KEY INSIGHTS

- Including a range of candidate energy storage types—both short- and long-duration—improves the ability of capacity expansion planning models (CEMs) to identify the optimal mix of resources to meet system needs.
- LDES has long chronological dependencies; temporal simplifications commonly used in CEMs need to account for this.
- The selection of LDES in a CEM is highly sensitive to the representative periods used to capture time; this is due to the multi-day or multi-week nature of renewables production.
- Decarbonization drives energy storage deployment, with more LDES under stringent carbon reduction targets.
- The amount and type of renewable resource deployment impact optimal storage investments; wind-dominant systems favor LDES, while solar-dominant systems favor shorter-duration storage.
- LDES can mitigate stressful events such as extended periods of high net demand, especially when other flexible resources are limited.

Advancing Long Duration Energy Storage (LDES) Modeling for Long-Term Resource Planning

by Karen Tapia-Ahumada, Sean Ericson, Andrea Staid, and Nidhi Santen

Research Overview

Long-duration energy storage (LDES) can shift energy across days, weeks, or even seasons, adding flexibility to power systems. However, incorporating LDES in resource planning tools can pose various analytical and computational challenges.

This research improves resource planners' understanding of how to incorporate LDES (storage with duration exceeding 10 hours) in long-term planning, focusing on the modeling approaches needed to model LDES alongside other shorter-duration storage technologies, and how these approaches interact with electricity system characteristics.

Using a standard unit-level capacity expansion planning model on a stylized test system that approximates the Western Interconnect, this study co-optimizes storage with durations of 4, 10, 24, and 100 hours across a range of scenarios, considering different modeling choices and system characteristics. Energy storage deployment metrics are analyzed, including capacity buildout by technology type.

Summary of Findings

- Choices about how to model chronology and temporal resolution can impact deployment of energy storage (**Fig. 1**):
  - Storage buildout is higher when a more detailed and chronological temporal resolution (**Hourly**) is used.
  - Short-duration storage is more sensitive than LDES to the aggregation of consecutive hours into a single period (**Agg Hours**).
  - LDES buildout is significantly impacted by the use of representative periods (**Rep Weeks**).
- LDES modeling requires that the selected representative periods are both sufficiently long and reflective of periods of potential stress or high net load.

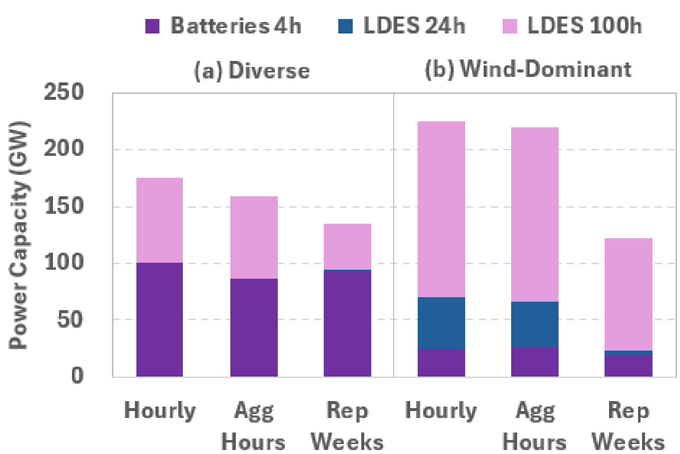

Figure 1. Storage buildout in a zero-CO_2 scenario by temporal aggregation method, for diverse (wind and solar PV mix) and wind-dominant portfolios.

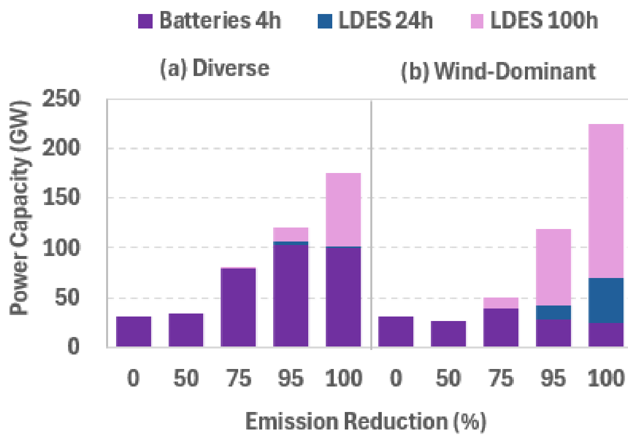

Figure 2. Storage buildout across CO_2 scenarios for both diverse and wind-dominant portfolios.

- In the absence of carbon targets, significant investments in short-duration storage may help manage wind and solar variability, shift midday solar generation, and meet peak loads.
- Overall energy storage deployment is higher under stringent carbon targets. LDES is economic when flexible resources like gas-fired technologies are limited (**Fig. 2**).
- Short-duration battery storage deployment tracks solar buildout (**Fig. 2a**), while LDES deployment tracks wind buildout (**Fig. 2b**). This suggests wind-dominant systems may benefit more from LDES to manage multi-day and seasonal variations, whereas solar-dominant systems benefit more from shorter-duration storage to manage daily fluctuations.

This research highlight is based on EPRI Report "Advancing Long Duration Energy Storage (LDES) Modeling for Long-Term Resource Planning," **Product ID 3002031338**

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