KEY INSIGHTS

- As intermittent energy resources expand, energy storage will become more important to balance electricity demand and supply.
- Different energy storage technologies offer varying advantages and disadvantages, and the electric grid of the future is expected to leverage these diverse technologies for specific applications.
- Market demand is expected to drive cost reductions, though resource planning may benefit from conservative cost reduction assumptions.

Storage Technologies in Energy System Resource Planning

by Romey James

Energy storage has historically played a crucial role in real-time balancing, supporting baseload generation, meeting peak demand, and responding to load fluctuation. For example, pumped hydro storage (PHS) has used electricity from nuclear units during off-peak hours to pump water to a reservoir for later use in a hydroelectric turbine. Such storage technologies have provided flexibility and reliability to the grid, addressing variability of weather and customer demand.

Higher levels of variable renewable energy resources can require more energy storage to manage the challenges imposed by increased intermittent generation. Future strategies to manage the grid will likely involve a combination of various energy storage technologies, advanced grid management systems, demand response programs, and low-carbon peaking generation.

Considerations from Resource Planning Perspective

Technology Readiness Level (TRL)
TRL indicates a technology's maturity. Pumped hydro storage (PHS) and lithium ion (Li ion) batteries have high TRLs, while newer technologies, including novel battery chemistries, thermal, and mechanical options have lower TRLs.

Round Trip Efficiency (RTE): RTE quantifies the ratio of energy discharged to charging energy, factoring in conversion losses. Li ion batteries, flywheels, PHS, and certain gravitational systems exhibit high RTEs. However, Compressed Air Energy Storage (CAES), flow batteries, and pumped heat energy storage typically show lower RTEs. Thermal energy storage systems integrated with existing power cycles may experience decreased efficiencies due to losses.

Value Stacking: An energy storage asset can serve multiple purposes, enhancing investment value. Beyond arbitrage, it can provide key ancillary services including peak load management, voltage and frequency regulation, and black start capability.

Duration: Li ion batteries are well-suited for quick response and daily load shifting. However, the demand for economical longer duration storage is driving investment in thermal, chemical, and mechanical storage technologies.

Siting and Scaling: Li ion batteries and other standalone AC-to-AC storage systems offer adaptable installations in various sizes and locations. In contrast, PHS and CAES require specific geological conditions. Siting flexibility is due in part to energy density. Higher energy density systems have smaller footprints. Also, safety concerns vary: Li ion batteries and hydrogen pose fire risks, while thermal storage entails high temperatures or hazardous materials.

Critical Minerals: Many non-battery storage technologies offer an advantage by not relying on critical minerals, addressing concerns over supply chain issues. In contrast, Li ion batteries rely on lithium, copper, nickel, cobalt, manganese, and graphite, which could have future supply chain concerns. Efforts are underway to improve the TRL of alternative battery chemistries that rely on abundant and cheap materials, including sodium ion and liquid metal batteries.

Costs: PHS could be a cost-effective energy storage option but faces siting and regulatory challenges. Chemical, mechanical, and thermal energy storage systems developers have aggressive price targets, but most of these products are not commercially available yet. Li ion batteries, driven by consumer electronics advancements, have become the most cost-effective solution for short-duration applications. Batteries using newer chemistries are pricier, but costs are expected to decline as technology matures.

Inflation Reduction Act of 2022
Energy Storage Incentives

30%* Investment tax credit

10% Domestic content bonus

10% Energy communities' bonus

*Subject to fulfilling labor requirements

This insight is derived from research conducted by Program 94 Energy Storage & Distributed Generation, Program P221 Bulk Energy Storage, and Program 178 Resource Planning for Electric Power Systems

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