# WHERE AND WHEN DOES SOLAR PLUS STORAGE MAKE SENSE FOR COMMERCIAL BUILDINGS?

## NREL Researchers Make Their "BESSt" Guess Using REopt Lite Modeling Tool

As the capital cost of battery energy storage systems (BESS) declines, opportunities for commercial buildings to achieve net savings through peak demand management and energy arbitrage are emerging. National Renewable Energy Laboratory (NREL) researchers modeled energy storage project economics—with and without accompanying solar photovoltaic (PV) systems—using local utility rates, building loads based on ASHRAE climate zones, and solar intensity data to identify regions where these systems deliver life cycle savings now and in future cost scenarios.

Improving project economics call for a new look at investment in solar-plus-storage systems. As with other distributed energy technologies, the opportunity for a site to cost-effectively deploy BESS depends on a variety of complex factors, including technology costs, incentives, co-deployment with other technologies, value streams monetized, utility rates, and site electricity consumption patterns. Previous studies[1,2] on the techno-economic potential of BESS in the United States have identified three primary drivers: the rate tariff of the site, whether the BESS is installed along with solar PV, and the capital cost of the technology.

This study builds on existing research by comprehensively evaluating storage economics through geospatial layers, illustrating the savings potential of BESS and solar-plus-storage systems. In addition to the static maps presented in Figure 1, interactive geospatial layers are also accessible at https://maps.nrel.gov/us-storage-economics.

## Where does investing in battery storage make economic sense?

**Percent life cycle cost savings from deploying behind-the-meter BESS**

**Percent life cycle cost savings from deploying behind-the-meter BESS, potentially coupled with solar PV**

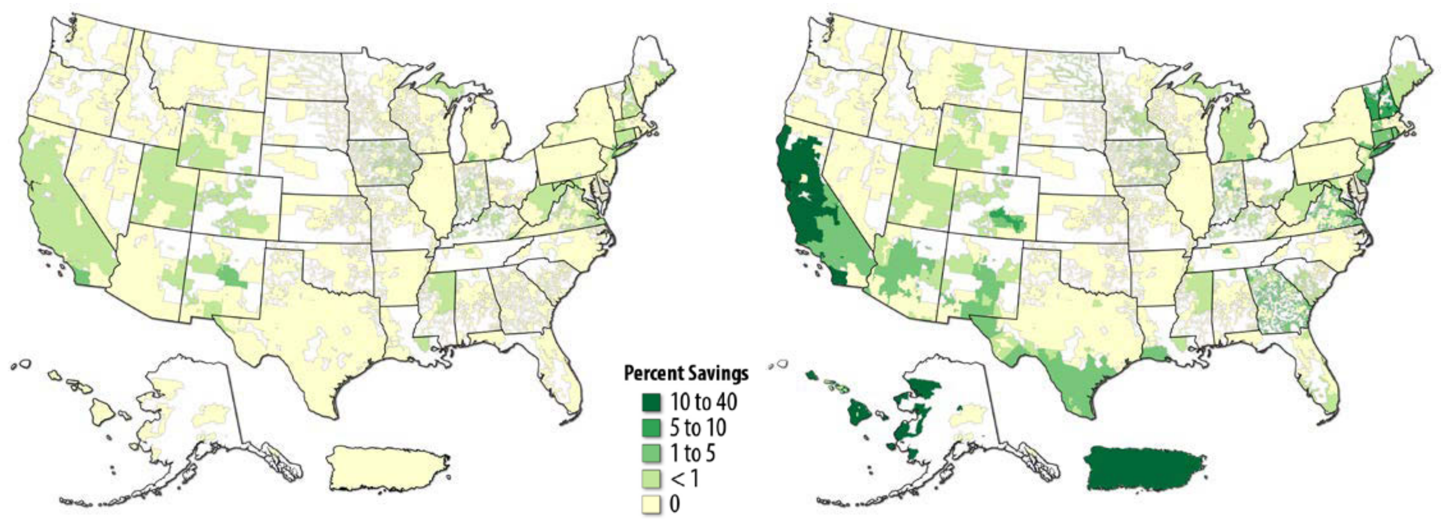


Figure 1. These maps show where in the United States there is potential for cost savings from implementing a behind-the-meter storage system alone (left), or in some cases with solar PV (right), compared to purchasing all electricity from the utility. Areas in green indicate percent life cycle cost savings (including utility costs as well as capital and operations and maintenance costs) of the deployed systems. Areas in yellow indicate that the area was evaluated, but a system would not provide life cycle cost savings. *Image from NREL*

[1] Long, Matthew, Travis Simpkins, Dylan Cutler, and Kate Anderson. 2016. "A Statistical Analysis of the Economic Drivers of Battery Energy Storage in Commercial Buildings." In IEEE, 1–6. *https://doi.org/10.1109/NAPS.2016.7747918*.

[2] McLaren, Joyce, Nick Laws, Kate Anderson, Nick DiOrio, and Hannah Miller. 2019. "Solar-plus-Storage Economics: What Works Where, and Why?" *The Electricity Journal* 32 (1): 28–46. *https://doi.org/10.1016/j.tej.2019.01.006*.

Table 1. BESS and Solar-Plus-Storage Capital Cost Scenarios and Savings

| Capital Cost Scenario | BESS | | | | | Solar Plus Storage | | |
|---|---|---|---|---|---|---|---|---|
| | BESS Capital Cost | | Cases with Savings >0 | Mean Savings* | Mean Storage Capacity* | Cases with Savings > 0 | Mean Savings* | Mean Storage Capacity* |
| | Power | Energy | | | | | | |
| Baseline +25% | $1,050/kW | $525/kWh | 16% | 0.3% | 8 kW/20 kWh | 21% | 9.1% | 26 kW/99 kWh |
| Baseline | $840/kW | $420/kWh | 21% | 0.5% | 12 kW/34 kWh | 27% | 9.5% | 40 kW/175 kWh |
| Baseline -25% | $630/kW | $315/kWh | 33% | 0.8% | 18 kW/75 kWh | 39% | 8.0% | 46 kW/221 kWh |
| Baseline -50% | $420/kW | $210/kWh | 48% | 1.4% | 27 kW/158 kWh | 55% | 8.5% | 55 kW/287 kWh |

*Mean savings and storage capacity for all cases where modeled savings are greater than 0.

REopt Lite™, a publicly available web tool for identifying optimal renewable energy and storage system sizes and dispatch strategies for behind-the-meter applications, was used to determine the cost-optimal energy storage system size—including the possibility of no system at all—across all investor-owned utility (IOU) territories in the United States, plus the territories of non-IOUs that serve more than 400,000 customers. Researchers used the most common rates (up to three) in each IOU service territory to evaluate savings potential. Federal Energy Regulatory Commission Form 1 submissions were used to identify the rates that either served the most customers, yielded the most commercial revenue, or accounted for the most energy sold.[3] For non-IOUs, general service rates were used. Within a utility territory, savings potential was further evaluated based on the building load for a medium office using ASHRAE climate zone and solar resource intensity region (distinguished every 0.5 kWh/m$^2$-year). BESS economics were evaluated with and without co-location of PV, using four capital cost scenarios for a total of 20,328 REopt Lite runs.

NREL's **REopt Lite** web tool can be used to evaluate the optimal combinations, sizes, and dispatch of PV, wind, and storage. Key inputs include location, hourly electric load profile, utility rate, technology costs and performance characteristics, and financial parameters. This analysis utilized the REopt Lite application programming interface (API), allowing programmatic access for evaluation of thousands of sites and scenarios.

The maps in Figure 1 illustrate BESS and solar-plus-storage life cycle cost savings across the United States. In locations shaded green, capital costs are recuperated over the analysis period, with additional savings.

## Energy storage is more likely to be cost-effective in territories featuring demand charge components and time-of-use (TOU) pricing.

BESS-only scenarios are cost-effective in 523 of 2,541 cases analyzed (21%). In the base-case BESS capital cost scenario ($840/kW plus $420/kWh), average cost savings are 0.5% and average system capacity is 12 kW/34 kWh (for reference, the average load for an office building in climate 6A is 115 kW). Areas with the greatest savings include the service territories of major New York and California IOUs and one electric cooperative in New Mexico, each of which feature rates containing demand charge components. Three-quarters of the territories with the greatest potential savings also feature energy TOU pricing.

As system costs continue to drop, modeling shows the case for BESS can be made in more areas of the country. A 25% reduction in storage capital costs increases the number of cost-effective scenarios to 830 cases across 27 states, while average storage capacities rise and mean savings increase from 0.5% to 0.8%. With a 50% reduction in storage capital costs, about half of all cases achieve at least some savings. Most of the *new* savings opportunities at this cost reduction are marginal and the average savings among these newly economical cases is below 1%.

## Solar-plus-storage systems generate greater savings across more tariff rates and more geographic locations than storage alone.

At baseline capital costs, over a quarter of solar-plus-storage cases are economical, and the average savings is 9%. The average storage sizes when coupled with PV are three to five times larger than the average for BESS alone (40 kW/175 kWh versus 12 kW/34 kWh). The additional capacity suggests that the system is not only offsetting additional demand charges, but also providing value by offsetting grid purchases at expensive times of day. The locations with the highest potential for solar-plus-storage savings include Alaska, California, Colorado, Hawaii, New Hampshire, New York, and Vermont. Even if storage capital costs were to increase 25%, these same states would still see comparable savings from solar-plus-storage systems.

## Learn More

Learn more about the REopt Lite web tool, API, and open source software at *reopt.nrel.gov/tool*.

For questions about using REopt Lite to optimize solar-plus-storage savings, contact *Emma.Elgqvist@nrel.gov*, *Ted.Kwasnik@nrel.gov*, or *Kate.Anderson@nrel.gov*.

[3] The Federal Energy Regulatory Commission Electric Utility Annual Report, also known as Form 1, made available from the ABB Velocity Suite (ABB 2019).

NREL

National Renewable Energy Laboratory
15013 Denver West Parkway
Golden, CO 80401
303-275-3000 • www.nrel.gov

NREL is a national laboratory of the U.S. Department of Energy
Office of Energy Efficiency and Renewable Energy
Operated by the Alliance for Sustainable Energy, LLC

NREL/FS-7A40-77112 • October 2020