Battery energy storage systems

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OVERVIEW

Battery Energy Storage Systems (BESS) is a technology that uses rechargeable battery systems to store electrical energy on a large scale. These systems capture energy from various sources, including the power grid, renewable energy installations like solar panels or wind turbines, or other generating assets. The stored energy can then be discharged when needed, providing a range of services such as load balancing, grid stabilization, peak shaving, and backup power. BESS plays a crucial role in the transition to renewable energy by addressing the availability issues associated with solar and wind power, helping to maintain a stable and reliable electricity supply. As technology continues to advance and costs decrease, BESS is becoming an increasingly important component of modern energy infrastructure worldwide.

Battery technology

The BESS industry continues to evolve, with research focusing on improving battery life, efficiency, safety, and reducing costs. Lithium-ion batteries are currently the most common technology used in BESS due to their high density (which packs more energy into a small space), long life cycle, decreasing costs and up to 12-hour storage. Nickel manganese cobalt (NMC) and lithium iron phosphate (LFP) are the leading chemistries used to create these batteries. This space is rapidly evolving and emerging technologies are entering the market. Flow batteries use liquid electrolytes stored in tanks and are beneficial for long duration storage. Sodium-sulfur batteries operate at high temperatures and are used for grid-scale solutions. Advanced lead-acid batteries could also provide improved battery performance and longer life span. Further, iron-air battery technology could provide lower-cost, 100-hour storage solutions that could advance even longer-duration needs, such as with data centers in particular. Innovations in battery management systems, thermal management, and integration with power electronics are also crucial aspects of BESS technology.

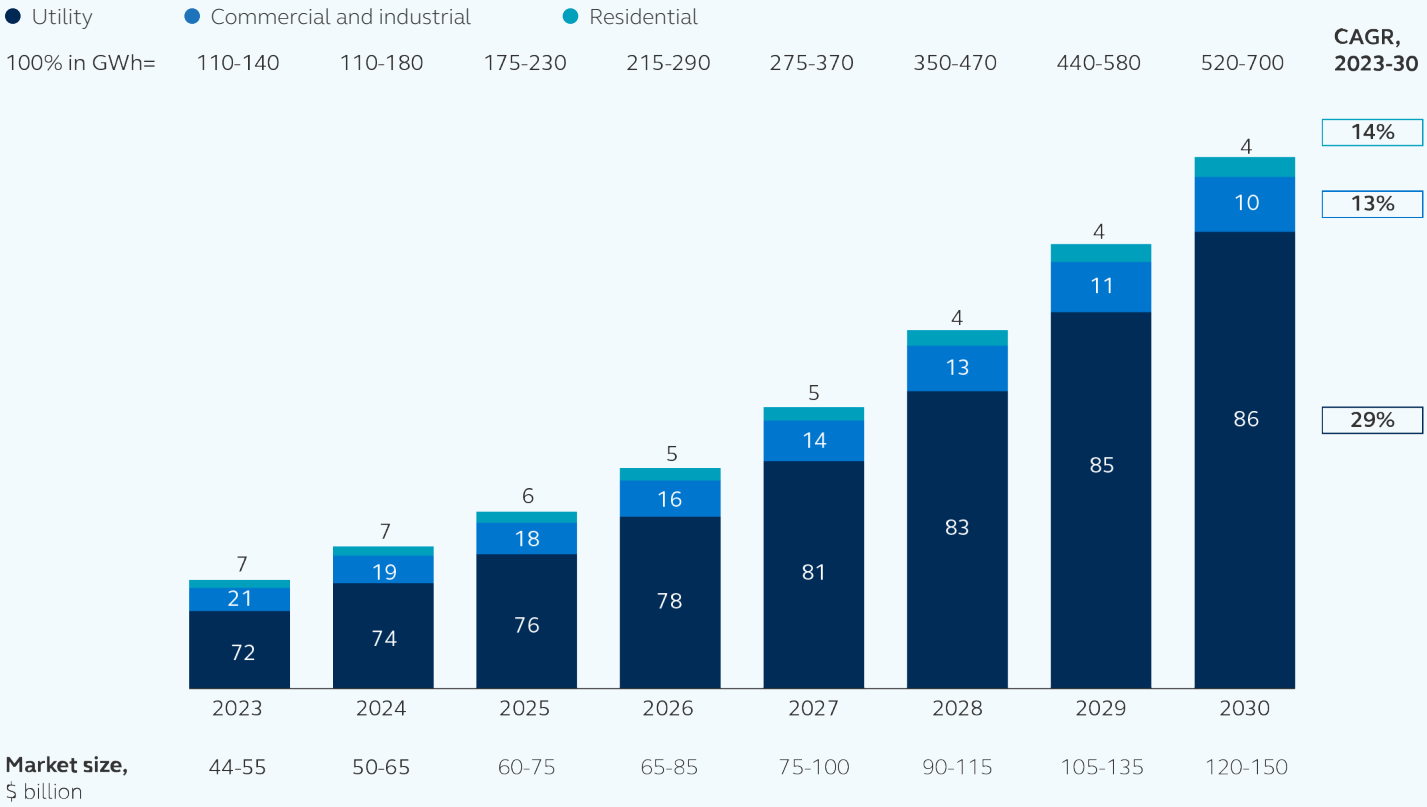
Energy landscape

The introduction of BESS is changing electricity market dynamics, creating new opportunities for energy trading and grid services. The impact of BESS on power grids has been significant and multifaceted. This technology helps maintain grid frequency and voltage which improves overall grid functions and provides backup power during outages, increasingly important given the rise in natural disasters and our aging grid infrastructure. Peak demand management, or the ability for discharging stored energy during high usage periods, reduces strain on the grid and potentially eliminates the need for additional peaker plants. BESS infrastructure strategically placed near energy sources can reduce the need for costly transmission and distribution equipment by providing a stable, base-load style of power supply when paired with intermittent renewable power generation facilities.

These impacts are reshaping power grids and making them more flexible, resilient, and capable of supporting the transition to a cleaner energy future. BESS can also act as an energy arbitrageur, allowing for the purchase of electricity when prices are low and selling when prices are high to reduce overall system costs. By rapidly responding to grid needs and market signals, BESS can optimize its operations to maximize revenue while simultaneously helping to balance supply and demand on the electrical grid.

Given the numerous opportunities to leverage BESS technology to enhance our energy landscape, capacity is projected to quintuple between 2023 and 2030[1].

EXHIBIT 1: Battery energy storage system capacity is likely to quintuple between now and 2030



Source: McKinsey Energy Storage Insights, BESS market model, August 2023

[1] Enabling Renewable Energy with Battery Energy Storage Systems by McKinsey & Company, August 2023

Note: Figures may not total 100% due to rounding.

Sustainability considerations

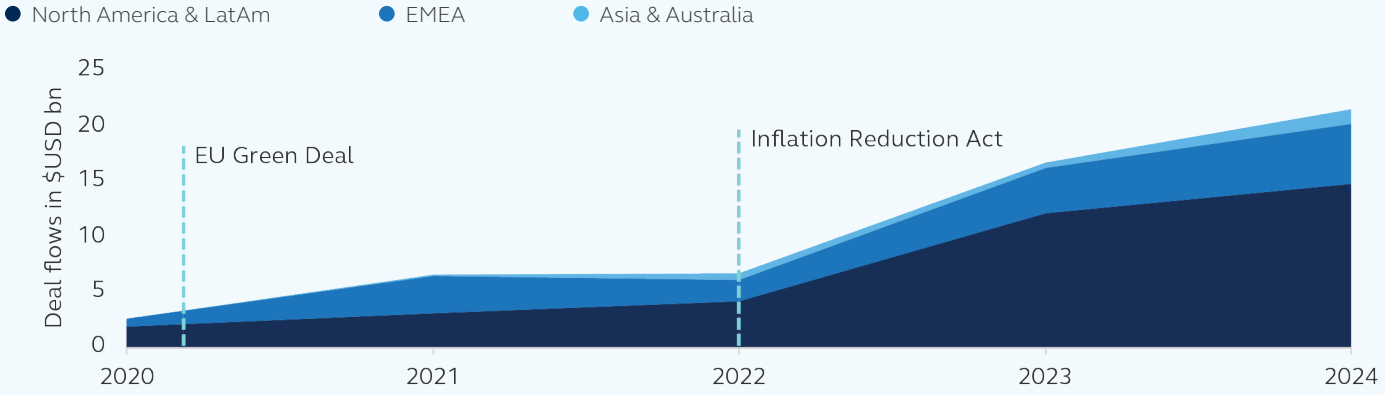
This BESS space has the potential to improve energy access and reliability in underserved communities, particularly in remote areas or developing countries where grid infrastructure may be lacking. BESS can enable more widespread adoption of renewable energy sources, contributing to cleaner air and reduced greenhouse gas emissions, which have positive impacts on public health and climate change mitigation efforts. However, there are also concerns about the environmental and social impacts of battery production, including issues related to raw material extraction, working conditions in manufacturing, and the need for responsible end-of-life management and recycling of batteries.

Additionally, the deployment of large-scale BESS projects may raise land use and community impact concerns, requiring careful stakeholder engagement and consideration of local perspectives. As the industry grows, understanding the complexities of both positive and negative externalities weighed against financial performance of the asset will be critical.

Policy impacts

From a global perspective, the regulations around the BESS industry are trending favorably. From increasing focus on grid resilience and flexibility to recognition of BESS in climate change mitigation strategies and growing attention to supply chain security and sustainability in battery manufacturing, the attention on this rapidly evolving space has reached a worldwide scale.

EXHIBIT 2: Battery storage deal volumes are growing rapidly



Source: Infralogic, December 2024

Europe

Overall, the European regulatory environment is generally favorable for the BESS industry, with policies aimed at accelerating the energy transition and recognizing the crucial role of energy storage in achieving climate goals. However, specific regulations and support mechanisms can vary significantly between individual EU member states.

Several key factors have shaped the European landscape, most notably the European Green deal, which is a policy framework aimed to make the EU climate neutral by 2050 through driving investment in clean energy technologies. The Renewable Energy Directive (RED II) has set targets for renewable energy adoption which indirectly supports BESS as a key enabler for integrating intermittent renewable sources. The EU has also implemented network codes that recognize the role of energy storage in providing ancillary services to the grid and as EU members, each state is required to develop National Energy and Climate Plans (NECPs), most of which include targets for energy storage deployment.

United States

A key contributor to this industry in the United States has been the Investment Tax Credit, expanded by the Inflation Reduction Act[1], which includes standalone energy storage projects that provide significant financial incentives for BESS development. Another federal order includes the Federal Energy Regulatory Commission (FERC) Order 841 which requires grid operators to remove barriers for energy storage participation in wholesale markets, which could reveal new revenue streams for BESS projects. There are many state level mandates as well, including storage deployment targets from California, New York and Massachusetts which are driving demand for BESS state side.

The Trump Administration has reduced federal support for clean energy, rolled back environmental regulations and paused tax incentives related to the IRA. While it is too soon to determine the impact of these changes on the BESS sector, it is important to note that this industry is largely driven by state-level policies. Market demand and technological advances will continue to support growth regardless of federal policy changes.

[1] The executive order "Unleashing American Energy" signed on January 20, 2025 has paused disbursements of funds supporting the "Green New Deal" for 90 days. At the date of publication, no specific details have been provided to indicate specific impact on BESS funding as this technology supports all forms of energy, not just renewable energy.

Development opportunities

As the demand for energy accelerates globally, battery storage locations will expand to strategic placements including:

- Regions with high renewable energy infrastructure given BESS's role in improving grid stability with intermittent renewable sources like wind and solar
- Urban and suburban areas with high electricity demand as these locations often face grid congestion issues and can benefit significantly from BESS to manage peak loads
- Areas with aging grid infrastructure as BESS can help extend the life of existing infrastructure by reducing strain during peak periods
- Remote communities that currently rely on expensive diesel generators
- Industrial zones as they utilize large amounts of energy and can benefit from on-site BESS to improve power quality and remain cost effective
- Areas prone to natural disaster as BESS can provide critical backup power and improve grid resilience
- Locations with electric vehicle charging infrastructure to manage increased load from EV charging stations
- Regions with time-of-use electricity pricing where BESS can enable energy arbitrage

Conclusion

As the world transitions towards renewable energy sources and grid stability becomes increasingly critical, BESS investments offer potentially attractive returns while contributing to resilient energy solutions. The growing demand for energy storage, coupled with declining battery costs and supportive government policies, creates a favorable environment for private investment in this sector. Additionally, BESS projects often provide multiple revenue streams through services like peak shaving, frequency regulation, and grid stabilization, which can help diversify investment risk. With the energy storage market projected to quintuple between 2023 and 2030, early investors in BESS infrastructure may be well-positioned to capitalize on this transformative technology.

Risk Considerations

Investing involves risk, including possible loss of principal. Past Performance does not guarantee future return. All financial investments involve an element of risk. Therefore, the value of the investment and the income from it will vary and the initial investment amount cannot be guaranteed. Infrastructure companies are subject to risk factors including high interest costs, regulation costs, economic slowdown, and energy conservation policies.

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