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Status report: the **U.S. ENERGY STORAGE MARKET** 2023 outlook

CONTENTS

INTRODUCTION

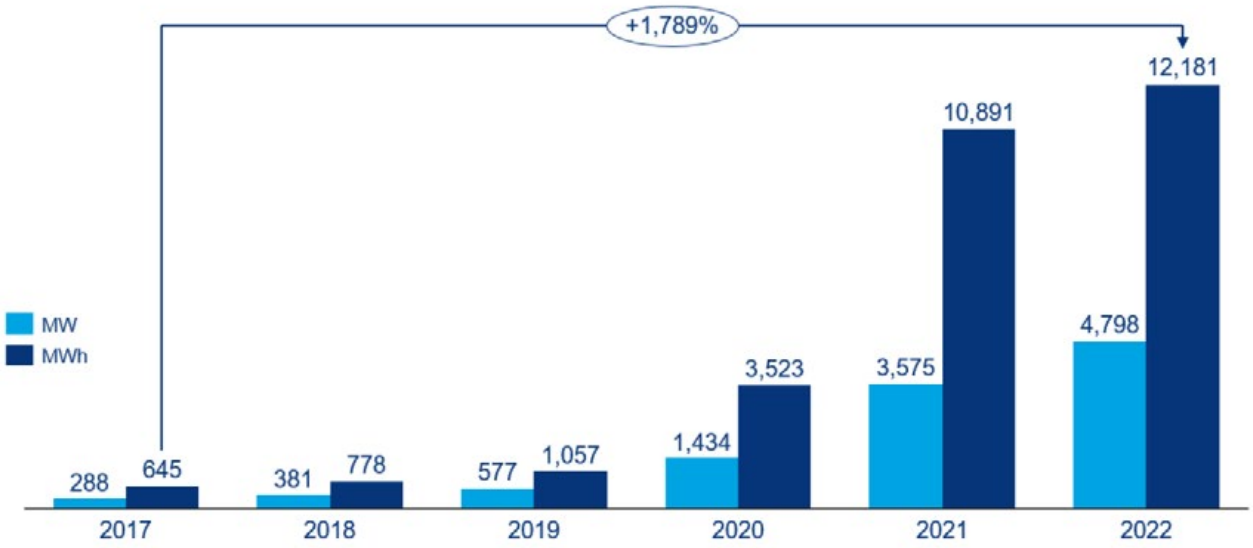
Energy storage is booming in the United States. The nation installed 4.8 gigawatts (GW) of battery capacity in 2022, almost equal to the 5 GW commissioned over the two previous years, according to a March 2023 Energy Storage Monitor report by trade body American Clean Power and analyst firm Wood Mackenzie.[1]

Cumulative operating utility-scale storage capacity increased by 80% in 2022, said John Hensley, American Clean Power Association's vice president of research and analytics. The figures refer to battery storage only, ignoring legacy pumped hydro storage. Based on current growth, Wood Mackenzie expects 75 GW of capacity to be installed between 2023 and 2027, consolidating the United States' position as the world's second-largest energy storage market, behind China.[2]

"Forecasted capacity for the grid-scale and CCI [community, commercial and industrial] segments will more than double in 2023, partly due to robust storage demand and to projects that were delayed from 2022 coming online," said the analyst firm. "Wood Mackenzie also expects residential capacity to increase by approximately 88% in 2023—with four times more residential storage to be installed in 2027 compared to 2022 volumes."[3]

U.S. ENERGY STORAGE DEPLOYMENTS ACROSS ALL MARKET SEGMENTS, 2017-2022.

Source: Wood Mackenzie.[4]



This growth is being driven by a range of factors, including ambitious procurement programs in renewables-heavy states, such as California and Hawaii, that are phasing out fossil fuel generation. And the economics of energy storage are set to improve in 2023 following the Biden administration's Inflation Reduction Act (IRA) of 2022.

The IRA includes an investment tax credit for standalone energy storage systems, along with other provisions likely to boost the deployment of wind and solar projects that could be paired with batteries. These incentives are set to run to 2032, giving project investors long-term visibility of revenue support. At the same time, falling battery costs are encouraging more and more American households to install residential storage.

The residential segment saw a record 171 megawatts (MW) of installations in the third quarter of 2022, according to the Energy Storage Monitor. Wood Mackenzie expects residential battery storage capacity to grow by about 88% in 2023.[5] The growth seen throughout 2022 is even more remarkable considering that global supply chain shortages led to increased prices and shipping delays across the battery value chain.

These issues are fading but the U.S. energy storage industry is not out of the woods. "System cost declines are anticipated in 2023 though other issues remain, such as supply delays and an increasingly tight labor market," said Wood Mackenzie.[6]

This report aims to provide a snapshot of the vibrant U.S. energy storage market as it embarks on this period of unparalleled growth.

THE U.S. MARKET OVERVIEW

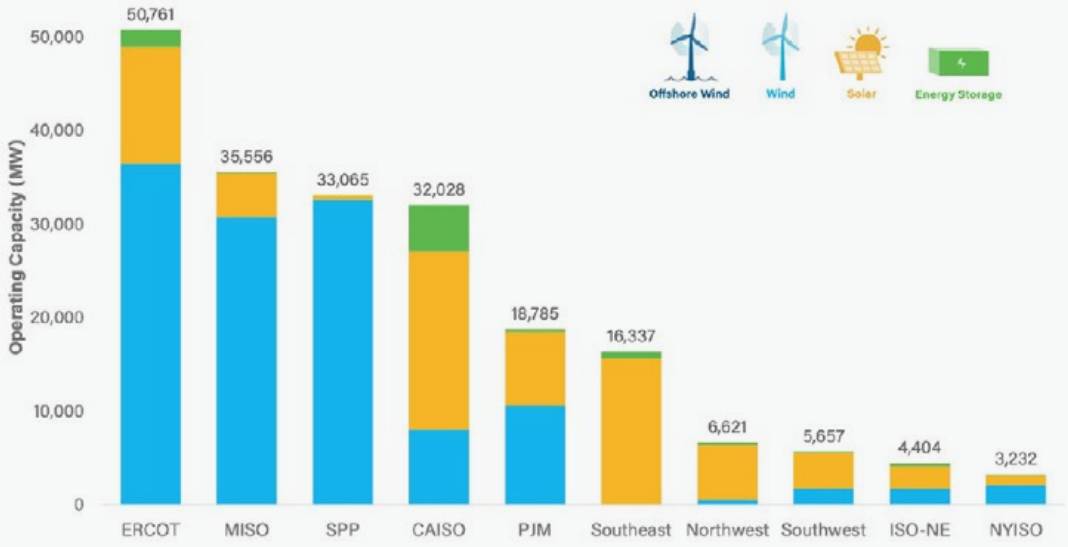
The United States has long been one of the world's top energy storage markets, mainly thanks to the state of California's world-leading decarbonization plans. Building on earlier policies, in November 2022 the state released what it said was "the most ambitious climate action of any jurisdiction in the world," with a goal of achieving carbon neutrality and a 100% clean energy grid by 2045.[7]

Previous policies had already given California a world-leading position in terms of low-carbon generation. In 2021, the state fleetingly achieved a record 95% of its electricity from clean power sources. Soaring levels of renewable energy on the grid have heightened the need for storage, with battery capacity on the CAISO grid ballooning 70% between April 2022 and January 2023 alone.[8]

Meanwhile, states such as Hawaii and Texas have begun to ramp up storage capacity in step with rising renewable energy production. Battery storage is being deployed aggressively in states with greener grids because the technology can provide ancillary services to stabilize electricity networks and serve as a buffer to avoid grid congestion, avoiding the need for costly infrastructure upgrades.

ONLINE RENEWABLE ENERGY AND STORAGE CAPACITY BY REGIONAL OR INDEPENDENT TRANSMISSION OPERATOR, AS OF THE FOURTH QUARTER OF 2022.

Source: American Clean Power.[10]



POLICY AND REGULATION

Although industry growth has so far mainly been driven by a need for flexibility in the wake of state renewable procurement programs, several states have historically set targets and implemented incentives specifically targeting energy storage. Notable examples include:[11]

- **California**, which passed the nation's first storage target legislation in 2010 and implemented a Self-Generation Incentive Program that fostered behind-the-meter capacity with more than $1.2 billion in support.
- **Massachusetts**, which approved a 1 GW storage target in 2018 and implemented America's first solar-plus-storage incentive as part of its Solar Massachusetts Renewable Target program.
- **New York**, which in 2018 set a target of 1.5 GW of capacity by 2025 and 3 GW by 2030, and committed almost $350 million in support for retail and bulk storage.

California's policies in particular have had a transformative effect on the energy storage industry. "California has almost single-handedly jump-started the advanced storage industry by setting statewide mandates for renewables, storage and carbon-free electricity," said Sandia National Laboratories in 2019.

"For the last decade, the state has been a frontrunner in both the development of storage technologies and the legislative and regulatory policies that are needed to enable the growth of a storage marketplace," it noted. "Energy storage factors prominently into California's clean energy goals, and in fact some market observers have concluded that California's goals are not achievable without a significant amount of new storage capacity being developed over the next two decades."[12]

At the other end of the scale is Texas, which has achieved the second-highest levels of energy storage deployment in the United States (after California) without procurement targets or incentive schemes.[13] The Electric Reliability Council Of Texas (ERCOT) operates a grid that is largely independent of the rest of the United States and has the highest amount of wind and solar generation in the country.

This situation can lead to major spikes in electricity spot market pricing when there is a mismatch between supply and demand. In February 2021, for example, wholesale market prices topped $9,000 per megawatt hour.[14]

Pricing variability on the ERCOT market has made the state a lucrative hunting ground for battery system operators seeking energy arbitrage revenues. In April 2022, the Texas Public Utility Commission reported a queue of 31 GW of standalone storage awaiting connection to ERCOT.[15]

INVESTMENT

Until 2021, storage-related incentives and procurement plans were mostly state driven, although battery systems could benefit from investment tax credits if the batteries were being charged with solar energy.[16] This situation has changed with the Biden administration, which in 2021 approved $6 billion in support for demonstration and supply chain development within the Infrastructure Investment and Jobs Act.

The act also included $14 billion in grid improvement funding that could help support storage deployment.[17] Then came the IRA, which for the first time provides an investment tax credit for standalone residential, front-of-meter and commercial and industrial (C&I) energy storage systems.

The law allows a tax credit of 30% against these systems up to 2033, rising to as much as 70% for non-residential installations if certain domestic content and community-related criteria can be met.[18] Industry insiders believe the IRA could drive up to $1 trillion in energy storage investment within a decade,[19] boosting capacity additions to 27 GW a year by 2031.[20]

Rapid growth in the energy storage market is driving demand for project financing, said law firm Morgan Lewis.[21] Recent energy storage deals include a $20 million grant from Breakthrough Energy Catalyst for Xcel Energy,[22] a 400 MW portfolio acquisition by Portland General Electric[23] and Greenwood Sustainable Infrastructure's purchase of a 1.4 GW solar-plus-storage pipeline.[24]

USE CASES AND DEPLOYMENT

An attractive feature of battery systems for investors is that batteries can carry out a wide range of valuable services, sometimes simultaneously, allowing projects to tap into diverse revenue streams. One study, prepared by The Brattle Group for battery maker Eos Energy Storage, listed more than a dozen potential storage applications, including energy price arbitrage, ancillary services, resource adequacy and grid upgrade deferral.

"Accounting for the 'stacked' benefits of battery storage by optimizing its dispatch across all analyzed value streams significantly increases the total value of the battery relative to any individual value stream (by a factor of at least 2x to 3x over individual uses cases)," it said. "Avoided generation capacity, frequency regulation and energy price arbitrage are the largest sources of quantified value. However, the 'depth' of each market should be taken into consideration when valuing large quantities of energy storage."[25]

Typically in most energy storage markets, batteries have been deployed primarily for frequency response in the early stages. Keeping electricity supplies within a specific frequency range is essential for grid control and becomes harder to achieve as thermal generation from fossil fuels gives way to intermittent renewables that do not possess spinning reserves.

However, the amount of frequency control required by a grid is finite, and as renewable contributions rise in the mix it can become more important to time-shift energy—creating arbitrage opportunities—or defer network upgrades. Thus, the ideal use cases for a battery system will depend on the requirements of the local grid and may vary over time.

Such considerations are less important for behind-the-meter installations, although here again batteries can fulfill a range of functions, from improving solar self-consumption rates to providing backup power.

CHALLENGES FACING UTILITY-SCALE STORAGE

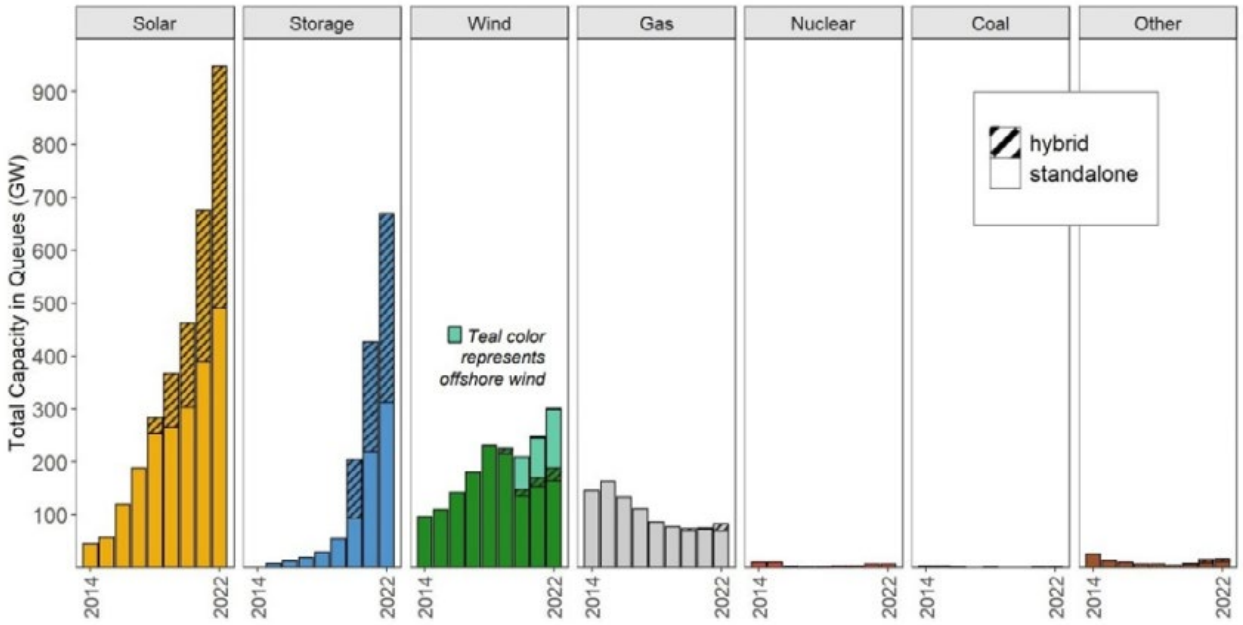
The U.S. Energy Information Administration (EIA) expects power utilities in the United States to triple their battery storage capacity in three years, from 7.8 GW in October 2022 to 30 GW by the end of 2025.[26] The EIA believes most of this near-term capacity addition will happen in 2023, when capacity could rise to 19 GW, and 2024, when it could grow by 28.4 GW. Battery storage will make up 17% of grid capacity additions in 2023, ahead of any other asset bar solar.[27]

More than three-quarters of the planned capacity additions up to 2025 are expected to take place in Texas in California. Texas is set to add 7.9 GW and California, 7.6 GW. More than 23 of the upcoming projects will boast capacities beyond 250 MW.[28] This scale of deployment is proving a challenge for electricity network operators, with grid connection queues for storage exceeding those for any other type of energy infrastructure bar solar in the last couple of years.

Competition for grid capacity is leading to rising connection costs as storage vies with wind and particularly solar for space on the network, according to the Lawrence Berkeley National laboratory (Berkeley Lab). Connection requests rose 40% in 2022, it said. U.S. connection costs are rising as more new projects require grid expansions and this will continue in the coming years as developers take advantage of IRA tax credits, Berkeley Lab program leader for grid connection costs Joachim Seel told Reuters in May 2023.[29]

POWER CAPACITY IN U.S. GRID CONNECTION QUEUES.

Source: Berkeley Lab, April 2023.[30]



SYNERGIES WITH RENEWABLES DEVELOPMENT

One way to overcome limited grid connection capacity is to deploy storage alongside renewable generation assets. This allows renewable generation to be stored if it cannot be immediately exported to the grid, either because of connection capacity limits or congestion on the local network.

The concept is particularly valuable for solar project developers, since their plants produce energy in a highly synchronized fashion based on the passage of the sun in the sky. This, plus the fact that until the IRA was introduced storage could only access tax credit funding when powered by solar, has led to an explosion in so-called hybrid projects where batteries are tied to renewables.

According to American Clean Power, almost 70% of grid-scale battery storage projects under development in 2022 were paired with solar or wind. Half the projects commissioned last year were hybrid schemes.[31]

Aside from energy storage and renewables, one other beneficiary of recent federal legislation is low-carbon hydrogen. The IRA includes tax credits that could pump more than $100 billion into clean hydrogen production.[32] That is on top of around $7 billion from the Infrastructure Investment and Jobs Act that the U.S. Department of Energy has pledged to put into as many as 10 hydrogen hubs—industrial centers where the gas can be produced and consumed at scale.[33]

Clean hydrogen can be made from renewable energy using electrolysis. It is unclear for now how hydrogen support might affect the energy storage market, since electrolyzers could either replace batteries as sinks for excess production or require batteries for more stable renewable electricity supplies.

Another trend that could have an impact on battery deployment is the spread of microgrids—infrastructures that can provide firm power for communities or facilities in the absence of reliable grid supplies. Energy storage is key to the operation of most microgrids. Currently, the deployment of microgrids in the United States is limited, but that could change in future as climate change compromises the reliability and resilience of electricity networks.

ADVANCEMENTS AND TECHNOLOGY

Energy storage in the United States is fundamentally based on just two technologies. By far the most widespread, accounting for around 95% of grid-scale capacity in 2022,[34] is pumped hydro, where reservoirs at different heights shuttle water to store or release energy.

Pumped hydro systems can store vast amounts of energy but can only be built in places with favorable characteristics and, even then, may be subject to lengthy permitting and construction cycles. No new projects have been built since the Clinton administration.[35]

The other technology commonly used for grid-scale energy storage—and almost exclusively in the last decade—is lithium-ion batteries. This is a mature technology, first deployed at scale in consumer electronics and now, alongside energy storage, in electric vehicles.

Manufacturing economies of scale mean lithium-ion batteries have fallen significantly in cost over recent years, while the availability of multiple global suppliers, including major corporations such as LG Energy and Panasonic, ensures security of supply. However, the lithium-ion battery industry suffers from three shortcomings:

- The lithium-ion supply chain is overwhelmingly dominated by China, which controls 56% of the electric vehicle battery market,[36] 75% of cell manufacturing capacity and 90% of anode and electrolyte production. This represents a significant geopolitical supply chain risk.[37]
- Lithium-ion batteries are only cost-effective for grid-scale applications with discharge times of up to around four hours today, and a maximum of 12 in the future.[38] For longer discharge times, new long-duration storage technologies will be needed.
- Lithium-ion batteries rely on materials such as cobalt and lithium for which there is little alternative demand and therefore only limited supply, creating a risk of raw material bottlenecks as the industry scales up to cope with vehicle electrification.

NEW TECHNOLOGIES

To overcome lithium-ion's shortcomings, in July 2021 the U.S. Department of Energy launched an Energy Earthshot Initiative aiming to reduce the cost of grid-scale, long-duration energy storage by 90% within the decade.[39] The search for long-duration concepts is generally focused on finding storage media that plentiful and cheap, as water is in pumped hydro. There is no shortage of contenders, with materials such as air, sand, concrete, salt, iron and zinc all being used to store energy.

In the battery space, potential competitors to lithium-ion include flow batteries and zinc, sodium-ion and liquid metal chemistries.[40] Plus there is a wide range of long-duration energy storage concepts besides batteries. They include ideas such as gravity storage, where excess energy is used to elevate heavy loads; thermal storage, where energy is stored as heat; or compressed air, which can be stored in caverns and released to power a turbine.

Of these, only thermal storage has been deployed at scale, alongside a renewable energy technology called concentrated solar power. And although investment in long-duration energy storage is rising, totaling $910 million worldwide in 2021, there are few applications today that require discharge times beyond four hours.

Commercializing novel storage systems is difficult when lithium-ion is widely available at low cost, and the sheer variety of long-duration systems offers little scope for standardization and cost reduction based on economies of scale. Because of this, there are some who believe the prospects for long-duration energy storage may be limited, particularly if low-carbon hydrogen scales to a point where it can be used cost-effectively for power generation.[41]

ENERGY STORAGE INNOVATION

Alongside new types of storage, the value of existing assets is being improved by a range of innovations. At the battery level, increasingly advanced management systems are helping to improve the performance and longevity of assets. And intelligent battery plant management systems formed the basis of a slew of corporate acquisitions around 2017.[42]

More recently, energy storage innovation has focused on the development of virtual power plants, where a diverse set of assets is aggregated and managed as a single entity. Virtual power plants can be made of a wide variety of components, from distributed renewable generation sources such as wind and solar to demand response program participants that can take loads off the grid when needed.

Batteries are particularly valuable to virtual power plants because they can act as loads or generators, depending on whether they are charging or discharging. Since they can be made from existing assets, tied together with smart controls and software, virtual power plants are much cheaper and easier to develop than their traditional counterparts.

Come 2030, the energy transition nonprofit RMI believes virtual power plants could cut U.S. peak electricity demand by 60 GW, enough to power 50 million households. Allied to this, an emerging technology called vehicle-to-grid could soon allow electric vehicle batteries to participate in demand response programs. California has already allowed vehicles to take part in its Emergency Load Reduction Program.[43]

"We can use our existing assets more efficiently as opposed to raising rates for all electricity users by doing things less efficiently," Jigar Shah, director of the Loan Programs Office at the U.S. Department of Energy, told Reuters in a January 2023 interview. "Virtual power plants are at the center of that."[44]

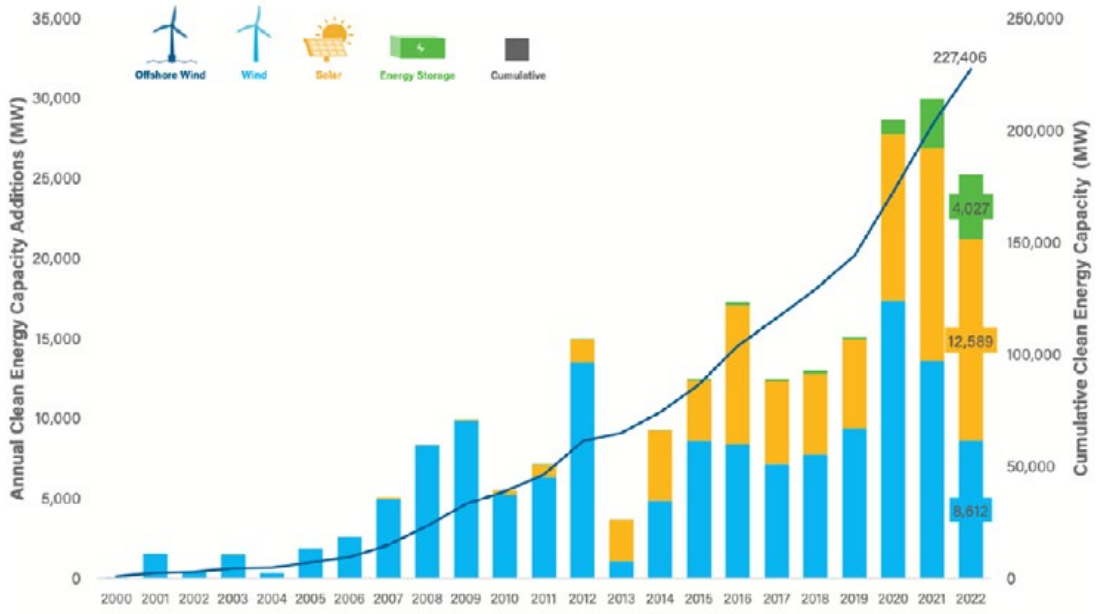
OUTLOOK AND CONCLUSIONS

California may have played a dominant role in launching the current era of battery-based energy storage, but in 2023 it is far from the only state embracing batteries. American Clean Power reported in February 2023 that half the states in the nation were developing battery storage and more than 14 had at least 100 MW of capacity in development.[45]

Arizona, Nevada and Texas all had energy storage pipelines of more than a gigawatt, while California boasted almost 5.9 GW in development after having installed more battery capacity than solar in 2022. The total battery storage pipeline in the United States was estimated to be a record 16.7 GW and 45.6 gigawatt hours.[46]

U.S. ANNUAL AND CUMULATIVE CLEAN POWER CAPACITY GROWTH.

Source: American Clean Power.[47]



Given the nation's energy transition ambitions, along with the incentives offered by regulations such as the IRA and the value of storage in overcoming increasingly acute grid congestion, this level will only increase. And the United States is not only aspiring to be an energy storage leader in terms of deployment. An important component of packages such as the IRA is to stimulate domestic manufacturing through local content requirements.

Battery manufacturing is a major focus for this, given the industry's current reliance on China. There are signs the IRA's local manufacturing objectives are bearing fruit. In March 2023, the South Korean battery giant LG Energy Solution announced a $5.6 billion investment in U.S. manufacturing, citing the IRA as the main reason for the move.[48]

If other manufacturers follow suit, then energy storage could become a key part of U.S. manufacturing as well as adding value to the grid.

REFERENCES

1 Wood Mackenzie press release, March 15, 2023: U.S. energy storage market continues to expand rapidly.

2 Ibid.

3 Ibid.

4 Ibid.

5 Ibid.

6 Ibid.

7 Office of Governor Gavin Newsom press release, November 16, 2022: California Releases World's First Plan to Achieve Net Zero Carbon Pollution. Available at https://www.gov.ca.gov/2022/11/16/california-releases-worlds-first-plan-to-achieve-net-zero-carbon-pollution/.

8 Sammy Roth, Los Angeles Times, April 29, 2021: California just hit 95% renewable energy. Will other states come along for the ride? Available at https://www.latimes.com/environment/newsletter/2021-04-29/solar-power-water-canals-california-climate-change-boiling-point.

9 Cameron Murray, Energy Storage News, January 23, 2023: Battery storage helping California avoid curtailment, but shedding set to grow further in 2023. https://www.energy-storage.news/battery-storage-helping-california-avoid-curtailment-but-shedding-set-to-grow-further-in-2023/.

10 American Clean Power Clean Power Quarterly 2022 Q4. Available at https://cleanpower.org/wp-content/uploads/2023/02/2022_CPQReport_Q4_Public.pdf.

11 From the Energy Storage Association, 2023: STATES IN THE SPOTLIGHT. Available at https://energystorage.org/policies-issues/states/states-in-the-spotlight/.

12 Sandia National Laboratories, September 2019: Energy Storage Policy Summaries For The Global Energy Storage Database. Available at https://www.sandia.gov/app/uploads/sites/163/2021/08/Sandia_StatePolicies_Book_v5.pdf.

13 Center for the New Energy Economy State Policy Opportunity Tracker for Clean Energy, July 2, 2021: TEXAS - ENERGY STORAGE STANDARD. Available at https://spotforcleanenergy.org/state/texas/energy-storage-standard/.

14 Tim McLaughlin, Reuters, February 15, 2021: Texas wholesale electric prices spike more than 10,000% amid outages. Available at https://www.reuters.com/article/us-electricity-texas-prices-idUSKBN2AF19A.

15 Rod Walton, EnergyTech, April 4, 2022: Texas Public Utility Commissioners considering new Distribution Interconnection standards for Battery Storage. Available at https://www.energytech.com/energy-storage/article/21238007/texas-public-utility-commissioners-considering-new-standards-for-standalone-battery-storage-projects.

16 Penny Liao, InfoLink Consulting, January 4, 2023: How Inflation Reduction Act reforms U.S. energy storage market? Available at https://www.infolink-group.com/energy-article/energy-storage-topic-impact-of-ira-on-us-energy-storage-market.

[17] Guillermo Pereira, CleanTechnica, August 18, 2022: 3 Barriers To Large-Scale Energy Storage Deployment. Available at https://cleantechnica.com/2022/08/18/3-barriers-to-large-scale-energy-storage/.

[18] Ibid.

[19] Utility Dive, November 7, 2022: IRA sets the stage for US energy storage to thrive. Available at https://www.utilitydive.com/spons/ira-sets-the-stage-for-us-energy-storage-to-thrive/635665/.

[20] Morgan Lewis, March 8, 2023: THE RISE OF ENERGY STORAGE. Available at https://www.morganlewis.com/pubs/2023/03/the-rise-of-energy-storage.

[21] Ibid.

[22] Tamarindo, May 4, 2023: Breakthrough Energy invests $20m in Xcel storage projects. Available at https://www.tamarindo.global/articles/breakthrough-energy-invests-20m-in-xcel-storage-projects.

[23] Tamarindo, May 2, 2023: Portland General Electric procures 400MW of storage projects. Available at https://www.tamarindo.global/articles/portland-general-electric-procures-400mw-of-storage-projects.

[24] Tamarindo, April 17, 2023: GSI acquires 1.4GW Saturn Power US solar-storage projects. Available at https://www.tamarindo.global/articles/gsi-acquires-1-4gw-saturn-power-us-solar-storage-projects.

[25] Ryan Hledik, Roger Lueken, Colin McIntyre and Heidi Bishop, The Brattle Group, September 2017: Stacked Benefits: Comprehensively Valuing Battery Storage in California.

[26] Deep Vakil, Reuters, December 9, 2022: U.S. utilities to triple battery storage capacity by 2025, EIA says. Available at https://www.reuters.com/business/energy/us-utilities-triple-battery-storage-capacity-by-2025-eia-2022-12-08/.

[27] Andy Colthorpe, Energy Storage News, February 8, 2023: EIA: US battery storage deployments expected to double during 2023. Available at https://www.energy-storage.news/eia-us-battery-storage-deployments-expected-to-double-during-2023/.

[28] Deep Vakil, 2022.

[29] Eduardo Garcia, Reuters, May 4, 2023: US grid data projects brighten outlook for wind, solar builders. Available at https://www.reuters.com/business/energy/us-grid-data-projects-brighten-outlook-wind-solar-builders-2023-05-04/.

[30] Ibid.

[31] Andy Colthorpe, Energy Storage News, February 28, 2023: US installed grid-scale battery storage capacity reached 9GW/25GWh in 'record-breaking' 2022. Available at https://www.energy-storage.news/us-installed-grid-scale-battery-storage-capacity-reached-9gw-25gwh-in-record-breaking-2022/.

[32] Catherine Clifford, CNBC, March 3, 2023: Inside the fierce debate over clean hydrogen, with $100 billion in federal subsidies on the line. Available at https://www.cnbc.com/2023/03/03/clean-hydrogen-industry-future-depends-on-ira-tax-credit.html.

[33] U.S. Department of Energy press release, September 22, 2022: Biden-Harris Administration Announces Historic $7 Billion Funding Opportunity to Jump-Start America's Clean Hydrogen Economy. Available at https://www.energy.gov/articles/biden-harris-administration-announces-historic-7-billion-funding-opportunity-jump-start.

[34] Julian Spector, Canary Media, January 25, 2022: Pumped hydro grid storage could be poised for a comeback. Available at https://www.canarymedia.com/articles/long-duration-energy-storage/pumped-hydro-grid-storage-could-be-poised-for-a-comeback.

[35] Ibid.

[36] Bruno Venditti, Visual Capitalist, October 5, 2022: ENERGYThe Top 10 EV Battery Manufacturers in 2022. Available at https://www.visualcapitalist.com/the-top-10-ev-battery-manufacturers-in-2022/.

[37] BloombergNEF, November 12, 2022: China's Battery Supply Chain Tops BNEF Ranking for Third Consecutive Time, with Canada a Close Second. Available at https://about.bnef.com/blog/chinas-battery-supply-chain-tops-bnef-ranking-for-third-consecutive-time-with-canada-a-close-second/.

[38] Nate Brinkerhoff, Medium, Apr 3, 2020: How Long Will Lithium-Ion Grid Storage Last? Available at https://medium.com/the-future-is-electric/how-long-will-lithium-ion-grid-storage-last-9c7b0ce82fa0.

[39] U.S. Department of Energy, July 14, 2021: Secretary Granholm Announces New Goal to Cut Costs of Long Duration Energy Storage by 90 Percent. Available at https://www.energy.gov/articles/secretary-granholm-announces-new-goal-cut-costs-long-duration-energy-storage-90-percent.

[40] David Roberts, Canary Media, May 14, 2021: Competitors to lithium-ion batteries in the grid storage market. Available at https://www.canarymedia.com/articles/batteries/battery-week-competitors-to-lithium-ion-batteries-in-the-grid-storage-market.

[41] Jason Deign, Foresight Climate & Energy, March 2, 2023: Long-duration energy storage faces a harsh commercial reality. Available at https://foresightdk.com/long-duration-storage-faces-harsh-reality/.

[42] Jason Deign, Greentech Media, November 6, 2017: Big Data and Artificial Intelligence Deals in the Energy Sector Are Up Tenfold in 2017. Available at https://www.greentechmedia.com/articles/read/big-data-and-ai-deals-in-energy-are-up-10-fold-in-2017.

[43] Laura Sherman, Utility Dive, February 2, 2023: Vehicle-to-grid charging is coming fast — here's how regulators and utilities can prepare now. Available at https://www.utilitydive.com/news/vehicle-to-grid-charging-is-coming-fast-heres-how-regulators-and-utiliti/641804/.

[44] Nichola Groom, Reuters, January 31, 2023: Explainer: What is a virtual power plant? Available at https://www.reuters.com/business/sustainable-business/what-is-virtual-power-plant-2023-01-31/.

[45] Colthorpe, February 28, 2023.

[46] Ibid.

[47] American Clean Power Clean Power Quarterly 2022 Q4.

[48] Heekyong Yang and Hyunsu Yim, Reuters, March 24, 2023: S.Korea's LGES revives Arizona battery factory with $5.6 bln investment. Available at https://www.reuters.com/technology/south-koreas-lges-resume-arizona-battery-factory-plan-with-56-bln-investment-2023-03-24/.