Highlights of GAO-23-105583, a report to congressional addressees

March 2023

TECHNOLOGY ASSESSMENT

Utility-Scale Energy Storage

Technologies and Challenges for an Evolving Grid

Why GAO did this study

The U.S. electricity grid connects more than 11,000 power plants with around 158 million residential, commercial, and other consumers. Energy storage technologies have the potential to enable several improvements to the grid, such as reducing costs and improving reliability. They could also enable the growth of solar and wind energy generation.

GAO conducted a technology assessment on (1) technologies that could be used to capture energy for later use within the electricity grid, (2) challenges that could impact energy storage technologies and their use on the grid, and (3) policy options that could help address energy storage challenges.

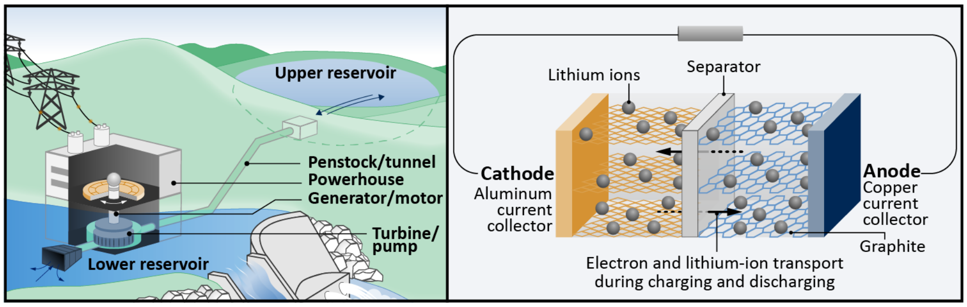
To address these objectives, GAO reviewed agency documents and other literature; interviewed government, industry, academic, and power company representatives; conducted site visits; and convened a virtual meeting of experts in collaboration with the National Academies of Sciences, Engineering, and Medicine. GAO is identifying policy options in this report (see p. 2).

View GAO-23-105583. For more information, contact Brian Bothwell at (202) 512-6888, bothwellb@gao.gov.

What GAO found

Technologies to store energy at the utility-scale could help improve grid reliability, reduce costs, and promote the increased adoption of variable renewable energy sources such as solar and wind. Energy storage technology use has increased along with solar and wind energy. Several storage technologies are in use on the U.S. grid, including pumped hydroelectric storage, batteries, compressed air, and flywheels (see figure). Pumped hydroelectric and compressed air energy storage can be used to store excess energy for applications requiring 10 or more hours of storage. Lithium-ion batteries and flywheels are used for shorter-duration applications such as keeping the grid stable by quickly absorbing or discharging electricity to match demand. Flow batteries represent a small fraction of total energy storage capacity and could be used for applications requiring 10 or more hours of storage. Metal-air batteries are being evaluated for applications requiring 10 or more hours of storage.

Pumped Hydroelectric (left) and Lithium-Ion Battery (right) Energy Storage Technologies



Sources: Department of Energy (left); GAO (right). | GAO-23-105583

Energy storage technologies face multiple challenges, including:

- **Planning.** Planning is needed to integrate storage technologies with the existing grid. However, accurate projections of each technology's costs and benefits could be difficult to quantify. Further, refinement of costs, benefits, and other data are needed to inform the planning process.
- **Regulation.** Rules and regulations vary across regions and states, which forces energy storage project developers to navigate a patchwork of potential markets. Developers that want to deploy storage across multiple markets may need to conduct separate analyses to determine each region's regulatory outlook and profit potential.
- **Standardization.** Codes and standards may need revising and must keep pace with maturing technologies to minimize public safety and welfare risks. However, the technology's evolution and deployment is outpacing codes and standards development. As a result, entities seeking to deploy new technologies may face challenges applying existing codes and standards to new technologies.
- **Valuation.** Realizing the potential of energy storage technologies may depend on the ability to value investments. For example, profit potential can vary because regions and states value storage differently, reflecting local market rules and regulations.

GAO developed six high-level policy options in response to these challenges. These policy options are provided to inform policymakers of potential actions to address the policy challenges identified in this technology assessment. They identify possible actions by policymakers, which include Congress, federal agencies, state and local governments, academic and research institutions, and industry. The status quo option illustrates a scenario in which policymakers do not intervene with ongoing efforts.

Policy Options to Address Challenges to Utility-Scale Energy Storage

Policy options and implementation approaches	Opportunities	Considerations
Status quo (report p. 48) Policymakers could maintain the status quo through: • Tax credits and funding • Research and development	• Previous plans and programs by states would continue, including actions for energy storage. • The federal government has various national capabilities to support energy storage technology incentives and demonstration. • DOE support for storage research and development would continue.	• Some policymakers may lack sufficient information to make decisions on evolving storage capabilities. • Storage development, deployment, and use could be left dependent on forces outside policymakers' control.
Integration (report p. 50) Policymakers could include clear goals and next steps in plans to help integrate storage, by: • Establishing roadmaps, based on storage costs and benefits • Assessing storage in plans	• Storage planning could help policymakers identify and remove barriers to energy storage deployment. • Plans could increase investors' confidence and help them determine storage investments.	• Plans that seek to alter conventional grid planning could be difficult to execute. • Stakeholders have set different goals for low-carbon electric generation. • Planning depends on factors such as location suitability; not every technology is suited for every location.
Regulation (report p. 52) Policymakers could revise and enact rules and requirements for how storage is defined, used, or owned by: • Identifying market barriers • Establishing targets or mandates • Modernizing ownership models	• Could promote energy storage technologies by improving grid efficiency while reducing costs for all customers. • Could help lower costs and reduce the timeline for interconnection. • Could accelerate permit approval timelines.	• Regulations differ across states, which could make finding the right regulatory model to achieve energy goals a challenge. • Integrating new technologies with conventional grid planning can be challenging. • Changes to rules and regulations could exclude certain technologies.
Standardization (report p. 54) Policymakers could update or create new codes and standards and provide education on storage safety risks.	• Could help stakeholders operate storage systems more safely. • Standards placed into regulations could help address storage performance requirements.	• Codes and standards take time to develop and could be outdated if not adopted in a timely manner. • Standards may be ambiguous, which could make it difficult to design storage systems.
Support manufacturing and adoption (report p. 56) Policymakers could support actions to help energy storage manufacturing and adoption challenges by: • Enacting battery reuse and recycling policies • Conducting outreach • Targeting activities to support storage development and deployment	• Reuse and recycling policies could increase the recovery of products and materials. • Stakeholder outreach and informational programs could help overcome awareness and familiarity challenges. • Federal and state financial support for longer-duration energy storage development and demonstration could be important in a future electricity system powered by wind and solar generation.	• Incentives and motivation to invest in new recycling applications is limited. • Funding may fluctuate year to year or favor short-term projects. • Development of new systems could be difficult because of engineering and economic uncertainty, particularly for longer-duration storage. • Low-cost, flexible natural gas generation could make it more difficult for new pumped hydroelectric facilities to compete.
Provide Incentives (report p. 58) Policymakers could create mechanisms to incentivize storage deployment, by: • Providing incentives, such as loan guarantees or tax credits • Considering policies to encourage the capture of multiple revenue streams	• Financial incentives could help developers and companies develop storage technologies. • Technologies with longer durations may benefit from policies that help industry to capture their full value.	• Incentives could lead to unintended outcomes for governments or developers, and some stakeholders may not believe they are necessary. • Technology value varies by region, which may affect storage incentives, valuation, and revenue streams. • Environmental and social costs and benefits could be difficult to quantify. • Low-cost, flexible natural gas generation could make it more difficult for new pumped hydroelectric facilities to compete.

Source: GAO. | GAO-23-105583