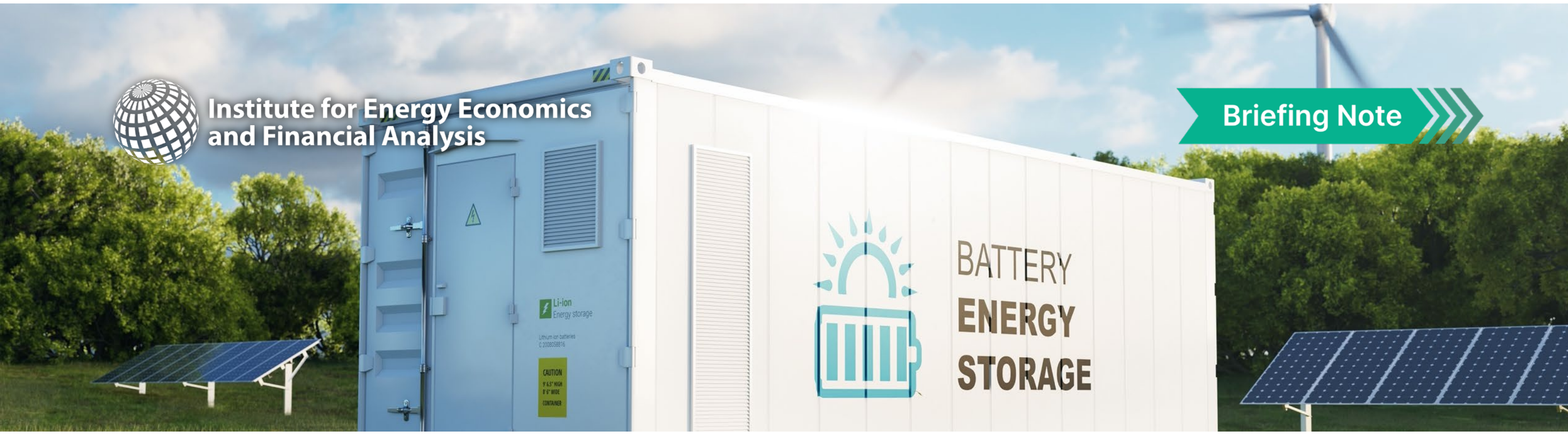

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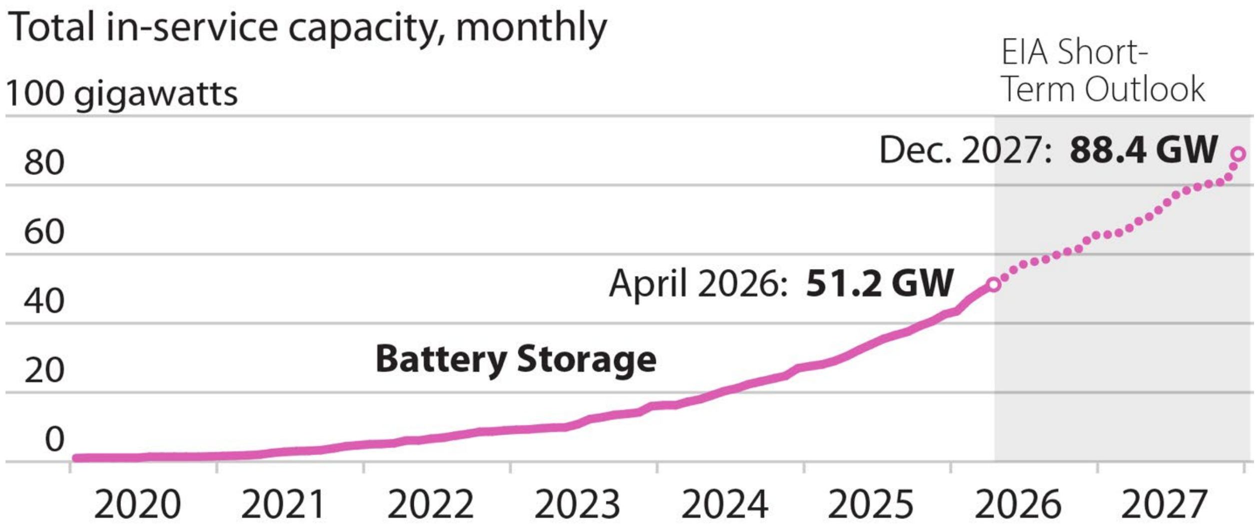
Market Success of Short-Duration Batteries Paves the Way for Longer-Lasting Storage

- Short-duration battery storage has increased 25x over the last five years.
- Installed capacity is expected to double again by the end of 2027.
- There is no fast-response, long-duration storage in the U.S., but the outlook for its development in the next five to 10 years is positive.
- Advances in technology, rising data center demand, and policy changes are likely to drive the development and growth of long-duration storage.

The success and soaring growth of two- to four-hour lithium-ion batteries over the past five years have created an opening for longer-duration storage solutions that can store up to four days of power.[1] In the U.S. today, there is essentially no fast-response, long-duration storage, but the outlook for growth in the next five to 10 years is positive. In fact, long-duration energy storage (LDES) could follow a growth trajectory like that of short-term storage, as advances in technology, demand from new data centers, and policy changes all align.

In just five years, installed short-duration battery storage capacity in the U.S. has increased from 1,694 megawatts (MW) in January 2021 to 43,419 MW in January 2026, according to the Energy Information Administration (EIA). Current forecasts call for installed capacity to double again by the end of 2027, reaching almost 90,000 MW. For comparison, there were 79,944 MW of conventional hydroelectric power capacity and 98,438 MW of nuclear capacity in the U.S. in January 2026—figures that are virtually unchanged from a decade ago.

Figure 1: Total In-Service Capacity, Monthly



Source: EIA.

IEEFA has written extensively about the positive impact shorter-duration battery storage is having on the grid. This research has focused on California and Texas, which have been early adopters of battery storage capacity due to the large and still-growing amount of solar generation in each state. Texas now has more than 18,000 MW of installed capacity, while California has just over 16,000 MW.

Those resources play a daily role in keeping costs down and reliability up in both states, with new records regularly being set. Battery discharge in the Electric Reliability Council of Texas (ERCOT), the system operator serving the bulk of Texas demand, topped 10,000 MW for the first time on March 13. When that record was set, batteries supplied more than 20% of total demand. The battery capacity also played a key role in pushing prices down; they peaked at $121/megawatt-hour (MWh) at 7:30 p.m., then fell to $71/MWh at 8 p.m. as stored battery capacity entered the system. Five years ago, all that generation would have come from the system's coal or gas resources, and prices likely would have remained higher for longer.

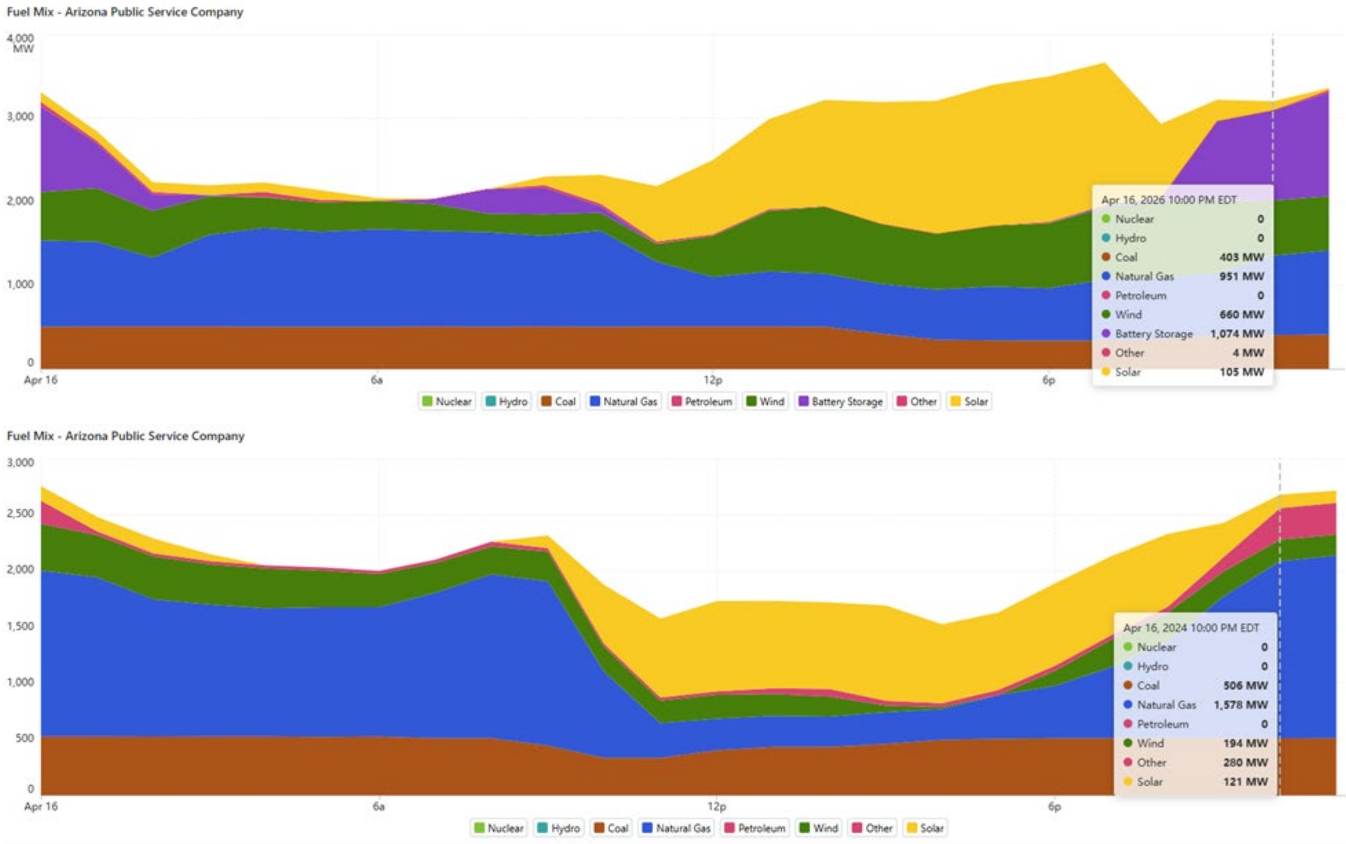
California also set a new battery discharge record on March 29, with supply topping 12,000 MW for the first time and accounting for 42 percent of total demand. The impact on prices within the California Independent System Operator (CAISO), which accounts for about 80 percent of the state's demand, was even more pronounced than in ERCOT: They hit $200/MWh at 6:55 p.m. that day before tumbling below $90/MWh at 7 p.m. as battery generation flooded into the market. Five years ago, in-state gas generation would have been the resource used to replace most of that battery capacity.

But the impact of storage is no longer limited to California and Texas. Data from Arizona Public Service, for example, underscores how rapidly batteries are changing daily generation patterns. In April 2024, the utility, which serves about 1.4 million customers across the state, did not show any battery storage generation in its daily reports to the EIA. Two years later, the utility now regularly dispatches more than 1,000 MW of storage capacity during the evening.

The graphics below show the utility's generation profile on April 16 in 2024 and 2026. While admittedly just a snapshot, they show how quickly change is occurring. In 2024, the utility's generation at 7 p.m. local time was 2,679 MW, with coal and gas producing almost 78 percent of the total. In 2026, the script has flipped. Renewables, led by solar-charged battery storage, which totaled 1,074 MW, provided 57.5 percent of the utility's demand at 7 p.m., with coal and gas generation falling to roughly 42 percent.

It is also noteworthy that the utility uses battery storage in the early morning before sunrise to eliminate the need to ramp up either its coal or gas resources. Here again, this tracks the proof-of-concept examples forged over the past five years in California and Texas.

Figure 2: 2024 Fuel Mix Versus 2026 Fuel Mix – Arizona Public Service Company



Source: Grid Status.

Early Moves on LDES

The success of short-duration storage has piqued interest in longer-duration options that can address other issues, such as replacing expensive, polluting gas peaker plants and providing power during periods when weather conditions limit wind and solar production. However, to date, the absence of market structures to make long-duration storage bankable has been a key roadblock to the technology's development. As Sandia National Laboratory researcher Ramesh Koripella explained in a 2024 webinar: "Today, no market mechanism[s] exist to address LDES needs."[2]

That is changing, quickly. Several states have enacted procurement mandates requiring utilities to install long-duration storage. In addition, companies in the data center and artificial intelligence (AI) sectors are emerging as major backers of LDES. Combined, these two developments provide certainty for companies looking to build long-duration storage and are likely to accelerate the market's rise.

State Targets Give LDES a Big Push

California was an early leader in advancing short-duration battery storage, and it is playing a similar role in advancing longer-duration solutions. In February, the California Public Utilities Commission adopted a measure requiring the state's load-serving entities to develop 6,000 MW of new generation capacity by 2032, with at least 1,500 MW of that total either resources capable of discharging for at least eight hours or clean, firm options that are not duration-limited.[3]

While California is a leader, it is not moving alone.

Legislation (HB 895) enacted in Virginia to update its 2020 Clean Economy Act is certainly the most aggressive energy storage effort this year in the U.S. The bill, signed by Gov. Abigail Spanberger in April, requires the state's two investor-owned utilities, Dominion Virginia and Appalachian Power, to install a significant amount of both short- and long-duration storage over the coming 20 years.[4] Dominion must add at least 4,000 MW of long-duration storage to its system by 2045, with half due online by 2035. Within the 4,000 MW mandate, the legislation calls for half to have a duration of between 10 and 24 hours and the other half to be capable of operating for more than 24 hours. Appalachian Power, which has a smaller footprint in the commonwealth, is required to install 520 MW of long-duration storage by 2045, with the same timing and operational requirements as those set for Dominion.

In addition, the legislature established short-duration storage requirements for both utilities. Dominion must add 16,000 MW of short-duration storage by 2045, with 4,000 MW of that total due online by the end of 2030. Appalachian Power is required to add 780 MW of short-duration storage by 2040.

Massachusetts is implementing legislation adopted in November 2024 that calls for adding 5,000 MW of energy storage capacity by 2030, including 3,500 MW of four- to 10-hour storage, 750 MW of 10- to 24-hour storage, and 750 MW of multi-day storage.[5] The first three contracts stemming from this legislation are currently being negotiated for 1,500 MW of storage with 10 to 24 hours of capacity (what Massachusetts labels mid-duration storage).[6] In May, the commonwealth started the process for a second solicitation for 1,000 MW of additional mid-duration storage projects. One innovative aspect of this proposal is that it will allow bidders to submit projects that use battery storage as a transmission asset. This use case could be a major driver of storage projects, given the difficulty of siting new or expanding transmission facilities.[7]

Gov. Maura Healey also issued an executive order in March that calls for adding 10,000 MW of energy supply resources and 5,000 MW of new energy storage capability within the commonwealth by 2035.[8] The order does not include numerical targets for storage types. Still, it points to the need for both mid- and long-duration storage and singles out two Massachusetts companies developing multi-day storage technologies: Form Energy and Fourth Power.

These state measures will give developers confidence that markets for longer-duration storage exist where they did not several years ago.

Hyperscalers Come Calling for LDES

Another boost for long-duration storage, ironically, could come from the rising demand for electricity from data center developers and hyperscalers. AI-driven demand increases are straining grids across the U.S. and putting significant upward pressure on consumer prices. This has prompted growing political backlash amid concerns about energy affordability. But in many cases, these power demands could help demonstrate the commercial viability of long-duration storage.

In Minnesota, Xcel and Google announced a deal in February under which the utility will power a new data center with 1,400 MW of wind, 200 MW of solar, and 300 MW of long-duration storage capacity.[9] Google will pay for the capacity, any required grid infrastructure enhancements, and contribute $50 million toward the utility's new distributed battery storage program.

The battery storage portion of the agreement will fund the development of Form Energy's iron-air battery system, which has a 100-hour discharge capacity. In total, the system will be able to inject 30 gigawatt-hours (GWh) into the grid, enabling charging during periods of excess renewable generation and discharging even on days with low or no wind and solar output.

Google has other deals in place backing the development of competing long-duration storage technologies. In 2025, it partnered with Energy Dome to commercialize the company's carbon dioxide (CO_2) battery, which "charges" by compressing gaseous CO_2 held in a container or dome and storing it under pressure as a liquid. It then "discharges" by evaporating the liquid, expanding it through a turbine to produce electricity, and sending the gaseous CO_2 back into the dome for another cycle.[10] In addition to Google, the Italian company, targeting storage durations of eight to 24 hours, is developing a 20MW/200MWh project with Alliant Energy in Wisconsin. State regulators approved the development in 2025, and construction is supposed to begin this year with commercial operations starting in 2027.[11]

Google is not the only AI-related company backing the development of 100-hour duration batteries. In March, Crusoe, which is pursuing a bring-your-own-power approach to its data center development efforts, announced a deal with Form Energy under which the battery company will supply it with 12 GWh of storage capacity beginning in 2027.[12] Then, in April, Noon Energy, which is developing a reversible solid oxide fuel cell that uses solid carbon and oxygen, announced a deal with Meta. Under the terms of that deal, Meta reserved 1 GW/100 GWh of storage capacity from Noon, with the first delivery slated for 2028.[13]

These AI-driven orders, coupled with the state mandates discussed above, create a market driver that will help spur the development of long-duration storage.

LDES' Potential as a Peaker Replacement

One potential early use for long-duration storage is as a replacement for seldom-used, expensive, and generally highly polluting gas- and oil-fired peaker power plants. IEEFA takes no position on the various technologies vying for market share in the LDES sector, but for this analysis, we used the 100-hour duration threshold to examine the potential to replace existing peaker plants. Specifically, we examined the possibility of using LDES to replace Unit 3 at the H.A. Wagner power plant in Maryland. The unit is a 60-year-old facility with a summer generating capacity of 305 MW.

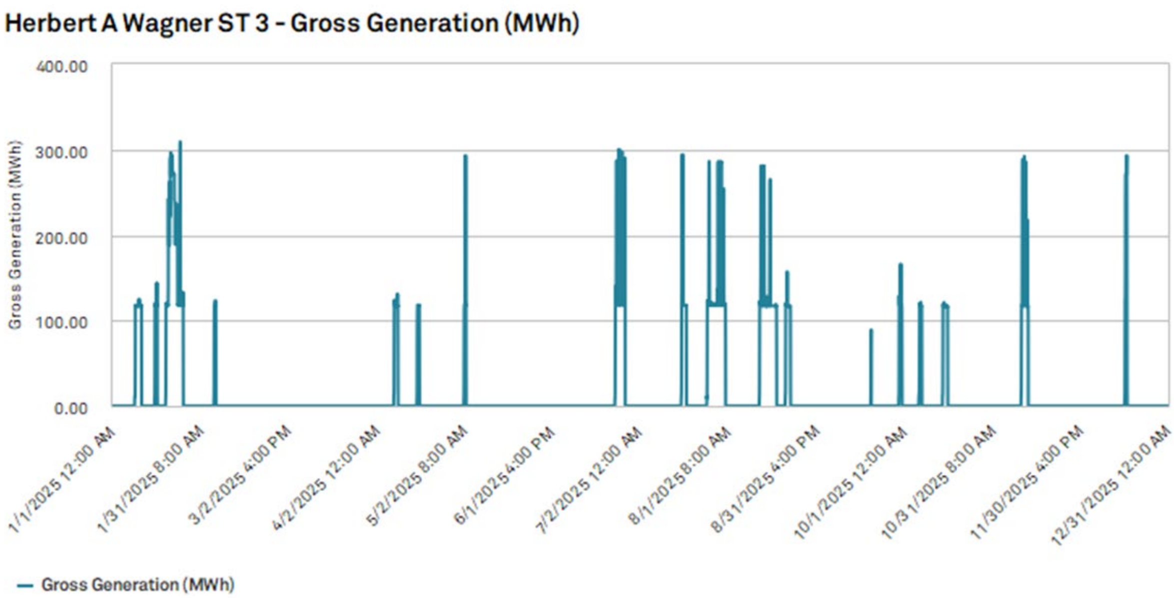
Talen Energy owns the Wagner plant, which includes two operating units that run on fuel oil. Unit 4 is slightly larger, with a summer capacity of 397 MW, and slightly newer; it entered commercial operation in 1972. Both units were scheduled to retire in May 2025, but they are now operating under a so-called reliability, must-run contract negotiated with PJM, the system operator, which will keep them online until 2029. As part of the deal, PJM will pay Talen $140 million to keep the two Wagner units open, and will also reimburse the company for fuel costs and its variable operations and maintenance expenses.[14] According to S&P, the plant's O&M costs in 2024 amounted to more than $309 per megawatt-hour (MWh).

EIA data shows that Unit 3 produced 138,781 MWh of electricity in 2025. If we assume the plant's O&M costs were the same as in 2024, that means the unit's production costs would have been about $43 million. Adding half the fee due Talen for keeping the plants open would boost the annual cost to run Unit 3 to roughly $113 million, pushing the operating costs per MWh above $800.

While the cost of 100-hour batteries remains uncertain, there is no doubt, at least for Wagner Unit 3, that they could meet PJM reliability requirements. The units would also have plenty of opportunities to earn revenue in the market when not needed by the system operator.

Unit 3 operated 18 times, covering all or parts of 58 days during the year. During those times, its maximum generation over any block of time was 27,678 MWh; a 100-hour-duration battery sized at 325 MW would have a discharge capacity of 32,500 MWh, leaving it with a 15 percent cushion even if it ran continuously and was unable to recharge during that peak period. Most of the generation events were significantly shorter in both length and output. Twelve lasted three days or less and required no more than 7,000 MWh of energy.

Figure 3: Herbert A Wagner ST 3 – Gross Generation (MWh)



Source: S&P Global.

Many Technologies in The Running

The push to develop long-duration battery storage technologies is well underway, with companies advancing different technologies with distinct operating characteristics, particularly in terms of operational duration. Which company(ies) will win the development race remains uncertain, and it seems particularly unlikely, at least today, that the sector will be dominated by one technology, as lithium-ion has come to rule the shorter-duration market. While far from a complete list, the companies below all have at least one development project under contract, giving them at least a shot to compete in the nascent LDES market.

Table 1: Development of LDES Technologies by Company

Company	Founded	Home base	Technology	Duration (hours)
Energy Dome	2020	Italy	CO_2 battery	8 to 24
EOS Energy	2008	U.S.	Zinc hybrid	4 to 16
Form Energy	2017	U.S.	Iron-air battery	100
Highview Power	2005	U.K.	Liquid air	6
Hydrostor	2010	Canda	Advanced compressed air	8+
Noon Energy	2018	U.S.	Carbon oxygen fuel cell	100+

Is Hydrogen a Long-Duration Storage Option?

Some tout the ACES renewables-to-hydrogen project in Utah as a potential way to provide dispatchable green energy at scale. IEEFA is doubtful that the project, a joint venture between Chevron and Mitsubishi, will prove economically competitive or environmentally beneficial.

The project, in development since 2019, is designed to produce about 100 metric tons of hydrogen per day and store it in salt caverns near the Intermountain Power Project in Delta. That hydrogen, so-called green hydrogen since backers say it will be produced using renewable energy, is earmarked for blending into the fuel supply of two gas turbines at the new Intermountain combined-cycle project, which will send power to the Los Angeles Department of Water and Power (LADWP). Initially, the two 420-MW Mitsubishi turbines are supposed to be fueled with a blend of 70 percent methane and 30 percent hydrogen. Ultimately, LADWP's plans call for the turbines to burn 100 percent hydrogen, which produces no greenhouse gases when combusted.

IEEFA's calculations show that it will take significantly more hydrogen production capacity than currently exists at the site for the project to reach even the starting goal of a 30 percent blend.

LADWP imported an average of 3.24 million megawatt-hours from the formerly coal-fired power plant in 2023-24, its last two years of full-scale operations. Producing a comparable amount of electricity at a gas-fired facility would require about 22.4 billion cubic feet of gas, using a heat rate of 7,100 British thermal units per kilowatt-hour (Btu/kWh). Replacing 30 percent of that gas (~6.7 billion cubic feet, or bcf) with hydrogen would require about 158 tons per day (using the hydrogen conversion factor published by the Department of Energy's Pacific Northwest National Laboratory). In other words, the project will only be able to produce about 63 percent of the hydrogen needed even to meet the planned blending target—and that assumes the installed electrolyzers will operate 100 percent of the time. Meeting the more aggressive 100 percent conversion would, by default, require significantly more hydrogen production capability at significantly higher cost.

In short, using hydrogen as a fuel for gas turbines, even in low-percentage blends, is unlikely to be economically or environmentally effective (a topic IEEFA covered at length in our 2024 report, Hydrogen: Not a Solution for Gas-Fired Turbines). It is possible, however, that green hydrogen could be used in the future to store excess renewable energy produced during periods of high output, particularly in the spring, and seasonally shift that energy to the high-demand summer season. There is no market for that product today, and projecting when/if such demand might develop is fraught with uncertainty.

Conclusion

Five years ago, there was essentially no installed battery storage capacity in the U.S. As of April, EIA data shows the total now tops 51 GW. This capacity plays a significant role in daily grid operations in California and Texas, and is growing quickly in other markets as well.

IEEFA believes a similar rapid expansion is possible in the long-duration storage market. The sector is admittedly in its initial stages. Still, strong currents are driving its development, including state mandates, federal tax incentives, and business demand, particularly from the fast-growing AI sector. The spectacular expansion of the short-duration battery storage market is another driver, and companies in the long-duration arena can see that developing the right product at the right price will be rewarded.

Endnotes

[1] There is no uniform definition of LDES. One common breakdown is intraday, eight to16 hours; multi-day, 24 to 100 hours+; and seasonal, shifting energy from spring to summer, for example.
[2] Sandia National Laboratory. Introduction to Long-Duration Energy Storage, Part 1. Electrochemical Technologies. September 20, 2024.
[3] California Public Utilities Commission. Decision 26-02-057. February 26, 2026.
[4] Viriginia Bills & Resolutions. 2026 Regular Session. HB895. Electric Utilities: Energy Storage Requirements, Depart of Energy to Develop Model Ordinance. March 31, 2026.
[5] Massachusetts Bill S.2967. An Act Promoting a Clean Energy Grid, Advancing Equity and Protecting Ratepayers. November 20, 2024.
[6] Massachusetts Clean Energy. Section 83E Round 1 Selection Announcement. December 19, 2025.
[7] Massachusetts Department of Public Utilities. Docket No. 26-75. May 8, 2026.
[8] Governor Maura Healey. Governor Healey Takes Action to Bring in 10 GW Of New Energy, Save $10 Billion and Promote Energy Independence. March 16, 2026.
[9] Xcel. Xcel Energy to Power New Google Data Center in Minnesota. February 24, 2026.
[10] Energy Dome. Google Partners With Energy Dome. July 25, 2025.
[11] Alliant Energy. Columbia Energy Storage Project. Accessed April 23, 2025.
[12] Crusoe. Form Energy and Crusoe Announce Agreement for 12 Gigawatt-Hours of Iron-Air Batteries for AI Data Centers. March 24, 2026.
[13] Business Insider. Noon Energy and Meta Announce Plans for Up to 1 GW of 100+ Hour Energy Storage for Data Centers. April 21, 2026.
[14] Talen Energy. Talen Energy, Other Parties Reach Reliability Must Run Settlement Agreement for Brandon Shores and H.A. Wagner Power Plants. January 27, 2025.

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The Institute for Energy Economics and Financial Analysis (IEEFA) examines issues related to energy markets, trends, and policies. The Institute's mission is to accelerate the transition to a diverse, sustainable, and profitable energy economy. www.ieefa.org

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