk power system grid services** that meet the requirements of the transmission grid and maintain essential reliability across the electric system.
2. **Distribution system grid services** that meet the requirements of the distribution grid and maintain essential reliability at distribution voltages.
3. **Grid edge services** that support customer and community needs, including managing microgrid and islanded electric grids.

## A. Bulk Power System Grid Services

Utility-scale storage directly provides bulk power system grid services. For example, storage as a transmission asset (SATA) is the use of battery or other energy storage systems to support the electrical grid's reliability, much like traditional wires or transformers. Instead of only generating power for the market, they are dispatched by grid operators to alleviate congestion, prevent overloads, and deliver backup power during emergencies. Energy and capacity are grid services from resources that inject power, reduce load, or consume energy.

While individual DERs can provide energy and capacity services at the distribution level, ADERs can provide these services at a level meaningful to the bulk power system as well. Utility operators have less experience planning for and operating distribution grids that leverage ADERs, such as FOTM or BTM storage.[26]

## B. Distribution System Grid Services

Some utilities install FOTM BESS to provide distribution grid support. Aggregated DERs, including storage, can provide many distribution system grid services.[27] Distribution system services can be identified through integrated distribution planning processes.[28] Individual and ADERs require advanced or smart inverters to provide essential reliability services. ADERs can respond to grid service signals by adjusting customer demand, storage, and/or generation. The mechanisms for controlling ADERs vary by grid service type and ADER technical capabilities. ADER control can be carried out by different parties depending on the state context and grid service design.[29] ADERs can provide many of the essential grid services that are required to run and maintain a reliable electricity service.[30]

25 Bieler, Stephanie, Goldenberg, Cara, McEvoy, Avery, Katerina Stephan, and Alex Walmsley. "Aggregated Distributed Energy Resources in 2024: The Fundamentals." National Association of Regulatory Utility Commissioners. July 2024. https://pubs.naruc.org/pub/98FBE453-02C0-1FE3-0249-3A456BA1E3E7.

26 ibid

27 ibid

28 For a comprehensive summary of state / utility integrated distribution system planning approaches, drivers, and data, visit: https://emp.lbl.gov/projects/integrated-distribution-system-planning.

29 ibid

30 ibid

**Table 1. ADER Grid Services Provided Today**[31]

| Service Category | Grid Service | Provided by ADERs in the U.S. as of early 2024? | Example |
|---|---|---|---|
| Bulk Power System Grid Services | Energy | Yes | Xcel Energy Solar Rewards Program |
| | Energy Imbalance | No | |
| | Capacity | Yes | National Grid Connected Solutions Bring Your Own Device (BYOD) Program in Massachusetts<br>Central Hudson NWS in New York<br>Holy Cross Power Plus Program |
| | Regulated Reserves | No | |
| | Inertial Response | No | |
| | Fast Frequency Response | Yes | Hawaiian Electric Power Partners and Energy Scout Programs |
| | Primary Frequency Response | Yes | ERCOT Demand Response in Texas |
| | Secondary and Tertiary Frequency Response | Yes | NYISO Demand-Side Ancillary Service Program in New York |
| | Reactive Power and Voltage Support (System) | Yes | Mosaic Power, Multiple States |
| | Ramping Reserves | No | |
| | Black Start | No | Currently being field tested |
| Distribution Grid Services | Energy | No | Net Energy Metering (NEM) |
| | Distribution Capacity | Yes | Consumers Energy NWS in Michigan |
| | Distribution Level Voltage Reactive Power | No | |
| | Power Quality | No | |
| | Resilience | Yes | Energy Vault in California |
| Grid Edge Services | Energy | Yes | Self-Consumption of Solar PV |
| | Distribution Voltage-Reactive Power | No | |
| | Power Quality | No | |
| | Resilience | Yes | Green Mountain Power (GMP) BYOD Program in Vermont |

31 ibid

## C. Grid Edge Services

As opposed to the distribution or bulk power grids, grid edge services explicitly serve individual customers and communities that are behind a metered grid connection (also referred to as "BTM") or as part of a microgrid. Individual DERs typically provide BTM customers and communities with the same services as for distribution systems to, with the exclusion of capacity. In some cases where multiple customers are located behind a single meter or microgrid islanding point, ADERs can provide these services. An example is a community microgrid.[32]

# VI. Use Cases

Across the U.S., storage growth has been driven by a complex combination of technology, policy, economic, and market factors. There are six significant use cases where storage has been an attractive option to help solve regional, state, or local electricity system challenges. Following **Table 2** this section describes each use case with more detailed explanations.

**Table 2. Use Cases Where Storage Can Address System Challenges**

| | System Challenge #1: High Variable Renewable Energy Grid | System Challenge #2: Grid Support Needed | System Challenge #3: Resource Adequacy / Reliability Concerns | System Challenge #4: Localized Reliability / Resilience Challenges |
|---|---|---|---|---|
| **Use Case #1:** Load shaping / lowering peak electricity demand supported by price differentials (arbitrage) | ✔ | | | |
| **Use Case #2:** Providing grid services beyond energy / capacity (e.g., frequency regulation, power support) | ✔ | ✔ | | ✔ |
| **Use Case #3:** Storing and smoothing renewable electricity generation (limiting curtailment) | ✔ | | | |
| **Use Case #4:** Deferring electricity infrastructure investments on transmission or distribution grid | | ✔ | ✔ | ✔ |
| **Use Case #5:** Providing back-up power / supporting microgrids | | | | ✔ |
| **Use Case #6:** Participating directly in capacity markets / offering resource adequacy (emerging) | | | ✔ | |

1. **Load shaping/lowering peak electricity demand supported by price differentials (arbitrage).** Charging an ESS during periods of lower electricity demand and discharging an ESS and using or selling the electricity during higher demand periods can help to flatten daily load or net load shapes. Shifting some or all of electricity use from peak demand periods to other times of day can reduce the amount of higher-

32 ibid

cost or seldom-used reserve generation capacity, which can result in overall lower wholesale electricity prices. The stored and discharged electricity may be sold by the storage owner/operator at a premium (arbitrage) above the price or cost of the electricity used to charge it, or it can be discharged to avoid using or purchasing higher-cost electricity.[33] Commercial and industrial electricity consumers can deploy on-site energy storage to reduce their retail electricity demand and associated demand charges, which are generally based on their highest observed levels of electricity consumption during utility-established peak demand periods. An ESS can also be used by participants in utility demand-side management (DSM) programs.[34]

2. **Providing grid services beyond energy/capacity (e.g., frequency regulation, voltage or reactive power support).**
   Power quality is an important attribute of grid-supplied electricity because momentary spikes, surges, sags, or outages can harm electric equipment, appliances, and other devices powered by electricity.[35] Energy storage can help balance electricity supply and demand on different time scales (by the second, minute, or hour). Fast response (ramping) ESSs are particularly well suited to provide ancillary services for electric power grids to help maintain electric grid frequency on a second-to-second basis (fast frequency response). Depending on the configuration, BESS can provide a range of grid services.[36]

3. **Storing and smoothing renewable electricity generation (limiting curtailment, renewable firming).**
   Energy storage can provide greater and more effective use of intermittent solar and wind energy resources. Pairing or co-locating an on-grid ESS with wind and solar energy power plants can allow those power plants to respond to supply requests (dispatch calls) from electric grid operators when direct generation from solar and wind resources are not available or limited. Alternatively, an ESS can help solar and wind power plants avoid reducing or curtailing generation when the availability of those resources exceeds electricity local demand or power transmission line capacity or as required by grid operators. With the proper configuration and equipment ESSs also allow for storing and using renewable energy where there is no access to an electric grid (an off-grid system).

4. **Deferring electricity infrastructure investments at transmission and distribution levels.**
   Localized pockets of increasing electricity demand sometimes require electric utilities to upgrade existing or build new, expensive substations and distribution lines. ESSs at strategic locations on the grid can help utilities manage growing electricity demand at lower cost than upgrading or expanding electric grid infrastructure.[37] Energy storage is often a component of "non-wires alternatives" for grid improvements and investments where localized pockets of demand are challenging to meet with additional generation.[38] Storage can relieve transmission congestion by shifting peak demand to off-peak time periods at constrained locations on the grid. In many markets, energy storage can act in this way as a transmission asset, remunerated with a regulated rate instead of through sales of a market product.[39]

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33 EIA: "Electricity explained: Energy storage for electricity generation." U.S. Energy Information Administration. 2022. Updated August 2023.

34 ibid

35 ibid

36 Bieler, Stephanie, Goldenberg, Cara, McEvoy, Avery, Katerina Stephan, and Alex Walmsley. "Aggregated Distributed Energy Resources in 2024: The Fundamentals." National Association of Regulatory Utility Commissioners. July 2024.

37 EIA: "Electricity explained: Energy storage for electricity generation." U.S. Energy Information Administration. 2022. Updated August 2023.

38 McNamara, Will, Passell, Howard, and Todd Olinsky-Paul. "States Energy Storage Policy: Best Practices for Decarbonization." Clean Energy States Alliance and Sandia National Laboratories. February 2023.

39 Resources for the Future. "Charging Up: The State of Utility-Scale Electricity Storage in the United States." Accessed May 19, 2026. https://www.rff.org/publications/reports/charging-up-the-state-of-utility-scale-electricity-storage-in-the-united-states/.

5. **Providing back-up power / supporting microgrids.**
An ESS owned by grid-connected electricity consumers can provide emergency back-up electricity during grid outages, whether in an emergency or supplementing an unreliable system.[40] Customer-sited ESS can be powered by the grid, but is commonly paired with customer-sited solar PV ("solar plus storage"). ESSs are being integrated into microgrids that supply a relatively small geographic area or customer base with electricity to provide some or all the uses and benefits of electricity storage listed above. A microgrid ESS may be isolated from a larger grid, or it may be connected to a larger grid with automatic isolation (disconnect) during grid supply interruptions.

6. **Participating directly in capacity markets / offering resource adequacy (emerging).**
In some markets, storage is a biddable resource in capacity market auctions. In California, 4-hour batteries are accredited at 100 percent of their rated capacity. In PJM, with the lowest regional storage deployment, 4-hour batteries are only accredited at 38 to 55 percent depending on the delivery year.[41]

# VII. Valuation and Compensation

This section discusses different approaches to establishing the monetary and non-monetary value of energy storage and outlines how energy storage valuation can inform pricing and program compensation mechanisms.[42]

## A. Valuation

The valuation of energy storage quantifies the relevant benefits of storage services needed to design programs, market rules, and rates that align the interests of energy storage participants, utilities, ratepayers, policymakers, and other stakeholders.[43]

Valuation of **energy and capacity grid services** for bulk power systems typically include: energy, energy imbalance, and capacity.[44]

Valuation of **essential reliability services** for bulk power systems include: regulating reserve, inertial response, fast frequency response, primary frequency response, secondary frequency response, operating reserves (spinning), operating reserves (non-spinning), operating reserves (tertiary), reactive power and voltage support, ramping, black start.[45]

Valuation of **distribution services** include: energy, capacity, reactive power and voltage support, power quality, resilience.[46]

Valuation of **grid edge services** include: energy, reactive power and voltage support, power quality, and resilience.[47]

Valuation of **non-energy benefits** can include: greenhouse gas reductions, pollutant emission reductions, social equity.[48]

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40 EIA: "Electricity explained: Energy storage for electricity generation." U.S. Energy Information Administration. 2022. Updated August 2023.

41 Baker, Scott. 2025 September 9. Energy Storage in PJM presentation at the World Bank LDES Study Tour.

42 Bieler, Stephanie, Goldenberg, Cara, McEvoy, Avery, Katerina Stephan, and Alex Walmsley. "Aggregated Distributed Energy Resources in 2024: The Fundamentals." National Association of Regulatory Utility Commissioners. July 2024.

43 ibid

44 ibid

45 ibid

46 ibid

47 ibid

48 ibid

**Table 3. Summary of Valuation Methodologies[49]**

| Value Category | | | Outside organized markets; utilities own generation assets | Within organized markets; utilities do not own generation assets | Within organized markets; utilities own generation assets |
|---|---|---|---|---|---|
| **Energy Benefits** | Energy & Capacity Grid Services | Bulk Power | Based on avoided costs or least cost solution, including ADERs. | Based on market values. | |
| | | Distribution | Based on avoided grid upgrade costs. | | |
| | | Grid Edge | Based on customer benefits from service, typically a reduction in bills. | | |
| | Essential Reliability Services | Bulk Power | Based on avoided costs or least cost solution, including ADERs. | Based on market values where they exist. Otherwise based on avoided costs. | |
| | | Distribution | Ancillary service and reliability values based on avoided grid upgrade costs. Resilience values based on value of lost load or reliability improvements. | | |
| | | Grid Edge | Based on customer benefits from service, typically through avoided outage costs for the customer. | | |
| **Non-Energy Benefits** | Reduction in GHG Emissions and Pollutant Emissions, Social Equity | | Modeled based on state-specific goals and societal impact assumptions or use values estimated by the EPA. | | |

In **vertically integrated** utilities, utility-scale storage investments are increasingly considered alongside other investment options for meeting projected system needs when developing an integrated resource plan (IRP), where the valuation depends on the state's policy goals, utility system, load profiles, and other factors. A cost-effectiveness, cost-benefit, or least cost-best fit analysis is typically used to assess investment options including storage.

In **restructured** states, wholesale market rules determine the value of benefits and services that storage can provide and how a storage owner will be compensated. The value of services varies by market, nodal location, technology type, and year. For example, different markets assign different effective load-carrying capacity (ELCC, on which market payments are based) to storage, which affects the revenue that storage assets can earn. ELCC's for storage in CaISO have ranged from 74 to almost 100 percent depending on configuration and year,[50] while those in PJM are much lower, between 38 and 76 percent.[51]

49 ibid

50 California Public Utilities Commission, 2023 IRP ELCCs Public Transmittal Memo, February 2023, https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/integrated-resource-plan-and-long-term-procurement-plan-irp-ltpp/2023-02-irp_mtr_elccs-public_transmittal_memo_v1.pdf. and California Public Utilities Commission, 2023 Updated Incremental Effective Load Carrying Capability Study, prepared by E3 and Astrape Consulting, January 10, 2023, https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/integrated-resource-plan-and-long-term-procurement-plan-irp-ltpp/20230210_irp_e3_astrape_updated_incremental_elcc_study.pdf.

51 Baker, Scott. 2025 September 9. Energy Storage in PJM presentation at the World Bank LDES Study Tour.

**Valuation methods** currently used in ADER/energy storage landscape include estimating avoided costs (counterfactual analyses) and estimating value using market prices.[52] See **Table 3** for a summary of valuation methods.

## B. Compensation

Compensation is how providers of grid services receive money in exchange for their services, whether they are utilities, developers, third-party aggregators, or utility / program customers.[53]

In **vertically integrated markets**, compensation for utility-scale storage is just like any other investable resource: utility-owned storage will be included in rate base and cost recovery on and of those investments would be included in a general rate case with all other resources, utility expenses and ROI; costs associated with a utility-procured power purchase agreement with a storage developer would similarly be recovered from customers.

In **restructured markets**, compensation for utility-scale storage varies by region due to differences in market rules and system needs. Merchant compensation will ultimately be based on auction results, performance payments, and/or contracts.

At the distribution or grid edge levels, storage has historically been compensated for direct export of power and demand response for resource adequacy including emergency and operating reserves.[54]

There are two key compensation mechanisms for distributed storage, whether stand-alone or aggregated: prices and programs.[55] See **Table 4** for more information on these two compensation mechanisms.

**Table 4. Compensation Mechanisms for ADER Grid Services, Comparing Prices and Programs**[56]

| | Prices | Programs |
|---|---|---|
| Compensation method | DER owners' electricity rates or export tariffs (when applicable) include time-varying components that provide them (or their utility or aggregator) opportunities for cost reductions or compensation based on ADER dispatch for the relevant grid service, including energy, demand, and ancillary services. | DER owners obtain funding, usually from a regulated utility, in exchange for adopting a DER and/or enrolling one in a program, making the device(s) available to dispatch in response to a range of ADER grid services during particular "events." The funding may be through an up-front incentive, or a payment on an ongoing basis. |
| Simple example | Time-of-use tariffs | Smart thermostat programs |
| Description | Price signals are sent to customers in the form of time-varying or demand-based electricity rates or export tariffs.<br>Responses to price signals may be through manual control or automation. | In programs, payments are given to incentivize customers to make DER capacity available for dispatch, either through adopting a DER or through enrolling a DER they already own in a program. |

continued

52 ibid

53 Bieler, Stephanie, Goldenberg, Cara, McEvoy, Avery, Katerina Stephan, and Alex Walmsley. "Aggregated Distributed Energy Resources in 2024: The Fundamentals." National Association of Regulatory Utility Commissioners. July 2024.

54 ibid

55 Ibid. Many additional details about the pros and cons of each type of pricing and program option are available in the cited report.

56 ibid

| | Prices | Programs |
|---|---|---|
| **Description** | DER response may be at the customer level, or through an aggregation operated by a utility or a third party, responding to prices.<br>Price signals can incorporate a number of required grid services, including energy, capacity, and transmission. Price signals can also be locational to reflect needs for specific grid services in specific locations on the electric grid.<br>In programs, payments are given to incentivize customers to make DER capacity available for dispatch, either through adopting a DER or through enrolling a DER they already own in a program. | Events are triggered by specific grid or economic conditions, meaning the utility or grid operator must seek a change in demand or generation patterns.<br>Events may be scheduled in advance, for example discharging batteries between 6 to 8 p.m. on weekdays; or they may be scheduled with shorter lead times, for example scheduled a day in advance based on weather or scarcity forecasts.<br>Events may be locationally specific to reflect the needs for specific grid services in specific locations on the electric grid. |
| **Compensation arrangements** | Arrangements for responding to prices may include:<br>• Wholesale market participation (through an aggregator)<br>• Export rates<br>• Time-of-use tariffs<br>• Critical peak pricing<br>• Real-time or "dynamic" pricing<br>• Monthly subscriptions | Arrangements for participating in programs may include:<br>• Pay-for-performance or performance payments (measurements can be based on kW dispatched, grid service met, or flat rate per dispatch)<br>• Incentive for device in exchange for program participation<br>• Direct payment in exchange for program participation<br>• Subsidy for interconnection in exchange for program participation |

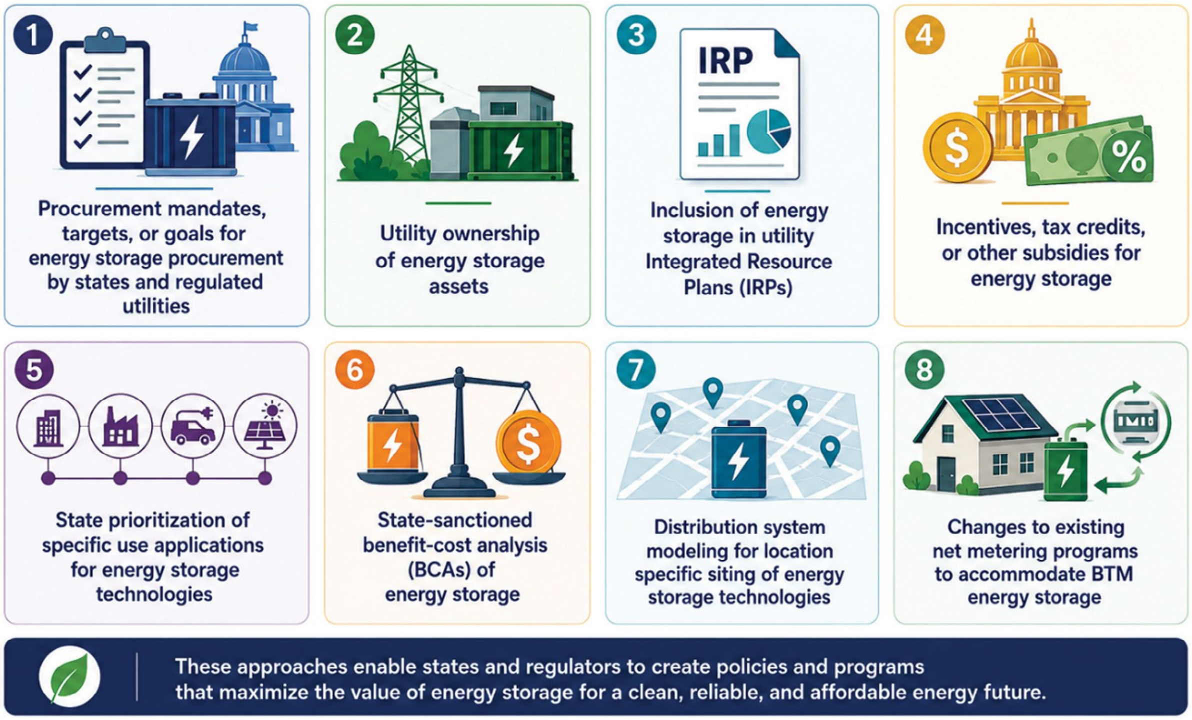
# VIII. Policy Approaches and Incentive Mechanisms

The following section explores the policy approaches and incentive mechanisms currently being used to shape the evolving energy storage landscape and accelerate its deployment.

## A. Policy Approaches

In the U.S., there are eight typical approaches to policy support for energy storage whether utility-scale or distributed, as depicted in **Figure 7.**[57] These approaches have been implemented in different combinations in various regions and states.

**Figure 7. Approaches to Energy Storage Policy Support**




Additionally, the U.S. Government Accountability Office identified six potential energy storage policy options that federal or state decisionmakers could use to support utility-scale energy storage including:

1. **Status quo**: maintained through tax credits, funding, research, and development.
2. **Integration**: inclusion of clear goals and next steps in plans to integrate storage.
3. **Regulation**: revision and enactment of rules and requirements for how storage is defined, used, or owned.
4. **Standardization**: updating or creating new codes and standards and providing education of storage safety risk.
5. **Support manufacturing and adoption**: supporting actions to help energy storage manufacturing and adoption challenges.
6. **Providing incentives**: creating mechanisms to incentivize storage deployment.[58]

57 McNamara, Will, Passell, Howard, and Todd Olinsky-Paul. "States Energy Storage Policy: Best Practices for Decarbonization." Clean Energy States Alliance and Sandia National Laboratories. February 2023.

58 GAO. "Utility-Scale Energy Storage: Technologies and Challenges for an Evolving Grid." U.S. Government Accountability Office. March 2023. https://www.gao.gov/products/gao-23-105583.

Federal, regional, and state policies and incentives have been steadily increasing over the past decade to expand deployment of energy storage in the U.S. State procurement mandates have proven successful in helping to integrate specified sources of energy and assist states in meeting environmental goals.[59] For example, in 2013, California implemented a mandate directing the state's investor-owned utilities to procure 1,325 MW of energy storage. In 2017, the state was effective in spurring an additional 500 MW of battery storage deployment over what would have been installed in absence of the policy.[60]

Interim steps towards achieving policy goals can vary and may not result in new programs or incentives initially.[61] For example, the Maine Public Utilities Commission launched an investigation into how rate design could support the legislature's goal of 400 MW of storage by the end of 2030.[62] Additionally, in Nevada, current regulatory proceedings are focused on how requirements for utility integrated resource plans (IRPs) will need to be revised, since the state's 1,000 MW by 2030 goal is being targeted largely through utility planning reforms.[63]

Setting a **direction** for what a state wants storage resources to provide is key in defining the right set of policies and programs for that state.[64]

1. Define the problem statement
2. Assess available information
3. Understand policy feasibility
4. Set a policy direction
5. Prioritize key enablers to deliver policy outcomes

Storage can be used by policy makers at all levels (federal, regional, state) to support **policy and economic goals** such as: greenhouse gas (GHG) emissions reductions, pollutant emission reductions, improving customer affordability, supporting social equity, improving the resilience, reliability and resource adequacy of the electric service, national security, deferring or avoiding infrastructure investments, increasing efficiency of the distribution system, supporting service reliability, and empowering customers.[65]

## B. Incentive Mechanisms

State-level incentives are viewed by many states as an important tool to accelerate and direct the storage market. State incentives can serve as "bridge funding" until storage becomes more cost-competitive in evolving markets. Incentives can also be used to direct storage development to areas and applications where market opportunities are lacking, such as resilient power applications in low-income and underserved communities. The six key **incentive mechanisms** that are used by states (and can be combined) include:

1. **Rebates**: states provide a direct cash payment to the storage system owner, typically after the battery is installed and interconnected to the grid.[66]

59 Boff D.S., B.L. Tarufelli, and J.B. Twitchell. "Do Mandates Deliver Cost Reductions for Energy Storage?." 13th IEEE Electrical Energy Storage Applications and Technologies Conference (EESAT). June 2025. https://www.pnnl.gov/publications/do-mandates-deliver-cost-reductions-energy-storage.

60 ibid

61 McNamara, Will, Passell, Howard, and Todd Olinsky-Paul. "States Energy Storage Policy: Best Practices for Decarbonization." Clean Energy States Alliance and Sandia National Laboratories. February 2023.

62 ibid

63 ibid

64 Bieler, Stephanie, Goldenberg, Cara, McEvoy, Avery, Stephan Katerina, and Alex Walmsley. "Aggregated Distributed Energy Resources in 2024: The Fundamentals." National Association of Regulatory Utility Commissioners. July 2024

65 ibid

66 ibid

Figure 8. Incentive Mechanisms


2. **Performance payments**: payments based on battery use rather than battery installation that require battery owners to charge and discharge their systems at certain times or in response to utility signals to provide grid services.[67]

3. **Capacity credits**: States may procure energy storage projects meeting certain technical criteria, such as storage duration, through competitive solicitation to meet state policy goals and targets. Successful projects are then awarded storage capacity credits subject to certain performance guarantees and penalties. These credits may be funded through surcharges in customer rates.[68]

4. **Grants**: offered on a competitive basis and used to support high-profile projects that demonstrate new technologies, applications, or business cases.[69]

5. **Incentive adders**: used when storage is added into an existing renewable energy incentive program—for example, a storage adder in a solar incentive—to encourage the pairing of the two technologies.[70]

6. **Storage as efficiency**: similar to an adder in that it incorporates storage into another existing program—in this case, a state energy efficiency plan and includes performance payments to storage-owning or storage-leasing customers though utility contracts.[71]

7. **State tax credits**:[72] such as net energy metering (NEM) tariffs, technology-specific incentives, and federal incentives.[73]

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67 ibid

68 See Maryland's storage procurement as an example https://mdpsc-ngea-storage.com/documents/

69 McNamara, Will, Passell, Howard, and Todd Olinsky-Paul. "States Energy Storage Policy: Best Practices for Decarbonization." Clean Energy States Alliance and Sandia National Laboratories. February 2023.

70 ibid

71 ibid

72 ibid

73 For up to date information on state and federal incentives, visit https://dsireusa.org/

# Additional Resources

For more information on energy storage, NARUC has developed a list of resources divided into key topic areas to enable further learning on energy storage challenges, potential solutions, and technologies. Visit the NARUC Storage Resource Library.

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