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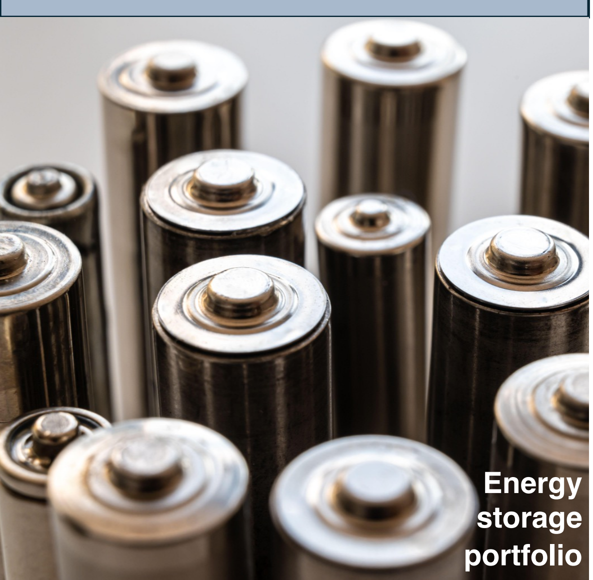
RESEARCH BRIEF

JULY 2024

KEY POINTS FOR DECISION-MAKING

- **In wind-and-solar-reliant energy systems, long-duration energy storage helps meet demand during times of the year with high electricity demand or low generation.** For example, a hydrogen storage system could store energy from strong winter winds to provide cooling in the hot summer.
- **Long-duration energy storage systems may satisfy short-term storage needs.** Hydrogen (or other long-duration) storage systems that are sized large enough to address seasonal and large-scale weather variations may also have sufficient power-capacity to handle short-term fluctuations in electricity supply or demand.
- **For wind-and-solar-reliant energy systems, long-duration energy storage is the most crucial type of storage technology for reducing system cost.** In both wind-heavy and solar-heavy regions, deployment of long-duration energy storage produced the lowest electricity system costs due to their low energy-capacity costs (~2 $/kWh for underground hydrogen storage and ~5 $/kWh for metal-air batteries).



Energy storage portfolio

Long-duration energy storage may satisfy short-term storage needs

The value of different storage technologies depends on their ability to cost-effectively provide electricity during gaps in solar and wind resources, and thus reduce the overbuild of solar and wind generation capacity needed to reliably meet electricity demand.

We investigated the influence of regional variability in wind and solar resources on the value of single- and multi-storage technology portfolios.

Long-duration energy storage can be charged slowly over time to accommodate seasonal fluctuations in electricity supply or demand, but still requires substantial discharge power-capacity to meet large demand spikes during weather events.

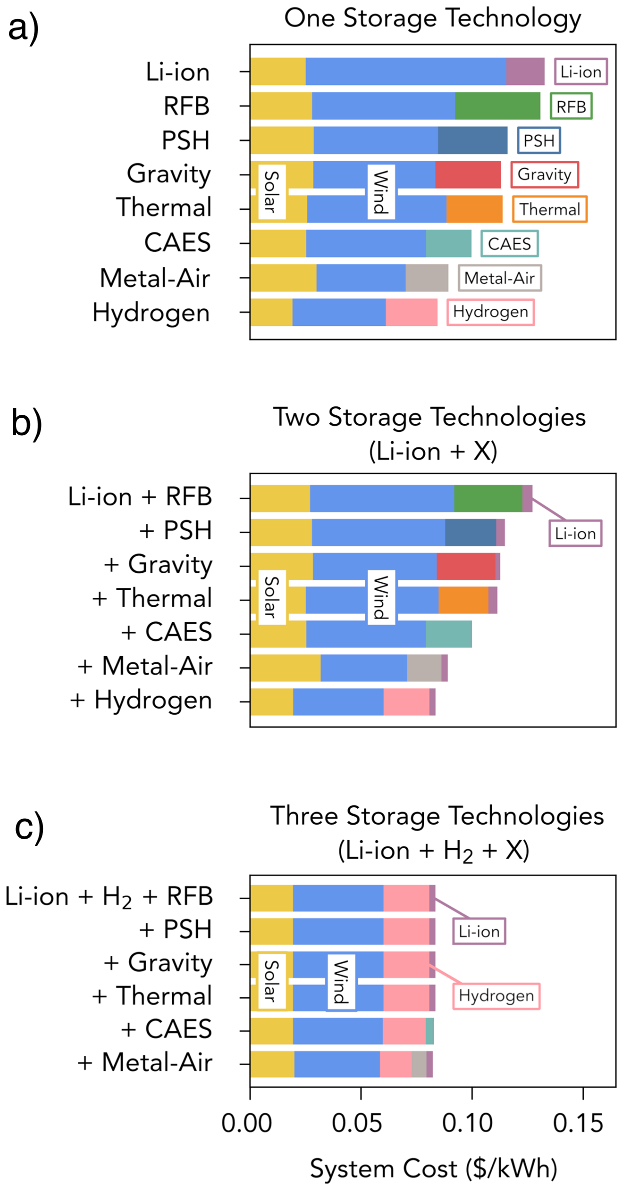
Long-duration storage technologies may serve a dual role by providing short-term storage with their existing power-capacity, making it more difficult for short-duration storage technologies to further reduce system costs.

In both wind-heavy and solar-heavy regions, least-cost systems contained sufficient power-capacity from long-duration storage to also meet short-term power needs, so that the addition of short-duration storage did not markedly reduce total system costs.

Thus, in electricity systems relying on wind and solar generation, contingent on social and geographic constraints, long-duration storage may be able to cost-effectively provide the services that would otherwise be provided by shorter-duration storage technologies.

Summary

Least-cost systems contained sufficient power-capacity from long-duration storage to also meet short-term power needs. Thus, consideration of Li-ion (short-duration) storage in conjunction with longer-duration storage only modestly reduced total system costs.



Electricity system costs for single- and multi-storage technology portfolios. a) Underground hydrogen-storage and metal-air batteries produced the lowest system costs due to being the cheapest long-duration storage technologies (with energy-capacity costs of ~2 $/kWh for hydrogen and ~5 $/kWh for metal-air batteries). **b)** When Li-ion batteries were considered in conjunction with other storage technologies, system costs were reduced only modestly. **c)** When three storage technologies are modeled (Li-ion batteries, hydrogen, and a third storage technology), neither Li-ion batteries or other storage technologies further reduce system costs as compared to a system with only hydrogen storage.

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This brief is based on the paper "**The influence of regional geophysical resource variability on the value of single- and multi-storage technology portfolios**" published in *Environmental Science & Technology* (2024).

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