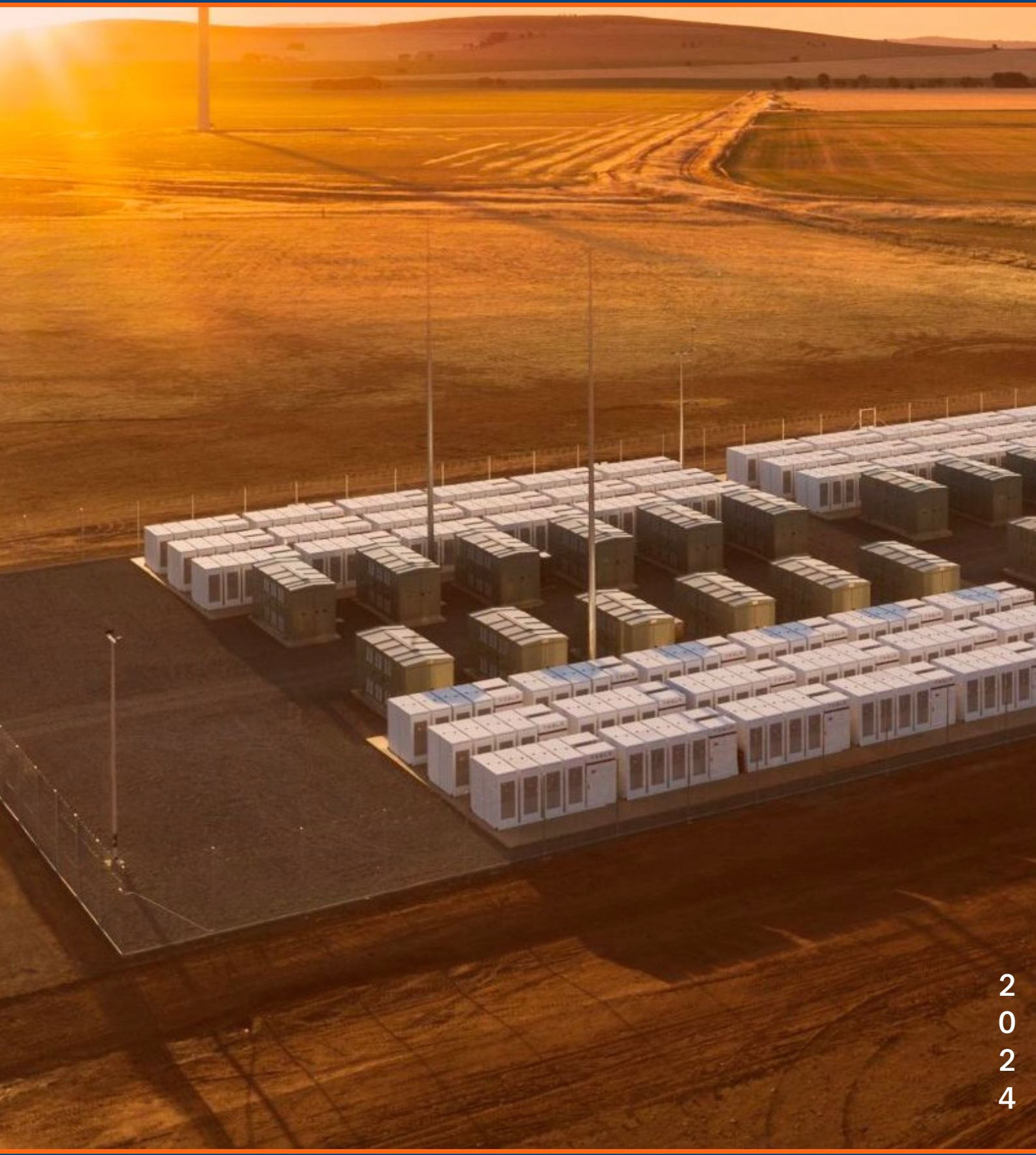
Global Energy Storage Market



2024

CLEANBRIDGE

About

Our Annual Global Energy Storage market report adds to our continued series of key energy transition focused industry reports. The collective works are the result of a valued research collaboration between ourselves and Alchemy Research and Analytics, a leading industry research group working actively across the energy transition markets. The report draws on macroeconomic data from multilateral institutions and industry-specific data from sources such as industry associations, government authorities / statistical departments, and the International Energy Agency (IEA). This was supplemented by news reports, trade journals, and related sources.

The report provides a current market overview of the global energy storage industry, including recent trends, drivers, challenges, and outlook in major countries across Europe and the Americas. The structure of the report begins with a summary of the industry's dynamics, including regional variations, and analyses of their implications. It then delves into detailed profiles of major markets by country, offering a holistic view of the industry's state in these countries, and highlighting growth opportunities, demand drivers, and current challenges.

CleanBridge's INSIGHTS series of industry reports, aims to provide a comprehensive understanding of the key characteristics and trends prevalent in major markets for various technologies that will shape the energy transition over the coming decades. We hope you find our annual review of the Global Energy Storage market informative and enjoyable to read and we look forward to briefing you on other renewable energy technologies in the upcoming months.

L. Warren Pimm, CFA

Partner, & Sr. Managing Director

CleanBridge

For any inquiries or communications pertaining to this report, please direct them to **Chaz Keiderling**. ckeiderling@panamfinance.com

Table of Contents

Cover Page Image courtesy Octopus Australia

01

Executive Summary

Designed by Freepik

Executive Summary

The growing significance of energy storage solutions within the context of the clean energy market underscores a pivotal transition towards sustainable power systems. The upsurge in investments in battery storage, soaring to $37 billion in 2023, reflects a threefold increase compared to 2021. This surge of capital is attributable to the rapid maturation and commercialization of energy storage technologies, coupled with the implementation of supportive regulatory frameworks that fortify the economic viability of grid-scale storage units.

While the concept of energy storage is not novel—fossil fuels and hydroelectricity serve as traditional reservoirs of stored energy—its recent relevance has been magnified by the ascendancy of renewable energy sources such as solar and wind. Unlike their conventional counterparts, renewable sources lack inherent storage capacity, necessitating bespoke storage solutions to effectively manage the intermittency of power generation.

Two primary storage technologies, namely pumped hydro and battery energy storage systems (BESS), emerge as pivotal low-carbon storage technologies that complement renewable energy assets. The inherent variability of renewable energy generation poses challenges for network operators, manifesting in unpredictable power supply dynamics and grid capacity constraints. Energy storage interventions offer a solution to alleviate these challenges, equipping operators with enhanced grid flexibility to optimize the balance between supply and demand.

Europe, a vanguard in renewable energy adoption, has grappled with grid capacity inadequacies precipitated by the growing share of renewable energy sources. In response, concerted efforts have been directed towards bolstering energy storage solutions, supported by financial incentives that have catalyzed the proliferation of both stand-alone and co-located storage facilities. These strategic interventions not only facilitate grid management utilities but also enable optimized power scheduling, thereby creating a compelling business case for investment.

Despite encountering supply chain vicissitudes, battery storage power capacity soared to 85GW by the end of 2023, marking a twofold surge in annual growth. However, this expansionary trajectory still falls short of addressing the scale necessitated for robust integration of renewable energy into the grid. Concurrently, ongoing technological strides, inclusive of refinements in Lithium-Ion batteries and the ascendancy of alternatives like Sodium-Ion batteries, are anticipated to galvanize further innovation and deployment within the energy storage domain.

Long-duration energy storage (LDES) has attracted a significant focus within the energy storage industry, as attention shifts from not only the power capacity but also the total storage capacity. This is crucial in ensuring grid reliability amidst the escalating penetration of renewable energy sources. While pumped hydro remains the quintessential LDES option, ongoing endeavours are underway to commercialize nascent battery technologies capable of meeting evolving storage requisites.

Projections predict a surpassing of the 200GW threshold in battery storage capacity within the ensuing five years, underpinned by every expanding project magnitudes and compelling pricing dynamics. Nonetheless, the regulatory framework and market dynamics have substantial influence over revenue potential for storage developers, underscoring the value of bespoke localized strategies and strategic collaborations to optimally harness the economic potential of the storage industry.

The main purpose of the initial 6 chapters of this report is to provide an overview of the essential factors that influence the energy storage market, such as the basic principles of the business case, the technologies, the trends and drivers including policy support and economics, and the prospects for the industry at a global level. After that, the report splits into geographical regions, Northern Americas, Europe and Latin America, and gives country-level profiles for each.

02

Introducing Energy Storage and Flex-Gen

Introducing Energy Storage and Flex-Gen

Globally, the long-term net-zero objectives necessitate flexibility in an increasingly complex power system. The pace of change in the power mix, driven by a rise in the share of renewable energy generation and energy transition objectives, has created demand for energy storage and flexible generation (flex-gen). Rising instances of grid curtailment demonstrate the need for grid operators to urgently increase their flexible delivery capacities. Energy storage systems, either integrated, co-located or standalone, are quickly emerging as an essential resource that can provide the power delivery flexibility needed.

The global transition to renewable energy sources has brought about a myriad of significant challenges in power-grid management. Infrastructure limitations and network instability due to voltage fluctuations are compounded by the phasing out of balancing assets in thermal power generation. The evolving grid-power mix is coupled with the proliferation of distributed energy sources and increased electrification. In this ever-developing and complex landscape, the role of energy storage and flexible generation assets is becoming crucial.

Distinguishing Generating and Storage Capacities

In the energy transition discourse and literature, there's often a tendency to conflate generating and storage capacities, potentially causing confusion. This section aims to outline the fundamental distinctions between these capacity types, emphasizing the convention of using megawatts (MW) for describing generating capacities and megawatt-hours (MWh) for storage capacities.

Supplying electrical power involves transmitting electrical current, carrying energy usable for various practical applications such as vehicle propulsion or water heating. Power involves the transfer of energy, either between objects or in converting energy between different forms. Electrical energy and power play crucial roles in the transition to sustainable energy, facilitating energy conversion into usable forms without carbon emissions. Additionally, electrical current serves as an efficient conduit for transporting energy to desired destinations.

However, storing electrical energy poses challenges due to its inherent characteristics. Capacitors or static charge storage devices are the primary means of "storing" electricity, achieved through charging. Nevertheless, this process emits powerful electrical fields from the storage apparatus. Interactions with nearby objects or the environment can result in energy losses, an undesirable outcome. Therefore, synchronization of electrical power generation with demand is necessary, as storing electrical energy remains problematic. As society shifts from energy sources with inherent storage mechanisms to those that are harder to store, new storage challenges emerge.

Energy originates from various sources, including fossil fuels (chemical) such as coal, gas, or nuclear, and renewable sources like wind (kinetic), hydro (potential), and solar (electromagnetic). Each energy form possesses distinct properties and natural availabilities.

For instance, solar energy is essentially limitless, while the practical availability of fossil fuels is finite. Although all forms can be converted into electrical energy, fossil fuels yield undesirable byproducts during this process. However, fossil fuels offer a significant advantage: they serve as both an energy source and an integrated storage facility. For example, a piece of coal serves as a storage device for chemical energy, convertible into electricity as needed. In contrast, harnessing wind energy doesn't involve directly "storing" wind energy itself, and wind energy availability remains beyond human control. If wind energy is captured and converted into electrical energy, it then requires further conversion if it is to be stored. This storage may be achieved through methods like pumped-hydro or battery energy storage, converting wind energy into potential or chemical energy, respectively.

This underscores the importance of distinguishing between the ability to generate electrical power and the ability to store energy. Power capacity is measured in watts, while storage assets are assessed based on their ability to deliver power and for how long, measured in watt-hours. Throughout this report, the difference will always be identifiable by the convention of units. For example, stand-alone wind and solar projects exclusively serve as generating assets, lacking storage capacity. Therefore, their generating capacity is described in watts, megawatts, or gigawatts. In contrast, a hydroelectric plant possesses both generating and storage capacities. These capacities can significantly differ; for instance, if a hydro-plant can generate 100MW of power for three days, it has a generating capacity of 100MW and a storage capacity of 7200MWh (100MW x 3 days x 24 hours) alternatively expressed as 7.2GWh.

Flex-Gen Assets Balance Supply-Demand Variation

Utilities are strategically deploying generating assets with capacities tailored to ensure the reliability and stability of the grid. These assets must be capable of swiftly adjusting their power output to accommodate fluctuations in demand. Traditionally, gas and hydro-based capacities have been favoured for their responsiveness to demand changes and their black start capability, meaning they can be activated without relying on external power sources. Gas peaker infrastructure, commonly found in existing power systems, is the primary flexible generation option used to manage contingencies in the grid. For addressing longer-term variations in demand, such as seasonal fluctuations, grid operators also rely on coal-fired power plants to supplement baseload power supply during peak periods.

In November 2023, TotalEnergies acquired 1.5GW of flexible generation capacity in the US power market of Texas (TotalEnergies, 2023). The capacity was across three gas-based power generation units for network requirements in the US cities of Dallas and Houston. In August 2023, French grid operator RTE planned an extension of coal-fired power plants to meet winter season demand (Euractiv, 2023).

Both hydropower and battery storage address the demand drivers for grid balancing against intermittent renewable energy sources and the phase-out of conventional baseload options. However, battery storage is faster to develop and can be located more flexibly, resulting in a wider range of potential applications across utilities, residential, and commercial sectors.

Hydropower plays a crucial role as a flexible generation asset due to its black start capability and rapid ramp-up, which aids in grid stabilization. Large-scale hydro facilities typically have elevated reservoirs that act as energy storage, and pumps can further enhance hydro-storage flexibility by moving water upstream during periods of surplus electricity. However, the growth of hydropower has been limited by geographical constraints and lengthy development periods. Additionally, pumped storage faces challenges such as environmental impact and high capital costs.

Batteries, a rapidly growing flexible supply subset, discharge previously generated electrical power instead of adding capacity. When coupled with assets like solar or wind farms, batteries act as flex-gen. However, grid-connected utility-scale batteries encounter limitations in discharge duration and capital expenditure, restricting their deployment to select markets. Despite these challenges, increasing recognition of storage's role in carbon transition is driving policy and regulatory support, which in turn is fueling demand for battery storage solutions globally.

Centralized grid systems worldwide are grappling with challenges stemming from the rapid evolution of power networks. Increasing demand volumes, coupled with a rise in supply from smaller renewable energy producers, are straining traditional grids. However, advancements in information availability and computing capabilities are enabling more sophisticated power distribution solutions. Localized supply balancing and micro-grid solutions are gaining favour as they alleviate strain on centralized grids and improve efficiency.

The transition to decentralized power systems is essential for building future adaptability in power generation and grid networks. In this model, power transmission between regions addresses large-scale systemic imbalances, while local power dispatch is achieved at a localized level. Generating assets are strategically positioned close to core demand, while energy storage assets smooth out imbalances between supply and demand. Battery energy storage systems are expected to play a pivotal role in decentralized grid systems.

One notable emerging use case is the deployment of battery storage assets to optimize power transmission infrastructure, known as the Storage as a Transmission Asset (SATA) model. Pilot SATA projects in the US and Europe demonstrate how strategically placed energy storage assets can defer capital expenditure on transmission infrastructure. In Germany, battery-based storage units are being utilized to bolster the hosting capacity of transmission lines and address regulatory requirements regarding capacity redundancy, known as the 'n-1' criterion. The project, known as Netzbooster, was initiated by the transmission system operator TransnetBW GmbH and contracted to developer and supplier Fluence Energy for a 250MW battery unit. This initiative aims to enhance grid reliability and flexibility, with the battery unit scheduled for commissioning by 2025 Fluence, 2022). Further deployments are necessary to establish the commercial viability of the SATA model, and a rapid decline in the cost of grid-scale battery storage may act as a catalyst in this context.

Utilities primarily procure flex-gen assets through capacity market mechanisms and technology-neutral auctions. Capacity markets involve the system operator procuring generation capacity well in advance to prepare for contingencies. These capacities are required to be available to supply power when needed, regardless of whether they are actively producing electricity.

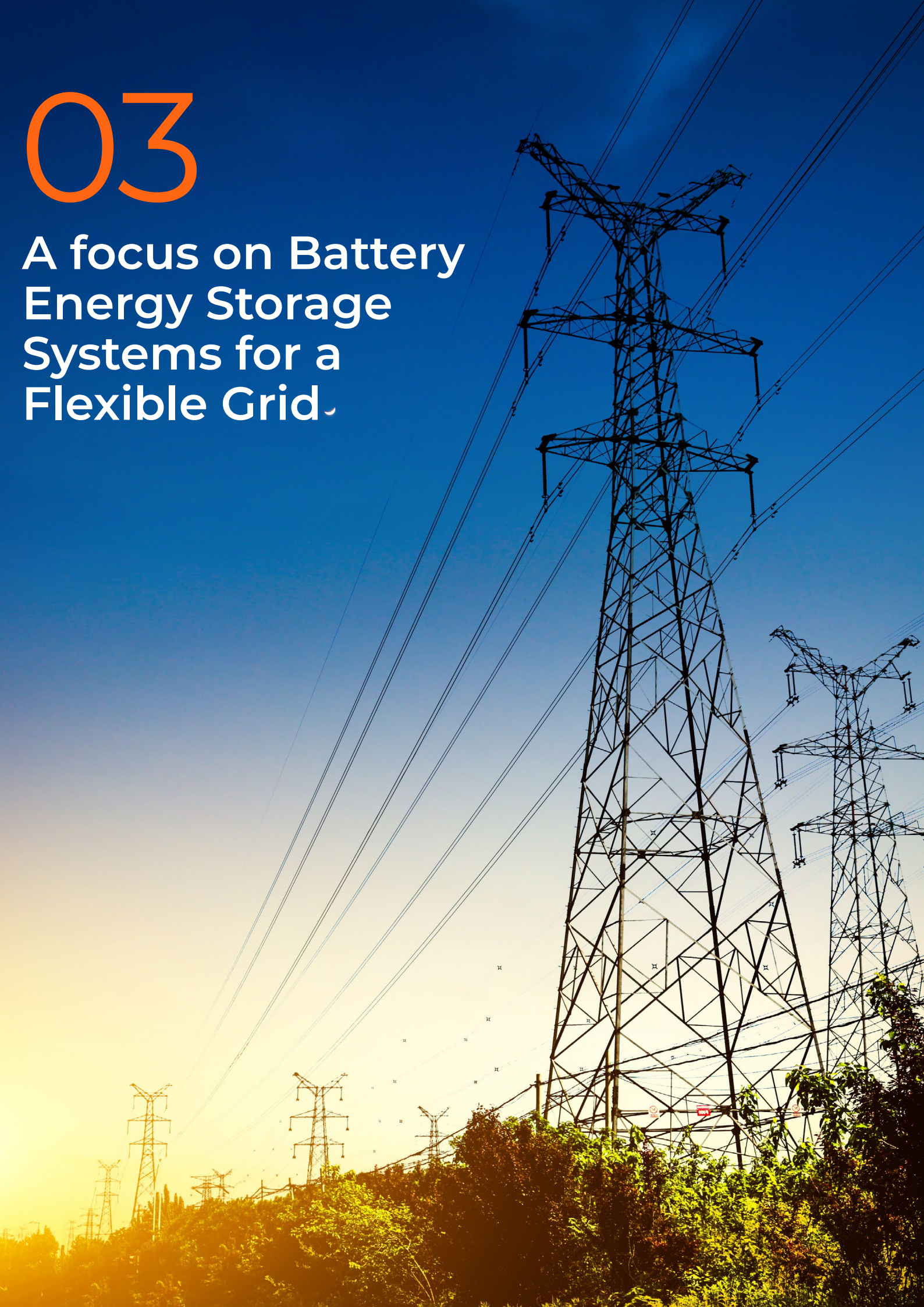
For example, in the US, PJM, a system operator, plans to conduct the next capacity market auction in June 2024 for delivery in 2026 and 2027 (Utility Dive, 2024). Similarly, European markets like Italy, the UK, and Poland have established capacity market mechanisms, offering revenue streams in addition to wholesale market transactions and providing long-term visibility through contracts. This trend has led to a gradual crowding out of thermal-based peaking power plants in these markets (Energy Storage News, 2023).

In addition to capacity markets, system operators are exploring incentives built into power generation contracts. For instance, in the Netherlands, the transmission system operator awarded 'capacity limitation contracts' to a solar PV plant in November 2023. These contracts serve as a form of congestion management, whereby the solar PV plant receives predetermined compensation in exchange for potentially reducing its output when needed for grid network stability (PV Magazine, 2023).

Image by dashu83 on Freepik

03

A focus on Battery Energy Storage Systems for a Flexible Grid.



A focus on Battery Energy Storage Systems for a Flexible Grid

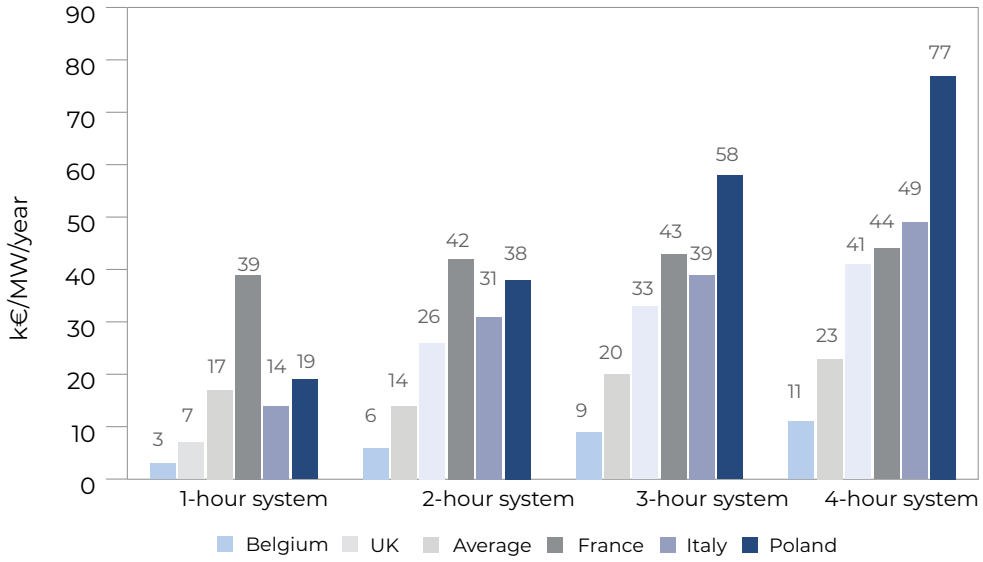
Batteries are increasingly playing a pivotal role in bridging the gap for flexible assets in the grid. The swift decarbonization efforts and the escalating penetration of renewable energy underscore the urgent need for grid operators to secure capacities that can be quickly mobilized for critical applications such as grid balancing, frequency regulation, and ancillary services. Stringent emission regulations have shifted the landscape away from gas or coal-based power generation facilities, making standalone battery storage units more competitive. Recent procurement auctions by transmission utilities reflect this trend, highlighting the emergence of batteries as viable options.

Hybrid renewable projects, which combine renewable energy generation with co-located storage units, are gaining momentum in numerous markets worldwide. Developers and utilities are adopting this approach to minimize curtailment by redirecting excess energy output from generation to times of peak demand. The US has been particularly proactive in this realm, with approximately three-quarters of solar projects now paired with batteries S&P Global, 2023). Similarly, the UK has witnessed a recent surge in co-located battery projects, with about half of all permitted utility-scale solar PV projects since 2022 incorporating battery storage (PV Magazine, 2023).

Auctions have proven instrumental in providing long-term visibility for investors and developers alike. Notable examples include Germany's 'innovative auctions,' initiated in 2021, which offer 20-year contracts for renewable-plus-storage projects. These auctions stipulate that selected battery storage projects must be charged from renewable energy assets and capable of providing automatic Frequency Restoration Reserve services. In Spain, similar auctions mandate a minimum energy storage capacity of 1MW or 1MWh with a minimum discharge duration of two hours. Selected projects are eligible for grants of up to €15 million per project and €37.5 million per company.

As energy storage deployment continues to rise, the power market is poised to become increasingly complex, necessitating the development of new procurement models to incentivize capacity expansion. However, it's crucial to note that regulatory changes in market participation must precede energy storage developers' involvement and investment. Many markets globally currently lack these regulatory frameworks, representing a vast untapped potential for energy storage development and integration.

Battery System Auction Remuneration



Note: The above data is as of April 2023; Auction remuneration data includes de-rating factor applied for each storage duration.

Source: Energy Storage News

04

Key Trends and Drivers in Energy Storage Capacity

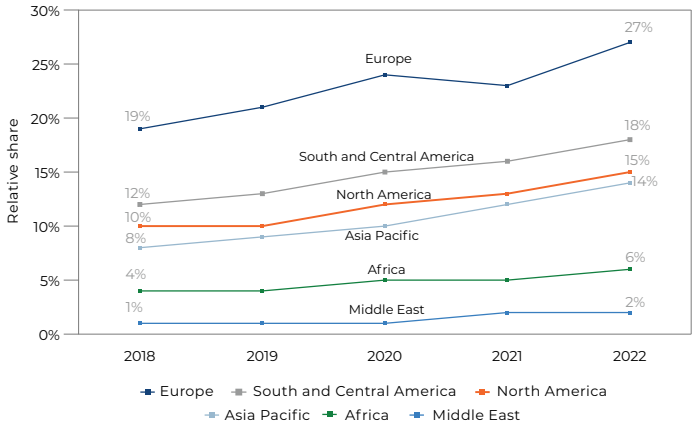
Key Trends and Drivers in Energy Storage Capacity

The global energy storage industry is characterized by dynamic growth, fueled by various factors encompassing energy policy, technological advancements, and trade dynamics. This section provides an overview of some of the major trends and drivers shaping the industry on a global scale.

Energy Transition and Renewable Energy Penetration

The increasing penetration of renewable energy globally, particularly in Europe, is driving the need for energy storage solutions. Just as Europe leads in renewable energy adoption, it also faces significant related challenges in grid management Energy Institute, 2023). Looking ahead at ambitious targets for renewable energy capacity expansion suggests integration challenges could intensify spurring the need for timely investments in energy storage capacities.

Renewable Energy's Share in Total Grid-Connected Power Generation

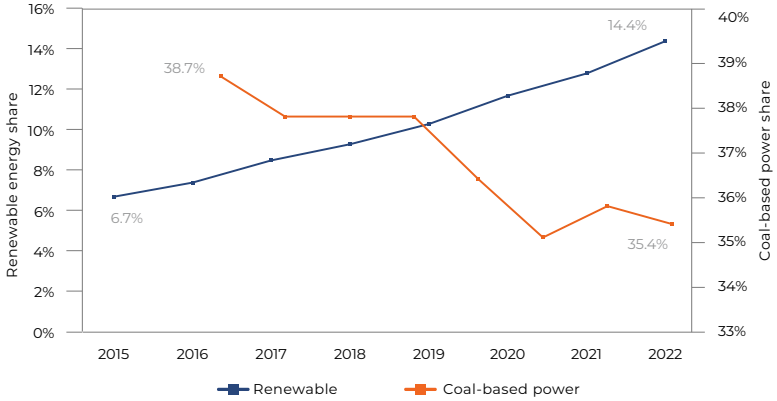


Source: Energy Institute Statistical Review of World Energy

High renewable energy penetration markets face several challenges, including grid supply curtailment, power market price cannibalization, and negative prices. Grid unpreparedness often results in curtailment, where excess renewable energy production exceeds grid capacity. California, a leader in renewable energy adoption, saw a significant 60% year-on-year increase in grid curtailment in 2022 ((AJOT, 2023). This oversupply depresses bulk power market prices, impacting project profitability, as fixed contracted prices are common. Additionally, grid curtailment leads to instances of negative prices, where operators cannot absorb excess energy and must compensate generators. The UK's National Grid paid £215m to generators in 2022 due to unabsorbed energy (Power Technology, 2023).

The rise of renewables also displaces conventional coal-based generation, accelerating the global phase-out of coal power. However, this poses challenges for grid operators, as coal plants provide baseload power crucial for grid stability. During the 2022 energy crisis, European countries faced coal plant postponements or reactivations due to restricted natural gas supply, highlighting the need for grid-scale storage and flexible energy sources.

Relative Share of Coal and Renewable in Global Power Generation



Note: Data refers to share of energy units generated by renewable and coal-based sources.
Source: Energy Institute Statistical Review of World Energy

Role of Policy support

Policy and regulatory measures play a crucial role in shaping the energy storage industry, given its early stage of techno-commercial viability, similar to renewable energy systems. Policy targets set by national or provincial authorities drive the energy storage project pipeline and investor interest, particularly in regions like Europe where renewable energy penetration is rapidly increasing. The European Union's response to the 2022 energy crisis by setting steeper energy transition targets further highlights the influence of credible policy target setting (Visual Capitalist, 2023).

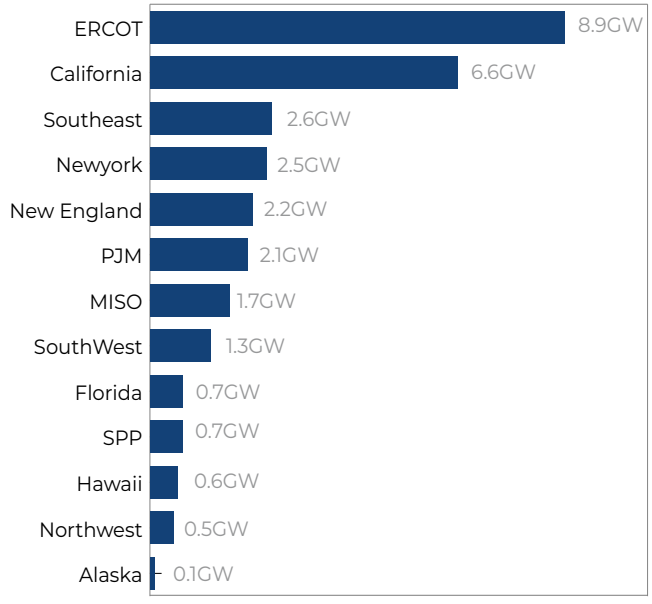
Renewable Energy Targets in the Major Markets/Regions

Country/Region	Renewable Energy Target of 2030
India	40% zero-carbon generation by 2030 (including nuclear power)
China	28% renewables by 2030
United States	739GW of wind and solar by 2030 to reach zero-carbon electricity by 2035
United Kingdom	60% renewables by 2030
European Union	42.5% renewables by 2030, under the REPowerEU

Source: Visual Capitalist

In the United States, the Inflation Reduction Act (IRA) has had a significant impact on the energy storage industry. This unprecedented policy measure provides substantial funding and tax incentives for standalone battery-based storage projects, with eligible projects receiving an investment tax credit of 30%. Further additional incentives can extend tax benefits to reach up to 70% for the project developers/owners (PV Magazine, 2023). The IRA provisions offer long-term visibility of incentives and promote the transition to clean energy by providing additional incentives for storage projects located in traditional energy communities, such as coal-based power plant sites. About 60GW of potential new storage capacity could be attributed to the US IRA (Energy Storage News, 2023).

IRA-led Potential Storage Build in the US Power Market Regions



Source: PV Magazine

Elsewhere, many countries, including those in Europe and China, support battery storage projects through government-led auctions or subsidy programs. These are typically designed as technology-neutral power procurement contracts but largely attract hybrid and standalone storage projects. European energy storage auctions, such as Germany's innovation tenders, allocate storage capacity through competitive bidding, encouraging hybrid and standalone storage projects. German authorities plan to award about 4GWh worth of storage contracts by 2028 (Fluence, 2023). Eastern European countries are also embracing battery storage, with plans to allocate grid connections to significant capacity and make regulatory changes to facilitate market participation. In Poland, there are plans to allocate grid connections to 9GW of battery storage projects, while another 16GW are registered for an ongoing market auction as of December 2023 (Energy Storage News, 2023). Hungary is in the process of implementing the first energy storage auction targeting 900MWh by 2026, and Estonia has announced energy-storage-specific grants pending the finalization of regulations.

China, the dominant country in battery production, implements subsidy programs to incentivize new energy storage capacities. In Xinjiang province, standalone battery storage units are entitled to compensation for discharged energy, with specific incentives for peak shaving and ancillary services. The standalone battery storage units were entitled to a compensation of CNY0.2/kWh (discharged energy) till 2025, with a 20% tapering off in each of 2024 and 2025. The subsidy scheme also outlined the incentives for specific services – peak shaving and ancillary services could qualify for CNY0.55/kWh in charging and CNY0.25/kWh in discharging without simultaneous capacity compensation (CESA, 2023).

Similarly, Chile is proactively promoting energy storage to complement its renewable energy generation base. In June 2023, the government's energy authority announced preliminary bidding information to procure 5.4GWh split for contracted delivery in 2027 and 2028. In the same period, the government also announced an additional $5 billion worth of investment towards the energy storage systems ready for commissioning within 2026. Notably, most of the planned storage units are co-located batteries with utility-scale solar PV generation units in the famed Atacama Desert region.

Chile's latest policy announcements follow previous steps at facilitating market participation of the grid-scale storage units (Energy Storage News, 2023).

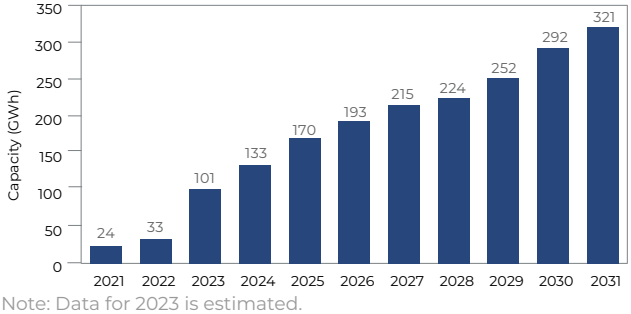
Overall, the policy-led funding approach is expected to gain traction in various markets as energy storage projects become increasingly important for achieving climate mitigation, decarbonization, and net-zero goals. As clean energy investments continue to grow globally, greater policy support and funding can be anticipated to accelerate the deployment of energy storage technologies.

Installed Capacity and Growth

The global push towards energy transition is driving accelerated deployment of storage capacity, with tracked battery storage capacities worldwide registering 200% year-on-year growth in 2023. Led by the US and Chinese markets, battery storage capacity expansion has been fuelled by supportive regulations, policy funding, targets, increased energy market volumes, and improved cost economics. Battery projects are becoming integral to clean energy investment plans, with an estimated $37 billion invested in batteries in 2023, triple the amount in 2021 (IEA, 2023).

As the demand for energy storage continues to rise, so does the projected annual capacity addition. This growth will stem not only from an increase in the number of projects but also from larger-scale projects. In August 2023, Vistra Energy, a US-based retail power supply and generation company and a battery storage developer, announced the completion of Phase-III of its Moss Landing project, bringing its total capacity to 3,000MWh. This marked the project as the world's largest, surpassing the 1,400MWh Californian battery storage project that held the title in 2022 (Electrek, 2023) (Energy Storage News, 2023). With enabling regulations and financing, more developers are likely to enter the market. In December 2023, Australia's largest grid-scale battery, with a capacity of 1,000MWh, received final investment approval for construction commencement in 2024 (ARENA, 2023).

Battery Storage Capacity Installation Trend and Projection

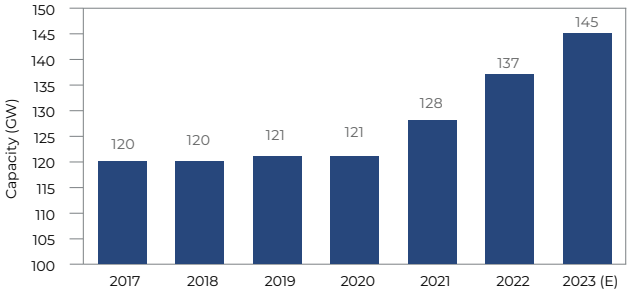


Note: Data for 2023 is estimated.

Source: Canadian Solar Investor Presentation March 2024 (data attributed to Wood Mackenzie)

Pumped hydropower, although a lagging sub-segment of energy storage, is experiencing renewed investor interest due to its capabilities as a mature long-duration energy storage resource. Despite challenges such as the gestation period, development obstacles, uncertain project costs, and environmental concerns, pumped hydropower capacity has shown a pickup since 2021 (IRENA, 2023). Examples like the £1.5 billion Coir Glas Pumped Hydropower Storage project highlight this resurgence, marking the first UK hydro investment in the last 40 years.

Pumped Hydro Storage Installed Power Capacity



Note: The capacity figure for 2023 is an estimated one using the average annual growth rates of 2021 and 2022

Source: IRENA, Alchemy Research

Major Pumped Hydro Storage Projects Under Planning or Development

Project	Capacity	Particulars
Coire Glas	1.5GW	UK's first large-scale pumped storage project proposed in over 40 years. The final investment decision is expected in 2024.
Snowy 2.0	2.2GW	Australian government approved the AUD12 billion project's revised development plans in December 2023.
Ebensee	170MW	Austrian project, targeting 2027 for commissioning.
Red John	450MW	Statkraft acquired this UK project from Intelligent Land Investments Group in December 2023.

Source: Power Engineering International, PV Magazine, Statkraft company press release

The drive for larger storage capacity sizes is closely linked to the demand for cost-competitive options and improved storage duration. In light of this, there is a renewed focus on pumped storage units in the upcoming energy storage growth. Leading energy storage markets are seeing an increase in the project pipeline for such projects. Despite significant upfront costs and gestation periods, the potential benefits of cost-effective and efficient storage solutions are compelling. Additionally, technological advancements in other battery options also contribute to this trend. Many advanced technologies, while promising, are still far from mass commercialization. Unlike pumped hydropower, new and emerging battery storage technologies may require additional financial support to achieve viability.

Progressively, there is a strong preference for co-located battery storage installations, led mainly by solar PV and battery combinations. A weak grid integration in most markets makes co-located batteries attractive in managing grid scheduling. An added benefit is the lower capital outlay and land and grid infrastructure optimisation. The US market's project pipeline for 2024 has a 70:30 split between co-located and standalone battery assets (Energy Storage News, 2024). Till 2022, co-location was incentivised with tax credits in the US market. The predominant share indicates that tax credits are not the only incentives for developers in this model.

The most common battery co-location projects are with solar PV. It is partly related to the relatively faster growth in utility-scale solar PV, among other renewable energy technologies. Battery storage co-located with a solar PV plant would enable grid services such as dynamic containment, besides mitigating the profitability risks that arise from excess supplies in the grid. Project pipelines in major battery storage markets, such as the US and UK, show a progressively rising interest in solar-plus-storage projects. The relatively higher investment returns in such projects potentially outweigh the complexities (such as separate permits, feasibility studies, etc.).

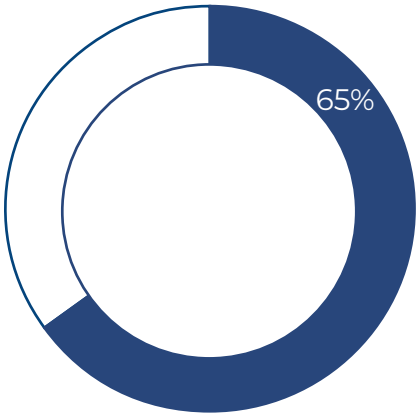
Some investment funds have also adopted the retrofitting route in battery colocation. In 2023, NextEnergy Solar Fund initiated retrofitting of battery storage to its solar PV portfolio for better returns. The declining subsidies in the renewable energy markets worldwide make co-located battery storage a better proposition for investors and developers seeking to maximise returns.

Emphasis on Utility-scale storage

Grid-scale storage is characterised by capacity sizes much higher than those used for residential or commercial purposes. The application of utility-scale batteries spans various roles in grid management such as SATA, frequency regulation, and supply arbitrage which has gained prominence alongside rising renewable energy deployment. Existing utility-scale energy storage, formed primarily of pumped storage, is already the largest portion of installed global energy storage capacity. IEA estimates 65% of existing energy storage facilities are grid-scale projects (IEA, 2023), largely reflecting commitments made by large utilities companies globally.

Government-backed large-scale tenders play a pivotal role in this space. For instance, New York State aims to add 6GW of storage capacity by 2030 through centralized procurement addition (Utility Dive, 2023), while Australia's Capacity Investment Scheme tender aims to expedite grid-scale storage capacity procurement (Construction World, 2023). In India, a planned $2.6 billion subsidy package aims to promote grid batteries (Mint, 2023). These tenders not only contribute to project pipeline capacity but also generate economies of scale, potentially leading to lower average costs.

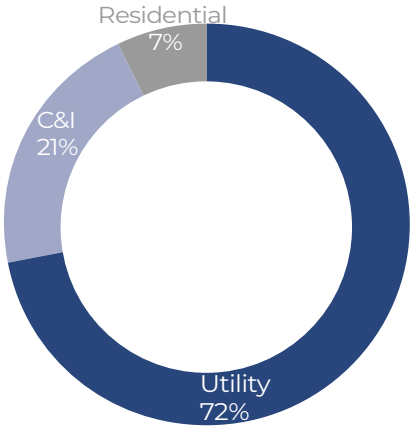
Share of Utility-scale Projects in Energy Storage Spending



Note: The above data is as of 2022

Source: IEA

Distribution of Storage Sub-segments in Capacity Addition of 2023



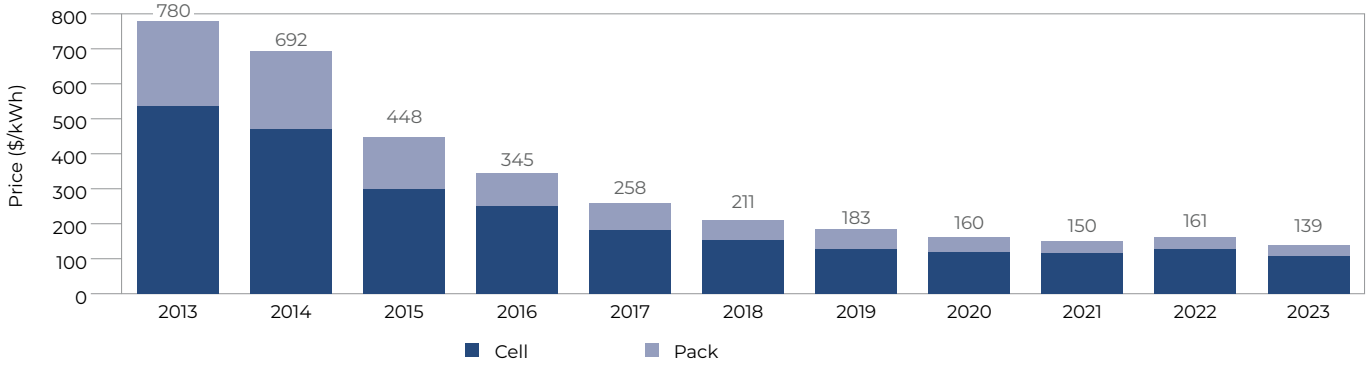
Note: Data above is based on estimated/projected capacity addition of 2023

Source: McKinsey

Cost economics

The dominance of Lithium-Ion battery technology remains strong in the storage sector, supported by its maturity and economies of scale driving down costs over time. Recent surveys, such as the BNEF Battery Price Survey, show a downward trend in average battery prices, partly due to decreases in raw material and component costs (BNEF, 2023). Notably, Lithium prices in China, the largest producer globally, fell 77% in 2023 – driven by a rapid growth in supply supported by the Chinese subsidy support for electric mobility (Reuters, 2023).

Average Lithium-Ion Battery Prices



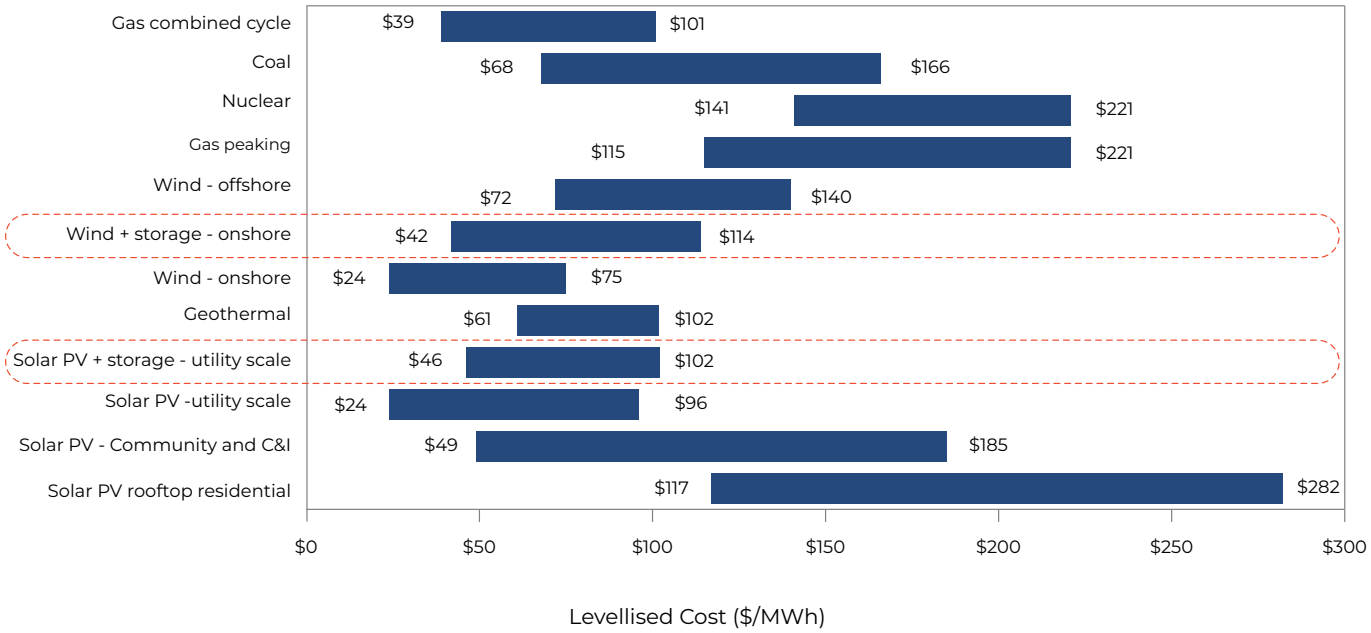
Note: Data for 2023 is as of November 2023

Source: BNEF Annual Battery Price Survey of 2023

However, battery prices vary widely across regions due to local market dynamics. China boasts lower average battery pack prices compared to the US and Europe, attributed to intense price competition and rapid manufacturing capacity expansion. Geopolitical factors, such as new US regulations targeting Chinese-origin battery components, introduce additional price distortions CNN, 2023). Whilst the average battery pack price in China, as of 2023, was reported at $126/kWh, elsewhere in the US and European markets prices were 11% and 20% higher respectively.

Despite these challenges, battery storage units are increasingly competitive in the grid power mix, particularly in hybrid renewables plus storage projects Lazard, 2023). Many of these projects are now competitive against gas-based peaking power units, driven by revenue stacking opportunities from grid services and wholesale power market transactions.

Comparative view of Unsubsidised Levellised Costs across Fuel Mix vis-à-vis Batteries



Note: Above data is illustrative, as of April 2023, and refers to the US market

Source: Lazard

The downward pressure on battery metal prices is anticipated to continue through 2024 and 2025 before any signs of recovery in the price trend emerge. Both demand and supply factors contribute to this outlook. On the demand side, a weaker electric vehicle market, driven by a slower Chinese economy, sluggish US market sales, and high interest rates, has dampened demand. This is significant as over 90% of battery demand comes from electric vehicles. Concurrently, miners have expanded the supply of critical minerals in anticipation of future demand. This expansion includes major battery metals such as Lithium, Cobalt, and Nickel. The pricing pressure is expected to persist due to the influx of additional supplies into the market as leading producers have expanded capacities in anticipation of future demand, despite the long lead times involved.

Lithium Supply and Price Outlook

	Absolute		Relative Change year-on-year	
	2024	2025	2024	2025
Production (kt)	1,271	1,528	29.0%	20.2%
Demand (kt)	1,252	1,444	22.5%	15.4%
Spodumene Price (Real, US$)	$2,237	$2,090	-41.8%	-6.6%
Lithium Hydroxide Price (real, US$)	$30,220	$28,220	-42.4%	-6.6%

Source: Australian Government Department of Industry, Science and Resources

Lower raw material prices are expected to alleviate the cost pressures on battery storage developers, particularly as they prepare for capacity auctions by regulators and grid operators. According to the BNEF battery survey of 2023, the projected average battery pack price for 2024 is $133/kWh (BNEF, 2023). BNEF's estimates further suggest that average battery pack prices could decrease to $113/kWh in 2025 and continue to decline, reaching below $100 by 2030 (Energy Storage News, 2023). As of December 2023, BNEF's tracked benchmark LCOE for four-hour battery storage reached its lowest point in decades, being 22% lower than the peak in 2022 (BNEF, 2023).

Crucially, the reduction in battery pack costs resulting from lower battery metal prices has been able to counterbalance the impact of higher financing costs in recent years. However, high interest rates remain a significant factor. There are expectations of a potential easing in 2024, with the US central bank's benchmark rates possibly peaking during the year before a potential reduction. Nonetheless, high interest rates are just one element in a mix of factors—including supply chain uncertainty, foreign trade restrictions, and regulatory developments—that collectively contribute to costs exceeding estimated ranges. It's worth noting that as of Q1 2023, over three-quarters of US-based clean energy projects, including storage projects, face delays in their planned commissioning within or before 2025 due to a combination of cost factors (Utility Dive, 2023).

Revenue streams

Battery storage projects typically adopt a revenue-stacking strategy, which involves leveraging multiple revenue streams simultaneously. These revenue streams commonly include arbitrage, ancillary services, and participation in capacity auctions.

The revenue-stacking approach allows projects to diversify their income sources, reducing reliance on any single revenue stream and enhancing overall profitability. By tapping into various revenue streams, battery storage projects can optimize their financial performance and mitigate risks associated with fluctuations in market conditions or regulatory changes.

Moreover, the scope of revenue stacking is a critical consideration in the financing decision-making process for battery storage projects. Investors and financiers assess the potential revenue streams available to a project and evaluate their stability and growth prospects. Projects with robust revenue-stacking opportunities are generally viewed more favorably by investors, as they offer greater financial resilience and potential for attractive returns on investment.

The revenue opportunities for battery storage projects vary across different local power markets, depending on their stage of development and maturity. Here are some notable illustrations:

Country/region	Battery Storage Revenue Drivers
Germany	The utility-scale battery storage market in Germany is growing rapidly, offering opportunities for new entrants. Ancillary and trading markets are promising revenue segments, with potential growth in day-ahead and intraday optimization. Regulatory measures, such as the introduction of a new capacity mechanism, could enhance revenue certainty for developers (Ion Analytics, 2024), (Timera Energy, 2023)
Italy	Italy's utility-scale battery storage market is nascent, with policy and regulatory measures incentivizing investments. Battery storage systems were allowed to participate in the wholesale and ancillary services segment in July 2023. A structural reform of dispatch procurement after 2025 may introduce new market-based services for battery storage units. Capacity markets offer 15-year contracts for new capacities, and regulators have proposed an auction-based scheme for procurement (Aurora, 2023)
United States	The ERCOT Contingency Reserve Service (ECRS), introduced in June 2023, addresses frequency recovery during generation loss and provides capacity during net load uncertainty. Despite running only 21 days in H1 2023, ECRS contributed 15% of battery storage revenues (Modo Energy, 2023)
United Kingdom	Frequency response services were previously dominant revenue sources for battery storage units but have become saturated due to rapid capacity addition. Balancing Mechanism and Arbitrage have emerged as primary revenue sources, with the grid operator projecting GBP2 billion spending on grid balancing by the end of 2024. Capacity markets also play a crucial role in providing guaranteed contracted payments (PV Magazine, 2024), (Energy Storage News, 2024)

05

Technology Developments

Technology Developments

The energy storage technology landscape is constantly evolving, with efforts focused on finding alternatives to Lithium-Ion battery technology while also improving existing Lithium-Ion solutions. There's a push to commercialize Long Duration Energy Storage (LDES) technologies, which presents a fundamental challenge for the industry. These advancements aim to enhance storage duration, address material degradation, and improve overall performance. It's a dynamic race to bring new solutions to market and meet the growing demand for energy storage across various sectors.

Commercializing Promising Technology Options

The current visibility of emerging energy storage technologies is primarily based on pilot projects or demonstration initiatives. These technologies often require financial support, such as upfront subsidies or viability gap funding, to establish their credibility among stakeholders like developers, grid operators, and regulators. However, it's worth noting that most funding in this space is directed towards electric vehicle (EV) battery production, with energy storage receiving considerably less support.

Unlike EV batteries, which prioritize energy density for range and charging time, energy storage batteries focus on parameters like cost, durability, and lifespan. Stationary batteries must compete with conventional energy resources in peak and frequency changes, requiring a longer lifespan of up to 10,000 charging cycles—about three times that of EV batteries Wood Mackenzie, 2023). The divergence between EV and energy storage batteries is driven by a combination of policy support, private sector innovation, and overall market demand.

Recent Grant-based Funding Support for Battery Technologies

Funding Authority	Amount	About the Funding
US Department of Energy	$325 million	The funding announced in September 2023, will be shared by nine projects qualified for LDES grants.
California Energy Commission	$30 million	A grant-based funding was confirmed in December 2023 for a pilot on Form Energy's 100-hour battery storage project.
Swedish Energy Agency	$8.4 million	A grant for a pilot and the world's first zinc-iron battery production unit. The targeted throughput is 100MWh.
UK Research and Innovation (UKRI)	£11 million	Total funding outlay for competing projects in early-stage feasibility and those in advanced research.

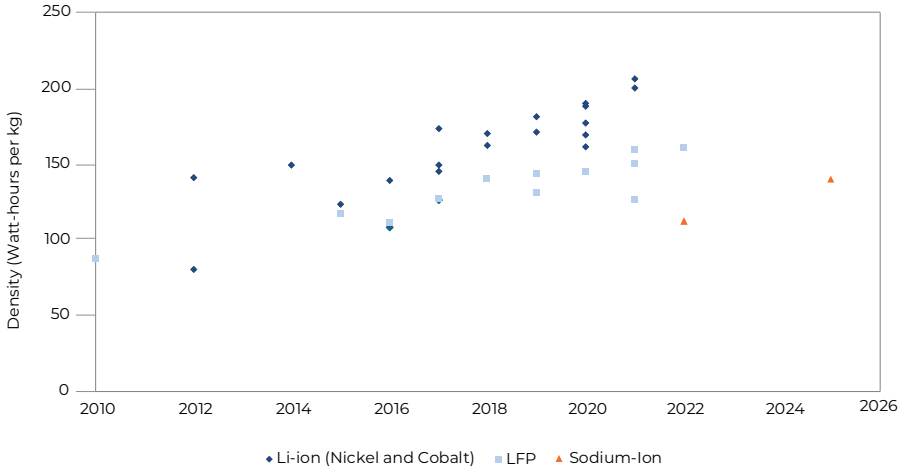
Source: Clean Technica, Energy Storage News, Enerpoly and UKRI

The market for Lithium-Ion battery technology remains strong, but within this technology, there's been a notable shift towards the use of different material chemistries. Lithium Iron Phosphate (LFP) cathode chemistry has seen increased demand, particularly in the electric vehicle market for shorter driving ranges. However, its application is also growing in the energy storage sector due to its relative cost advantage in raw material usage compared to the dominant Nickel-Manganese-Cobalt (NMC) cathode chemistry (Fastmarkets, 2023).

Another promising challenger in the battery landscape is Sodium-ion (Na-ion) batteries. In July 2023, the Chinese market saw the first grid-scale application of Na-ion batteries with a 5MW unit, signaling their potential for broader adoption Energy Storage News, 2023). Major producers like CATL and BYD have integrated Na-ion batteries into their mass production schedules, and companies like Northvolt are investing in Na-ion battery cell manufacturing for energy storage applications (CnEV Post, 2023) (Northvolt, 2023).

Early production estimates suggest a steady improvement in battery density, with Northvolt reporting over 160 watt-hours/kg in energy density for Na-ion batteries. Trend data indicates that by 2022, the energy density of Na-ion batteries was approaching the level of lower-end Lithium-ion batteries in 2012 (MIT Technology Review, 2023). However, it's important to note that the scale and learning curve advantages of Lithium-ion batteries have been relatively higher due to their larger production base.

Energy Density of the Lithium and Sodium-based Batteries



Note: Sodium-Ion data for 2025 is a projection

Source: MIT Technology Review

As existing mass production plans for alternative battery technologies come to fruition, there's potential for even greater improvements in battery performance parameters. Many of these planned ventures are occurring outside of China as developers and major consumers seek to diversify their supply chain options. While Chinese manufacturers like CATL and BYD lead in sodium-ion battery supply, their focus has primarily been on the electric vehicle market. However, the market for sodium-ion batteries can deepen as more storage developers collaborate with manufacturers and technology providers for battery development tailored to energy storage applications.

Notable Mass-production Ventures in Sodium-Ion Batteries Beyond China

Entity	Initiative in mass production
Natron Energy	The company partnered with Lithium-Ion battery producer Clarios International for a 600MW sodium-ion facility at Michigan, US.
LiNa Energy	The company has a partnership with Comau Automation for sodium battery production line. The planned 10KWhr pilot/demonstration storage is in India.
Tiamat Energy	A 5GWh sodium-ion facility planned in northern France, helped by part-funding from automaker Stellantis.
Northvolt	The planned sodium-ion battery cell differentiates against Chinese suppliers by obviating the Cobalt, Nickel or Manganese mineral usage.

Source: Financial Review, Electrive, Energy Storage News, Company press releases

As alternative battery technologies continue to advance, storage developers are presented with a broader array of options. Among these, iron-air batteries stand out for their promising technical capabilities and cost-effectiveness. Notably, major utility companies like Xcel Energy and Puget Sound Energy are spearheading efforts to deploy large-scale iron-air battery storage projects (Energy Storage News, 2023). Recently approved by regulatory authorities in Minnesota and Colorado, these initiatives align with state mandates to phase out coal-based power generation and achieve carbon neutrality by 2030 (Energy Tech, 2023).

In a similar vein, zinc-based hybrid batteries are gaining traction, supported by significant investment from the US Department of Energy. Eos Energy, a leading provider in this space, has secured substantial funding to expand its production capacity for zinc-halide batteries (MIT Technology Review, 2023). With a planned 8GWh capacity by 2026, Eos Energy's endeavors are bolstered by incentives provided under the Inflation Reduction Act of August 2022 (PV Magazine, 2023). Moreover, these emerging technologies are strategically positioned to capitalize on opportunities arising from the decommissioning of coal-fired power plants.

In essence, the commercialization of alternative battery technologies hinges on several factors, including mass production feasibility and raw material sourcing costs. As the industry evolves, a select few leading technologies are expected to emerge victorious, challenging the dominance of incumbent Lithium-Ion batteries in the energy storage landscape.

Long-Duration Energy Storage is Key

The global energy storage technology landscape is increasingly influenced by the demand for long-duration energy storage (LDES), typically defined as storage lasting beyond 4 hours. Many emerging technologies, whether in pilot phases, testing, or demonstration, aim to address this segment. With the rising penetration of renewable energy into the grid, LDES becomes essential for ensuring reliability and stability. However, commercially viable options in this space are still limited.

Technologies like Pumped Hydro Storage (PHS) and Compressed Air Energy Storage (CAES) are well-suited for long-duration storage. Projects utilizing these technologies are gaining traction. For instance, in July 2023, Dutch energy storage technology provider Corre Energy signed an exclusivity agreement to acquire a 280MW CAES project in the US, with plans for a final investment decision by 2025 (Renews Biz, 2023). Corre Energy has also secured agreements for CAES projects in the Netherlands and Germany (Renewables Now, 2023). Similarly, Canadian company Hydrostor is repurposing existing mining assets in Australia to develop CAES storage capacity (Energy Storage News, 2023). Meanwhile, there is a growing momentum for PHS-based projects, supported by various policy and regulatory incentives and targets.

Long Duration Energy Technologies in Focus

	Construction time (years)	Market Readiness	Location Fexibility	Key value areas			
				Congestion relief	Energy Arbitrage	Ancillary services	Operating cost
Pumped hydro storage	3-8	●	○	◕	◕	Inertia, reactive power, SCL, Black Start	◕
Li-ion batteries	1-2	◔	●	◔	◕	Frequency	◑
Liquid Air	2	◑	●	◕	◑	Inertia, reactive power, SCL, Black Start	◑
Flow batteries	0.5-2	◑	●	◑	◕	Frequency, reserve, inertia, reactive power	◕
Compressed air	3-5	◑	◑	◕	◔	Inertia, reactive power, SCL, Black Start	◑
Gravitational	2	◔	◑	◕	◕	Frequency, reserve, Black Start	◑
Thermal (Molten salt)	2	◕	◑	◕	◔	Inertia, reactive power, SCL, Black Start	◕
Hydrogen to power	3-4	◑	◔	◕	◑	Inertia, reactive power, SCL, Black Start	◔

● More Applicable ○ Less Applicable

Note: 1) Short duration Li batteries are market ready, long duration is not yet seen to be established in the market; 2) Suitable power conditioning system required; 3) Molten salt refers to concentrated solar power with storage; 4) Hydrogen-to power refers to CCGT only; 5) Under operating cost category, a full Harvey ball implies favourable operating costs, i.e., low.

Source: Aurora Energy Research

Policy support plays a crucial role in the commercial development of early-stage Long Duration Energy Storage (LDES) technologies. Examples abound in regulatory directives, such as those seen in California and Arizona, explicitly requiring LDES solutions. Notably, California recently approved an 8-hour Lithium-Ion LDES project, with other proposals under evaluation. These battery technologies, including iron-air batteries, are tailored to meet LDES demand and receive grants and support from regulatory authorities.

In the United States, the Department of Energy (DoE) oversees the Earthshot program, a $1 billion initiative aimed at reducing LDES costs by 90% to achieve Net-Zero targets (US DoE, 2021). The DoE plans to extend the Earthshots program globally, starting with collaborations with Canada and India (Clean Technica, 2023). Meanwhile, the UK government pursues LDES through different avenues, defining it as storage duration of 6 hours and above. The government has floated consultations on proposed measures, such as cap-and-floor regulations and exclusion of Lithium-Ion, to promote the LDES sub-segment. Stakeholders have until March 5, 2024, to provide feedback on these consultations (Energy Storage News, 2024).

The significance of major policy support measures lies in their role in bolstering experimental initiatives that stabilize the energy storage business and its nascent technologies. LDES technologies are critical for achieving Net-Zero objectives and facilitating the energy transition process by providing economical options that enhance energy system flexibility.

Image by wirestock on Freepik

06
Outlook

Outlook

The optimistic outlook for the energy storage market mirrors the robust underlying factors propelling its growth –increased penetration of renewable energy, significant decline in battery costs, and regulatory shifts in power markets. The extensive project pipelines and exploration of new technologies suggest a broad spectrum of opportunities on the horizon. However, in the near to medium term, growth may be concentrated in a few countries with mature and large-scale power sectors. Nevertheless, regulatory bodies worldwide are progressively integrating energy storage into long-term power procurement strategies. On April 30, 2024, the G7 Ministerial Communique for Climate, Energy, and Environment agreed to a global energy storage power capacity target of 1,500MW by 2030 (G7 Italia, 2024). A meaningful statement of support from international leadership to target growth in the global energy storage power capacity.

Pointers in Growth and Challenges

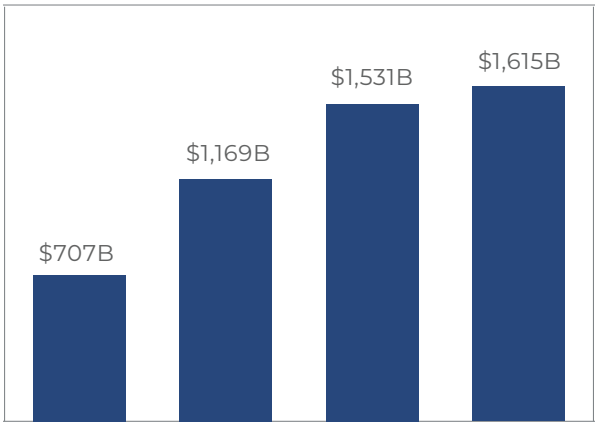
Regulatory authorities, alongside policy-level support, are poised to play a pivotal role in shaping the energy storage project pipeline and market opportunities. An emerging trend is the inclusion of battery storage in bulk renewable energy tenders in an increasing number of countries. Many upcoming contracts are designed as technology-neutral, where battery-based projects compete with other clean energy technologies to provide the required energy solutions. This trend is particularly noticeable in European and other markets' auction announcements. In the US, there is a mixture of procurement plans and targets, with 10 states having specific targets for energy storage procurement. Additionally, states like California, Connecticut, Illinois, and others offer fiscal incentives to achieve similar objectives (S&P Global, 2023).

Progressive Adoption of Storage-based Auctions and Tenders in Countries (Illustrative)

Country	Development
Brazil	The energy auctions of 2024 will have battery-based and other storage technologies actively compete for securing the power reserve auctions (peak demand capacity).
Italy	Grid operator Terna's capacity market auctions initiated since 2022, would have deliveries commence from 2024. This marks an important start to the country's storage market.
Greece	A second auction is in the works for 2024, to award 10-year guarantee, Contracts-for-Difference to the winning projects.
Chile	Auctions planned in 2024, after the regulator took note of the dissenting points in the previously planned auction of 2023.
Japan	Expected launch of new ancillary services markets in 2024. The planned energy storage auctions in 2024 (for delivery in 2027 or earlier) are thus critical for developers.

Source: Reuters, Energy Storage News, PV Magazine, Wood Mackenzie

Projected Investment Requirement for Grid Strengthening and Expansion Worldwide



Note: Projections above are based on pledges/targets by national governments in emission reduction, energy transition and renewable energy expansion. It includes transmission and distribution network.

Source: IEA

There is considerable interest in forthcoming regulatory changes due to the European Union's planned power market structure reform. This initiative aims to overhaul the existing market structure, which currently favours fossil fuel generation, in favour of clean energy resources and flexible power generation, including energy storage. As of December 15, 2023, the European Parliament proposed a set of rules reflecting discussions and proposals aimed at promoting the integration of energy storage systems (European Parliament, 2023). However, industry associations have highlighted areas of concern, such as 'double charging,' where storage units may be subjected to grid fees both as generation and additional supply units in many European regulatory regimes (Energy Storage News, 2023).

Regulatory signals indicate increasing demands on energy storage systems, posing challenges not only in terms of technological robustness but also market depth and developer efficiency. A recent example is the California Energy Commission's approval in December 2023 for the development of the state's first multi-day (100 hours) battery storage resource (S&P Global, 2023). The project, supported by a $30 million state funding, aims to demonstrate iron-air battery technology and establish use-cases for targeted commissioning by 2025, driven by CEC's policy goals on long-duration energy storage (Energy Storage News, 2022).

The readiness of grid infrastructure will also be crucial for regulatory frameworks and market development. Many mature power markets face challenges in this regard, especially concerning grid connectivity pressure for renewable energy developers. Projections from the IEA on grid investments suggest a doubling of investment outlay between 2016-2022 and 2031-2040 to fulfill government pledges to reduce emissions and enable energy transition. Delays in grid interconnections for storage projects are exacerbating challenges, particularly as renewable energy developers increasingly opt for co-located battery storage (IEA, 2023).

07

Conclusion

Conclusion

The global energy storage industry is taking centre stage in the ongoing energy transition, marked by significant capacity growth and increasing investment commitments. Various stakeholders, including technology providers, developers, investors, and regulators, are actively shaping the trajectory of this growth. Notably, certain technology configurations, such as co-located battery storage, are emerging as viable options for capacity expansion due to their favourable risk-return trade-offs. Additionally, traditional yet well-proven technologies like pumped hydropower are experiencing renewed investor interest in diverse contexts.

This concluding section summarises the critical points of the battery storage industry that hold significance for its growth outlook.

Growth of the Energy Storage Asset Class

In the clean energy sector investments, storage accounts for a relatively insignificant share. As of the end of 2023, global investment commitments for storage reached $36 billion (Energy Storage News, 2024). However, this was a 76% year-on-year growth, and it is set to accelerate to keep up with the renewable energy sector's expansion. BNEF estimates point to an annualised $93 billion in spending on storage over the next decade. The opportunities will be manifold across markets as renewable energy penetration rises significantly in the power mix.

Leading companies' investment plans support the emerging energy storage theme. The survey of 2023 Reuters Energy Transition Insights report had over 40% of the respondent companies focusing on energy storage systems over the next three years (Reuters, 2023). Notably, this survey had storage exceeding the solar PV investment plans. The takeaway from such studies is the favourable outlook on storage as an asset class within the energy transition segment. Storage technology is thus placed among the top priorities of energy transition spending commitment during 2024-2026.

The power sector offers a vast and untapped scope for energy storage capacities. Decarbonisation and energy transition progress have imposed a greater need for utility-scale storage to manage grid fluctuations and ensure reliability. The rising instances of capacity market auctions by transmission system operators globally offer clear evidence in this regard – battery storage projects are making inroads in the capacity market auctions due to advantages in emissions profile besides costs.

Of note here is the demand for Long Duration Energy Storage (LDES), generally referring to storage duration of 6-10 hours and above. The LDES segment is critical in power systems and is primarily met by the legacy hydropower generation capacity base. Existing battery storage systems have been unable to get this right, hence the race among technology providers for the early-mover position. The near-term visibility of a few leading battery technologies, such as sodium-ion, is based on recent deployments. The commercial-scale rollout of LDES batteries could mark the next growth phase for battery storage systems.

Revival of Pumped Hydro in Power Mix

The unmet demand for LDES-based battery solutions makes investors and policymakers revisit hydropower generation. It is a mature and proven technology and can be instrumental in bridging the storage gap in most of the power systems globally. The legacy pumped hydropower capacities are, in fact, the predominant storage systems at present. The stagnant growth seen in this segment will likely give way to a sharp turnaround.

Policy-led funding in some of the major markets would help enable private investments. In February 2024, the US Department of Energy announced its most significant single investment in hydropower, with a selection of 46 projects to receive up to $71.5 million. The UK's largest pumped hydropower project, Coire Glas, with planned 40GWh storage, could have a final investment decision by 2024. Other European countries like Romania and Bulgaria were notable for the recent developments in reviving pumped hydropower projects in the respective countries.

Though the capital markets are yet to show a tangible shift in interest towards hydro-based storage projects, the acquisitions of pumped hydropower assets indicate the developers' priorities. Some pointers supporting the hypothesis are notable cases such as Statkraft's and EDF's acquisitions. Also, it opens up the space for entrants with innovations – the Swedish entity Mine Storage International, for instance, has been working on developing abandoned open-cast mines into pumped hydropower storage facilities.

Market Readiness for Standalone Battery Storage Business

The standalone grid-scale battery storage is at a nascent stage of its business growth. It significantly depends on the policy and regulatory structures in the respective markets. Market access in turn determines the revenue stack associated with any standalone battery storage project, impacting its financial viability.. The capacity growth observed in the US, UK, and other select European countries reflects the progress made in power market regulations and corresponding incentive structures. The same does not hold equal strength for other countries, such as Chile. This might mean a lag in battery storage investment. As planned by several TSOs, auctions could help get the momentum for the process.

In line with regulations, the policy-level credibility in decarbonisation and renewable energy targets is an essential signal for investors. The European region's binding renewable energy penetration goals highlight this well. Storage investment prospects can be strengthened or weakened depending on the pace of the energy transition process. Though renewable energy targets need not be the only factor for battery storage, they are certainly among the significant factors in consideration. The top ten ranked countries in the World Economic Forum's Energy Transition Index rankings (October 2023) are from Europe, followed by the US and the UK. As the rankings improve with progress in significant areas like shutting coal and gas power plants, so does the market's attractiveness for standalone grid-scale battery storage capabilities.

Globally, the grid Infrastructure capacity is under strain, not least because of an accelerated rate of capacity added from renewable resources. This impacts everyone in the business, including storage developers. Long interconnection queues, as seen in the US energy markets, affect the projects' viability. Ageing grid assets require expansion and refurbishment on a priority basis. It may become a focal area for practically all the countries seeking private investments in clean energy. Also, it is pertinent to highlight the role that interconnectors could play. Transmission interconnector lines, as typical in Europe, are also instrumental in the power system's balance. As Denmark's experience shows, the interconnector network could obviate the urgency of battery storage capacity.

Institutional Capital with Sector Maturity

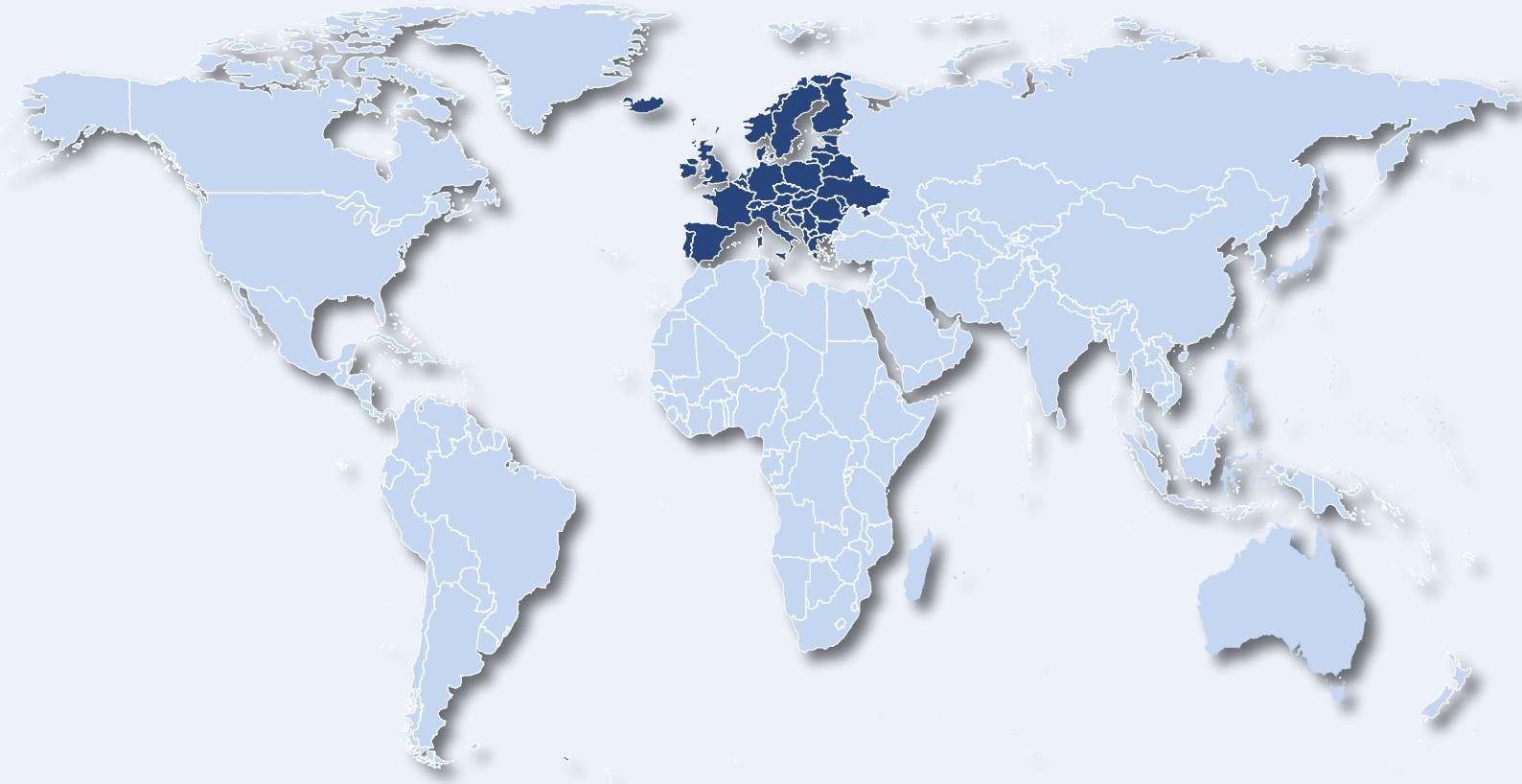
The shift in its investor mix marks the battery storage industry's gradual progression towards a maturity stage. With some established use cases of the technology and its revenue models, a mix of institutional investors, such as infrastructure funds and private equity, join the fray. As of Q42023, eight Private Equity deals in energy storage were worth $1.1 billion.

In February 2024, the Ardian Clean Energy Evergreen Fund reported its first investment in the battery storage business through a Finnish project. With this, the Fund extended its energy transition and renewable energy assets' base to the batteries. This development builds upon the steps taken by other infrastructure investors, such as GLIL and Brookfield, which have entered this business through acquisitions of battery project pipelines and partnerships with operators.

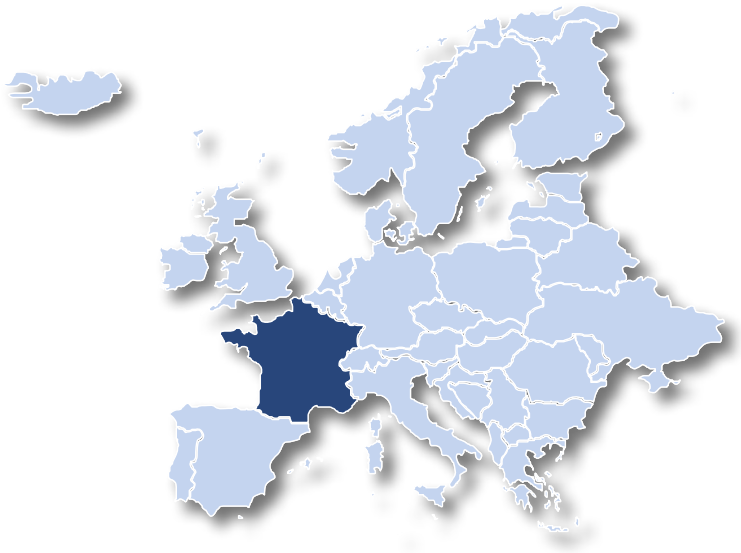
08

Key Regional Markets

Key Regional Markets - Europe



France



GDP (Current Prices) USD (2022)	2,780 bn
GDP Growth Forecast (constant prices) (2023-2027)	1%
10yr Govt Bond Yield (12-month rolling average)	3.00%
Country Credit Rating (S&P)	AA
Battery Storage Capacity	2.0GWh/ 500.0MW
Pumped Hydro Storage Capacity	101.1GWh/ 4.9GW
RE share of Total Electricity Capacity	44.60%
Battery Storage Outlook (Power Capacity)	1.5GW by 2030

Note: Battery Storage Capacity Expressed in GWh assuming an average 4 hours of duration.

Source: IMF, Fred Economic Data, S&P Global, Aurora Energy Research, Encyclopédie de l'énergie, Ember

There are renewed efforts underway in France to expand renewable energy penetration. Legislation was enacted in 2023 to prioritise the renewable energy project pipeline. In taking such steps, the transmission network management would also gradually change. Grid-scale battery storage units are coming to the fore despite a limited market proposition due to the lack of proportional regulations. Though nascent, battery storage is emerging as a critical component of the French energy mix dynamics.

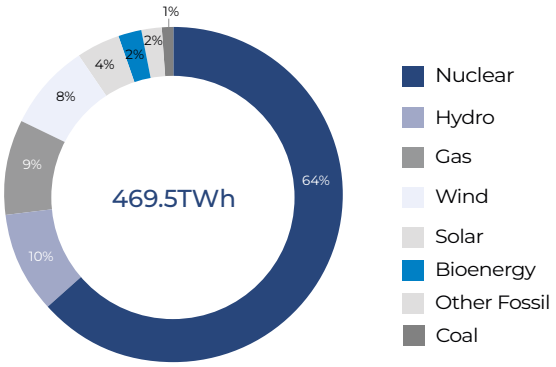
France

Energy Mix and Case for Storage

Led by nuclear energy, the French power generation has a very low dependence on fossil fuels. Hydro and nuclear energy-based generation enable a competitive baseload grid supply. Such a fuel mix also supports decarbonisation. The emissions profile of the French power sector is among the lowest in Europe and overall advanced economies worldwide (Reuters, 2023). In such a backdrop, renewable energy sources (wind, solar and bioenergy) are yet to play a significant role. Such a fuel mix does not impact the country's energy policy, especially regarding clean energy sourcing.

Inadequate renewable energy, however, could impact the planned transition to net zero by 2050. The transmission system operator (TSO) has clearly outlined that reliance on nuclear power is insufficient for a net zero carbon-neutral operation (Power Technology, 2023). The renewables' capacity addition thus must rise manifold to diversify the power generation mix in the upcoming period. This gives rise to the demand for flexible generation assets, including battery storage. The business case for the standalone battery storage units remains weak, considering the high (and rising) share of nuclear power generation.

Power Generation Fuel Mix as of end-2022



Source: Ember

Capacity: Status and Trend

The French grid-scale storage capacity lags behind European counterparts such as Germany and the UK. The capacity growth has picked up in recent years, reflecting the steps taken in tendering capacity contracts for frequency regulation, among other applications. Estimates from Aurora Energy Research indicate an installed battery-based power capacity at around 500MW by around mid-2023 (Aurora Energy Research, 2023) – representing almost five times the level achieved by 2020. Such a jump in capacity reflects the systemic changes underway in the French energy mix.

Utility-scale storage is a predominant factor in the country's existing storage market – marking another distinction from other key European markets like Germany or Spain, where the residential segment is the growth driver (due to solar power). The transmission system operator's role in securing storage capacities through capacity market auctions is critical in shaping the demand for utility-scale storage capacity.

Pumped hydropower capacity has been a traditional energy storage source. The existing installed capacity of 1.7GW (IRENA, 2023) is an essential grid-scale storage option for the operator to deploy for managing volatility. The trend, however, shows a stagnancy in the pumped hydropower capacity base. Without tariffs or other incentives, any significant rise in this capacity is almost ruled out.

So far, TSO's grid-scale storage capacity requirements have mainly been around the need for network stability. Primarily, the operators provide primary frequency response (stabilisation for frequency deviations generally within 10 seconds). The market expansion will, however, be contingent on a broader scope of opportunity, such as ancillary services for grid management. In this regard, the existing capacity base is constrained for options. For instance, one of the significant battery-based storage operators, TotalEnergies, with 61MW installed capacity, has services limited to primary frequency response.

France

Policy and Regulation

The basis for energy storage is laid out in the French Energy Transition Law, which mandates the expansion of the share of renewable energy in total power consumption. Specifically, the French Energy Code, which includes regulations related to electricity (its generation and related aspects), also covers energy storage based on batteries or other forms. The storage operators are thus viewed as two-way grid tariffs users, consumers and generators.

The measures on integrating energy storage are primarily led by the French state-owned grid operator RTE. In undertaking its grid management responsibilities, RTE has recently initiated vital steps to enable storage options, especially those based on batteries. One such notable measure is Project Ringo. This EUR80 million (regulator-funded) project involves testing the feasibility of an automated industrial-scale (or utility-scale) battery network. There are three battery storage sites aggregating 100MW, spread across Fontelle in the east of France, Bellac in the west, and Ventavon in the southeast – and are all closer to installed renewable plants.

Project Ringo's ongoing trial aims to establish the techno-commercial case of a software-controlled battery network system. The objective is to deploy a storage system that could absorb excess renewable energy injected in the grid at a point in time and subsequently deliver such energy at a later time point to meet peak demand. Such a storage system could potentially prevent the need for significant transmission capacity addition if successfully deployed. In terms of technology configuration, this is a pioneering project in automated battery networks.

The TSO's grid balancing activity underscores the role of storage (among other options) in the power network. Progressively, the grid power balancing market (involving multiple parties on either side of injection and drawal) has been opened for energy storage facilities. Since 2014, storage units (other than hydro) have been permitted to participate in frequency ancillary services. Such participation is limited to the automatic frequency restoration reserve category for now. The latest system balance report shows that about 190MW of battery capacity was certified for the overall frequency containment reserve (FCR) in the ancillary service domain. In January 2024, France's energy regulator CRE reopened a postponed auction for secondary reserve/aFRR due to an increase in BESS capacity (Energy Storage News, 2024). There are expectations of enhanced participation in battery-based storage in the near term and France should deploy 300MW a year of BESS capacities over the coming years.

Market Developments and Opportunities

The emerging battery storage pipeline is led by utilities and power generation entities seeking a transition from a legacy fossil fuel base. Gazel Energie, the French power generation and distribution entity, is undertaking a project to transform its existing Emile Huchet coal-based power plant. The renewable energy developer Q Energy is constructing a 44MWh at the site (Renewables Now, 2023). Q Energy has a development pipeline worth 400MW within France, indicating the business interest. It also helps that the grid operator's tenders (also referred to as 'call for tenders') seeking capacities for grid flexibility services under a capacity market help create visibility for prospective standalone battery providers (IEA, 2022). RTE's call for tenders is reserved for new generation and demand response capacities and takes place four years ahead of schedule (RTE, n.d.).

The regulatory framework's guidelines (French Energy Code, under the Climate and Resilience Act, 2021) that require contracting of storage capacity present a competitive opportunity for standalone battery units (White & Case, 2022). A battery-based storage contract was recently awarded in this regard for public utilities. The renewable energy firm Entech secured a 50MWh battery storage capacity contract in May 2023 (Entech, 2023). The planned capacity is meant for frequency regulation services in the French and European grid networks. More such capacities could be in the offing due to the measures taken in the energy transition. Similar notable capacities commissioned earlier through competitive bidding contracts include 61MWh battery facility commissioned in 2021 by TotalEnergies (TotalEnergies, 2021).

The application of battery units as a virtual transmission asset has been largely theoretical. Its relevance is, however, getting stronger by the day as rising renewable energy penetration brings forth recurring instances of grid curtailment and negative wholesale power prices. Against such a backdrop, RTE's pilot project, Ringo, aimed at testing battery-based virtual transmission, holds significant promise (Renew Economy, 2023). By the time Project Ringo ends in 2024, it is expected that the French market could make way for battery storage services in frequency control and other grid ancillary services.

While the utility-scale storage sub-segment picks up, residential solar PV installations have a vast untapped potential. As of end-2022, it is estimated that only about 1,000 homes had solar PV systems equipped with batteries (PV Magazine, 2023). The battery-based solar systems adoption is far lower than in other European countries. It could be related to relatively lower energy prices and a lack of incentives. A rise in wholesale power prices could strengthen the case for battery-based solar PV systems.

France

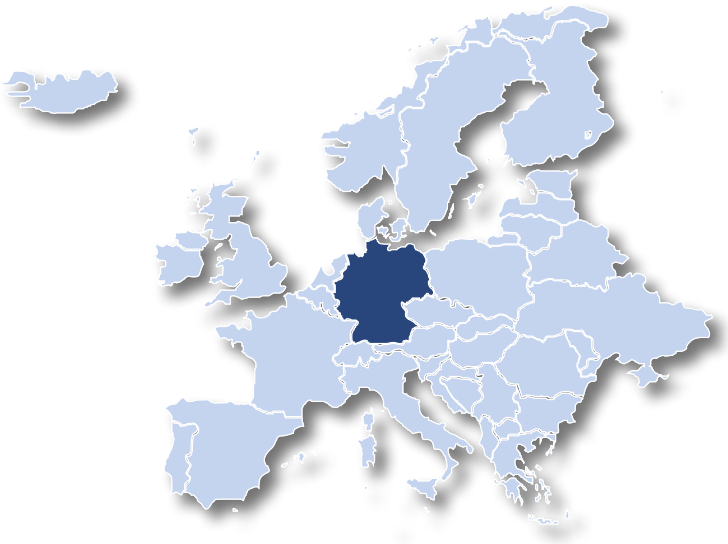
Outlook

The rapidly rising role of renewable energy in the French energy markets makes grid-scale storage almost an inevitable option. The auction-based route of securing capacities is one avenue. More profound changes to get the capacities would involve changing the power market design to enable multiple revenue streams in battery storage. A study by Aurora Energy Research projects a 1,500MW worth of energy storage power in France by 2030. The projected growth is tied to the launch of the secondary reserve power market (expected in 2025) and the ongoing rise in renewable energy penetration. Progressively, batteries participating in the French power market may be applicable in the arbitrage role.

With renewable energy integration acting as the only driving factor, the role of storage facilities in the power network is likely to become more critical. One crucial factor in this regard is the transmission infrastructure's requirement for expansion and refurbishment. About EUR20 billion worth of investment is projected in RTE's ten-year development plan (2021-2030) to accommodate the transitioning energy mix. Storage facilities will play an essential part in this equation.

The successful integration of energy storage would also hinge on the competing options of nuclear and hydropower in the French energy mix. Both currently play a vital role in the bulk power market, influencing the potential capacity requirement in grid balancing, among other applications. Furthermore, the phase-out of coal-based power plants appears to be a long-drawn-out process, as grid operators and regulators approve extensions to enable grid security. RTE's network planning projections have indicated the same, emphasising the role of thermal capacities to balance the rise in renewable energy generation – which means a possibly diminished role of grid-scale storage.

Germany



GDP (Current Prices) USD (2022)	4,086 bn
GDP Growth Forecast (constant prices) (2023-2027)	1%
10yr Govt Bond Yield (12-month rolling average)	2.43%
Country Credit Rating (S&P)	AAA
Battery Storage Capacity	11.2GWh/ 7.6GW
Pumped Hydro Storage Capacity	31.5GWh/ 6.3GW
RE share of Total Electricity Capacity	58.60%
Battery Storage Outlook	8.8GWh by 2031

Source: IMF, Fred Economic Data, S&P Global, Fraunhofer ISE, JRC Publications Repository, Forschungsstelle fur Energiewirtschaft, Energy Institute, Wood Mackenzie

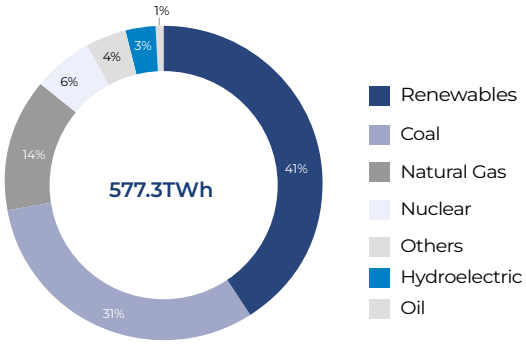
Germany ranks among the leading European countries in its energy storage market. However, unlike many of its counterparts, the residential storage sub-segment holds the dominant share due to the solar PV installations. The utility-scale storage lags and is in its early growth phase. A rapidly changing energy market, with rising renewable energy penetration, progressively imposes significant demand on grid management. Grid-scale storage is thus emerging as a critically untapped opportunity.

Germany

Energy Mix and Case for Storage

Renewable energy holds the maximum share in the German power sector fuel mix. The share will rise further with progress towards the decarbonisation goals. Measures to expedite the renewable energy project pipeline since the Ukraine-Russia armed conflict helped accelerate the progress. The ensuing phase of the energy crisis also drove steeper targets – in June 2023, the European Union member countries agreed to the new 45% target of renewable energy share in consumption by 2030 (against 32% earlier) (AP News, 2023). The transitory phase of rising renewable energy penetration is challenging. This has been the experience of the German utilities and operators seeking options in baseload and flexible energy generation.

Power Generation Fuel Mix as of end-2022



Source: Energy Institute Statistical Review of World Energy

Coal-based power generation is a critical option in balancing grid load and intermittency. The government's statements have indicated that its plans to phase out coal by 2030 are not a given if feasible replacements are unavailable (Clean Energy Wire, 2023). In October 2023, the government approved the continuation of its 2022 order that permitted coal-based power plants to operate till March 2024. The step taken for energy price stability (Power Technology, 2023) points to the lack of flexible energy systems in the transitioning grid power mix. Added pressure comes from the exit of nuclear power generation – the last of the nuclear power plants was shut down in April 2023 (CNBC, 2023).

Capacity: Status and Trend

The German grid-scale storage capacity has been limited primarily to its hydropower generation – as of the end of 2022, the pumped hydropower storage stood at about 5.3GW (IRENA, 2023). This storage segment, while ideal to meet long-duration energy storage demand, has stagnated over the last decade due to uneconomical costs in project development. Against such a backdrop, stationary storage systems, such as battery units, are assuming a gradually rising importance in the German energy system.

In 2022, the utility-scale battery storage sub-segment added 0.47GWh, an over 900% year-on-year growth (PV Magazine, 2023). In 2023, installed battery capacity doubled, increasing from 4.4GW in 2022 to 7.6GW in 2023, while storage capacity rose from 6.5GWh to 11.2GWh (Fraunhofer ISE, 2024). The spike reflected the low base and nascent growth stage. Comparatively, the residential and commercial/industrial sub-segments have had annual growth rates of 52% and 24%, respectively, during the same period. Almost 80% of the total installed energy storage capacity base, worth 7GWh, is from the residential sub-segment. Germany is among the top European countries in residential battery storage market.

So far, growth has been through the volumes in the residential storage market segment. The volumes are much more prominent in the residential market than others due to the broad reach of solar-powered residential systems in both grid-connected and off-grid mediums. Capacities are also gaining traction through hybrid storage projects (storage paired with generation projects). This includes not only wind-storage or solar-storage combinations but also hydro-storage ones. However, there is a much more significant and untapped role for utility-scale storage systems in the grid ancillary services comprising secondary reserve requirements.

Germany

Policy and Regulation

Germany's legal amendment of June 2022, defining energy storage as a distinct asset, was the most critical regulatory development for the industry (Energy Storage News, 2022). The framework was thus established for potential standalone storage assets to be integrated as one of the energy market participants. Added support for the storage assets is available from the regulations, exempting grid fees for those units commissioned within 2029 (BVES, 2023). The immediate impact of the exemption from grid connection charges is for the commercial viability of the projects in the pipeline.

Taking the longer-term perspective, the regulatory authorities also provide for experimenting with new technologies and solutions to support energy transition. A notable development in this context is the regulatory sandbox JenErgieReal launched in November 2022 (IEA, 2023). With €20.5 million in funding support, the regulatory sandbox could potentially aid the development of technologies in large-scale storage systems and test significant innovations such as virtual power plant linkages between generators, consumers, and storage systems. As an outcome of the sandbox, technology demonstration projects could help set up the avenue for energy storage project development. Besides, the German regulators published an energy storage strategy at the end of 2023 to bring changes to existing logjams, slowing down the rapid expansion of energy storage (BMWK, 2023). This is expected to improve the regulatory environment for energy storage significantly.

Commercialisation of projects is critical to expanding the market. The biannual innovation tenders have been instrumental in developing the pipeline. Established under the country's Renewable Energy Law ('Erneuerbare Energien Gesetz', referred to as "EEG" henceforth), the tenders are aimed as technology-neutral market mechanisms to introduce and test incentives for grid services and integration of renewable energy generation. The projects involve hybrid renewable projects combined with storage. Remuneration for the installations awarded is for 20 years (10 years for biomass-based projects) (European Commission, 2022). EEG funding was increased for 2023, as evident in the maximum value of 9.18 cents/kWh (against the usual 7.35 cents/kWh) announced by the regulator (Energate, 2023).

While grid-scale storage is prioritised, Germany's behind-the-meter energy storage segment leads the way. Policy support for residential rooftop solar PV installations helped drive the battery storage. Beyond federal policy support, state governments have incentivised battery storage systems in household rooftop installations (Interact Analysis, 2023). The state of Bavaria, for instance, provides loan subsidies jointly with KfW for renewable energy projects and energy storage. At Berlin, the SolarPlus scheme provides subsidy support for plug-in solar modules and storage systems. Such provincial subsidies, alongside state support, drove residential PV plus storage system installation. The reports by the Federal Solar Industry Association indicate that the number of BESS installed almost doubled in 2023, reaching about 1.2 million (PV Magazine, 2024).

Market Developments and Opportunities

In 2023, the energy storage market doubled, with half a million new solar batteries installed. About 150% growth was observed in the residential and commercial storage segment (Renewables Now, 2024). The German energy storage market expanded by 30% in 2022, with sales of €12.1 billion compared to €9.2 billion in 2021. The residential storage sector held about 59% of the industry revenue, with thermal storage leading the way. New residential solar PV installations determine the uptake. About three-quarters of residential solar installations, ranging from 5kW to 15kW, have storage attached (BVES, 2023).

The utility-scale energy storage segment held about 23% of the sector's revenue in 2022, primarily led by pumped hydro storage (BVES, 2023). The commercial and industrial consumers segment registered a rise in storage installations as energy supply security became an issue after the Ukraine-Russia armed conflict (BVES, 2023). Standalone battery storage projects constitute a vital sub-segment catering to the grid-scale storage requirements. In July 2023, NorEco Stor announced a €250 million investment plan for a 600MWh battery storage facility in Förderstedt in eastern Germany (GTAI DE, 2023) (Renewables Now, 2023). So far, the most significant battery project approval came through in November, with Kyon Energy's 275MWh unit planned in Lower Saxony (Smart Energy International, 2023). With planned commissioning in 2025, the standalone battery project is aimed at peak demand management and could potentially help add to the flexibility in grid capacity. For the same objectives, pumped hydropower storage projects continue to attract investors' interest despite the time and cost overruns. In May 2023, the German energy company EnBW announced the launch of its €280 million, 54-57MW pumped hydropower project based on conversion of an existing conventional hydropower plant. The project is planned for commissioning by 2027 (EnBW, 2023).

Hybrid renewable projects constitute another vital avenue for grid-scale battery storage. In October 2023, the German Federal Network Agency awarded 408MW (Renewables Now, 2023) of solar PV capacity integrated with storage as part of an innovation auction tender for storage-linked hybrid renewable projects. There were 32 investment

Germany

bids which qualified to receive the funding in June 2023; a similar auction yielded just one winning bid (Norway's Statkraft AS) for a 47MW solar power project integrated with 16MW storage (Renewables Now, 2023).

Many of the utility-scale storage projects are planned around the existing infrastructure of the power projects with grid connection and related infrastructure. In such projects, developers are repurposing the coal-based power generation facilities for the battery storage plants. The German utility RWE's €140 million, 235MWh battery storage project is one notable example. It is planned at RWE's 200MW power plant in Neurath and Hamm (RWE, 2023). Foreign companies are also taking a keen interest in the German storage market. In November 2023, Swiss asset manager Reichmuth Infrastructure announced co-developing a 100MW/200MWh BESS with Zug-based developer MW storage in Arzberg, Germany. The project already has construction permits and is expected to become operational in early 2025 (Energy Storage News, 2023). Another notable development is French-based oil and gas major TotalEnergies acquiring Germany's top BESS developer, Kyon Energy, with a €90 million deal value (Energy Storage News, 2024).

In June 2023, German coal miner LEAG signed an agreement with technology firm ESS Tech to develop a €200 million, 500MWh iron redox flow battery at the site of a 2.5MW coal-based power plant (Energy Storage News, 2023). The project could be scaled further, with 7GGW-14GW worth of renewable energy and 3GWh storage. (Balkan Green Energy News, 2023). More such investment could join the fray as coal-based power plant operators join the process of capacity phase-out.

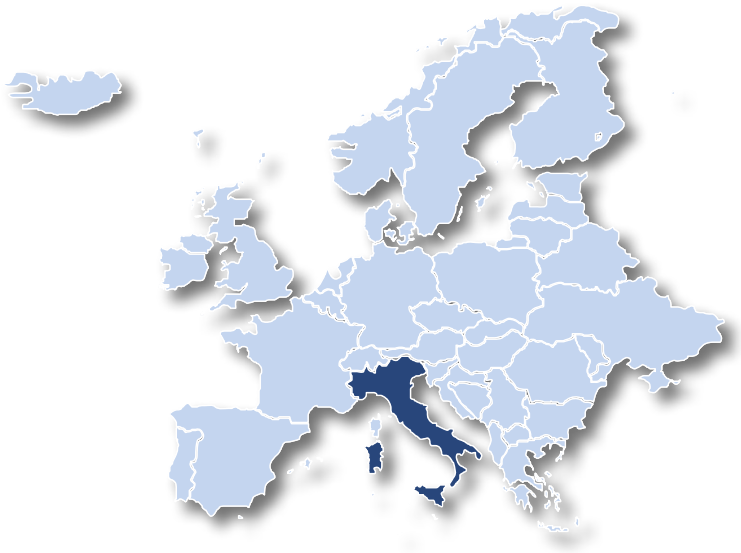
Outlook

The German residential behind-the-meter sub-segment has a leadership position relative to European countries and is essential in the country's storage market outlook. The grid-connected storage is gradually catching up. Wood Mackenzie's projections indicate 8.8GWh (Wood Mackenzie, 2022) of aggregated grid-scale storage capacity by 2031. With behind-the-meter storage capacity, it could be among the top European storage markets. A rise in the grid prices, market transaction opportunities in grid ancillary services, and favourable regulatory measures (such as the auctions) could help add a fillip to the grid-scale energy storage.

The need for grid-scale storage could be far higher than the projections. The energy transition, effected by rising renewable energy penetration and policy goals of phasing out nuclear power generation, imposes significant constraints in grid management. The German government, for instance, is unsure about its commitment to phase out coal-based power generation by 2030 without feasible options (Clean Energy Wire, 2023). Coal-based power fills the gap arising from nuclear phase-out and rationed gas supply. The recent approvals for some of the significant grid-scale battery storage projects thus highlight the policy's focus on flexible power generation sources in the grid's power mix.

The rise in renewable energy penetration and the push to undertake economy-wide decarbonisation already impose significant demands on the grid infrastructure. The four German grid operators will spend about €250 billion by 2045 to expand and develop the infrastructure (Montel, 2023). Battery-based storage systems will likely be integral to the capacity development roadmap.

Italy



GDP (Current Prices) USD (2022)	2,012 bn
GDP Growth Forecast (constant prices) (2023-2027)	1%
10yr Govt Bond Yield (12-month rolling average)	4.21%
Country Credit Rating (S&P)	BBB
Battery Storage Capacity	4.9GWh/ 3.0GW
Pumped Hydro Storage Capacity	>700.0GWh/ >7.0GW
RE share of Total Electricity Capacity	49.20%
Battery Storage Outlook (Power Capacity)	~9.0GW by 2030

Source: IMF, Fred Economic Data, S&P Global, Energy Storage News, Digital Object Identifier, The Energy Institute

Italy has revised its decarbonisation targets upwards per the updated National Energy and Climate Plan ("PNIEC") submitted to the European Commission in July 2023. The latest plan envisages a 65% and 40% share of renewables in electricity production and total energy consumption, up from 55% to 30% in the 2020 plan (Reuters, 2023). The European Commission's directive to member states triggered the revision to ensure alignment with the Fit-for-55 and REPowerEU energy packages. REPowerEU targets will require Italy to install 85GW of incremental renewable capacity by 2030, including 58GW of solar PV installed capacity. This will likely draw €6 billion in funding from the REPowerEU scheme, bolstered by an estimated €3 billion from the country's national funding sources (Reuters, 2023).

The pickup in momentum in energy transition, revolving around a more than 3x growth in installed solar and wind capacities over the next 6-7 years, is likely to trigger further development of the energy storage market. The latter has been skewed towards residential rooftop solar-linked battery energy storage systems ("BESS"), and the market structure is expected to undergo a paradigm shift towards utility-scale storage.

Italy

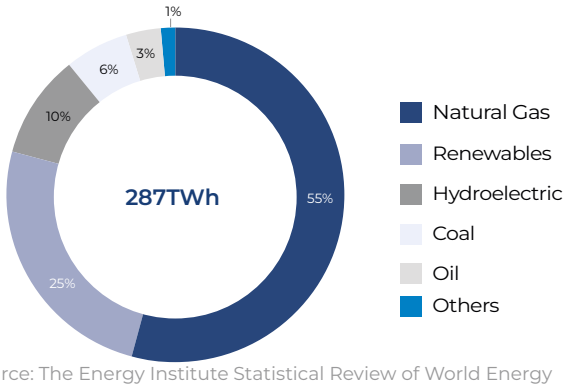
Energy Mix and Case for Storage

Electricity generation in Italy remains skewed towards natural gas, which accounted for 55% of the country's electricity generation in 2022. The collapse in natural gas prices in 2023 enabled the Italian government to contemplate advancing the timeline for replacing coal-based power generation capacity by a year to 2024 (Reuters, 2023). Although the updated PNIEC envisages increasing the share of renewables in electricity generation from one-third currently to two-thirds by 2030, it does not specify the means through which these targets will be achieved.

Italy's grid capacity constraint has been a concern for the renewable power generation pipeline. Steps are underway to expand the capacity. Without systems to absorb the energy injected, the power market prices across Italy's regional market zones may diverge to reflect the grid constraints (Reuters, 2023). Storage also assumes a critical role in capturing prices from high-demand conditions. In July 2023, Italy had the most significant increase in electricity demand on the grid due to prevalent high temperatures (REVE, 2023).

As per transmission system operator (TSO) Terna, 71GWh of grid-scale energy storage capacity, equating to ~9GW of installed capacity, will be needed to be deployed in Italy by 2030 to enable achievement of the country's Fit-for-55 targets (Energy Storage News, 2023). The country's nascent energy storage market could reach 800-900MW in installed capacity by 2023/24. In June 2023, Italian regulators approved new auction rules for grid-scale energy storage, enabling Terna to proceed with capacity market auctions (Energy Storage News, 2023). Other supportive measures have included reviewing and opening up new revenue streams for battery project developers in the ancillary services market.

Power Generation Fuel Mix as of end-2022



Source: The Energy Institute Statistical Review of World Energy

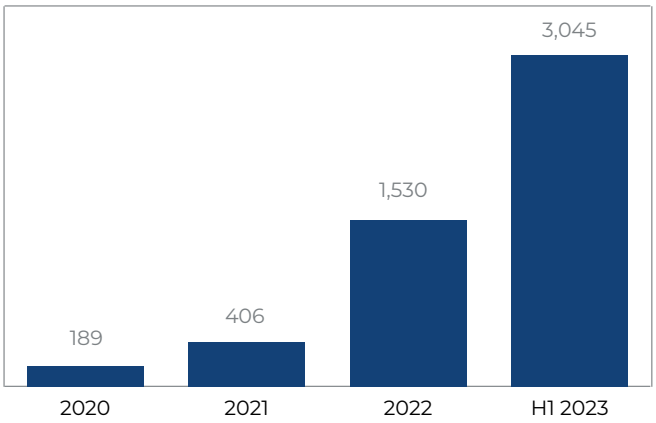
Capacity: Status and Trend

The cumulative energy storage power capacity, excluding pumped hydro storage, stood at 1,530MW in 2022, an increase of almost 4x over the 406MW recorded in the preceding year (ANIE, 2022). 99% of this capacity is based on Li-ion batteries. Capacity addition has continued to accelerate in 2023, with installed capacity doubling to 3,045MW by June 2023 (Energy Storage News, 2023). Around 1,500MW storage power capacity was added in the first six months of 2023, marking Italy's most robust growth recorded semi-annually. Italy also has the seventh largest pumped hydro power storage capacity globally. However, pumped storage is entirely legacy capacity, primarily static over the last two decades.

While the energy storage market has traditionally remained skewed towards the residential rooftop segment, there is growing evidence of a larger share of grid-scale capacity in new installations coming online.

Northern Italy, comprising the provinces of Lombardy, Venetia and Emilia Romagna, account for more than 50% of the storage capacity, mostly represented by small distributed systems (E3 Analytics, 2023). Utility-scale installations are concentrated in southern Italy, particularly the islands of Sardinia and Sicily. Residential buildings will continue to play a critical but declining role in battery storage capacity addition as the Superbonus Scheme continues to 2025. Per Italy's NECP targets and subsequent revisions, 8.5 – 9.0GW of energy storage power will be installed by 2030 to support Italy's decarbonisation targets, split approximately equally between residential rooftop and utility-scale installations.

Trend in Aggregate Installed Energy Storage Power (MW)



Source: ANIE Rinnovabili

Italy

Policy and Regulation

Italy has ascended to a leading position among energy storage markets in Europe in the last twelve months and is currently considered a top investment destination along with the UK. There has been a marked shift towards utility-scale installations as electricity market rules were tweaked to accommodate battery storage operators. The transition commenced in early 2022 through Legislative Decree No. 210/2021, which allowed transmission system operator (TSO) Terna to procure new energy storage capacity in advance (Energy Storage News, 2023).

In February 2022, Terna awarded a 1GW capacity contract to Enel. This was followed by a more robust showing in the capacity auctions held in late 2022, where storage projects secured over 30% of the total capacity allocated, amounting to 1,121MW (E3 Analytics, 2023). The steep decline in battery costs has helped rationalise energy storage capex, making projects competitive in auctions. In June 2023, the regulator ARERA approved new criteria and conditions for large-scale energy storage capacity auctions to be run by Terna (Energy Storage News, 2023).

The development of the energy storage market in Italy has diverged from that of its British or German counterparts. While ancillary services represent a vital constituent of the revenue stack for energy storage projects elsewhere in Europe, the capacity market (15-year contracts), along with energy arbitrage, has driven the growth of the Italian market. The last fast reserve auction was held in late 2020 and saw 250MW of BESS projects on 5-year contracts being awarded to Enel and Engie, with projects slated to come online in 2023-27.

The revenue stack would also depend on geographic parameters as those located in the South, in conjunction with the bulk of the solar PV pipeline, would focus on load shifting while the ones in the North focus on grid balancing services. Consequently, Italy is poised to move to medium discharge durations of 4-8 hours, faster than the UK or German markets at similar points of the market trajectory. Terna envisions a requirement of 9GW of battery storage, having a long duration of 8 hours or more by 2030 (LinkedIn Pulse, 2023).

A supportive policy environment has enabled the favourable evolution of the energy storage market in Italy, in turn drawing increased participation from the capital markets. Additional incentives continue to be rolled out, notably, the National Recovery and Resilience Plan's offer to channel €2.2 billion for self-consumption of renewable electricity, including energy storage systems. Italy also plans to earmark €675 million for offshore wind projects that use energy storage (E3 Analytics, 2023). In December 2023, Italian regulators announced the introduction of a state aid package of €17.7 billion for subsidizing centralized electricity storage systems. The scheme will select beneficiaries of eligible technologies (electrochemical lithium-ion systems and pumped storage hydropower plants) through a competitive and transparent bidding process (Balkan Green Energy News, 2023). The developers will receive annual payments for investments and operating costs over the next ten years.

Market Developments and Opportunities

The Italian energy storage market is pivoting towards the utility-scale segment significantly, evident from the recent investment trends. Several gigawatts plus pipelines have emerged as a result, starting with Enel, which secured a contract from Terna in early 2022 to provide 1.6GW/6.6GWh of storage capacity slated to come online in 2024 (PV Magazine, 2022). In June 2023, UK-based Aura Power received permission to commence construction on a 200MW/800MWh BESS project in Italy, which is part of their 1GW energy storage pipeline (Aura Power, 2023). In June 2023, US-based Emeren Group (formerly ReneSola) launched a partnership with TPG Rise-backed Matrix Renewables for the development of 1.5GW of BESS projects in Italy, of which 260MW projects have already been delivered (Renewables Now, 2023). In June 2023, developer Eku Energy signed a Framework Agreement with Renera Energy to deploy 1GW battery storage projects in Italy. In December 2023, UK-based utility Octopus Energy announced entering Italy, forming a joint venture with developer Nexta Capital to deploy up to ~1.5GW of BESS (Energy Storage News, 2023). Another foreign IPP, Cubico, entered Italy through a joint venture with local developer Storaltil to develop 1GW+ of BESS (Energy Storage News, 2024).

The scope of battery-based storage in the power market could be widened in the near term, with a pilot project underway on the first distribution network-based flexibility market. As of September 2023, the Italian Distribution System Operator (DSO) E-Distribuzione was in the process of executing a pilot on the flexibility market (in partnership with platform provider Piclo) to test ancillary service procurement (Smart Energy, 2023).

The recent spate of investment announcements follows from the previous year when the likes of Innovo Group and Aquila Capital made significant investment commitments in the Italian energy storage sector. In November 2022, the newly launched Innovo Energy announced targeting a 1.5GW/9GWh Li-ion BESS portfolio in the UK and Italy. Spain-based Powertis partnered with German investment firm Aquila Capital to co-develop 421MW solar PV and 90MW energy storage projects in Italy in January 2022 (PV Tech, 2022).

Italy

Strong growth prospects for the energy storage sector have attracted institutional investors across the industry ecosystem. In July 2023, Aviva Investors picked up a 35% stake in Innovo Renewables with the option of expanding its holding to 50% over the next two years (Reuters, 2023). In the same month, Oman's sovereign wealth fund announced an investment in Milan-based Energy Dome, which specialises in compressed air energy storage (CAES) technology (Reuters, 2023). Existing developers are also looking to capitalise on the positive market outlook. Notably, Altea Green Power announced the sale of 2GW of BESS projects in Italy, having a ready-to-build status of Q2 2025.

Tax incentives such as the Super bonus (110%) and Renovation bonus (50%) schemes have driven the residential battery storage segment since their introduction in early 2021. However, policy reorientation and high wholesale energy prices concerns have shifted the growth engine to the utility-scale detail. Policymakers tweaked regulations to accommodate energy storage projects in different segments of the electricity market, thus enabling their ambit of revenue generation across capacity markets, fast reserve and ancillary services. Efforts are also underfoot to explore the feasibility of opening new markets, such as frequency response to battery operators. A separate auction mechanism is also being developed for long-duration energy storage (LDES) projects for 6 hours or more, with contracts awarded for such assets' entire operating life.

Outlook

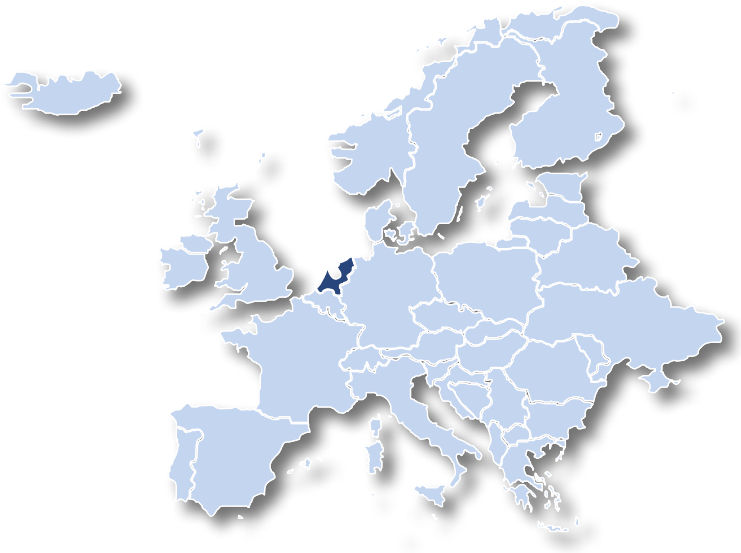
The project pipeline attests to Italy's growing stature in the European energy storage market. As per Terna's technological evaluation, Li-ion-based BESS and pumped hydroenergy storage (PHES) are the preferred storage technologies to be leveraged to reach the target capacity of 71GWh by 2030 (Energy Storage News, 2023). Volatility in wholesale gas prices and rapidly declining storage costs have provided an impetus to adding energy storage capacity, even though the former has eased considerably from its 2022 peak.

Coal-based generation capacity in Italy is scheduled to be retired in 2025. It is estimated that 3GW of new gas generation capacity and 3GW of new energy storage capacity located in the South of Italy and on the islands will be required as replacement capacity (IEA, 2023). There is a growing realisation to shift from gas-based power generation, particularly that designated as a "must-run" capacity with flexible energy storage that would help ease curtailment of renewables-based power. Energy storage assumes added significance to enable the transition to renewables by operating, among other functions, as a peaking capacity to help cool wholesale electricity prices.

Broadening the revenue stack for battery project developers has been a critical objective of policymaking in Italy. As per Milan-based MBS Consultancy, an estimated 60-65% of a battery project's capex is recovered by trading in the spot market, while the remaining 35-40% is sourced from ancillary services (LinkedIn Pulse, 2023). The recent uptick in capex costs has dampened investor enthusiasm, but Italian policymakers have been quick to reiterate their long-term commitment towards energy storage.

A minor slowdown in capacity addition is expected as the Superbonus incentive is progressively phased out. Still, the impact is likely to be limited to the residential and commercial & industrial (C&I) segments. This will be more than offset by the continued growth in the utility-scale segment. Overall, the fundamentals of the Italian energy storage market are robust enough to support the projection of Italy becoming Europe's third-largest energy storage market by 2030 when the share of renewables in the country's energy mix reaches 65% (Energy Storage News, 2023).

The Netherlands



GDP (Current Prices) USD (2022)	1,010 bn
GDP Growth Forecast (constant prices) (2023-2027)	1%
10yr Govt Bond Yield (12-month rolling average)	2.79%
Country Credit Rating (S&P)	AAA
Battery Storage Capacity	NA
Pumped Hydro Storage Capacity	NA
RE share of Total Electricity Capacity	54.90%
Battery Storage Outlook (Power Capacity)	9.0GW by 2030

Source: IMF, Fred Economic Data, S&P Global, Energy Institute, The Energy Institute, Battery Industry

With the rapid growth in renewable energy capacities, grid-scale energy storage is emerging as a critical need for network reliability and management. The transmission system operator's roadmap clearly shows the minimum storage requirement for a smooth energy transition. Against such a backdrop, the gradual rise in battery storage investments is encouraging. Most planned storage units involved co-located battery storage units combined with renewable energy generation. With the right regulatory incentives, the Dutch storage market can rapidly expand to accommodate the demand, as has been the experience in its neighbouring markets.

The Netherlands

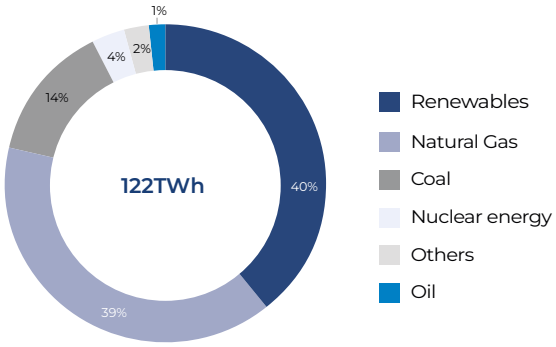
Energy Mix and Case for Storage

There is a sharp focus on energy transition, driven predominantly by the binding targets on clean energy. Despite progress, the role of hydrocarbons remains high in the Netherlands' power mix (Energy Institute, 2023). Furthermore, regarding the final energy consumption, the share of renewable energy sources is far lower than observed at the power generation level. With each progressing year, there is an added urgency to close the gap in targeted emissions.

The planned phase-out of ageing coal-based power generation is part of the decarbonisation goals (Deloitte, 2023). The target is a 49% reduction in emissions by 2030, compared to the 1990 level. The power sector must rationalise its emissions by at least 26% by 2030 to meet the national emission targets. Pursuing such goals is thus underway through measures, including planned induction of small-scale nuclear power generation and the acceleration of renewable energy projects, led primarily by solar and offshore wind.

By the end of 2023, share of renewable energy was half of the total power generation from all sources. The Nationaal Klimaat Platform of the Netherlands tracked this. But it has been a challenge to absorb the rising renewable energy in the grid. In June 2023, entire solar and wind power generation outstripped demand for 140 hours in the grid (PV Magazine, 2023). The excess energy was channelled to the neighbouring countries in the region based on interconnector linkages. But not all the excess energy could be exported. For the year 2023, the grid operator had over 300 hours' worth of negative prices, for which the due payouts were done as the excess energy could not be integrated (NL Times, 2023). With the rise in the renewable project pipeline, the market will likely face negative prices without storage options.

Power Generation Fuel Mix as of end-2022



Note: The above representation does not explicitly show hydropower generation with a 0.04% share in the total.

Source: The Energy Institute Statistical Review of World Energy

Capacity: Status and Trend

The Netherlands' grid-scale energy storage has yet to reach the required scale corresponding to the renewable energy share in total grid-connected power generation. With hydropower contributing a negligible share in the country's energy mix, the option of pumped hydro-based storage is ruled out. As deployed so far, battery storage units were initially led by technology demonstration projects and later co-located battery units with renewable energy generation projects (Frontis, 2020), (PV Magazine, 2022). Standalone storage, especially in the long-duration segment, is relatively insignificant in the Dutch energy market due to the limited regulatory incentives in the bulk power market. The installed storage capacity is engaged for short-duration grid balancing services such as frequency regulation and congestion management. Long-duration energy storage is yet to be deployed on a commercial scale.

Netherlands' Existing Utility-Scale Battery Storage (Indicative)

	Capacity (MWh)
Giga Rhino Netherlands	12
Heerhugowaard battery and flywheel storage (combined with wind project)	13
Netherlands Advancion Energy Storage Array	10
Alfen Hartel Rotterdam	10
Amsterdam ArenA	4
Bonaire Wind-Diesel Hybrid	3

Source: PV Energy, Frontis Energy

The Netherlands

Policy and Regulation

The country's policy and regulatory framework, while recognising the energy storage assets in the system, is yet to be aligned with the industry's needs. Fundamental regulatory changes are required in areas such as charges payable by the storage units or the tax incidence. Recent steps taken indicate progress. For instance, since January 2022, the regulatory authorities have exempted storage assets from double taxation on the import and export of power (CMS, 2022). With the amended regulations, storage units could avoid dual tax if the storage operator had a large-scale consumption connection and declared its exemption from the levy to the supplier.

Yet, there are other norms overdue for revision. The energy storage assets are liable to pay grid fees (as a consumer of grid power). Such an arrangement is misplaced as the same storage assets are also expected to inject the energy back into the grid at a designated time slot and capacity. With a typical standalone battery storage asset charging entirely from the grid, the charges levied could be a sizeable part of operational expenditure. The regulatory gap in this context must be closed as soon as possible to enable new capacities. Notably, the European Union guidelines suggest scrapping the grid transportation cost for energy storage. It is thus also incumbent on the country to revise its regulations.

In other instances, the regulations regard storage assets as power generation sources. Grid access is one such instance. Under existing rules, battery storage operators must contract network capacity for charging and discharging. Such a process shuts out the batteries during times of network congestion. With the rising share of renewable energy supply (intermittent), grid congestion frequently impacts storage assets. Pilot storage projects led by network operators will explore the possibility of deploying large-scale batteries to circumvent the issue of renewable energy clogging the network.

Rising challenges around network congestion prompted a revision in the grid code (as of November 2022). The revised regulations stipulate the creation of Congestion Service Providers (CSP) to manage the peaking power while operating as independent operators between grid operators and final connected customers (PV Magazine, 2022). The role of CSPs is to manage the peaking capacity in the grid supply for a fee. Such a norm favourably impacts the standalone battery units, many of whom are seeking congestion management as one of their revenue stacks.

Market Developments and Opportunities

The high-voltage standalone battery storage market (grid-scale batteries) is gradually coming into prominence. One example is the business model of companies such as Lion Storage (Energy Storage News, 2023). As an independent developer, the company's pipeline is worth 350MW targeted by 2025. The company's model is to develop the project up to the final investment decision stage, at which point it is sold to a strategic or financial buyer. From there on, it is generally 2-2.5 years for operationalisation.

Many other grid-scale projects under construction continue with their variants of business models. The 30MW Project Pollux, for instance, has one entity, SemperPower, to develop, finance and operate the storage system and an energy storage firm, Alfen, to manage the design, supply, civil works, installation, tests, and maintenance (ETN, 2023). Project Pollux is meant for a grid-integration role and has come online on December 2023 (Energy Storage News, 2023). In November 2023, SemperPower inaugurated a 30.7MW/62.6MWh BESS project, Castor, in the Netherlands. Several equipment manufacturers and technology providers are similarly exploring ventures for standalone grid-scale battery storage units, with the rise in demand for grid integration services. A congested grid strengthens the business proposition of battery storage units. For instance, utility-scale renewable energy developers are exploring co-located battery units to circumvent the Dutch network constraint. German utility RWE, as of September 2023, finalised the investment decision for a €24 million, 35MW co-located battery storage at its OranjeWind offshore wind project in the Netherlands (RWE, 2023). The battery unit is meant for grid frequency management in combination with the generation project. The project construction has begun and will be commissioned in 2025 (RWE, 2024). The co-located battery storage units are also instrumental in the faster commissioning of the projects. The Dutch developer PowerField, for instance, could expedite its Valthermond-based solar park mainly due to a 12MWh battery linked with the project (PowerField, 2023). Without the grid-scale battery, the grid-connectivity requirements related to the project would have meant commissioning by 2028. Instead, with battery storage connected, the solar park is planned to be commissioned in 2023. Further, municipalities are backing the Dutch BESS market. In December 2023, the Dutch Municipality drafted a zoning plan for the Netherlands's first 1GWh scale BESS. The project is expected to secure permit applications in 2024, begin construction in 2025, and become operational by 2026 (Energy Storage News, 2024).

The Netherlands

Other grid-scale technologies are in the fray to meet the demand for long-duration storage. One such technology is Ocean Battery – which uses the pumped hydropower generation route for storage at the bottom of a sea-bed or lake to supply long-duration power at short notice. Ocean Grazer, a developer, had won a tender floated by RWE for a project based on Ocean Battery in the Hollandse Kust West VII offshore wind farm site (Windpowernl, 2022). Ocean Grazer's project initiative has attracted investor interest. In November 2022, Rabobank approved an innovation loan in this regard. Around the same time, the Groningen regional fund approved 40% financing to develop the first full-scale Ocean Battery system (Knowesg, 2023).

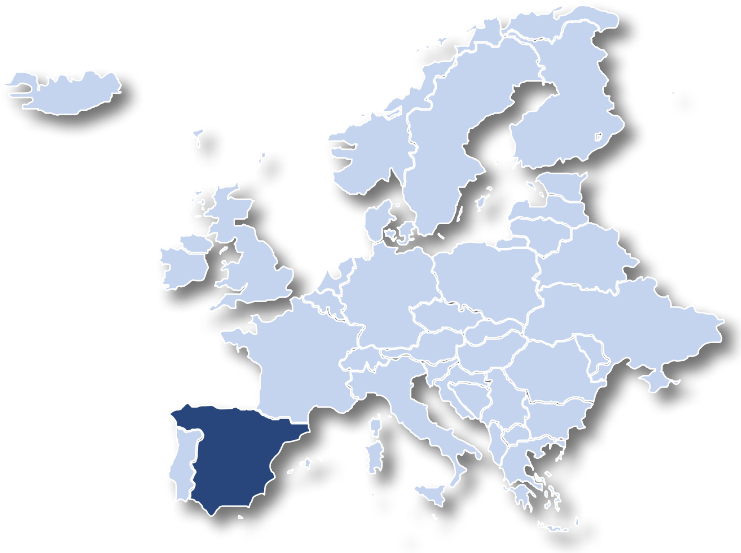
Outlook

The Dutch grid operator's projected grid storage requirement by 2030 is 9GW, based primarily on battery units. System stability and flexibility are two of the most critical factors driving the grid-scale battery storage demand in the Netherlands (Battery Industry, 2023). The need for frequency restoration reserve could rise among specific areas, with a decline in conventional energy units traditionally used for grid balancing services. Other potential battery-based grid service areas include congestion management and reactive power supply. The emphasis is securing large-sized battery storage (above 70MW) and strategically placing them across regions with varying demand loads and renewable power generation.

The recent private investments towards standalone grid-scale battery storage units indicate the interest in tapping into the emerging opportunity. Policy and regulation must extend the supporting measures to develop the storage market. Net metering is one such case. In February 2023, the Dutch lower chamber had approved a proposal to phase out net metering from 2025. But the same was rejected by the Dutch Senate later in February 2024 (PV Magazine, 2024). Political issues are likely to have played a role in such a decision. A phase out of net metering strengthens the case for distributed energy storage (based on the rooftop solar PV).

The need for enabling regulatory measures is even higher in utility-scale storage. One such area of concern is the grid charge levied on batteries. Grid charges make battery units less attractive when compared to other European countries. Also, battery units are subject to a non-firm grid connection, implying possible temporary disconnection from the grid – a drawback on the revenue model. Policy and regulatory authorities are deliberating on the options to resolve the issues battery developers face. The incentives available in the Dutch battery storage business will determine how flexible generation can accommodate the energy transition in the grid's power mix.

Spain



GDP (Current Prices) USD (2022)	1,419 bn
GDP Growth Forecast (constant prices) (2023-2027)	2%
10yr Govt Bond Yield (12-month rolling average)	3.47%
Country Credit Rating (S&P)	A
Battery Storage Capacity	NA
Pumped Hydro Storage Capacity	73.0GWh/ 3.3GW
RE share of Total Electricity Capacity	58.20%
Battery Storage Outlook (Power Capacity)	22.0GW by 2030

Source: IMF, Fred Economic Data, S&P Global, MDPI, Energy Institute, Reuters

The Spanish energy market is gradually emerging as the frontrunner in decarbonising power generation segment. The energy crisis of 2022 helped reinforce the policy resolve. The government's draft climate strategy plan document aims for an over 80% renewable energy penetration by 2030. The grid operator's network planning factors in a similar estimate, at about three-quarters' share of renewable by 2030, to expand the capacity. Energy storage might be a vital missing piece in the upcoming energy frame. A rising share of renewable energy generation faces either curtailment or price cannibalisation in the absence of storage capacity operating in the power market. Of late, the rise in storage-linked renewable generation projects has been encouraging progress.

Spain

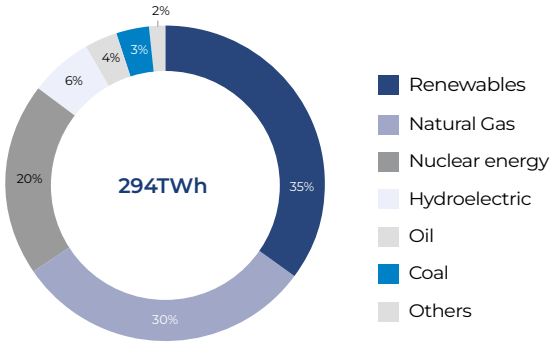
Energy Mix and Case for Storage

The Spanish energy mix is in a rapid transitory phase. Its renewable energy market, among Europe's top, got a boost after the energy crisis in 2022. Despite the temporary push for fossil fuels in 2022, there is a marked shift in the power mix towards renewable energy generation. Between 2018 and 2022, the share of renewable energy in total grid-based power generation rose from 25% to 35%, effectively displacing the role of hydrocarbons (Energy Institute, 2023). By the end of 2023, an enhanced capacity addition rate ensured a renewable energy generation share of over 50%, based on the Spanish grid operator's estimates (Renewables Now, 2024).

Solar PV generation is driving renewable energy penetration in the grid (Red Electrica, 2023). The total solar power generation for 2023 registered a 34% year-on-year growth. A rapidly expanding solar project pipeline is straining the approval process, besides adding to the transmission connectivity queue. At the same time, there is a policy approval to phase out coal-based power generation by 2025, five years ahead of the original plan (Euro News, 2023). The country's largest coal-fired power plant (1.4GW) is confirmed for closure by the end of August 2024. Retiring such baseload generation capacity adds to the urgency of strengthening grid infrastructure.

In the absence of preparedness in the grid, the rise in renewable energy share makes curtailment a strong likelihood. IEA's estimates indicate that renewable energy curtailment has risen in Spain – from 0.2% in 2019 to 1.5% by 2022 (IEA, 2023). The fast clip of wind and solar generation capacity addition means that in the absence of storage capabilities, the grid could disincentivise potential investments with a cutback in generation. Already, the power market faces cannibalisation in short-term prices – the influx of new solar capacity has been causing prices to dip in the daytime due to excess supply (S&P Global, 2023). Without storage, as studies indicate, Spain's renewable energy curtailment rate could reach 5% during 2025-2035 (Montel, 2023).

Power Generation Fuel Mix as of end-2022

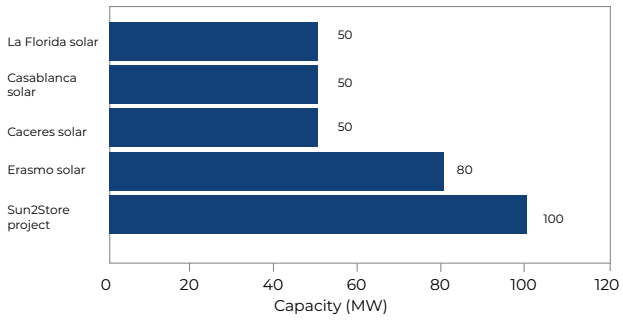


Source: The Energy Institute Statistical Review of World Energy

Capacity: Status and Trend

The Spanish power system's grid-scale storage is limited to pumped hydropower generation capacity. As of the end of 2022, this stood at 3.3GW (IRENA, 2023). The stationary storage capacity, in terms of batteries, is, however, at a negligible level. Some recently commissioned battery storage projects pertain to the renewable-plus storage category, with the battery storage unit co-located with solar or wind generation. Standalone battery storage for grid management has yet to play any significant role in the Spanish power system. In 2023, 128MWh of battery storage capacity was added. Interest rate hikes and temperance of power prices are among the dampening factors (Renewables Now, 2024).

Leading Energy Storage Projects in Spain



Source: Statista

Spain

Policy and Regulation

The regulations provide a basic definition of energy storage, its ownership, functions, and participation in providing services in the energy market. Further, the regulatory norms also describe the grid access for such capacities (in line with power generation) and allow for co-location with new or existing generation capacities. Standalone capacities are thus subject to similar requirements of permits and related procedures to seek transmission access toward the injection of power (Lexology, 2023).

While the basic regulatory outline is in place, the comprehensive framework for grid integration of storage capacities is yet to be developed or clarified. The potential standalone storage units need to consider the business models to sell the power back to the grid in specific time slots. The existing power market regulations need to be more well-defined for such business models as arbitrage pricing, frequency regulations, etc. However, the rules refer to hybrid renewable projects with co-located energy storage capacities. In effect, the laws allow co-located energy storage units to capture energy from the renewable generation project at a time point when the grid price may not be economically viable and discharge the same later when prices are higher (CMS, 2022).

The policy scope of utility-scale storage capacity in Spain is limited to hybrid renewable power projects. This implies challenges in the viability of private sector standalone grid-scale storage projects. The policy stance appears to be encouraging the hybrid storage model. In December 2022, the government announced a grant-based funding scheme for 600MW worth of storage capacity, which must be combined with renewable power generation (PV Magazine, 2022). The scheme allocated €15 million for each project by a developer and will be valid till December 2025. In late 2023, the Spanish government launched its first PERTE tender for energy storage co-located with renewables. About 1.9GWh was awarded for storage projects co-located with renewable technologies (Energy Storage News, 2023). This covers 40-50% of the project costs, with a total funding of €160 million. Under the PERTE tender, Iberdrola received a total of €37.5 million in funding towards their deployment of six BESS projects in Spain with a total of 150MW/300MWh, co-located with existing solar PV plants (Energy Storage News, 2024). In December 2023, the Spanish ministry unveiled state aid of €150 million to incentivize hybrid projects across Spain for 36 energy storage projects co-located with renewable energy totalling 905MW (Renewables Now, 2023). The highest was allocated for 632.4 MW of storage projects located at Castile-La Mancha and Extremadura, with a total aid of €95.4 million. The hybrid storage project in the Balearic Islands received €28 million with 4.6MW of solar PV and 53.5MWh of storage (Renewables Now, 2023), and Statkraft received €2.5 million for developing a BESS at its solar farm in western Spain (Renewables Now, 2023). State aid towards encouraging hybrid or co-located storage projects is surging in Spain, leaving behind an urgent need for policy packages for developing grid-scale storage projects.

Support for standalone storage projects came through in July 2023, with the Spanish Ministry for Ecological Transition launching two funding schemes aggregating €280 million to promote energy storage projects (Renewables Now, 2023). About €180 million is allocated towards standalone and thermal-based storage projects, while the rest is for pumped hydropower projects. The funding allocation for each standalone storage project is capped at €50 million.

Market Developments and Opportunities

The co-located capacities will likely lead to the growth of the Spanish storage market in hybrid renewable generation projects. Storage-based hybridisation is also gaining traction in the Spanish market due to rising price cannibalisation in renewable energy (Power Engineering, 2023). In March 2023, Naturgy Energy Group announced its planned investment of €117 million across eight energy storage projects aggregating 290MW (WSJ, 2023). Seven of the planned projects are to be linked to solar farms. Among other notable projects is Soto Solar's 1GW solar farm, integrated with battery storage and hydrogen electrolysing plant (ICEX, 2021).

Battery projects are slowly gaining traction in Spain, primarily supported by the aid distributed by the Ministry for the Ecological Transition. One such is Spain's largest Escuderos BESS project, developed with 18% state aid. In November 2023, Grenergy unveiled its plans to invest €2.6 billion in Spain to develop solar and storage projects during 2023-2026 (Power Technology, 2023). In December 2023, the company announced the construction of an 87.6MW/175MWh two-hour battery storage capacity in its 200MW solar farm in Cuenca (El Periodica de la Energia, 2023).

The upcoming auctions present a significant opportunity for developers and investors. In June 2022, the Spanish Ministry for Ecological Transition's draft order indicated the planned auction of 5.8GW of grid access for renewable energy generation and storage at 17 nodes across the Spanish mainland's transmission network (Renewables Now, 2022). The public comments for this auction will be received till June 2024. The auction rules incentivise projects meeting specific criteria, such as storage co-location, share of self-consumption, hybridisation, repowering and commissioning schedule.

Spain

Pumped hydro is the other important sub-segment for Spain's grid-scale storage capacity. While fraught with challenges in environmental clearances and development delays, pumped hydropower storage is vital as a long-duration energy storage resource in the Spanish grid. The 200MW Salto da Chira at the Gran Canaria Island is one significant project presently under construction. In this case, the grid operator is the developer, investing about €400 million (PV Magazine, 2023).

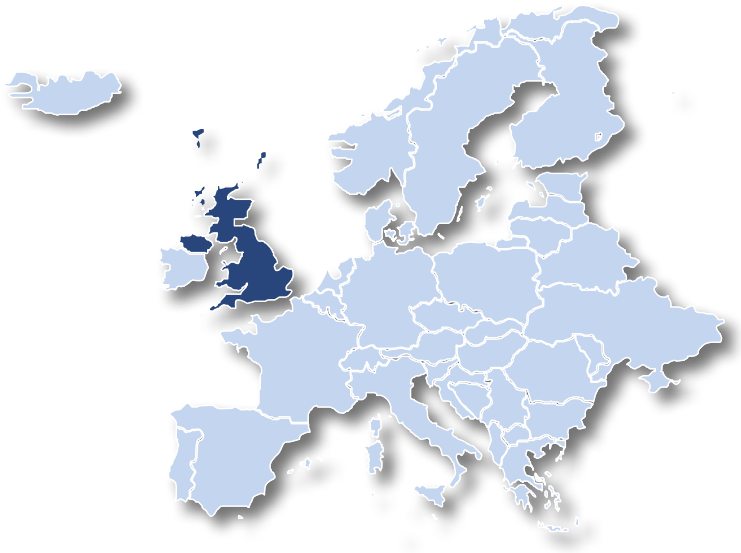
Outlook

The Spanish transmission system operator's network development plan has projected renewable energy to contribute almost three-quarters of grid-connected generation by 2030 (Red Electrica, 2021). Battery-based storage plays a small role in the transmission operator's projected energy scenario – about 500MW worth of grid-scale battery capacity was provisioned for the Spanish mainland network plan's energy study projection 2026. Other planned battery projects include two storage units, aggregating 140MW, to strengthen the transmission interconnection between the Spanish mainland and the Balearic Islands. The interconnector capacity addition, while critical, will take over a decade to commission.

The grid constraints, meanwhile, could intensify with an accelerating renewable energy project pipeline. In December 2022, the government notified rationalisation in grid approvals for renewable energy projects (DLA Piper, 2023). Over 30GW in wind and solar power projects awaited grid access permits as of September 2023. The need for grid-scale energy storage will be far higher than the TSO's latest long-term plan indicated. The government's draft climate strategy document has pointers in this direction (Reuters, 2023). About 22GW of storage is targeted for 2030 to accommodate the 81% renewable energy share aimed for by then. Post consultation, the climate strategy plan could be finalised for implementation by June 2024.

The successful realisation of grid-scale energy storage capacities would hinge upon conducive regulations. Following the examples in leading energy storage markets globally, Spain's grid-scale storage targets must be followed through with the regulatory framework for standalone storage units to participate in power trading markets. The incentives in such power market reforms will likely have a more significant impact than government budgetary allocations.

United Kingdom



GDP (Current Prices) USD (2022)	3,082 bn
GDP Growth Forecast (constant prices) (2023-2027)	1%
10yr Govt Bond Yield (12-month rolling average)	4.14%
Country Credit Rating (S&P)	AA
Battery Storage Capacity	14.0GWh/ 3.5GW
Pumped Hydro Storage Capacity	27.6GWh/ 2.8GW
RE share of Total Electricity Capacity	49.50%
Battery Storage Outlook (Power Capacity)	24.0GW by 2030

Note: Battery Storage Capacity Expressed in GWh assuming an average 4 hours of duration.

Source: IMF, Fred Economic Data, S&P Global, Solar Power UK, MDPI, Energy Institute, Rystad

The UK's energy storage market has grown rapidly to meet the demand imposed by a rising renewable energy penetration in the grid. Renewable energy sources contributed over 40% of the total power supply by the end of 2023 (Carbon Brief, 2024). The grid operator has the responsibility to provide flexible energy supply options, including battery-based storage units, to maintain stability and reliability as the demand for offshore wind energy increases. The introduction of capacity auction contracts has facilitated the development of the storage capacity pipeline. However, further efforts are required, especially in market design, to boost the usage of battery storage units.

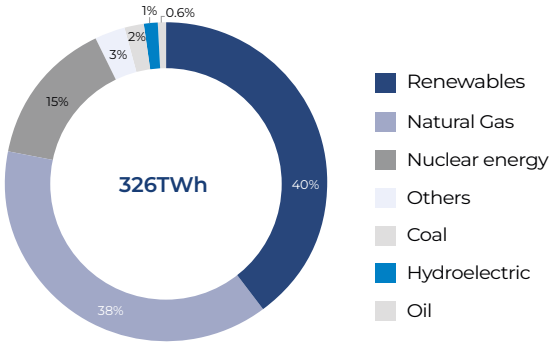
United Kingdom

Energy Mix and Case for Storage

Compared to many other developed markets, the UK's electricity generation mix relies less on traditional fossil fuels. By the end of 2023, renewables, primarily wind and solar power, contributed more electricity than natural gas. With coal facilities reaching the end of their life, the grid will mainly rely on renewable, nuclear, and natural gas energy sources. The power sector plays a crucial role in achieving the UK's net-zero goal. In this context, having flexible utility-scale energy storage is vital for managing the complexity of the grid.

The utility sector is the most significant segment in the UK's battery-based energy storage market. This is because there is an increasingly critical need to integrate intermittent renewable energy into the UK's grid dispatch commitments. By the end of 2023, the share of renewable energy in total power generation is expected to reach 43%, compared to its 23% share in 2016. Additionally, battery-based storage capacities are one of the options for the UK's system operator to mitigate renewable energy curtailment. In 2022, National Grid paid £215 million to wind generators for curtailment as part of the grid balancing mechanism, as the network would not have been able to absorb excess energy at specific times (Sky News, 2023).

Power Generation Fuel Mix as of end-2022

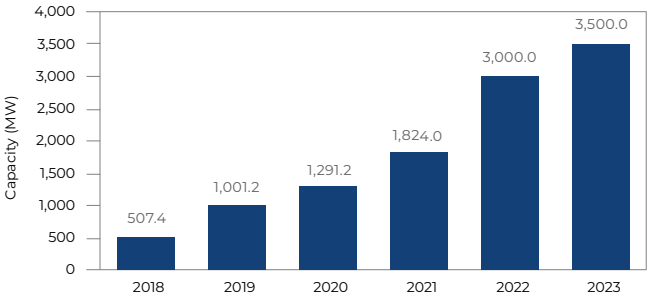


Source: The Energy Institute Statistical Review of World Energy

Capacity: Status and Trend

UK's grid-scale energy storage, primarily battery-based, has grown almost sevenfold in capacity between 2018 and 2023. Grid-scale energy storage saw a significant increase in capacity additions in 2022, indicating a strong growth trend in the project pipeline. The utility-scale segment is contributor to additions – about 800MWh worth of storage in 2022 came from the utility-scale energy storage (National Grid, 2023). In Q4 2023, the highest capacity additions were 420MW, bringing the total to 3.5GW by year end (Solar Power UK, 2024).

Trend in Aggregate Installed Energy Storage Power



Source: BNEF and National Grid (The 2022 data point was sourced from National Grid's report, 2023 from Renewables Now)

Since 2014, capacity auctions have incentivized grid-scale storage and attracted battery-based capacities in the UK's power market (Reuters, 2023). The number of battery storage units winning contracts has been increasing every year. In February 2023, the system operator confirmed that 627MW of battery capacity was procured in the T-1 capacity auction for 2023-24 delivery, which is an increase from the previous year's 385MW. The latest capacity market auctions of February 2024, held for 2024-24 delivery, awarded 655.1MW in standalone battery storage at £35.79/kW/year (Energy Storage News, 2024).

Utility-scale units are the main drivers of the UK's battery-based energy storage market. They focus on managing the grid and play a significant role in the country's storage capacity growth. Auctions provide price transparency for contracted capacity and encourage new investments. Regulations related to grid frequency management in the power market are crucial for the revenue models of utility-scale storage. Battery storage from residential and commercial segments represents a relatively small share. However, since 2022, the rise in energy costs has led to growth in these segments.

United Kingdom

Policy and Regulation

The UK government aims to achieve net zero by 2050 and requires the power sector to be decarbonised by 2035 as part of its net zero target (UK Parliament Post, 2023). Such a target sets the base for energy storage, as a flexible energy supply is a critical part of the energy transition. The energy market policy and regulations thus seek to accommodate energy storage business in the otherwise legacy-driven wholesale power market.

The UK regulatory authorities are reviewing the wholesale power market structure so that alternative sources such as energy storage have a fair chance (UK Government, 2022). Natural gas continues to skew the market, dissuading potential investments in other technologies. As indicated in the consultation process undertaken for the upcoming market reforms, there is a general view that the existing regulations do not fit the requirements. Key focus areas in this context include reforming the capacity market to improve the participation of various flexible energy solutions, including battery storage (UK Parliament, 2023).

Capacity market regulations constitute the most essential part of the regulatory framework towards supply security and reliability (BEIS, 2023). The procurement process, in place since 2014, is technology-neutral. The generators/suppliers across technologies must compete for capacity commitments instead of guaranteed payments. Lately, with the rise in clean energy generation, the role of energy storage systems in the capacity market has come to the fore. This is observed in the capacity auctions for T+1 (one year ahead) and T+4 (four years earlier) contracts in the capacity market, wherein storage technologies have progressed even if they are still behind the conventional capacities.

A few other regulatory steps in the recent past that contributed to the easing of energy storage projects include exemption (April 2023 onwards) from the charges that non-domestic (commercial and industrial) properties are liable to pay for local services. Per the policy statement, this exemption was valid until 2035. During the same period, the government also expanded the scope of contracts-for-difference (CfD) auctions to include those renewable energy projects with storage options attached. In February 2024, the UK government exempted retrofitted BESS from the 20% value-added tax available only for domestic BESS if installed with a new solar system. The exemption applies to residential and charitable building BESS retrofitted to an existing solar/heat pump installation and will continue till 31 March 2027 (Energy Storage News, 2024). In July 2022, the energy market regulation was amended to recognise energy storage as part of the generation resources.

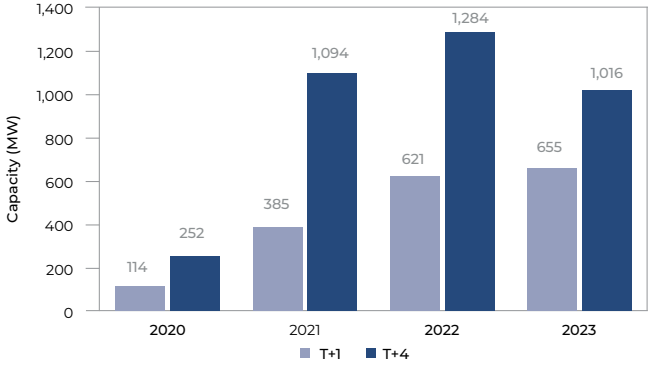
The most important focus point is on long-duration energy storage, where the UK authorities plan to devise a policy and regulatory structure. As the UK's Department of Business, Energy and Industrial Strategy (BEIS) reports show, such projects face entry barriers due to the high upfront costs, uncertainty in the revenue streams, and weak market signals. Instead, the current market structure is tuned to the shorter duration flexibility requirement.

Market Developments and Opportunities

Investors are optimistic about the UK's battery storage market and are committing funds accordingly. Some of the leading investment groups and fund houses have already made significant investments. In March 2023, the UAE-based company Masdar announced its plan to invest £1 billion into the UK's battery storage market. Earlier in 2022, Masdar had also acquired the UK-based storage developer Arlington Energy. Many other assets are being developed with co-located energy storage and generation to take advantage of potential grid arbitration and merchant trading opportunities.

The system operator's capacity auctions are a significant catalyst for new battery storage investments. The revenue stream visibility acts as a substantial incentive. As of February 2023, about 5GW of new-build battery storage systems secured the 2026-27 T-4 capacity auction contract (National Grid report, 2023). Almost half of the contracted capacity is based on a two-hour storage duration. During the same period, the battery storage projects ranked third (after gas and nuclear) in securing the 2023-24 T-1 capacity auction contracts. There was a 63% rise in the capacity won by battery-based storage (National Grid report, 2023). Furthermore, the auction clearing price in this process, at £60/kW, was the second-highest after the previous year's £75/kW.

Battery Storage Power Capacity in Capacity Market Auctions



Source: National Grid

United Kingdom

Frequency response services have been the primary revenue-earning source for most storage assets commissioned. By the end of March 2023, the system operator increased its high-frequency dynamic containment procurement volume (Modo Energy, 2023). A record level was procured, as battery storage systems were called up for managing short-duration grid management services. Also significant is the progressive shift in the business model of grid-scale storage assets. Battery storage assets' revenue is aligned with the merchant business models of trading energy and moving away from the saturated ancillary service segment (Current, 2023). An example is the low Firm Frequency Response (FFR) auction prices as of May 2023. The FFR prices reached the lowest level since 2019.

The potential revenue streams for battery storage assets also include the wholesale power markets (half-hour slots for transactions with a range of contracts), balancing mechanisms (varying timescales for power system balance in daily half-hour trading periods, or for other system requirements), deployment as embedded or behind-the-meter assets and in local flexibility markets (Next Energy, 2023).

UK's Energy Storage Commissioned/Finalized Construction

Project	Location	Capacity	Details
Buxton BESS	Buxton, Derbyshire	60MWh	In January 2024, the project's construction is completed, which is a joint venture between Atlantic Green, Israeli renewables developer Nofar Energy Ltd, and investor Interland.
Blandford Road BESS	Dorset, southwestern England	25MW/ 50MWh	In January 2024, the project came online. It was developed by the Norwegian oil and gas group Equinor ASA and operated by UK-based battery storage company Noriker Power.
Tiln BESS	Lincolnshire, England	25MW/ 50MWh	In February 2024, the project became operational. This is developed by Lightsource bp and is co-located with its 61MWp Tiln solar farm.
Richborough Energy Park BESS	KENT, England	100MW/ 100MWh	The project is connected to the National Grid's transmission network and is developed by Pacific Green on the former site of a coal plant. The project is connected to the 400kV Richborough substation.

Source: Energy Storage News, Renewables Now, PV Magazine, Company Websites

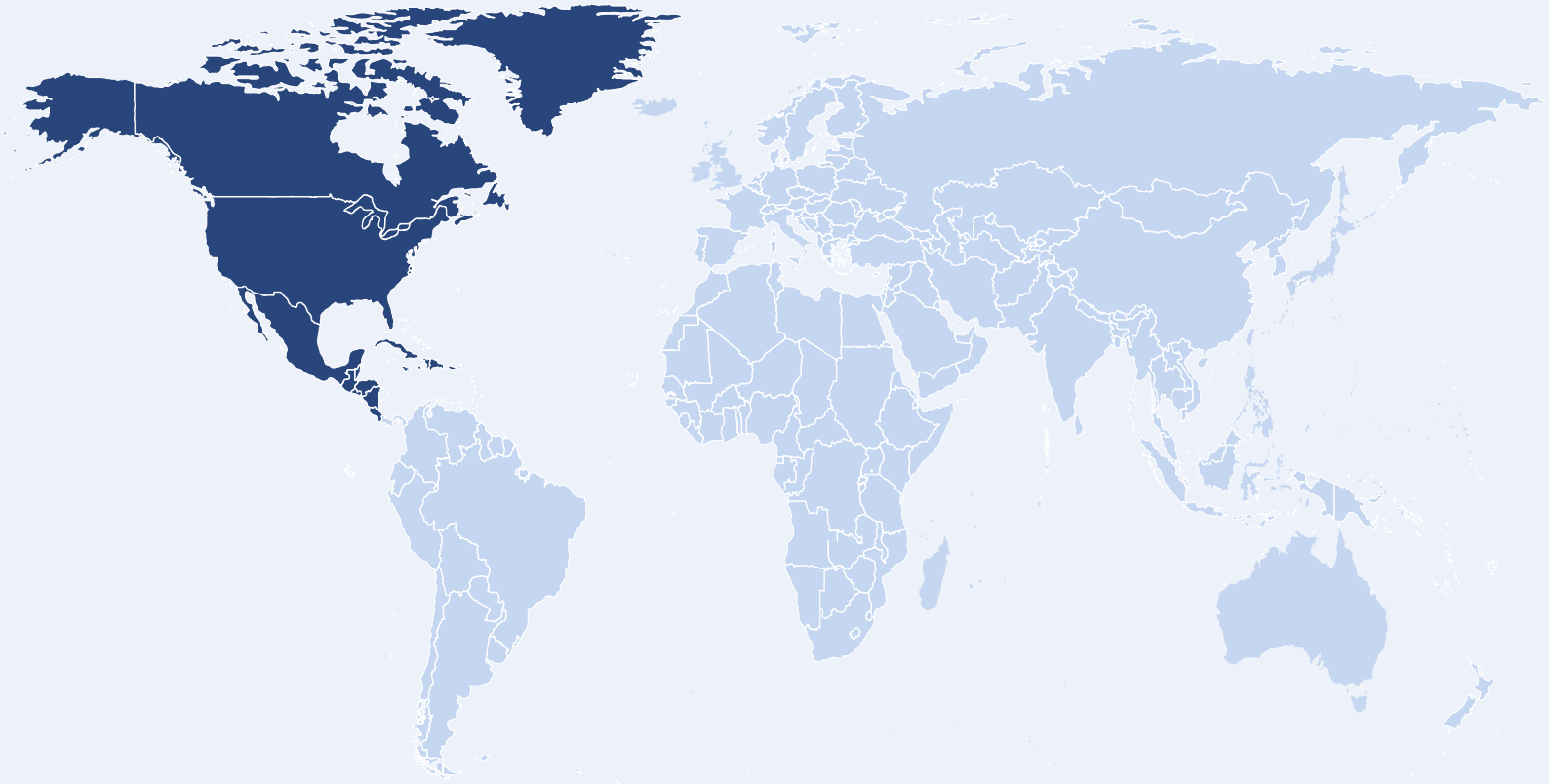
Outlook

The project pipeline attests to the UK's emerging prominent role in the global grid-scale energy storage market. Over 66GW worth of battery capacity is in the planning stage (Solar Media, 2023). In July 2023, the UK-based Carlton Power secured the planning permits to develop a 1GW battery storage system in Manchester, UK. The project, due for commissioning by 2025, is regarded as the world's most significant (Energy Monitor, 2023). Rystad Energy's report, as of April 2023, projected 24GW battery-based energy storage capacities in the UK by 2030 (Rystad, 2023). UK's Energy System Operator, National Grid, projected this even higher, at 31GW by 2030 (National Grid, 2023).

An essential precondition for the projected storage market growth is the timely transformation of the grid network and the transition to achieve net-zero and decarbonisation objectives. The progress in retiring coal-based generation (the only remaining coal-based power plant will operate till September 2024) and expanding renewable energy penetration (40% of total power generation) helps strengthen the base for the grid-scale energy storage systems (Guardian, 2023). In fact, with the changing grid profile, the need for storage systems is also poised for a shift – from existing short-duration systems to ones capable of longer-duration support.

Long-duration energy storage systems are likely to constitute the next area of focus to support the ongoing energy transition as a flexible power generation resource, besides contributing to managing transmission capacity constraints. The technologies in this regard are nascent, with government support enabling the demonstration and commercialisation process. A well-defined policy approach for long-duration storage, expected by 2024, could help set the growth roadmap.

Key Regional Markets - North America



Canada

GDP (Current Prices) USD (2022)	2,138 bn
GDP Growth Forecast (constant prices) (2023-2027)	2%
10yr Govt Bond Yield (12-month rolling average)	3.42%
Country Credit Rating (S&P)	AAA
Battery Storage Capacity	1.4GWh/ 356.0MW
Pumped Hydro Storage Capacity	4.8GWh/ 174.0MW
RE share of Total Electricity Capacity	69.40%
Battery Storage Outlook (Power Capacity)	5.0GW by 2030

Note: Battery Storage Capacity Expressed in GWh assuming an average 4 hours of duration.

Source: IMF, Fred Economic Data, S&P Global, CanREA, HYDROVISION International, Energy Institute, Energy Storage News

In March 2022, Canada released the 2030 Emissions Reduction Plan, which outlines the country's national targets for decarbonisation. The goal is to reduce greenhouse gas (GHG) emissions by 40-45% over 2005 levels by 2030, and achieve net zero emissions by 2050. The plan involves a multi-sector approach towards decarbonisation, which includes a commitment to a net zero electricity grid by 2035. This target was set out by Prime Minister Justin Trudeau in 2021 and brings Canada in line with the rest of the G7 nations, who also committed towards achieving this objective in May 2022 (ESG Today, 2023).

A study by consultancy Power Advisory for trade body Energy Storage Canada estimated a requirement of 8-12GW installed energy storage power to achieve net zero in its electricity sector by 2035 (Energy Storage News, 2022). Pumped storage hydro (PSH) represents an alternative source of energy storage to help balance the electricity grid with more than 8,000GW of potential capacity identified at nearly 1,200 sites (Hydro Review, 2023). Canadian Renewable Energy Association (CanREA) has set a target of adding 3.8GW of wind and 1.6GW of solar annually till 2050 to meet the Net Zero goal (Taiyang News, 2021). To complement the build-out of solar and wind, storage has been highlighted as a critical third aspect by CanREA.

Canada

Energy Mix and Case for Storage

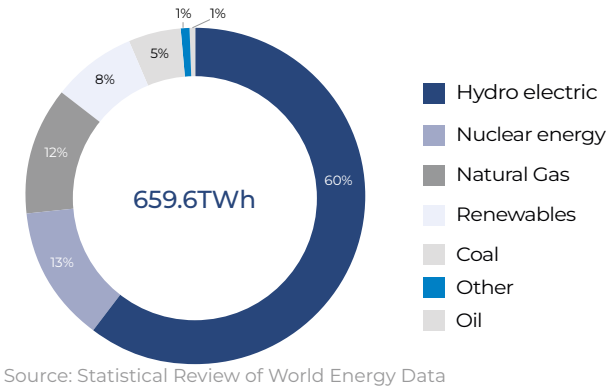
Hydroelectric power is responsible for generating almost 60% of electricity in Canada. Nuclear and renewable energy sources, which include wind and solar power, account for 13% and 8% of electricity generation respectively, as of 2022. Renewable hydropower makes up the largest part of Canada's renewable installed base, which stands at approximately 107 GW, accounting for roughly 78% of the total. However, the share of hydropower in the country's cumulative installed capacity has gradually decreased over the years as new incremental capacity has been primarily added through wind and solar energy. In 2022, solar and wind energy together contributed a cumulative installed capacity of 1.7 GW, while hydropower added 814 MW of incremental installed capacity (IRENA, 2023). Canada's renewable energy sector grew by 11% in 2023, with wind and solar together adding 2GW in generation capacity. In the process, the industry added 140MW in total energy storage capacity in 2023 (CanREA, 2024).

The cost of solar and wind power has been decreasing significantly, making them a competitive alternative to natural gas-based power in the provinces of Ontario and Alberta. Experts predict that renewable energy costs will decrease by 40% by 2035, which is when Canada aims to achieve net-zero electricity generation (Clean Energy Canada, 2023). Notably, the country's legislation provides for phasing out all unabated coal-based power generation facilities by 2030 (Canada's National Observer, 2024). Adding energy storage to the energy mix will allow wind and solar to offer cost-competitive grid power that is dispatchable, beating gas peakers and coal baseload plants.

The legal framework surrounding energy storage in Canada varies by province, given the decentralised nature of governance in the country. Ontario and Alberta have taken the lead in enacting legislation to facilitate the integration of energy storage in their power grids and market systems. In October 2022, Ontario confirmed that 1.5GW of capacity had been set aside for utility-scale battery storage out of a total requirement of 4GW of new power capacity, expected to come online in 2025 (PV Magazine, 2022). Canada is estimated to reach 5GW of battery storage installed capacity by 2030, with Ontario and Alberta accounting for the bulk of that capacity (Energy Storage News, 2023).

PSH represents another storage technology that can be potentially tapped given Canada's capabilities in hydropower, estimated at 83.7GW installed capacity, the fourth largest globally after China, Brazil, and the USA. However, PSH installed capacity is minuscule compared to 174MW installed capacity as per IRENA. This is likely to change as several PSH projects, such as the 75MW Canyon Creek PSH project (TC Energy) and the 900MW Brazeau PSH Expansion project (Power Technology, 2023), both located in Alberta, are in the pipeline undergoing technical evaluation.

Power Generation Fuel Mix as of end-2022



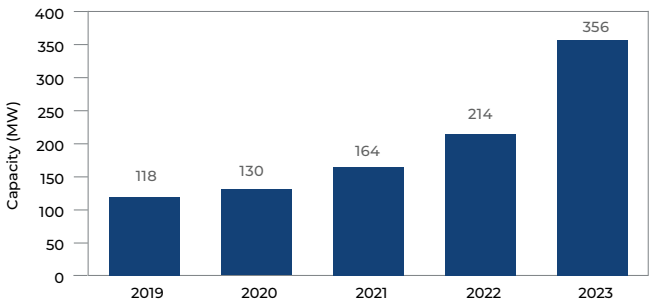
Source: Statistical Review of World Energy Data

Capacity: Status and Trend

The Canadian energy storage market is gradually gaining momentum, as evident in the rise in incremental capacity addition. By the end of 2023, 142MW of new storage capacity came online. This marks a drastic jump from the previous year's 50MW in new capacity. Furthermore, between 2019 and 2022, the total capacity base shows an over 300% rise (CanREA, 2024). A policy-led thrust by various provinces helped in achieving the growth in renewable energy and storage capacities.

Of late, the Canadian province of Alberta has been at the forefront of energy storage capacity growth. As of end-2023, Alberta contributed over 90% of the country's total energy storage capacity growth. The province has a huge pipeline of projects under various stages of development, which could help sustain the pace of growth. Another province, Ontario, leads the way in terms of total installed storage capacity (over 100MW) but not in terms of new capacities. Ontario's project pipeline and conducive policies could change its existing relative position.

Installed Energy Storage Power



Source: Canada Renewable Energy Association

Canada

CanREA's 2050 Vision document estimates requiring more than 5GW of new wind and solar capacity to be added to the grid yearly to achieve Net-Zero by 2050 (CanREA, 2023). 2GW of renewable projects are under construction, with an additional 6GW in advanced stages of development, of which 5GW is wind, 2GW solar and the balance 1GW of energy storage is expected to come online in the short term. While a majority of prevailing energy storage capacity is of the short duration of 1-2 hours, 4-8 hours long-duration energy storage (LDES) installations are being added to the pipeline and are likely to offer a very cost-competitive solution to daily electricity load management and contribute meaningfully to achieving grid stability (Clean Energy Canada, 2023).

Policy and Regulation

Canada's decarbonisation initiatives hinge on the 2035 Net-Zero electricity generation target, which factors in a scenario that involves an increase in electricity demand and the progressive phaseout of carbon-intensive generation resources. Canada's Federal Budget for 2023 allocates an estimated $25.7 billion between 2024 and 2035 through the Clean Electricity Investment Tax Credit (ITC) (Canadian Climate Institute, 2023). The ITC provides up to 30% refundable investment tax credit for the capital cost of "clean technology property", which includes a variety of energy storage solutions such as batteries, flywheels, supercapacitors, magnetic energy storage, compressed air storage, pumped hydro storage, gravity energy storage and thermal energy storage (Lexology, 2023). Funding support has also been made available through the Smart Renewables and Electrification Pathways (SREP) program, which provides $3 billion over 13 years for renewable energy and electricity grid modernisation projects (Government of Canada, 2023). Financing for storage projects is also made available through the Canada Infrastructure Bank, which allocated $10 billion for clean power and an additional $10 billion for clean growth infrastructure projects (Government of Canada, 2023).

The challenge associated with varying legislation across various provincial power markets is also being tackled by developing a Clean Energy Standard (CES) defining Clean Energy Regulations (CERs). The draft CERs were released in August 2023 and set emission standards for electricity generation expected to deliver an estimated $29 billion in net benefits between 2024 and 2050 (Government of Canada, 2023). In being technology-neutral, policymakers have tried to impart flexibility to integrating energy storage in the electricity grid, depending on provincial factors and the availability of generation assets. For instance, storage assets can be paired with hydroelectric projects to dispatch power to urban centres without investing in expensive transmission assets. Co-located with solar or wind generation, batteries can mitigate the intermittency of energy supply while enabling power dispatch at appropriate time slots.

At a provincial level, Ontario is leading the way by organising the largest battery storage capacity procurement process in Canada's history, aimed at procuring 2.5GW of new, standalone energy storage resources. RFPs for the Procurement of Expedited Long-Term Electricity Reliability Services (E-LT1) and Procurement of Long-Term Electricity Reliability Services (LT1) were started in March 2023 (Ontario Canada, 2023). The Independent Electricity System Operator (IESO) has awarded 739MW and 142MW storage capacity in two phases in E-LT1, with the LT1 process expected to procure approximately 1,600MW until April 2024 (JD SUPRA, 2023).

In Alberta, the regulatory authority approved the rules framed in Energy Storage ISO Rule Amendments, on June 13, 2023. These will come into effect on April 1, 2024 (AESO Canada). There are 19 grid-scale storage projects in the Alberta Electric System Operator's (AESO) active connection queue, two of which with a cumulative capacity of 86.5MW are under construction, while 11 are co-located storage projects, awaiting approvals in the aftermath of the provincial government's pause on new renewable energy plants till February 2024 (Lexology, 2023).

Canada

Market Developments and Opportunities

Ontario and Alberta have been market leaders for energy storage in Canada, accounting for more than 90% of the anticipated capacity (Energy Storage News, 2023). Investment into the storage sector has been mobilised from private and public sources. In Ontario, the E-LT1 contract winners include Boralex (380MW across two projects), Capital Power (114MW), and NRSTor/Northland Power (250MW). SolarBank Corporation was awarded the EPC contract valued at $26 million for three storage projects of 4.74MW capacity, each with a 4-hour discharge duration (Construct Connect, 2023). These projects are expected to be operational by the summer of 2025.

The Ontario IESO is expediting the procurement of additional battery storage capacity as shortfalls are projected from 2025 onwards due to increased demand for electricity and planned refurbishments to nuclear generation assets. The IESO expects to add 46GW of new generation capacity from current levels by 2050, requiring additional BESS capacities (Energy Storage News, 2024). In Alberta, Natural Resources Canada (NRCan) invests more than $160 million into nine solar-plus-storage projects with an aggregate generation capacity of 163MW and storage capacity of 48MW (Government of Canada, 2023).

The Alberta IESO (AESO) has reported a pipeline of 2,500MW energy storage projects in the queue for grid connections, two-thirds of which are standalone installations. At the same time, the rest are co-located with renewables or thermal-based generation assets (Energy Storage News, 2023). Other provinces, such as New Brunswick and Nova Scotia, have also launched energy storage initiatives. NB Power has invited proposals for 50MW of energy storage projects in New Brunswick. At the same time, Nova Scotia amended its Electricity Act in March 2023 to enable competitive procurement of energy storage solutions, which was previously the sole purview of Nova Scotia Power (Energy Storage News, 2023). As of February 2024, the Canada Infrastructure Bank announced a $138.2 million commitment towards the storage project to be developed by Nova Scotia Power (NS Power) (Cision, 2024).

Behind-the-meter (BTM) storage applications are expected to pick up as incentives linked to the Greener Homes Grant, which offers up to $1,000 in incentives to install batteries combined with a solar PV system (ZENO, 2022). Growth is not restricted to the residential segment alone. At a provincial level, Ontario's 'Global Adjustment (GA) electricity charge has been instrumental in driving energy storage installations within the commercial and industrial (C&I) consumer segment. Battery storage offers consumers alternate power sources during peak demand periods, thus optimising GA charges. Ontario is reported to host 225MW of large-scale BTM energy storage installations at commercial & industrial (C&I) applications to offset the GA charge. Global players such as Enel have been expanding their presence in Ontario, doubling its capacity to 37MW in 2022 from 16MW a year earlier. Sustained expansion in Ontario is central to Enel's $5 billion investment programme in North America, buoyed by supportive factors such as growth in electricity demand, growing electrification of industries and declining battery technology costs (Sustainable BIZ Canada, 2023). The Imperial's Sarna petrochemical complex is developing North America's largest BTM battery storage system, having an installed capacity of 20MW, owned and operated by Enel X. Its participation in Ontario's demand response program will help establish the feasibility of using distributed energy resources (DERs) in decarbonisation initiatives.

Most of the energy storage procurement done to date has been primarily short-duration (4 hours or lesser discharge). As the role of energy storage in Canada's energy transition plan expands, the focus will shift to long-duration energy storage (LDES). Notable LDES projects in Canada include the 174MW OPG pumped storage hydro (PSH) project in Niagara Falls. Other major PSH projects that are proposed include the 400MW Marmora project at an abandoned iron ore mine in Ontario and three others across Alberta (2) and Georgian Bay in Ontario (1) (Canada's National Observer, 2023). The Canadian energy company TC Energy is working on developing a new revenue framework for its planned $3.3 billion PSH project that has been in consideration since 2019 but held up for an official sign-off. With recent inputs from the Ontario government, this company aims to submit the proposed revenue framework by July 2024, after which construction can commence subject to approval. The proposed plant is for 1GW of long-duration storage capacity (Energy Storage News, 2024).

In April 2022, the Canada Pension Plan Investment Board (CPPIB) committed $25 million in investment into Hydrostar, a leading long-duration energy storage solution provider, to develop Advanced Compressed Air Energy Storage ("A-CAES") facilities (CPP Investments, 2022). This follows Goldman Sachs Asset Management's recently announced $250 million investment into Hydrostar (Hydrostor, 2022). Public funding for energy storage has also been available through the Department of Natural Resources or NRCan. Initiatives such as the Charging the Future Challenge, launched in 2019, aim to accelerate battery technology innovations.

The energy storage sector's long-term growth depends on access to various services within the electricity grid. This would open up potential revenue streams that would enhance the financial viability of storage assets. CanREA's position paper to promote energy storage identifies 13 service areas, such as capacity, peak shaving, voltage support, frequency regulation, and demand charge reduction. However, existing market structures and payment mechanisms will need to be modified to accommodate the characteristics of energy storage projects to mobilise investment.

Canada

Outlook

Canada will reach at least 5GW of cumulative battery storage capacity by 2030 based on the prevailing project pipeline. Trade Association has projected a requirement of 8-12GW of energy storage capacity by 2035, factoring in catalysts such as substantial growth in demand for electricity (electricity demand in Ontario to average 1.7% annual growth over the next two decades), growing electrification of processes in key manufacturing industries and replacement of capacity vacated by emitting generation sources (Energy Storage News, 2022).

The Canadian regulatory authority projected battery storage power capacity to reach 6GW by 2050 to meet the requirements of Canadian Net Zero objectives (Canadian Energy Regulator, 2023). Hydrogen and hydro power are other sources which may supplement the battery storage capacity addition in the projected energy mix by 2050.

The subsequent growth stage can revolve around developments in the LDES segment. Industry working groups have begun consultations that will eventually enable supporting fiscal benefits such as preference within the tax credit scheme to spur investments. Additionally, increased transparency into remuneration mechanisms for a growing portfolio of ancillary services is likely to attract vital private investment into the sector.

Mexico

GDP (Current Prices) USD (2022)	1,466 bn
GDP Growth Forecast (constant prices) (2023-2027)	2%
10yr Govt Bond Yield (12-month rolling average)	9.16%
Country Credit Rating (S&P)	BBB
Battery Storage Capacity	NA
Pumped Hydro Storage Capacity	NA
RE share of Total Electricity Capacity	31.20%
Battery Storage Outlook (Power Capacity)	4.6GW by 2036

Source: IMF, Investing.com, S&P Global, Energy Institute, REGlobal

Energy transition initiatives have continued to decelerate in Mexico, as the administration of President Andrés Manuel López Obrador (AMLO) favoured backing state-owned enterprises such as national oil firm Pemex and power utility CFE. The reversal in climate change initiatives has seen Mexico's share in Latin American clean energy investments decline from 35% in 2017 to 7% in 2022 (Infrastructure Investor, 2023). Consequently, Mexico lags behind its peers, such as Brazil (1st position), Chile (4th), and Colombia (6th) in the Energy Transition Index. Decarbonisation targets have been scaled down, raising uncertainty about the country's ability and intent to chart a path to Net Zero by 2050.

The Mexican government has pledged to generate 35% of its electricity from clean sources by 2024, with an additional 5% subject to international support. However, including natural gas as a clean energy source has diluted the significance of this development. Despite the lack of political support, supporting market dynamics and favourable geographical conditions have contributed to a 50% increase in the share of renewables in electricity generation in the last five years.

Mexico

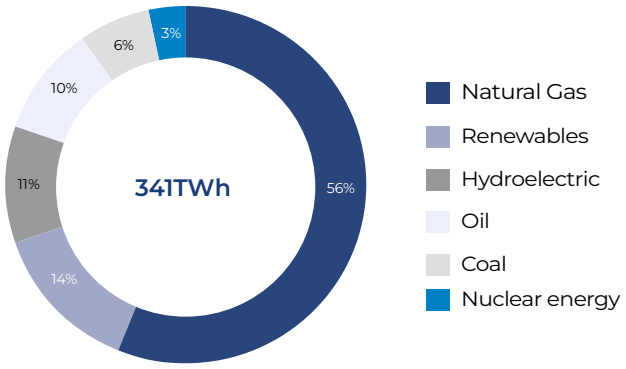
Energy Mix and Case for Storage

About 56% of Mexico's power generation is gas-based, with renewables and hydroelectric power constituting ~25% share cumulatively. Renewables accounted for 31% of the country's cumulative installed capacity of 102GW in 2022 (IRENA, 2023). Of the 31.9GW renewable installed capacity, hydropower accounted for the largest share (13.3GW), followed by solar PV (9.3GW) and onshore wind (7.3GW).

Mexico has continued to slip as a destination for renewables investment as policy support waned in the aftermath of the current administration coming to power in 2018. Policy reversals have dampened investor enthusiasm, including a reversion to fossil fuels and a proposal to roll back foreign investment in Mexico's energy industry.

The government, on its part, announced supportive measures in favour of renewable energy expansion. At COP27 in November 2022, Mexico's Foreign Minister Marcelo Ebrard committed to adding 30GW to the country's renewable installed base by 2030. $48 billion in government funding was outlined to achieve a combined solar and wind installed capacity of 40GW, more than double that of prevailing levels (Mexico Energy, 2023). However, the support for renewables and energy transition has been aligned along partisan lines depending on political affiliations and related biases. This was evident in the defeat of the Energy Reform Bill in the Mexican Congress in April 2022 through concerted efforts by opposition parties. The judiciary has also played a role in protecting investor interests. In 2023, the Mexican courts nullified the regulatory decision to designate natural gas as a clean energy source (Mexico Business News, 2023).

Power Generation Fuel Mix as of end-2022



Source: Statistical Review of World Energy Data

Capacity: Status and Trend

The prevailing regulatory framework in Mexico has not supported the development of the energy storage market, which continues to be marginal. However, the increased proliferation of renewables, estimated to average around 2.5GW of solar and 1.3GW of wind annually between 2023 and 2030, in the country's electricity grid has shifted focus back to energy storage (Mexico Business News, 2023). Consequently, individual projects are being developed, but these are not evidence of a broad-based shift in investor interest towards energy storage.

Notable projects include a 190MW storage project co-located with the 1GW Puerto Peñasco solar PV plant developed by Quartux (Energy Storage News, 2023). Quartux has also made inroads into the commercial & industrial (C&I) segment with major deployments at hotel sites and had indicated a pipeline of 300MWh as of October 2022 (Energy Storage News, 2022). Similarly, On. Energy has indicated an operational pipeline of 65MWh primarily comprising behind-the-meter (BTM) applications for the C&I segment (Mexico Business News, 2023).

Restrictions on trading energy on the wholesale markets placed by the AMLO administration have limited the development of the energy storage market to the BTM segment. There continues to be a strong case for sustained penetration of energy storage within the C&I segment, mainly as BTM installations offer scope to rationalise capacity charges, which constitute almost 20-40% of the electricity bill, through peak shaving (Energy Storage News, 2022). While the limited scope of the revenue stack for grid-scale energy storage projects has moderated investor interest, the government has outlined ambitious plans by stating a target of 4.6GW of utility-scale battery storage during 2022-36 in its PRODESEN (National Electric System Development Program) plan (REGlobal, 2022).

Mexico

Policy and Regulation

The energy storage sector in Mexico continues to be unregulated, with no specific laws defining it or governing its use. Consequently, there is limited visibility on the incentives associated with battery storage projects, which has deterred private investment. It is generally regarded as a limited source of energy generation that must adhere to some requirements to inject power into the grid for a short duration.

While there are no specific incentives for energy storage, it is presumed that its classification as a source of energy generation would make it eligible for the same incentives offered to renewable energy. In this case, projects are presented with accelerated depreciation for tax purposes. Without a legal definition of energy storage and ambiguous market regulations, the development of the industry has been stunted. While there are isolated large battery installations in the country, the regulatory uncertainty and the perceived absence of a policy push have worked to deter any substantial investment in the sector, either domestic or foreign.

Regulatory changes since May 2020, skewed the power market in favour of the state-owned utility CFE (Comisión Federal de Electricidad) (Reuters, 2022). Most detrimental among all changes were the curtailed open access to private market participants and arbitrary methods of evaluating interconnection requests. The new policy also authorises new ancillary services for the grid's stability and safety, in addition to existing services that already receive remuneration, such as reactive reserve, reactive power and grid re-energization. Energy storage will likely be commercialised as an ancillary service under the wholesale electricity market, with frequency response and regulation as the key focus.

The Mexican energy market's practice of demand average formula instead of dynamic pricing based on real-time supply and demand, have deterred the development of the storage market (LinkedIn, 2023). Most storage companies base their business models on demand-saving methods that involve storing energy during low demand and discharging during peak demand to deliver savings. Such models' financial feasibility is adversely impacted when the demand average is factored in.

The nationalisation of the considerable lithium deposits in the country in April 2022 added to the uncertainty within the private sector. The newly created state-run enterprise LitioMx lacks the technical skill or the capital to exploit the clay-based lithium deposits, estimated to amount to 1.7 million tons (Reuters, 2023). In February 2023, a Presidential Decree designating a 900 square-mile lithium mining zone in northern Sonora was notable as a first step towards granting exclusive exploration rights to LitioMx, further deepening the uncertainty among private investors.

Market Developments and Opportunities

Recent adverse legislative changes have made it harder to trade energy on the wholesale market, thus stymying the development of utility-scale energy storage. Consequently, the BTM C&I segment will likely drive growth for energy storage in Mexico in the short term. Mexico's substantial base of industrial facilities presents a significant scope to deploy battery storage in industrial microgrids. Such deployment can enable industrial consumers to secure reliable power supply and optimise consumption curves, delivering 20-40% savings on electricity costs by avoiding peak hour tariffs. This is evident from the major battery installations in Mexico that the C&I segment has primarily commissioned.

Recent examples are a 25MWh BESS system integrator Quartux and battery storage technology provider Sungrow installed in Cancun in August 2023 to provide peak shaving and backup power services to unnamed customers in the area (Energy Storage News, 2023). Revolve Renewable Power Corp operationalised a 3.2MWh battery storage unit at a hotel chain site in Cancun in May 2023 (Revolve, 2023). The Quartux installation is purported to be the largest C&I battery installation in Latin America.

Even with the limited market growth and political flux, there are new business models in consideration. One example is the energy storage-as-a-service business of Fotowatio Renewable Ventures (FRV), US-based energy analytics and software company Energy Toolbase and local developer Ecopulse. Consumers are not required to make upfront capital expenditures on installation. Instead, the project partners will be paid by sharing the electricity savings in a model similar to what Stem Inc. and Enel X have offered C&I customers access to energy savings via battery storage in the US and Canada. The first installation under this model will be a 480kW two-hour Li-ion BESS in the Mexican industrial region of Iztapalapa (Energy Storage News, 2022).

The possibility of developing the domestic energy storage supply chain offers an additional upside potential to the market. Despite the uncertainty introduced by nationalisation of lithium resources, broader global efforts to pivot away from a China-centric battery supply chain in favour of nearshoring is likely to benefit Mexico. Global battery manufacturing major CATL has been reported to be scouting for sites in Mexico to establish what can be Latin America's first Li-ion cell battery gigafactory. The leading battery storage system integrator, Powin, had already shifted its assembly plant to Monterrey. In March 2023, Tesla announced its plans to open a battery gigafactory in Nuevo Leon state, with the total investment amount pegged at $15 billion over two years (Reuters, 2023).

Mexico

Hybrid renewable energy plants, particularly solar-cum-storage installations, constitute another significant growth driver for energy storage in Mexico. State-owned utility CFE is constructing a 190MW battery storage unit co-located with a 1GW solar PV project, which is due for completion in 2028 (Energy Storage News, 2023). Wind energy projects have also started incorporating storage elements, as evidenced by the 50MW Eolica Coromuel wind farm, which has a 10MW BESS onsite, supplied by Wärtsilä, and was operationalised in October 2022 (Bussiness Wire, 2022).

Outlook

Mexican policymakers are shifting focus to energy storage to stabilise the power grid despite the increased share of renewables in power generation. The PRODESEN 2022-36 Plan outlines an addition of 56GW of generation capacity, of which 4.6GW has been allocated to battery energy storage systems (BESS) (REGlobal, 2022). However, only 72MW of BESS integration is planned for 2022-25, implying continued sluggish growth for the energy storage market unless there is a rollback in policy steps after the elections due in June 2024.

There are expectations that the upcoming elections realign Mexican energy policy and its investment climate. The contenders of the presidential elections pledge focus on renewable energy capacities for decarbonization. Energy transition could be among the major areas that the incoming government could take up (Argus, 2024). The emphasis on renewable energy projects is widely agreed as an indication of prioritization towards climate change and clean energy, contrasting the current regime's stance (New York Times, 2024).

A rising renewable energy project pipeline is helping drive the co-located storage units. The Delicias solar park in Guanajuato, which includes a green hydrogen production plant and a battery storage unit of unspecified capacity, is expected to start construction in June 2024 (BNAmericas, 2023). Similarly, the Neptuno 1 solar park in San Luis Potosí state is focused on green hydrogen production with a battery storage component and has been in the environmental review process since June 2021. BTM applications for the C&I segment are expected to drive growth in the short term as companies such as Grupo Bimbo, Walmart and others look to achieve savings of 35% or more on their utility bills, besides ensuring stability in power supply (Mexico Business News, 2023).

The lack of a concerted policy push and supportive regulatory environment continues to be an overhang on the growth potential of the energy storage sector in Mexico. A holistic approach requiring the involvement of research institutions, policymakers, and financial institutions will be needed to develop a mechanism to make storage projects financially feasible. Lack of clarity on financial returns remains a crucial challenge to widespread adoption and investment since remuneration mechanisms on possible revenue streams are absent.

United States

GDP (Current Prices) USD (2022)	25,463 bn
GDP Growth Forecast (constant prices) (2023-2027)	2%
10yr Govt Bond Yield (12-month rolling average)	4.04%
Country Credit Rating (S&P)	AA+
Battery Power & Storage Capacity	61.4GWh/ 15.4GW
Pumped Hydro Storage Capacity	550.0GWh/ 22.0GW
RE share of Total Electricity Capacity	29.50%
Battery Storage Outlook (Power Capacity)	66.0GW by 2027

Note: Battery Storage Capacity Expressed in GWh assuming an average 4 hours of duration.

Source: IMF, Fred Economic Data, S&P Global, EIA, Department of Energy, Energy Institute, Wood Mackenzie

The US energy storage market is the world's largest and is poised for outsized growth to support the influx of renewable energy generation. Critical systemic requirements such as network reliability, capacity planning and clean power procurement are setting the pace of change in the US energy storage market. An outsized growth in solar PV projects and the policy incentives for cleaner energy sources reinforce the business case of energy storage. For most of the grid operators, battery storage is progressively an integral part of the long-term procurement plans.

United States

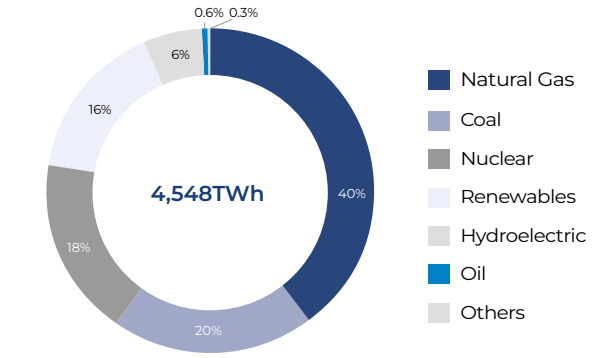
Energy Mix and Case for Storage

The US energy mix is in the middle of a rapid transition in favour of renewable energy. The share of natural gas, which dominates the power generation mix, has been within the ballpark of 40% between 2019 and 2022 (Energy Institute, 2023). The share of renewable-based generation rose from 11% to 16% during the same period. The trend reflects the growing competitiveness of renewable energy, led by wind and solar, in grid-connected power generation. Lazard's estimates on the unsubsidised levellised cost of energy show utility-scale solar PV at $24/MWh - $96/MWh. A typical combined cycle gas power plant stands at $39/MWh - $101/MWh (Lazard, 2023). The gap is wider when compared to coal-based power.

Progressively, there is a stronger case for retiring coal-based power generation capacity. The cost economics suggest that a new solar PV plant in the US could be cheaper than running an existing coal-based plant. The plant operators, thus, may find it challenging to schedule coal-fired power against cheaper options in the grid. In 2024, coal-fired power plant retirements are projected in the range of 6-8 generation units. In 2023, the same stood at 22. A lesser number of retirements in 2024 is only due to the delayed phaseout schedule and grid operators' push to temporarily retain them to bridge short-term reliability demand (Argus, 2024). Displacement of coal-based power with cheaper natural gas and renewable energy capacities is already a foregone conclusion across power market regions. At the same time, such a transition also implies pressure on network operators to accommodate renewable energy against a falling share of a baseload power source, such as coal.

In varied measures, grid-scale battery storage is finding traction in the US energy markets as operators seek options in flexible energy. This includes standalone battery storage units and hybrid renewable-plus storage projects through which developers tap into the wholesale power market.

Power Generation Fuel Mix as of end-2022



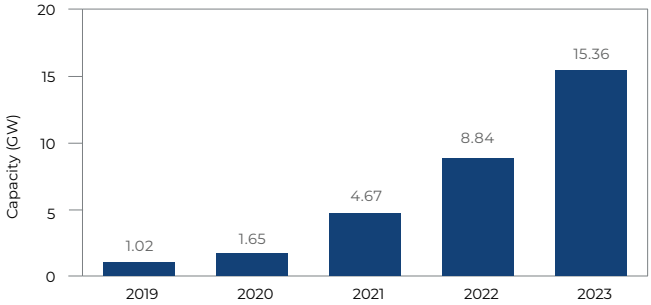
Source: Energy Institute Statistical Review of World Energy

Capacity: Status and Trend

As observed in the reported nameplate operational capacity, installed battery storage capacity in the US power market grew over 15 times between 2019 and 2023 (EIA, 2024). But for the grid constraints, the operational capacities would have been even higher for the year. The power capacity ratings of the operational storage units range from 1MW to 409MW. A significant share of the incremental storage capacity is due to the co-location of batteries with renewable energy generation projects. Till the passage of the direct policy incentives for battery storage in August 2022, co-located battery storage was a preferred route due to the prevalent tax incentives. Over the year, co-location declined in relative importance. Meanwhile, standalone batteries continue to gain momentum with evolving power market norms allowing incentives for grid services.

The installed battery storage capacity is spread across 39 states. About 80% of the storage capacity (In energy terms) is concentrated between California, Texas, and Florida. This is due to the conducive regulatory framework that incentivises standalone battery units through wholesale power market participation for grid services. Rapid scale-up in renewable energy capacities and the resulting changes in the grid made some of the states take a leading role in adopting flexible options like battery storage. The state-wise growth of energy storage is mapped one-for-one with renewable energy generation or penetration and related bulk power market structure.

Installed Battery Storage Power Capacity



Note: Data refers to nameplate operational capacity reported as of December of every year.

Source: US Energy Information Administration (Monthly generation reports)

United States

The total installed storage capacity is thus skewed towards the utility-scale segment. This will likely be this way, as grid management is the primary demand driver in the US storage market. Notably, the grid services segment is gradually poised to expand as network operators consider changing the market structure for battery storage options. The competitive cost of batteries against the competing options in conventional fuels (mostly natural gas) is another supporting factor in the emerging scenario. In contrast, the growth in residential and commercial segments depends on volumes. Residential and commercial solar units are the key avenues for the deployment of batteries (both grid-connected and off-grid).

Policy and Regulation

There are no national-level standard rules or a centralized regulatory authority for energy storage. In its 2018 order, for instance, FERC directed all the Regional Transmission Organisations (RTOs) and Independent System Operators (ISO) to ensure an updated tariff structure that recognizes the specific energy storage characteristics for market participation (Utility Dive, 2023). Since then, the progress in formulating appropriate regulations has been through the respective state authorities or the regional RTOs/ISOs. The existing system is thus a complex combination of states prescribing varied norms in the energy storage capacity addition. The energy storage requirements in many states have been a part of their renewable purchase standards. In a few others, there are explicit targets. California, for instance, mandates utilities to install storage units (Reuters, 2023). In Texas, however, the growth stems from the boom in utility-scale solar PV projects. Both states have renewable energy penetration at the core battery storage regulations.

The Californian wholesale power market CAISO's resource adequacy rules incentivise four-hour batteries. In Texas, there are ancillary services regulations incentivising two-hour storage. In many regulatory markets, the four-hour storage duration has gained currency, enabling utilities to provide such capacities during the peak summer demand time. A few other states, such as New York, Massachusetts and Connecticut, have incentives for smaller retail and commercial battery systems to ensure a wider adoption of the storage capacity.

Distributed energy resource participation is another vital segment poised for expansion with FERC's regulatory directions. In its order of September 2020, FERC asked all the authorities to remove barriers to the participation of distributed energy resources for electrical energy, capacity, and ancillary services in the wholesale power markets. The full implementation of this could be a long-drawn process. California and New York's ISOs have already met this, while others sought extension or are in the roll-out process.

About 15 US states have some form of energy storage policy support in place, including procurement targets, regulatory norms on integration, technology demonstration projects, incentives, etc (Morgan Lewis, 2023). States with specific procurement targets include California, Oregon, Nevada, Illinois, Virginia, New Jersey, New York, Connecticut, Massachusetts, and Maine. Procurement targets help act as signals for investors and enable a stable visibility for project development.

A major boost for the energy storage pipeline came with the Inflation Reduction Act (IRA), which came into effect in August 2022. Aimed primarily at funding clean energy investments, the US IRA's major support lies in its Investment Tax Credit (ITC) for standalone battery storage projects. The tax credit helps improve the cost economics of the battery projects, which earlier availed such a benefit only through co-located or generation-paired storage schemes (Energy Storage News, 2023). Further, IRA's Energy Community Tax Credit Bonus program provides an additional 10% in tax credits for the solar and storage projects set up in locations of closed coal-fired power stations (Reuters, 2023).

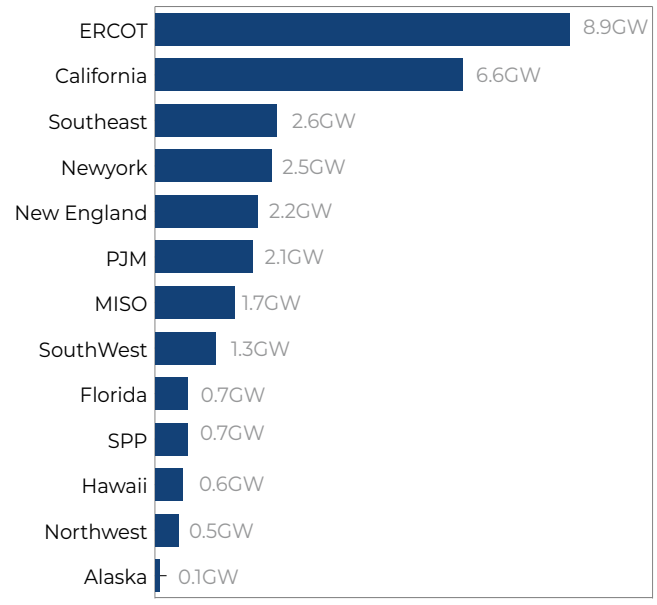
United States

Market Developments and Opportunities

Policy objectives and related regulatory steps for decarbonisation and renewable energy penetration set the base for the US energy storage market. The existing and emerging battery storage pipeline is shaped by the utility-scale solar PV market. The US grid interconnection queue is one indicator of the emerging demand. As of August 2023, out of the total tracked capacity worth 2,050GW in the queue for grid connection, there were 473GW of standalone batteries and 690GW of hybrid renewable plus battery storage projects (S&P Global, 2023). Added momentum is from IRA's incentives for standalone battery storage projects.

The change in incentive structure due to IRA impacted the project pipeline. IRA's tax benefits for the standalone battery projects blunted the importance of hybrid/co-located storage projects. Till the IRA's passage, the co-located projects had an edge due to the tax advantages. By the end of Q3 2023, about half of the storage projects in development were hybrid – a stark difference against their 70% share in 2022 (Reuters, 2023). The trend of the rising share of standalone battery projects is likely to be sustained, as planned coal retirements present a significant opportunity for investors and policy authorities alike. There is, therefore, a significant capacity boost expected across the US wholesale power market areas due to IRA incentives (PV Magazine, 2023). Projections show that the potential varies due to the relative progress of solar and battery capacities in those respective regions.

IRA-led Potential Additional Storage Build in the Power Market Regions



Source: PV Magazine

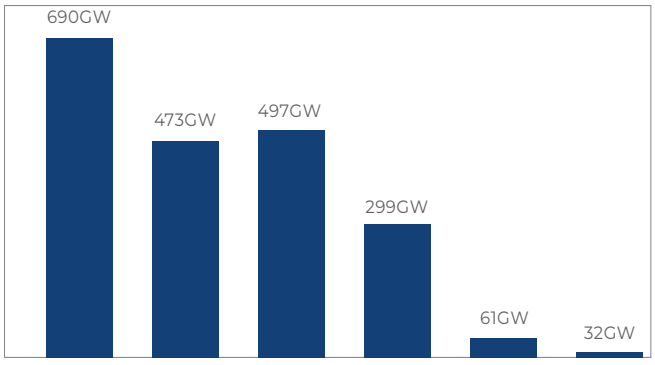
Federal incentives are available for emerging long-duration energy storage technologies. The US Department of Energy's $325 million funding package is aimed at storage technology projects across 17 states. Funded under the US Bipartisan Infrastructure Law, the objective is to progress the commercial viability of long-duration storage through a set of demonstration projects (Tamarindo, 2023). Some of the leading states have taken the same route. New York's $15 million funding for four demonstration projects is one example (Utility Drive, 2023).

The regulatory measures by the ISOs and RTOs are critical in attracting capacities. For instance, ERCOT provides an energy-only market where generators are paid only after providing power to the grid daily. This is an attractive scenario for developers to tap into the battery storage demand segment (Thomson Reuters). The California Public Utilities Commission requires load-serving entities to procure an additional 11.5GW of between 2023 and 2026 from preferred sources, including energy storage (CPUC GOV, 2023). In 2023, the utility PGE procured 400MW of battery storage capacity for peak demand management. PGE's storage procurement stemmed from the Oregon Public Utility Commission's mandate to procure storage capacities under the overarching goals of clean energy share. Other utilities face similar mandates based on which capacities will be selected through competitive bidding (Energy Storage News, 2023).

In the last 2-3 years, the co-located storage projects emerged as a major growth driver in the US market. The fiscal incentives (investment tax credit in the US) played an important role in the spike of such projects. A subsequent re-alignment of incentives in favour of standalone battery storage took place with the Inflation Reduction Act (IRA) that came into effect in August 2022. This helped moderate the skew. About 60% of the total capacity (as of June 2023) awaiting grid interconnection, was towards either hybrid (i.e. batteries co-located with generation) or standalone battery storage projects (S&P Global, 2023).

United States

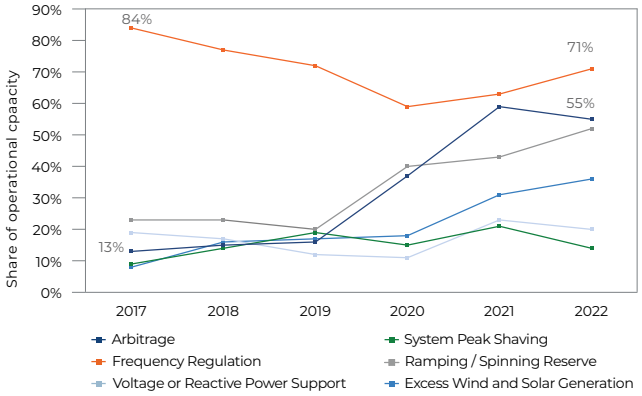
US Grid Interconnection Capacity Queue



Note: Data above is as of June 2023

Source: S&P Global

Major Areas of Battery Storage Application in the US Power System



Note: (a) Data represents a select set of applications among others reported in EIA publication. (b) Grid-scale battery systems are typically deployed for more than one application.

Source: EIA Annual Generation Reports till end of 2023

Grid management services are among the most important applications driving demand for battery-based storage. An indication to this effect is evident from the capacities in queue for interconnection requests. About 60% of the total capacity (as of June 2023) awaiting grid interconnection, was towards either hybrid (i.e. batteries co-located with generation) or standalone battery storage projects (S&P Global, 2023).

The US has New York's grid operator (New York Independent System Operator, or ISO) evaluating the pros and cons of deploying storage assets to operate as the state's power transmission network (NYISO, 2023). In the regulatory context, it means treating the grid-connected energy storage as a transmission asset, in addition to being a generation asset. In effect, it means the storage assets could contribute as non-wire alternative to the transmission network to enable dispatch and management of the generated energy. NYISO's proposal has an obvious background in the ambitious renewable energy penetration targets (70% by 2030 and net zero by 2040) and a massive transmission buildout to support it.

Outlook

The US Energy Information Administration, in its estimates of January 2024, projected installed battery capacity reaching 30GW by 2024, if the projects under pipeline are commissioned in time (EIA, 2024). In effect, this means a doubling of the existing capacity base. Such an outlook also means the battery storage capacity outstripping some fuel types in the power mix, such as petroleum liquids, geothermal, wood and wood waste. The outlook for the period beyond 2024 is equally bullish across all studies. Wood Mackenzie's projections for 2023-2027 point to 66GW of energy storage capacity installation, with over 80% of them as utility-scale ones.

Notably, the planned storage capacity expansion is likely to get added support from a decline in costs. Projections by the US National Renewable Energy Laboratory show a declining trend in the cost of four-hour battery projects based on Lithium-Ion technology. By the end of 2030, the per-unit costs could potentially halve, lending competitive strength to the commercialization of grid-scale storage (Energy Storage News, 2023). At the same time, the technology dynamics of energy storage could change with ongoing efforts underway.

The provision of timely interconnection continues to be a systemic issue in the industry. This will impact the commercials for energy storage projects. As observed in the curtailment of capacities, the rising delays due to transmission constraints have already begun impacting the industry. With IRA incentives, the manifold rise in a capacity pipeline may have intensified the pressure on the interconnection queue. The investment commitments, such as the Department of Energy's $3.5 billion funding (S&P Global, 2023) as a first tranche of spending for grid expansion, could help mitigate the challenge.

Key Regional Markets - South America

Brazil

GDP (Current Prices) USD (2022)	1,920 bn
GDP Growth Forecast (constant prices) (2023-2027)	2%
10yr Govt Bond Yield (12-month rolling average)	11.29%
Country Credit Rating (S&P)	BB
Battery Storage Capacity	250.0MWh
Pumped Hydro Storage Capacity	NA
RE share of Total Electricity Capacity	84.30%
Battery Storage Outlook	NA

Source: IMF, tradingview.com, S&P Global, ETN, Energy Institute

Brazil has started to revise its decarbonization targets and climate change policies in sync with the new administration of President Lula, which began in January 2023. Previously, the country had pledged to reduce its greenhouse gas emissions by 37% by 2025 and by 50% by 2030, ultimately leading to the milestone of achieving net-zero emissions by 2050 under the Bolsonaro administration (World Economic Forum, 2023). In September 2023, these targets were revised to a 48% reduction by 2025 and 53% by 2030 compared to 2005 levels (Argus Media, 2023). In addition, a new target of achieving zero deforestation by 2030 was announced. It is estimated that the revised targets would require an investment of over $200 billion, more than double the $100 billion in funding that has been committed so far. Decarbonisation of the energy sector will remain a top priority in Brazil. A target to achieve a 45% share of renewables in primary energy demand by 2030 will require 81GW of renewables capacity, excluding hydropower, within that timeframe (CIF, 2021). This is expected to trigger the buildout of utility-scale energy storage in the country, which has traditionally been skewed towards distributed storage.

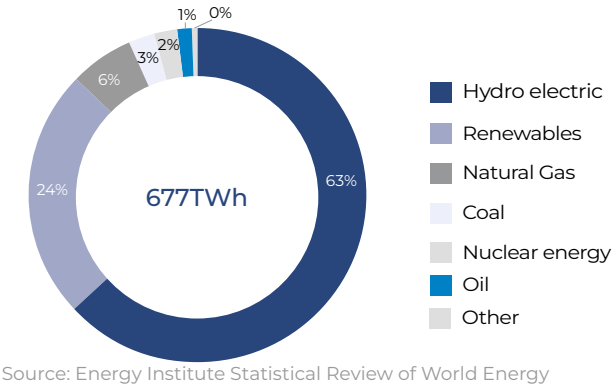
Brazil

Energy Mix and Case for Storage

Brazil has a unique energy mix, with hydropower being the main source of electricity generation. In 2022, hydropower accounted for 63% of Brazil's total electricity generation (Energy Institute's Statistical Review of World Energy), making it one of the world's least carbon-intensive energy sectors. Brazil's energy transition involves shifting towards renewable energy sources such as wind and solar, with abundant natural resource. According to IRENA, in 2022, out of the 14.5GW of additional capacity installed, solar and wind accounted for approximately 13GW, with solar PV being the largest contributor at 9.9GW (IRENA, 2023). This trend towards solar and wind power is expected to continue, which will increase renewable energy capacity, but also the amount of intermittent energy supplied to the grid.

Auction-based capacity allocation has played a crucial role in the development of the renewable energy industry. In May 2023, the government released its Electricity Transmission Grants Plan (POTEE), outlining three planned auctions. The first auction resulted in an investment of BRL 15.3 billion ($3.2 billion), which allocated more than 6,000 km of transmission network capacity in June 2023 (The Brazilian Report, 2023). The second power transmission auction, held in December 2023, attracted significant interest with massive discounts offered by companies to secure contracts (Valor, 2023), with a value of BRL 20 billion. The third and final auction is scheduled for 2024, also with a value of BRL 20 billion (Renewables Now, 2023). The second power transmission auction, held in December 2023, attracted significant interest with massive discounts offered by companies to secure contracts (Valor, 2023).

Power Generation Fuel Mix as of end-2022



Source: Energy Institute Statistical Review of World Energy

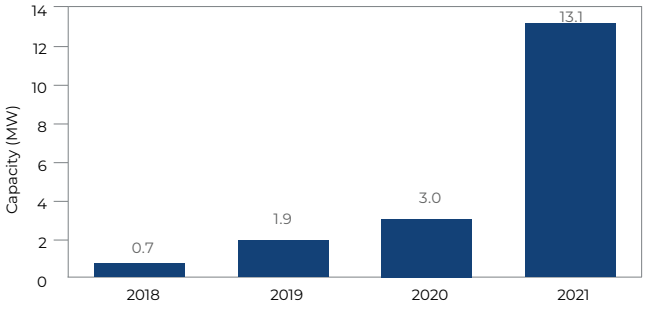
The upcoming bidding in March 2024 could sustain the same momentum, as power network capacity is crucial to support the buildout of renewables-based generation capacity, which added 5.1GW in the first half of 2023, accounting for ~84% of the incremental capacity added (Mercom, 2023).

Despite significant investments, Brazil's transmission infrastructure lags behind the addition of renewable energy capacity, with an expected average of 3-5GW annually over the next decade (BNAmericas, 2023). As transmission capacities catch up, energy storage solutions will become a vital component of network management as the share of intermittent renewable energy rises. Even with abundant hydro power resources, the case for battery-based storage strengthens each day due to its multiple functionalities in grid management.

Capacity: Status and Trend

Brazil's energy storage market remains a marginal one with an estimated capacity of 250MWh, comprising primarily of rural and rooftop installations (ETN, 2023). Solar PV-based distributed generation represents an attractive growth opportunity for the storage market. In 2023, the predominantly solar-based distributed generation capacity reached 24.4GW, contributing about 11% to total power generation (Renewables Now, 2023). Policy and regulatory focus on distributed generation ensured that battery growth picked up. Conventionally, lead-acid battery systems have been used for small off-grid generation systems. In commercial applications involving relatively higher capacity, off-grid applications have had hybrids such as solar-diesel-battery combinations gaining currency due to the benefits in both costs and emissions. Such applications are also deployed in isolated communities and rural/agricultural consumer segments.

Aggregate Energy Storage Power Capacity



Source: BNEF

Brazil

Utility-scale energy storage segment has a negligible share in the Brazilian power system, although steps are being taken to address this. In December 2022, Brazil's first utility-scale BESS project, offering 30MW/60MWh capacity, located on the south coast of Sao Paulo, commenced operations (PV Magazine, 2022). The absence of a regulatory framework defining the incentives and payment mechanisms for energy storage projects has long hampered market development. However, this will likely change in the short term as policymakers evaluate using energy storage in future energy auctions. With about 12GWof utility-scale solar capacity as of end-2023 (Renewables Now, 2024), colocation of storage capacities is a likely next step for developing the utility-scale energy storage market.

Policy and Regulation

For a long time, Brazil's energy storage segment was not given priority in its policy and regulatory structure. This may have been due in part to the country's predominantly hydropower-based power system. However, with the significant increase in renewable energy, there has been a shift in the scenario. Despite this, the response in terms of policy and regulations has been slow. Nevertheless, the growing adoption of renewables-based generation is leading to a reassessment of utility-scale storage's role in managing the grid.

The Brazilian government announced in September 2023 that it is considering the feasibility of including energy storage in the upcoming power reserve auction scheduled to take place in the first half of 2024 (Reuters, 2023). Various options are being considered, including hybrid renewable energy projects with collocated storage capacity and standalone battery storage projects. In addition, battery storage is being considered as a replacement capacity for remote communities in the Amazon region, which were previously reliant on diesel generators. However, the development of the energy storage market is unlikely to occur significantly until regulatory changes are made public.

The regulator's recent guidelines for the distributed generation segment could indirectly benefit battery storage. In January 2022, updated norms on distributed generation were introduced that require all capacities to be included under the net metering regime from 2023 onwards. This move will make it easier for solar PV-based prosumers, who inject net surplus generation back to the grid, to use battery storage. Under the previous regime (without net metering), such capacities would have had to pay fees to inject excess energy into the grid.

Development of the utility-scale energy storage market has been primarily driven by the regulator ANEEL through a 3-year R&D programme that started in 2016. There are 30 such projects, which include various storage technologies besides Lithium-Ion, to establish feasibility (BNAmericas, 2023). The first of these projects, a 30 MW/60 MWh BESS operated by the transmission system operator (TSO) ISA CTEEP, became operational in December 2022 (PV Magazine, 2022). The results from these projects as more become operational in the coming months and years will likely shape the regulations for grid-scale storage.

Brazil

Market Developments and Opportunity

Although the adoption of utility-scale storage projects has been slow, they are gradually gaining traction. TSO ISA CTEEP's 30MW/60MWh project went online in December 2022 after receiving approval from the regulator ANEEL in 2021. The project was developed with an investment of $27 million and is allowed, under regulations, to generate annual income of up to $5 million by operating as a backup power source during peak electricity demand. This project is an example of "storage-as-a-transmission asset" and provides a less expensive alternative to traditional transmission lines (Energy Storage News, 2023). Another example is Vale's 5MW/10MWh lithium-ion BESS project at a large port facility in Rio de Janeiro, launched in September 2020 (BNEF, 2020).

The pipeline of utility-scale solar PV projects in the country can be a significant driver of demand for grid-scale energy storage. This is because hybrid projects that combine solar and storage configurations are becoming more prevalent. The lack of timely grid connectivity can reinforce the need for linked-storage systems.

There are pilot projects underway to assess the feasibility of new storage technologies. A recent example is a 1MWh thermal energy storage project by an Israel-based company, Brenmiller Energy, in partnership with Fortlev, the largest provider of water storage solutions in Brazil. The project became operational in August 2022 and is a pioneering initiative in the region to use renewable-based (biomass in this case) thermal energy stored in crushed rocks for subsequent use in manufacturing processes as a process-heat application. The system can also discharge electricity based on a steam turbine.

Off-grid energy storage in Brazil presents more significant opportunities in the near term than the utility-scale segment. Battery-based energy is a competitive option in several Brazilian states due to the substantial difference between peak and off-peak tariffs. A study by consulting entity Greener (as of July 2022) found that for a typical commercial/industrial consumer, the difference between peak and off-peak tariffs in the state of Rio Grande do Norte stood at $R3.004/MWh. The study also found that battery storage translated to 36% savings on the tariff.

Outlook

The energy storage market in Brazil is new and underdeveloped due to the lack of supportive regulations and high import tariffs on battery modules. However, despite the slow growth, there is a high potential for growth in the future. The utility-scale segment is expected to experience the most growth and investment as the focus shifts towards using energy storage as a transmission asset to support the expansion of the electricity transmission network. ANEEL has authorized the development of a pipeline for 100GW of solar PV and 20-30GW of wind energy, which may worsen the existing grid congestion issues (BNAmericas, 2023). This is expected to trigger regulatory changes that allow for a greater role for energy storage in Brazil's energy mix.

It is expected that the capacity pipeline will gradually expand with the implementation of important projects such as the CTEEP's and the regulator-approved technology demonstration projects. The commissioning of the CTEEP project towards the end of 2022 is particularly noteworthy as it will help establish the use case of ancillary services for which regulations are yet to be defined. In addition, the commercial and industrial consumer segment of the power sector is expected to continue driving the demand for storage, as it has done so far. The demand for battery storage projects is likely to come from distributed solar PV installations. Despite the introduction of a grid fee in 2023 for prosumers with distributed installations exceeding 5MW installed capacity, demand is expected to remain high because those with installations below that threshold will still be eligible for net metering tariffs until 2045 (PV Magazine, 2022).

As the capacity of renewable energy sources in utility-scale rises, it will become crucial to balance the grid through activities available in ancillary services. Capacity markets will also play an equally important role to ensure network reliability. The network operator may need to provide timely battery storage to avoid incurring high opportunity costs of preventing generation or deterring prospective investments.

Chile

GDP (Current Prices) USD (2022)	301 bn
GDP Growth Forecast (constant prices) (2023-2027)	2%
10yr Govt Bond Yield (12-month rolling average)	5.65%
Country Credit Rating (S&P)	A
Battery Storage Capacity	1.0GWh/ 261.0MW
Pumped Hydro Storage Capacity	NA
RE share of Total Electricity Capacity	59.70%
Battery Storage Outlook (Power Capacity)	6.4GW of Storage Pipeline

Note: Battery Storage Capacity Expressed in GWh assuming an average 4 hours of duration.

Source: IMF, Fred Economic Data, S&P Global, ACERA, IRENA, PV Magazine

In November 2022, Chile took steps to strengthen its climate policies and decarbonisation goals by updating its Nationally Determined Contribution (NDC), which is an emission pledge made during the COP27 climate summit held in Egypt. The updated targets aim to reverse the trend of increasing methane emissions by 2025, expand the protection of its ecosystem by 1 million hectares by 2030, and reduce CO2 emissions by 45% by 2030 compared to 2016 levels. Furthermore, Chile aims to achieve carbon neutrality by 2050 (IMF, 2023).

Chile is aiming to reduce its carbon footprint by focusing on two major industries: energy and transport. These industries contribute significantly to the country's overall emissions, with the energy sector alone accounting for nearly three-quarters of the total emissions. To achieve this goal, the Chilean government has laid out a plan to retire 30% of the country's coal-fired power plants by 2024, with the remaining plants being phased out by 2040. The transport sector, which is heavily reliant on diesel vehicles, will also need to undergo significant changes to reduce emissions (Solar Paces, 2021). In November 2022, the Energy Ministry proposed establishing a 60% electricity generation target, an upward revision from the 40% target set out earlier (BNAmericas, 2022). Chile considers energy storage as a crucial element of its transition policy towards renewable energy, which will help stabilise the electricity grid.

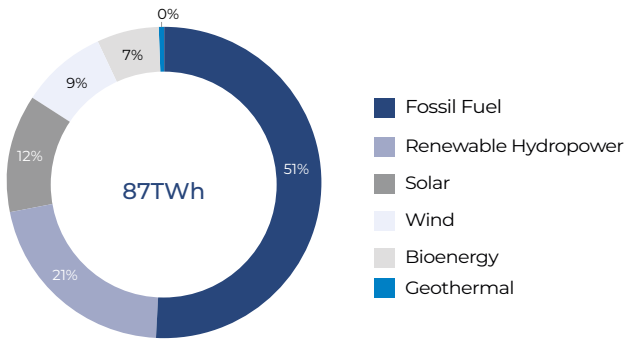
Chile

Energy Mix and Case for Storage

Despite the increasing capacity of renewable energy sources, fossil fuels still account for a significant portion of electricity generation in Chile. According to IRENA's estimates for 2022, around 87 TWh of electricity was generated in Chile, of which 51% was from fossil fuel-based sources. Renewable hydropower accounted for the largest share of the remaining 49% (21%), followed by solar (12%) and wind (9%) (IRENA, 2023). The country's installed capacity has progressively improved to reach ~60% in 2022, with solar and wind accounting for approximately 80% of the ~3GW added during the year.

Phasing out coal-based power generation ahead of the target year of 2040 is a top priority for policymakers in Chile, considering its disproportionate share in the country's overall emissions. According to a recent study, phasing out 5GW of coal-based generation capacity will require 4GW of new replacement capacity every year, mainly sourced from renewable energy, for the remainder of the decade. In the first decade, 30GW of new electricity generation facilities will be needed, consisting of 15GW of solar, 5GW of wind, 8GW of battery storage, and 2GW of flexible gas generation capacity (BNAmericas, 2023). Between 2014-2022, the share of coal-based power generation in the total Chilean power mix declined from 41% to 23%, placing the country among the top ten for the pace of such a transition (WRI, 2023). Battery storage and flexible gas generation are expected to play a crucial role in facilitating the transition.

Power Generation Fuel Mix as of end-2022



Source: IRENA

The importance of having enough energy storage capacity is clear from the rising amounts of curtailment observed in Chile's power grid. According to ACERA, Chile's National Renewable Energy Industry Association, the power grid curtailed 735GWh of renewable energy in the first five months of 2023, which is an 86% increase from the previous year (ReThink, 2023). The situation is likely to exacerbate as the project pipeline for solar PV, amounting to 1.6GW in the pre-commissioning stage, 4.2GW under construction, 20.5GW post-approval and 3.5GW in pre-approval settings massively dwarfs that for battery storage (ReThink, 2023).

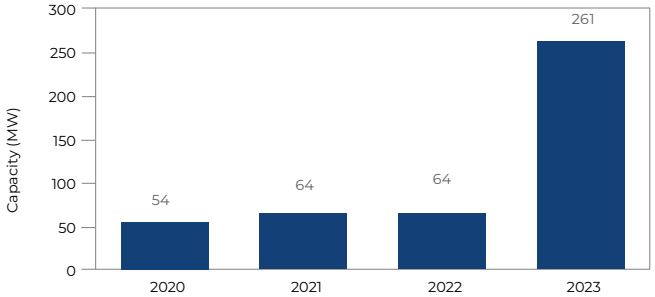
Capacity: Status and Trend

The installed capacity for energy storage has been growing rapidly despite a low starting point. This growth has been particularly significant as energy storage has traditionally played a marginal role. According to the year-end report of 2023 from the Chilean Renewable Energy Association (ACERA), the installed battery storage capacity was 261MW. This included 114MW of operational capacity and 147MW in testing. It is worth noting that almost all of the operational battery storage capacity (113MW) installed as of December 2023 was co-located with utility-scale solar PV plants (ACERA, 2023).

The focus on storage capacities linked to power generation in Chile is a reflection of the country's energy market growth pattern. The recent surge in renewable energy generation capacity has presented a number of challenges for industry players. While there has been a rapid increase in renewable energy capacity, the necessary modernization of transmission infrastructure has not kept pace, leading to issues such as congestion, curtailment, and zero marginal costs for producers.

The revenue losses emanating from these issues have served to dampen investor enthusiasm. As per Chile's National Electricity Co-ordinator (CEN), there is an emerging consensus that battery storage capabilities are more likely to mitigate the prevailing issues through load shifting than sustained investment in expanding transmission lines. The share of renewables in electricity generation amounted to 30% in 2023, and this is likely to increase to 80% by 2030 as per Chile's National Energy Policy, and eventually 100% by 2050. This will likely drive demand for sustained investment into developing energy storage capacities to balance the grid.

Installed Battery Storage Power Capacity



Source: ACERA

Note: Data is as of December of every year.

Chile

Chile is home to the largest reserve of lithium in the world, accounting for 36% of the world's economically recoverable lithium reserves. It is worth noting that Chile processes its lithium deposits into lithium carbonate, for which it holds a 61% share globally. Lithium carbonate plays a critical role in the manufacturing of LFP batteries, which are increasingly replacing other lithium-ion battery technologies. From 2020 to 2023, the share of LFP batteries is expected to grow from 20% to 40% (Columbia SIPA, 2023). As a result, there is a natural bias towards BESS solutions for energy storage in Chile.

Other storage technologies are also being considered. Notable examples include a 300MW pumped hydro storage project developed by Chilean firm Valhalla (Valhalla). A UK-Chilean JV called Highview Enlasa is developing a 50MW liquid air energy storage project that recently got approval (Renewables Now, 2022). AES Andes is seeking environmental clearance for converting a coal-based power plant into a 560MW molten salt energy storage unit, reputed to be the first of its kind globally once operational (Renewables Now, 2022). If successful, the technology is likely to set a template for converting the remainder of Chile's coal-based generation assets, thus accelerating the timeframe for decarbonising the power sector. Molten salt thermal storage projects are prevalent in Chile, with five operational assets having a cumulative installed capacity of 1.6GW (PV Magazine, 2023).

Policy and Regulation

In early October 2022, the Chilean Senate passed the Electromobility Bill to accelerate the development of the energy storage market. The new legislation provides incentives for the deployment of standalone energy storage and outlines the remuneration mechanism for it in Chile's power market. This resulted in a surge in investment in the energy storage sector for standalone projects and a pipeline of more than 2GW of hybrid renewable energy projects co-located with solar and wind generation assets (LinkedIn, 2023). In June 2023, the Chilean government announced its intention to introduce a bill to procure large-scale energy storage systems via a $2 billion energy storage auction in 2024, with commissioning planned in 2026. This is in addition to the 5GWh of energy storage sought for commissioning in 2027-28 (BNAmericas, 2023).

The Electromobility Bill of 2022 defined the regulatory framework around energy storage and is subsequently being amended to expand the scope of storage on the broader energy market. The Chilean Energy Ministry has proposed additional rules for capacity payments to decree DS62/2006 that regulates the capacity market (BNAmericas, 2023). Notable amongst these is a proposal that enables hybrid renewable energy projects with a storage component to be compensated separately for each element. It also proposes the inclusion of storage in capacity market rules, enabling storage projects to be compensated for providing capacity to the grid. 100% capacity recognition is proposed for a storage capacity of five hours and beyond, progressively lowering to 50% for a capacity of up to 1 hour. These amendments, once enacted, could be a key growth enabler as capacity payments are expected to account for 40% of the BESS revenue stack (Local Information Services, 2023).

An amendment is proposed to the decree DS125/2017 that governs power grid coordination. The amendment aims to include energy storage in the overarching grid coordination plan, which will allow installations to draw and inject power from and to the grid. This change is expected to be enacted in the third quarter of 2024. Subsequent legislation is anticipated to provide more transparency into the full range of ancillary services and their compensation rules, which will give investors a clear understanding of the revenue stacking of battery storage projects and determine their financial viability.

Renewables curtailment reached its peak in 2023 due to the prevailing transmission network's inability to match the rapid buildout in renewable generation capacity, hamstrung by unique geographical constraints. Energy storage is widely seen as the viable option to balance the grid, with estimates indicating that a 2GW energy storage capacity by 2026 will deliver savings of $513 million to the national power grid (BNAmericas, 2023).

The Chilean Ministry of Energy and the Ministry of National Assets unveiled a new resolution to allocate public land for energy storage projects that will start operations in 2026 and cover projects of about 13GWh, mainly in the regions from Arica y Parinacota to Atacama (PV Magazine, 2023).

Chile

Market Developments and Opportunity

The energy storage market in Chile has expanded rapidly since October 2022, in the aftermath of the Electromobility Bill. The bill has spured development and investments across the energy storage space, with both hybrid and standalone BESS projects planned, as well as alternative technologies.

The project pipeline looks particularly robust for hybrid renewable energy projects with cumulative capacity at 2GW and counting. Chilean utility AES Andes is particularly active with several projects in the pre-construction phase. The $800 million Papas Hybrid Park project consists of 140MW wind, 252MWp solar and 624MW battery storage to provide power for up to 5 hours (LinkedIn, 2023). The $750 million Parque Terra Energía Renovable project involves 350MW wind, 513MW solar and two battery storage systems (LinkedIn, 2023). The $710 million Cristales hybrid project will have 379MW solar PV capacity and 542MW battery storage capacity. In July 2023, AES commenced operations on the 180MW solar/112MW BESS Andes Solar IIB project, which is purported to be the largest installation in Latin America (ETN, 2023). In November 2023, Grenergy unveiled its 2023-2026 plan and highlighted its 4.1GWh BESS with a 1GW solar project in Chile (Energy Storage News, 2023). Global players are also expanding their footprint in Chile, with Engie's 337MW wind farm with 291.2MW of BESS, EDF Renewables' 416MW wind, 198MW solar and a battery storage system, Stakraft's 671MW solar plant with BESS being some notable examples.

Standalone battery storage projects are also gaining traction. Canadian IPP Innergex has two projects in Chile slated for commissioning in 2023. This includes the 35 MW/175 MWh San Andrés battery energy storage project and the 50MW/250MWh Salvador battery project (INNERGEX, 2023). Finland-based Flexens was reported to have put three standalone BESS projects having a cumulative capacity of 1GW in the interconnection queue in September 2023 (Energy Storage News, 2023).

The storage technology deployment is skewed towards battery storage, with lithium-ion being the preferred technology, accounting for 79 projects out of a total pipeline of 85 energy storage projects in various stages of development as of August 2023. About 15 standalone energy storage projects involving investments of around $1.93 billion are submitted for environmental assessment in Chile, and all are battery-based (Bnamericas, 2023). In March 2024, Atlas Renewable Energy marked its entry into the standalone battery storage market through a 15-year PPA with Chilean energy trader Emoac. The agreement, based on a public tender, entails building a standalone battery storage unit (Renewables Now, 2024).

There is also scope for alternate technologies to capitalise on the growth of the energy storage market. The Santiago Cryobattery Storage System is a 2GW installation scheduled to be commissioned in 2023 (Power Technology, 2023). Highview Enlasa is planning a 50MW/500MWh liquid air energy storage plant. In addition, a hydrogen energy storage project is being developed by HIF Chile and is in the planning stages (PV Magazine, 2023).

Outlook

Rapid growth is expected in the Chilean energy storage market until 2030, driven essentially through utility-scale renewable energy projects. As of October 2023, the tracked battery storage project pipeline stood at 6.4GW across 85 projects (PV Magazine, 2023). Such estimates are highly dynamic as the market continues to attract new storage units in tandem with the renewable energy projects. The ACERA's December 2023 report pointed to 346MW of approved battery storage capacity and another 610MW under construction (ACERA, 2023).

The decarbonisation of the power sector remains a significant milestone for Chile's climate goals, and phasing out the country's 5GW coal-based generation capacity will require at least 15GW of renewables and storage capacity (BNAmericas, 2023). Renewable energy projects are facing financial challenges due to increasing curtailments and zero marginal costs. In response, developers are choosing to build hybrid projects that include storage components. Capacity payment mechanisms have helped to support this trend. According to a recent study by the grid co-ordinator CEN, there will be a need for 1-4GW storage capacity between 2026 and 2032 to stabilize the grid (BNAmericas, 2023).

Chile has been working on creating regulations for energy storage as a crucial part of its energy transition plans. The private sector has shown a lot of interest in investing due to the clarity regarding payment mechanisms for different types of storage applications, starting with the capacity market. To further boost the storage market in Chile, it is important to expand the use of energy storage for both generation and transmission applications, and establish a remuneration framework for ancillary services.

08

About CleanBridge

About CleanBridge

CleanBridge has a deeply experienced team, combining professionals with financial expertise (investment banking, capital markets) and operational experience (engineering, project development, business process management). These complementary skill sets allow us to understand the most attractive opportunities for growth within the following value chains.

Sustainable Energy

Climate Finance

Sustainable Living

Disclaimer

This presentation is for informational purposes. The information contained in this presentation does not purport to be complete. All of the information contained herein is subject to change without notice. Each recipient of this presentation should conduct its own independent investigation and assessment of the contents of this presentation and make such additional enquiries as it deems necessary or appropriate.

CleanBridge Securities LLC and its affiliate CleanBridge Advisors (UK) Ltd. (together "CleanBridge") have based this document on information obtained from sources it believes to be reliable, but which have not been independently verified. Except in the case of fraudulent misrepresentation, CleanBridge makes no representation or warranty (express or implied) of any nature or accept any responsibility or liability of any kind for the accuracy or sufficiency of any information, statement, assumption, or projection in this document, or for any loss or damage (whether direct, indirect, consequential, or other) arising out of reliance upon this presentation. Statements made in this presentation relating to the fund are intended as a summary and not a complete description and may be subject to change. CleanBridge is under no obligation to keep current the information contained in this document.

This document is not intended for distribution to, or use by, any person or entity in any jurisdiction or country where such distribution or use would be contrary to law or regulation. The information herein does not constitute an offer to sell or solicitation of an offer to make investments in designated investments in any jurisdiction. The information herein does not take into account the investment objectives, financial situation or needs of any person and should not form the basis of any investment decision.

The returns and valuations in this presentation are preliminary and tentative only. Nothing in this presentation is, or should be relied on as, a promise or representation as to future developments.

CLEANBRIDGE

Contact us

CleanBridge Group LLLP, CleanBridge Securities LLC and CleanBridge Advisors (UK) Ltd
Miami office: 2601 South Bayshore Drive, Suite 1130, Miami, FL 33133, United States
London office: 50 Grosvenor Hill, London W1K 3QT, United Kingdom
Tel: +1 (305) 577 – 9799 · Fax: +1 (305) 577 – 9766