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Storage Futures Study: Key Learnings for the Coming Decades

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Thanks to the Storage Futures Study Team!

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Storage Futures Study

- Multiyear research project
- Explored the rapidly increasing role of energy storage in the electrical grid through 2050
- Supported by the U.S. Department of Energy's Office of Strategic Analysis and Energy Storage Grand Challenge

Storage Futures Study Questions

- How might storage cost and performance change over time?
- What is the role of diurnal storage in the power sector?
- How much storage could be economically deployed in the United States?
- What factors might drive deployment?
- What are the impacts to grid operations?

Storage Futures Study Reports

1. The Four Phases of Storage Deployment
2. Energy Storage Technology Modeling Input Data Report
3. Economic Potential of Diurnal Storage in the U.S. Power Sector
4. Distributed Storage Customer Adoption Scenarios
5. The Challenges of Defining Long-Duration Energy Storage
6. Grid Operational Implications of Widespread Storage Deployment
7. Key Learnings for the Coming Decades

Important Caveats

Factors that Could Impact the Future of Energy Storage

Important Caveats

- Storage growth and compensation (both energy and capacity)
  - How do markets appropriately value and compensate storage
- Technology evolution
  - Significant R&D efforts could improve other storage technologies, potentially competing with lithium-ion batteries

Important Caveats

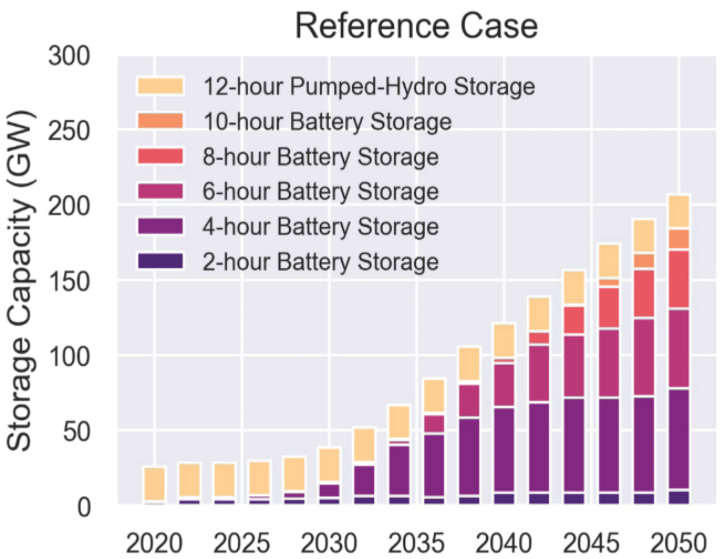
- Role of flexible loads
  - Need better characterization of demand response, flexible load contribution potential, and cost
- Value of distributed storage
  - Emerging value streams and bi-directional EV's
- Evolving storage duration and seasonal storage
  - Multiplied uncertainty as renewable fuels likely shared across sectors (industrial sector)
  - Could long-duration tech displace diurnal storage?

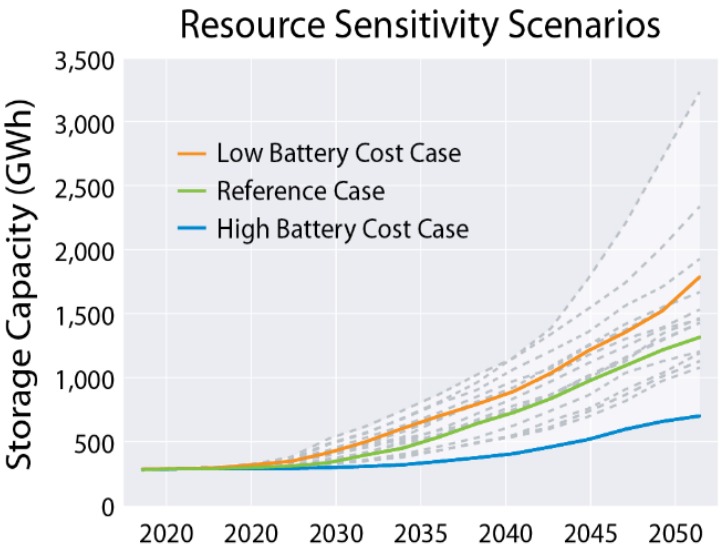
Eight Key Learnings

What to Know for the Coming Decades

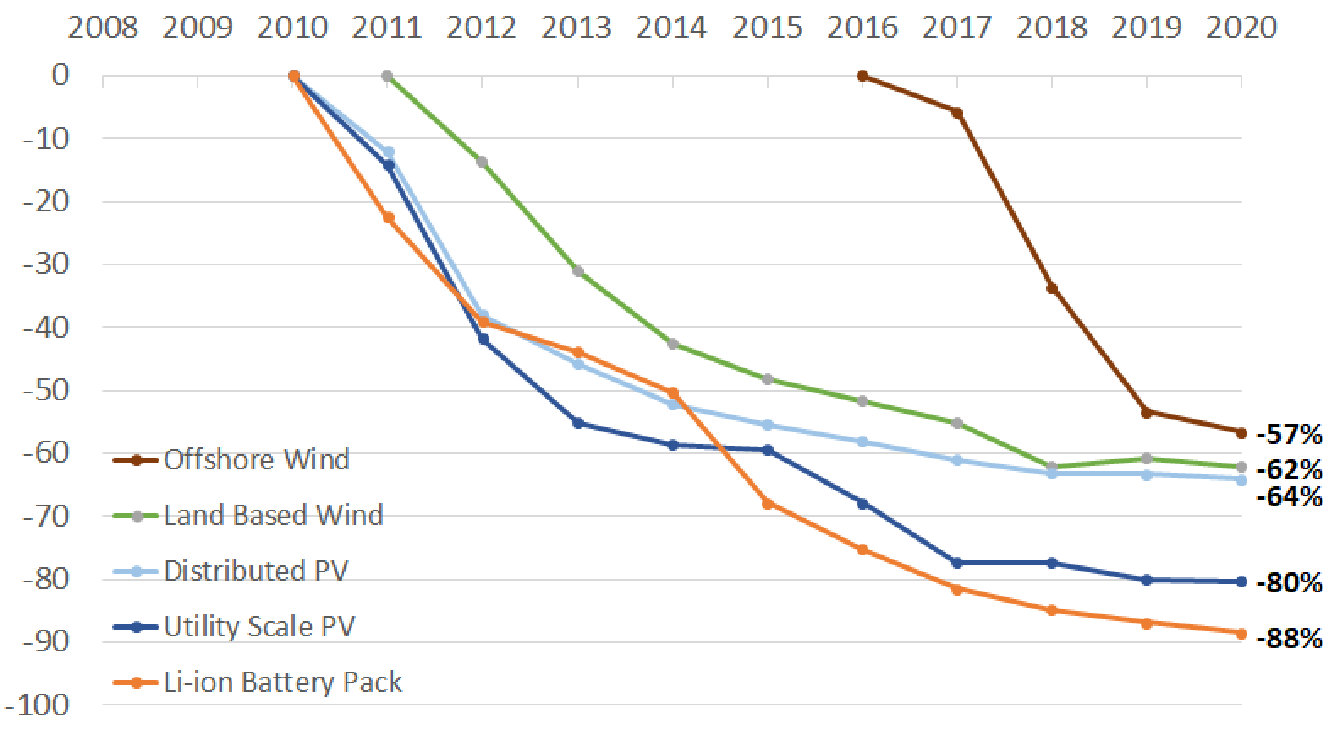
Key Learning 1: Storage is poised for rapid growth.

- 100–650 GW (600 to 3000+ GWh) in 2050, or 5X today's capacity
- Driven by storage costs, natural gas prices, renewable energy cost

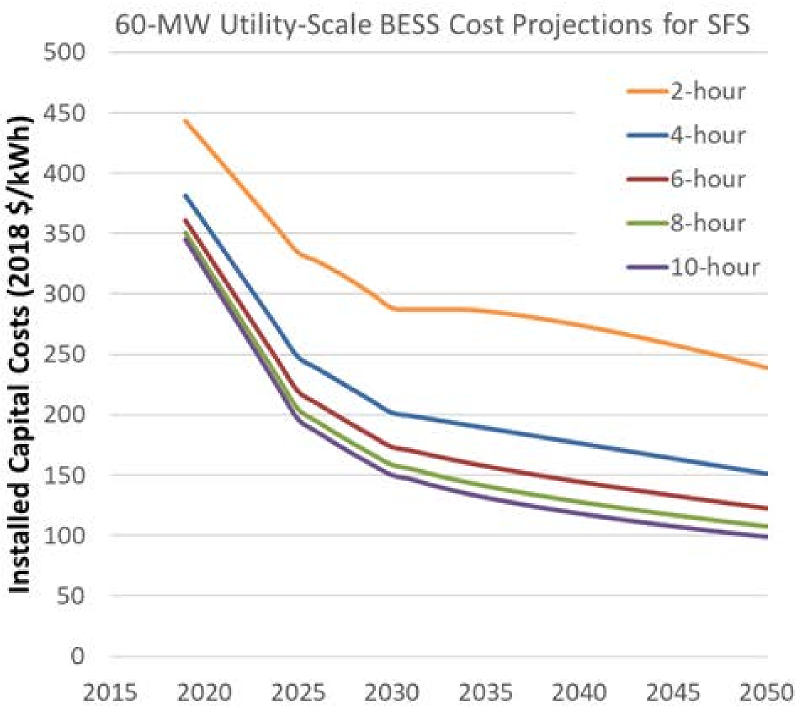


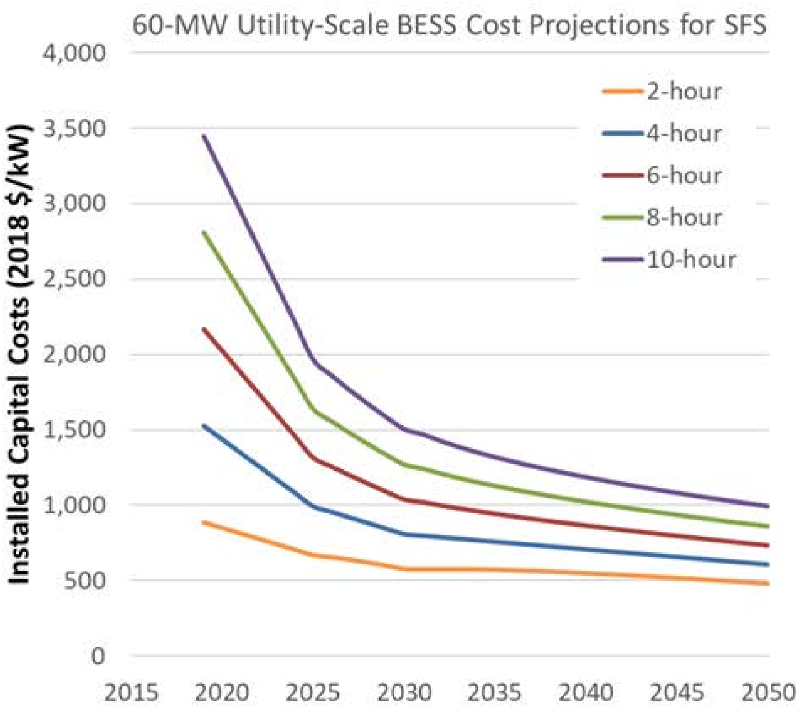


Key Learning 2: Recent storage cost declines are projected to continue, with lithium-ion batteries continuing to lead the market share for some time.



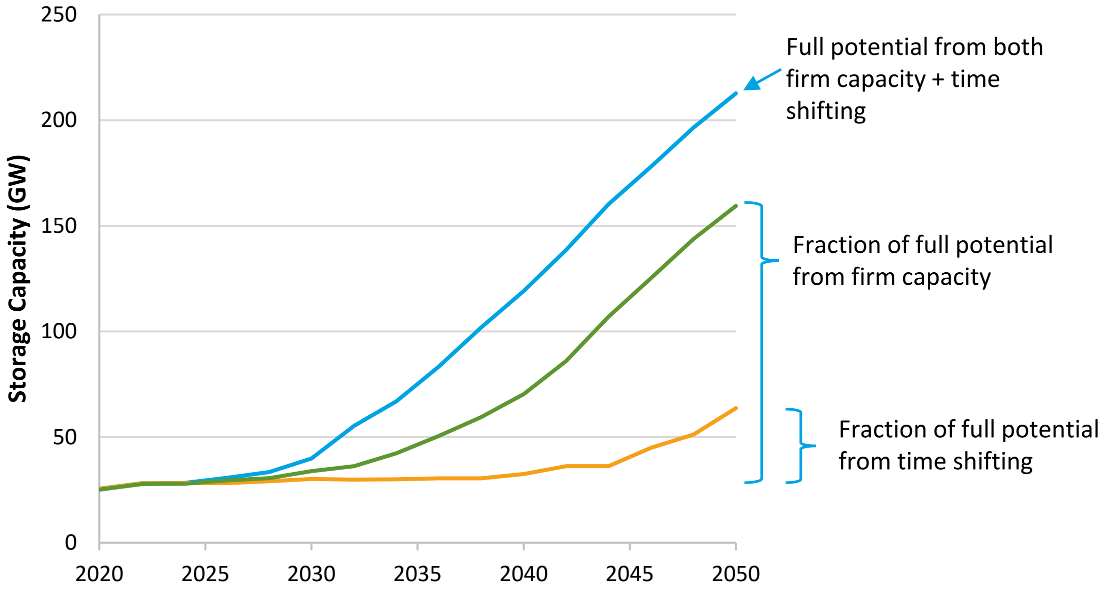
Key Learning 2 continued: Recent storage cost declines are projected to continue, with lithium-ion batteries continuing to lead the market share for some time.



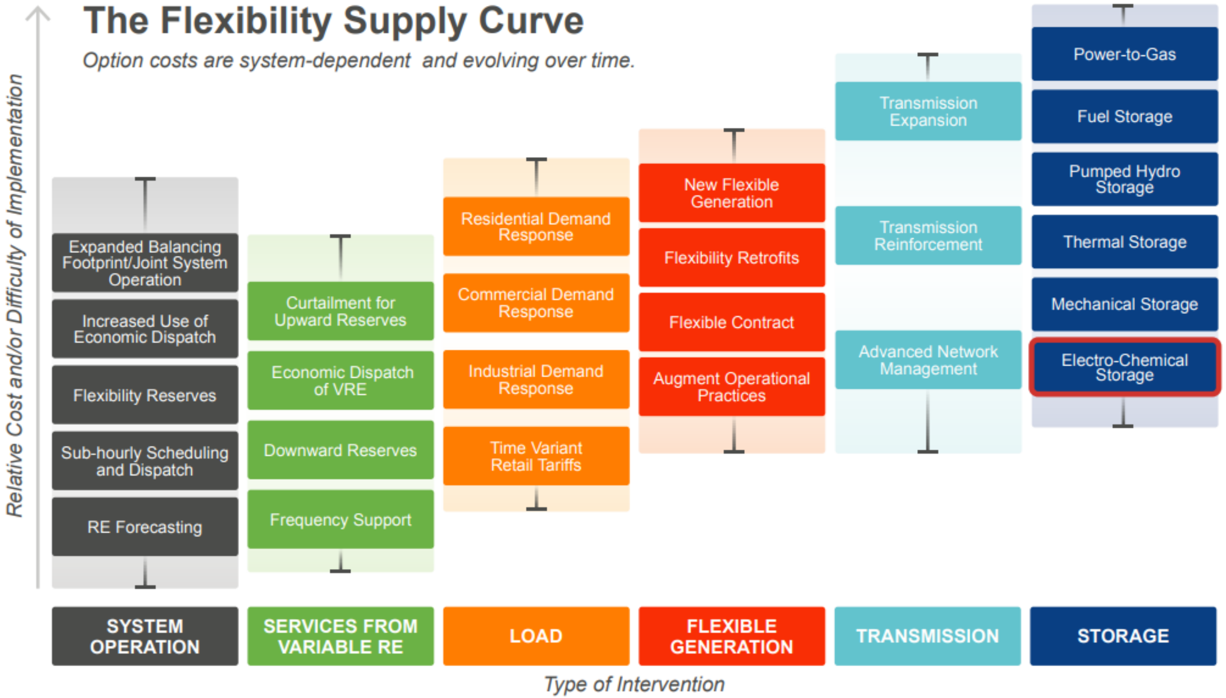


Key Learning #3: The ability of storage to provide firm capacity is a primary driver for cost-effective deployment.

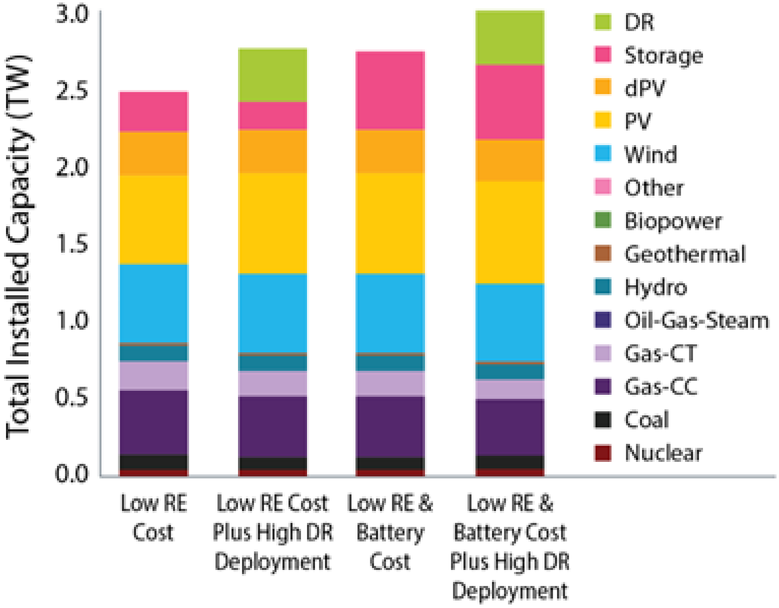
Storage achieves 75% of its full potential when it can provide firm capacity



Key Learning 4: Storage is not the only flexibility option, but its declining costs have changed when it is deployed vs. other options.

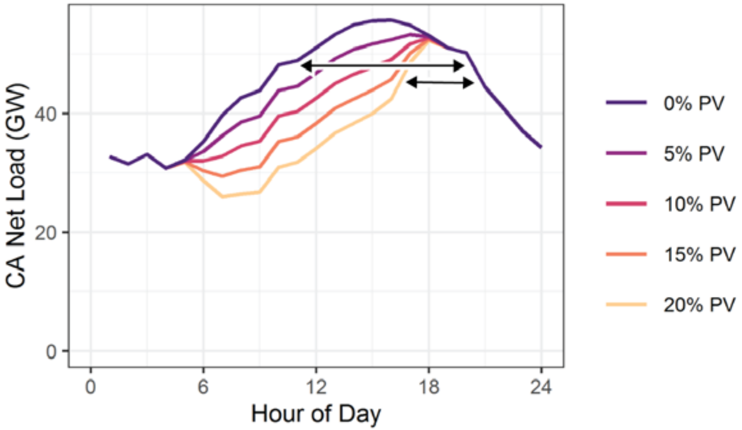


Key Learning 4 continued: Storage is not the only flexibility option, but its declining costs have changed when it is deployed vs. other options.

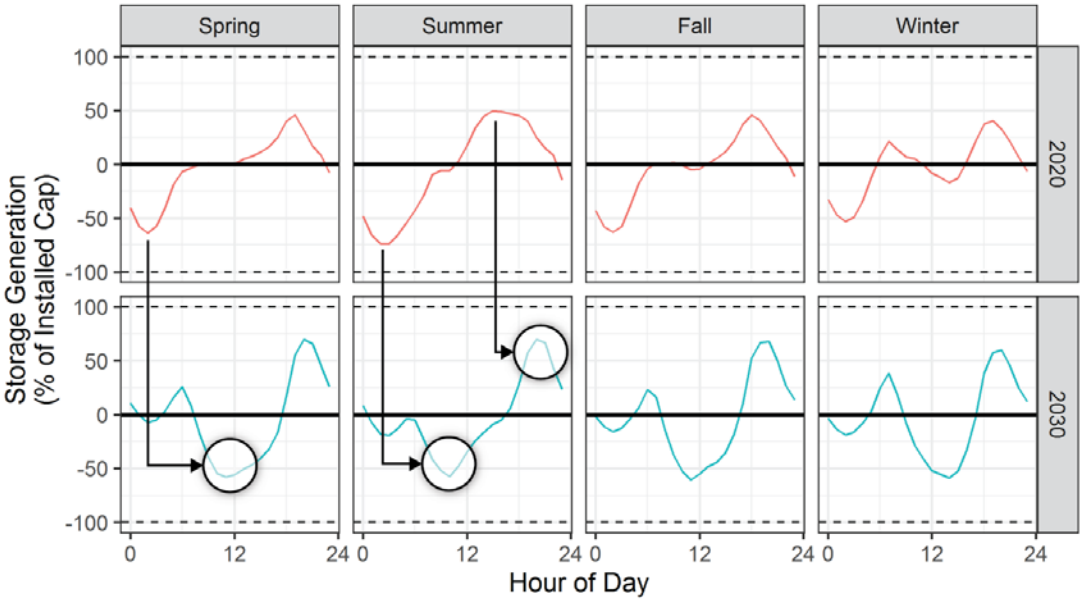


- Additional scenarios in which demand response (DR) is assumed in the system.
- Flexible demand reduces the overall need of firm capacity and the value of energy time shifting.

Key Learning 5:
Storage and PV complement each other.

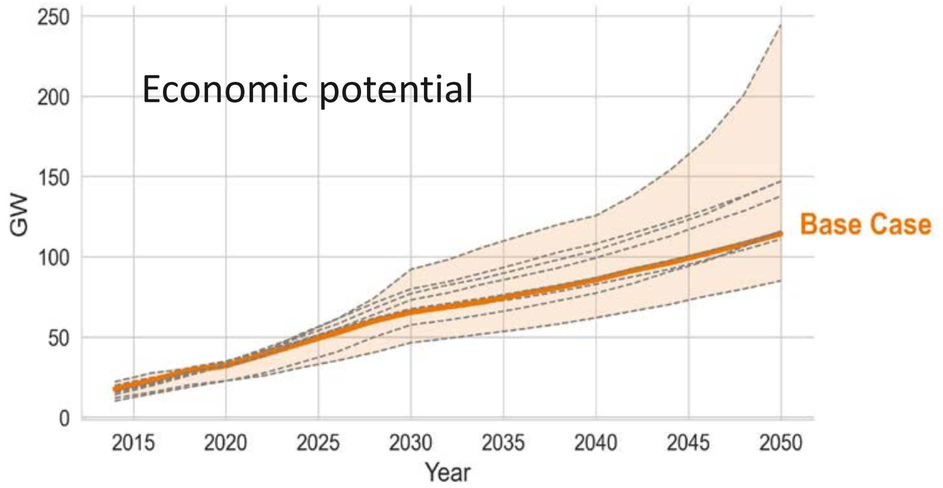


Increased PV deployment reduces duration required for energy storage to provide firm capacity.

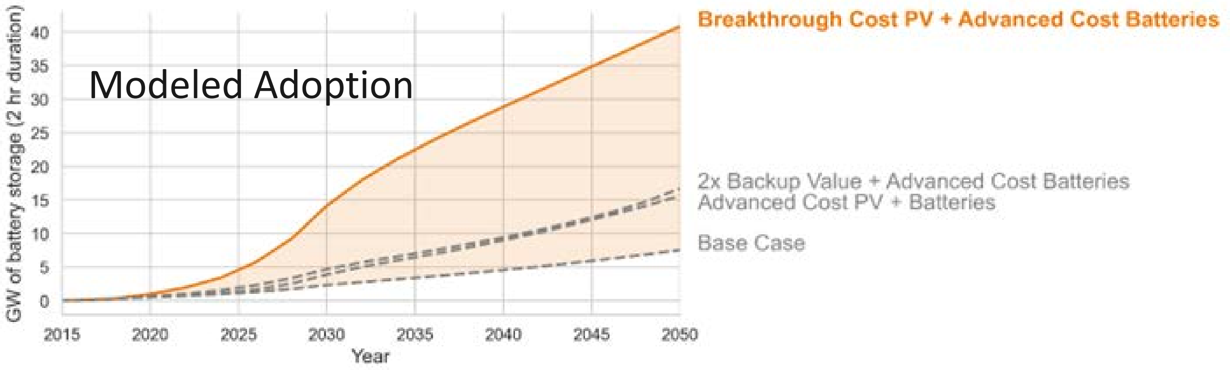


More PV on the system in 2030 (vs. 2020) moves charging from nighttime to daytime and shortens the peaks

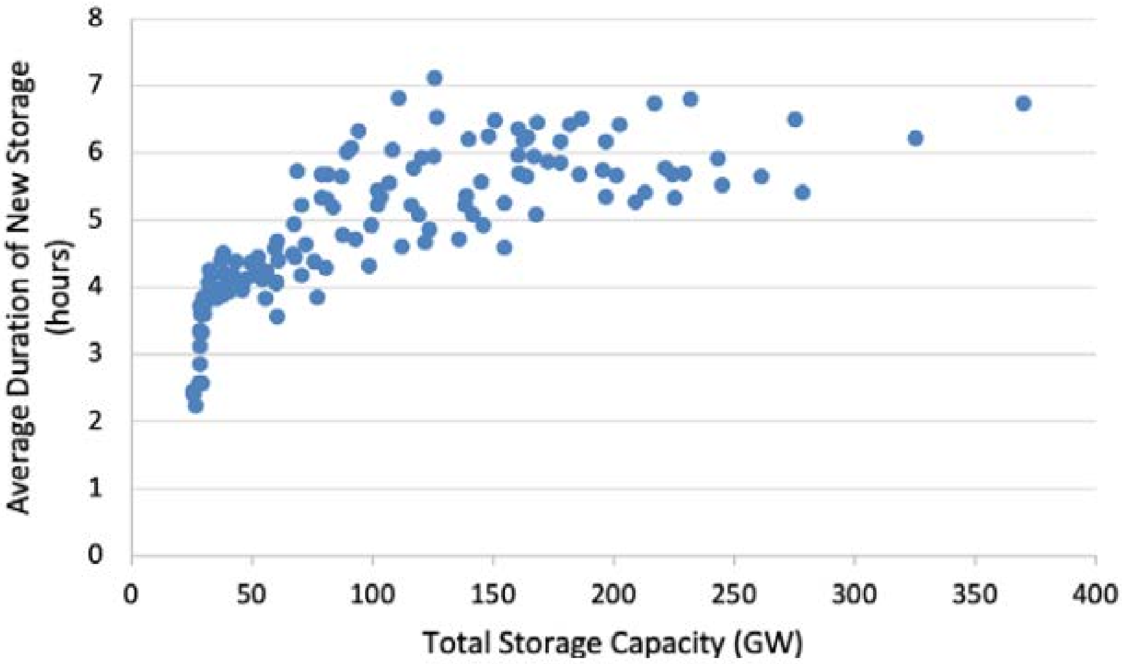
Key Learning 6: Cost reductions and the value of backup power increase adoption of building-level storage.



- 85–244 GW: Economic potential for distributed PV-plus-storage systems (assuming 2-hour duration)
- Low adoption levels due to long payback periods
- Adoption levels sensitive to costs and value of backup power

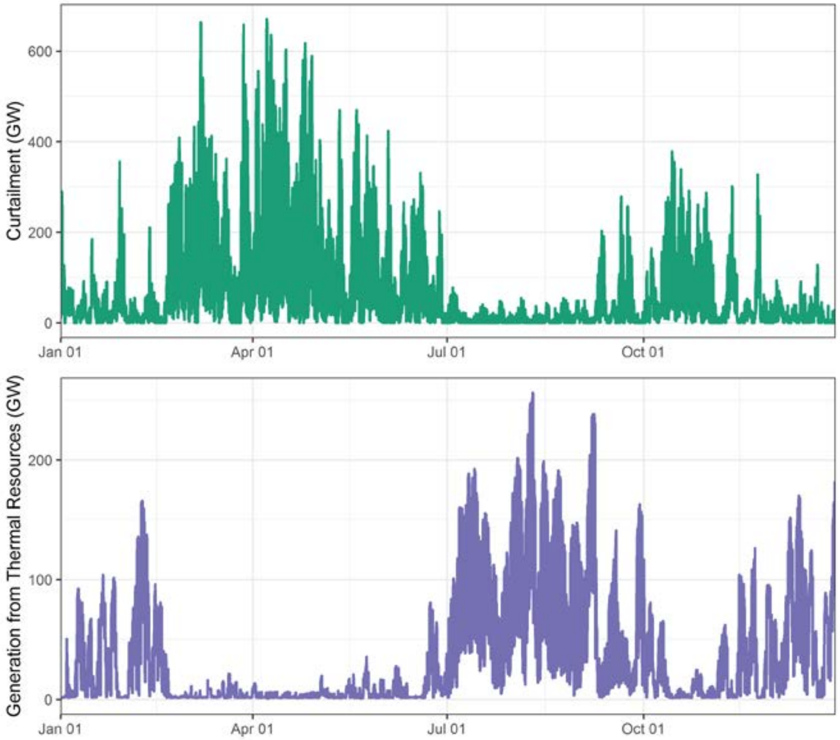


Key Learning 7: Storage durations will likely increase as deployments increase.



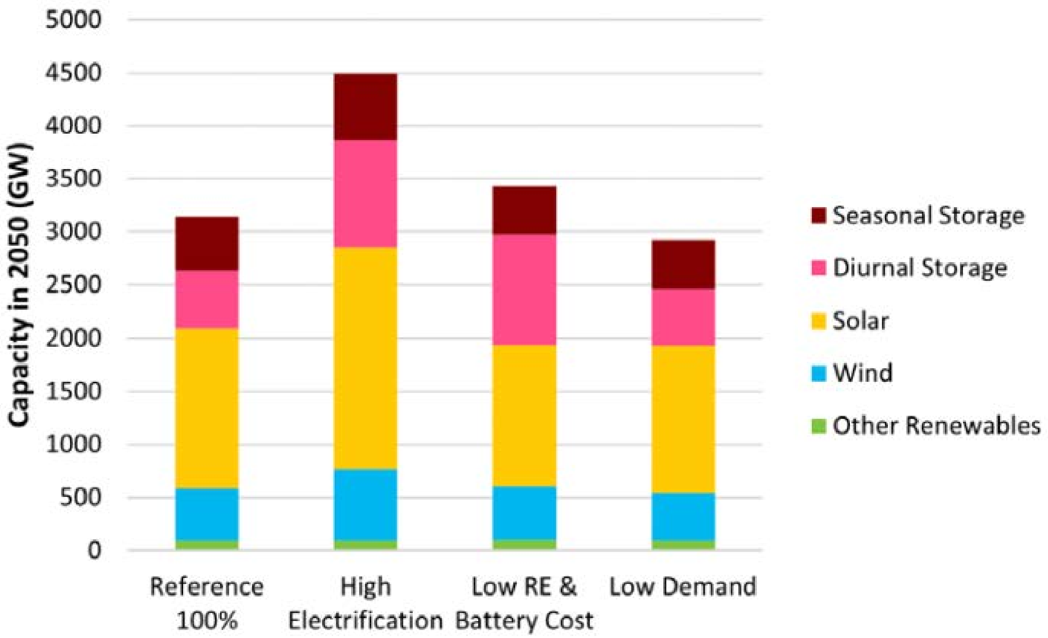
- Net peak load periods widen with more storage deployments requiring longer-duration storage to provide firm capacity.
- PV narrows the peaks but only to a point.

Key Learning 8:
Seasonal storage technologies become especially important for 100% clean energy systems.



- 100% decarbonization scenarios
- 94% of national demand is met by VRE plus hydropower and geothermal
- 6% of demand is met by renewably-fueled thermal resources such as combustion turbines burning hydrogen and biofuels.
- Thermal resources used during low wind and lower solar periods.

Key Learning 8 continued: Seasonal storage technologies become especially important for 100% clean energy systems.



- 100% decarbonization scenarios
- In these scenarios, large amounts (greater than 400 GW) of seasonal storage technologies are deployed
- Demonstrating the value of having a technology that can overcome the seasonal mismatch in renewable energy production and electricity demand systems

Learn more about the Storage Futures Study

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www.nrel.gov/analysis/storage-futures