NEW ENERGY OPTIONS

RESEARCH BRIEF

SEPTEMBER 2020

KEY POINTS FOR DECISION-MAKING

For wind and solar electricity generation

- **Highly reliable electricity with minimal curtailment of generation would require energy storage costs to decrease several hundred-fold from current costs.**
- **The role of energy storage varies. High-cost storage competes with curtailment to fill short-term gaps between generation and hourly demand, while near-free storage fills seasonal troughs.**
- **As storage capacity increases, additional storage is used less frequently, and hourly electricity costs become less volatile. These factors diminish price arbitrage opportunities for the added storage.**

Co-located solar farm and energy storage facility (Primus Power)

How reduced energy storage costs affect reliable renewable electricity systems

Several U.S. states and other regions of the world have set policy goals for all electricity generation to come from zero-carbon or renewable resources by 2050. Because wind and solar resources vary daily and seasonally, a reliable electricity system requires energy storage, flexible demand, or infrequent use of other zero-carbon generation technologies. The economics of energy storage depend on the frequency, magnitude, and duration of storage used. And investment in energy storage competes with investment in additional wind and solar generation capacity.

We assessed the effects of reductions in energy storage costs on electricity systems based only on variable renewable energy (VRE) resources such as wind and solar.

We found that in the least-cost systems, the role of energy storage shifts from filling hourly gaps when storage costs are high (>$100/kWh) to filling seasonal gaps when storage is near-free. To yield highly reliable electricity while minimizing curtailment of VRE generation, energy storage costs would need to decrease several hundred-fold (to ~$1/kWh) from current costs.

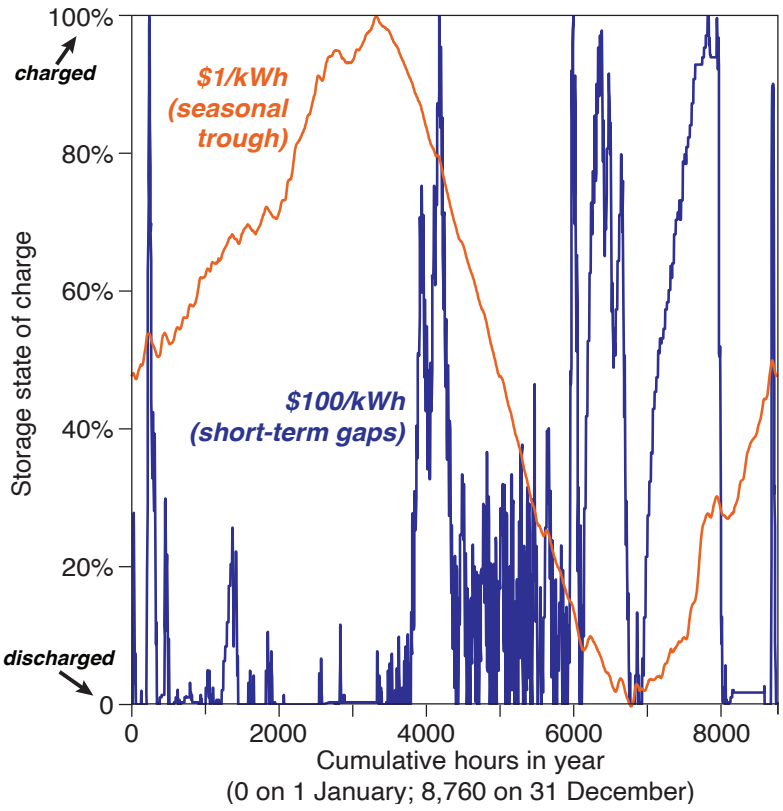
The amount of money spent on energy storage, for least-cost VRE/storage systems meeting continental U.S. electricity demand, would remain mostly constant. However, the total system costs may decrease substantially as a result of declining storage costs.

Summary

New battery chemistries may help meet cost targets for seasonal energy storage. These chemistries would be used infrequently in storage applications that use only abundant, inexpensive raw materials in conjunction with ultralow-cost manufacturing processes.

Steep diminishing returns for energy storage cost reductions in variable renewable electricity systems underscore a need for additional technologies to ensure the cost-effectiveness of zero-carbon energy. These include expanded electrification and demand response in heating, industry, and transportation, low energy-cost long-duration storage technologies (e.g., thermal storage, power-to-gas, and power-to-liquid fuels), and high-voltage direct-current (HVDC) transmission lines.

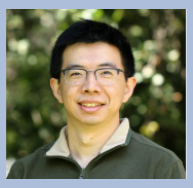
Potential tradeoffs between the private benefits of system cost reductions vs. the public benefits of energy storage expenditures suggest a need for public R&D support.



Effect of storage cost on the state-of-charge. In least-cost electricity systems based exclusively on variable renewable energy sources (VREs, here both wind and solar at current costs), high cost storage ($100/kWh, blue) is charged and discharged within a day, but the dominant charge/discharge cycles of low cost storage ($1/kWh, orange) fill in the annual generation trough in VREs.

NEW ENERGY OPTIONS

ABOUT THE AUTHORS



Fan Tong
fantong@lbl.gov

Fan Tong is a project scientist at the Lawrence Berkeley National Laboratory.

Ken Caldeira
kcaldeira@carnegiescience.edu

Ken Caldeira is a senior scientist emeritus at the Carnegie Institution for Science.

Nathan S. Lewis
nslewis@its.caltech.edu

Nate Lewis is the George L. Argyros Professor of Chemistry at the California Institute of Technology.

This brief is based on the paper "**Effects of deep reductions in energy storage costs on highly reliable wind and solar electricity systems**" published in *iScience* (2020).

We acknowledge a gift from Gates Ventures LLC to the Carnegie Institution for Science.

Solar cells transform energy. Stored energy makes wind- and solar-based systems more reliable. (Steven Davis)

FOR MORE INFORMATION

Visit the New Energy Options website at new-energy-options.org.