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Behind-the-Meter Solar+Storage: Market Data and Trends

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As the distributed solar market evolves toward more dynamic forms of deployment, interest in paired solar-plus-storage applications continues to gain steam, but details on the current state of the market are relatively sparse. To fill that void, Berkeley Lab has released an in-depth analysis of this budding market segment. The report, entitled *Behind-the-Meter Solar+Storage: Market Data and Trends*, draws on the Lab's *Tracking the Sun* dataset to characterize trends in deployment, system sizing and equipment selection, installer-market development, and system pricing. The report also provides indicative analyses of the financial and resilience value that host customers in several key markets presently receive by pairing storage with solar.

This summary factsheet highlights a number of key trends from this analysis. For additional details, please refer to the full report.

How much behind-the-meter solar+storage has been installed, and where is it most prevalent?

Through year-end 2020, roughly 550 MW of storage has been paired with solar in "behind-the-meter" (BTM) applications, representing about 17% of all U.S. battery storage capacity installed through 2020. Residential installations make up the bulk (roughly two-thirds) of all paired BTM storage capacity, partly because almost all residential storage capacity is paired with solar. In contrast, non-residential storage is more often installed on a stand-alone basis.

Deployment trends for BTM solar+storage are often described in terms of attachment rates, which refers to the percentage of solar installs each year that include storage. As shown in Fig. 1, attachment rates, nationally, are still quite low: just 6% of all U.S. residential PV systems and 2% of all non-residential systems installed in 2020 included storage. However, much higher attachment rates have been realized within individual states and utility service territories. Hawaii, in particular, is in a class of its own, with roughly 80% of all residential PV systems installed in 2020, and 40% of all non-residential PV installs paired with storage. Trends in Hawaii have been driven to a significant degree by the state's transition from net metering. California has also seen relatively high residential attachment rates, driven by a combination of direct cash rebates for storage equipment and growing concerns about wildfire-related power outages. Given the sheer size of the California market, the state represents the overwhelming majority of all BTM solar+storage systems installed to-date.

This work was funded by the U.S. Department of Energy Solar Energy Technologies Office, under Lawrence Berkeley National Laboratory Contract No. DE-AC02-05CH11231. If you have questions or need clarification of any points, please contact Galen Barbose at GLBarbose@lbl.gov. Interested in other LBNL Electricity Markets and Policy Group publications? Join our notification list here.

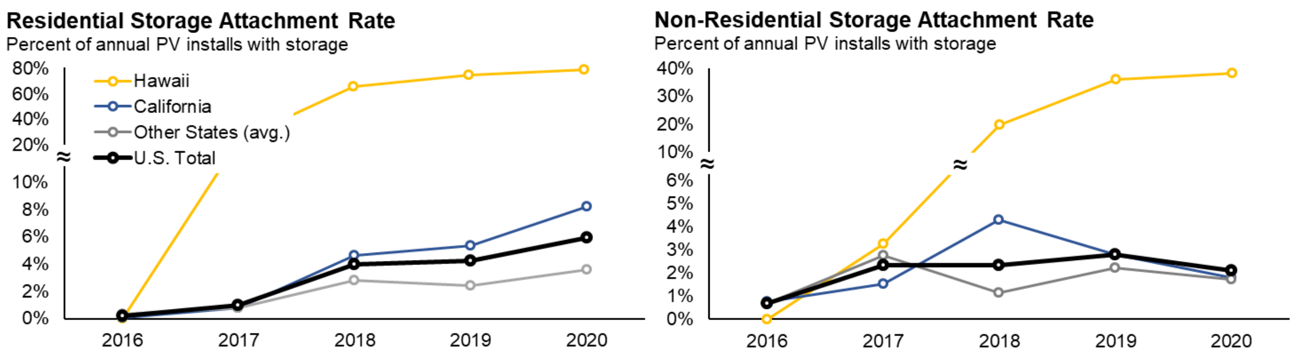

Figure 1. Storage attachment rates over time for residential (left) and non-residential (right) solar installations in each year.

The report explores these deployment trends and others, including utility-level BTM solar+storage installs in California before and after the Public Safety Power Shutoff events in Fall 2019, zip-code level attachment rates in several key state markets, income trends of residential solar+storage adopters, customer segmentation details on non-residential solar+storage adopters, and trends in retrofitting existing solar systems with storage.

How are these systems typically sized and configured?

The residential solar+storage market has thus far been dominated by two storage products: Tesla's Powerwall and an LG Chem's RESU 10H (Fig. 2, left-hand panel), both rated at a 5-kW power output, with 2.7-hour and 1.9-hour durations, respectively. The majority of paired residential systems consist of a single battery storage unit, though the fraction of systems with multiple batteries has been steadily growing (see Fig. 2, center panel). That latter trend likely reflects growing interest in the use of these systems for backup power purposes, with a desire to ensure longer periods of backup or larger amounts of load to backup. Given the sizes of PV and storage equipment typically installed in paired applications, most systems have the ability to store somewhere between 30% to 80% of average daily PV generation (the kWh ratio shown in the right-hand panel of Fig. 2). That fraction can be important when considering the ability of storage to absorb paired solar generation, either for utility bill management or backup power purposes. A similar set of trends for non-residential systems are discussed in the full report.

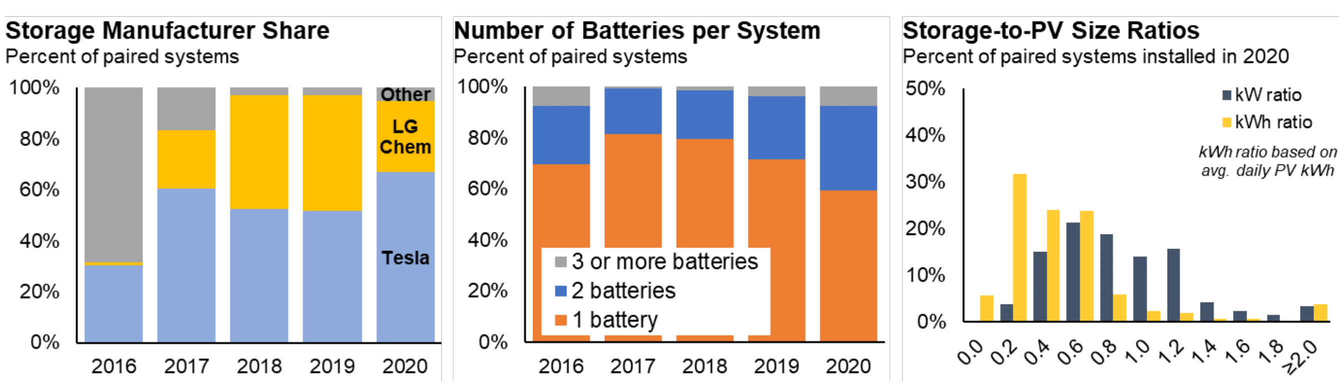

Figure 2. Technical characteristics of residential solar+storage systems.

How broadly have PV installers embraced storage?

PV-installer experience with paired solar+storage systems is substantially broader than what attachment rates might suggest, particularly in the residential sector. As of 2020, roughly 50% of all active residential installers had installed at least one paired system, either in 2020 or in a prior year (left-hand panel of Fig. 3). Notwithstanding that breadth, the market remains highly concentrated, with just 10 installers comprising about 60% of all U.S. residential PV+storage installs in 2020 (Fig. 3, center-panel). Tesla and SunRun each comprised roughly 20% of the market, and most others in the top-10 are local California and Hawaii firms. At the individual firm level, attachment rates can vary quite dramatically, even among the largest residential installers in California (see Fig. 3 right-hand panel), suggesting divergent business and marketing strategies. The full report provides similar details for the non-residential PV installer market.

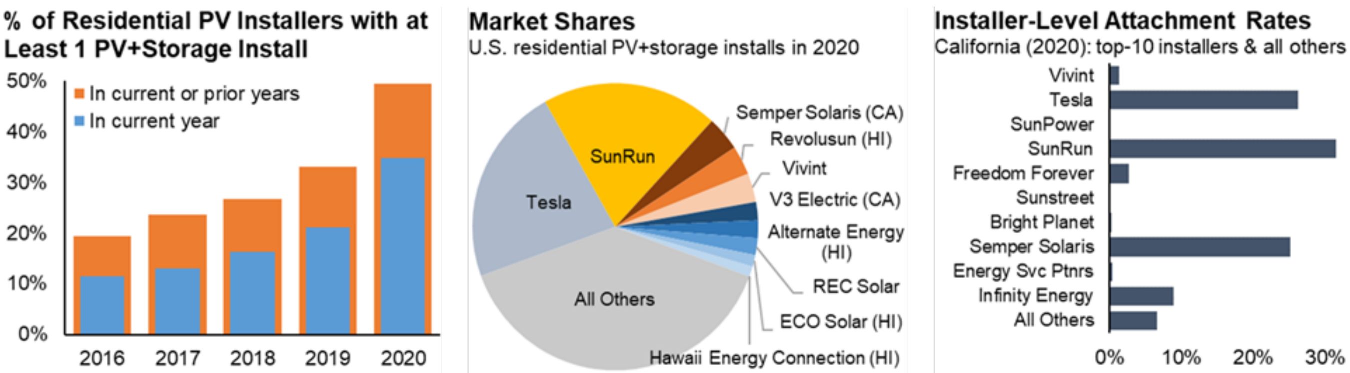

Figure 3. Installer-market characteristics for residential solar+storage systems.

What is the incremental cost of adding storage to behind-the-meter PV?

Comparing median installed prices for residential PV systems with and without storage suggests a premium of roughly $1.2/W of PV capacity for adding storage (see Fig. 4), equivalent to about 33% of the median price of stand-alone residential PV systems in 2020. The pricing differential is similar for small non-residential PV systems, and is somewhat smaller for large non-residential systems. That pricing differential implies a storage cost of roughly $700/kWh for paired residential systems. Several other data sources explored within the analysis, including storage cost data reported through California's Self Generation Incentive Program (SGIP) and installer-quote data provided by *EnergySage*, tend to suggest somewhat higher costs in the range of $1000-1200/kWh for residential storage paired with PV. Surprisingly, both total system-level prices for paired systems as well as storage costs reported through the SGIP program have been rising in recent years, though those data also show a high degree of heterogeneity in how installers price their systems.

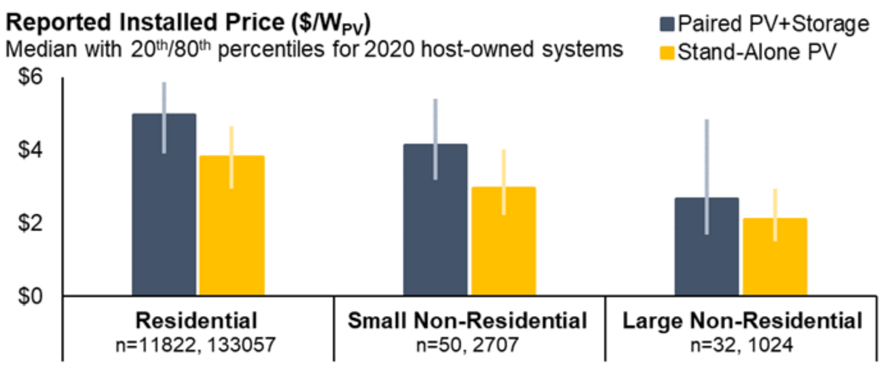

Figure 4. Installed prices reported for paired PV+storage and stand-alone PV systems.

Do the customer-economics of adding storage to PV currently pencil out?

The study provides indicative estimates of the total value of the financial benefits that customers receive from adding storage to BTM PV, focusing on the current, standard benefit streams in several key markets with relatively high attachment rates. In the residential sector (Fig. 5, left-hand panel), the present-value of these financial benefits ranges from roughly $500-1000/kWh across the utilities and system sizing scenarios considered. Given the aforementioned storage costs, the net customer economics in these markets would appear fairly borderline, at least based on the cases and benefit streams considered. This suggests that residential co-adoption in these markets is likely being driven either by customers with unique conditions that allow for more-favorable economics or by non-financial considerations, such as the resilience value associated with backup power applications.

In contrast, the customer-economics on the non-residential side are considerably better. As an illustration, the study considers the two largest California utilities (see Fig. 5, right-hand panel), estimating present-value benefits ranging from roughly $1200-2000/kWh, depending on the building type and available electricity rate options. The greater value for non-residential customers is partly due to the availability of accelerated depreciation (MACRS, which is also available for third-party owned residential systems). In addition, non-residential electricity tariffs with relatively high demand charges offer much greater bill savings potential than what can be achieved under the corresponding set of residential tariff structures.

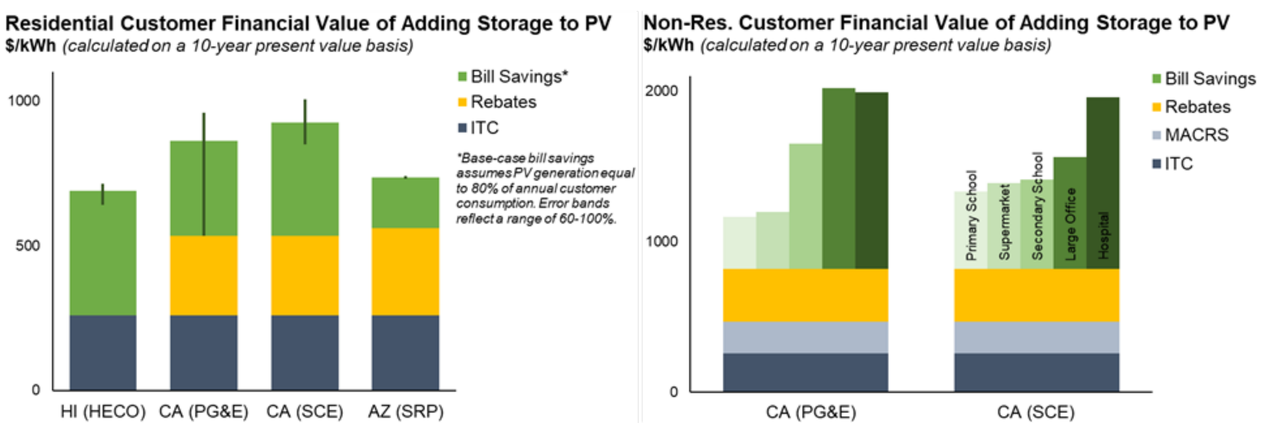

Figure 5. Financial benefits to the host-customer from adding storage to BTM PV.

What level of backup power assurance can these systems provide?

As noted, residential co-adoption of storage with PV is likely being driven to a significant degree by backup power considerations. To illustrate the potential backup power capabilities of paired PV+storage, the study simulates the percentage of residential customer daily consumption that could be maintained by BTM PV+storage across four diverse climates (AZ, CA, HI, and MA). The analysis shows that a standard residential system configuration with 7 kW PV paired with 5 kW/10 kWh battery storage could serve, on average, 60-80% of a typical customer's daily consumption over the course of a year (see "base load" results in the right-hand panel of Fig. 6). However, those values tend to vary seasonally (see left-hand panel), and can vary even more dramatically on a day-to-day basis as a result of cloud-cover. The study also estimated the system sizes required to serve progressively higher percentages of customer-load. For example, meeting 90% of annual load would require 8-14 kW PV with 15-22 kWh storage, depending on the state, for customers with average consumption levels. Going beyond 90%, system sizing requirements tend to increase quite rapidly.

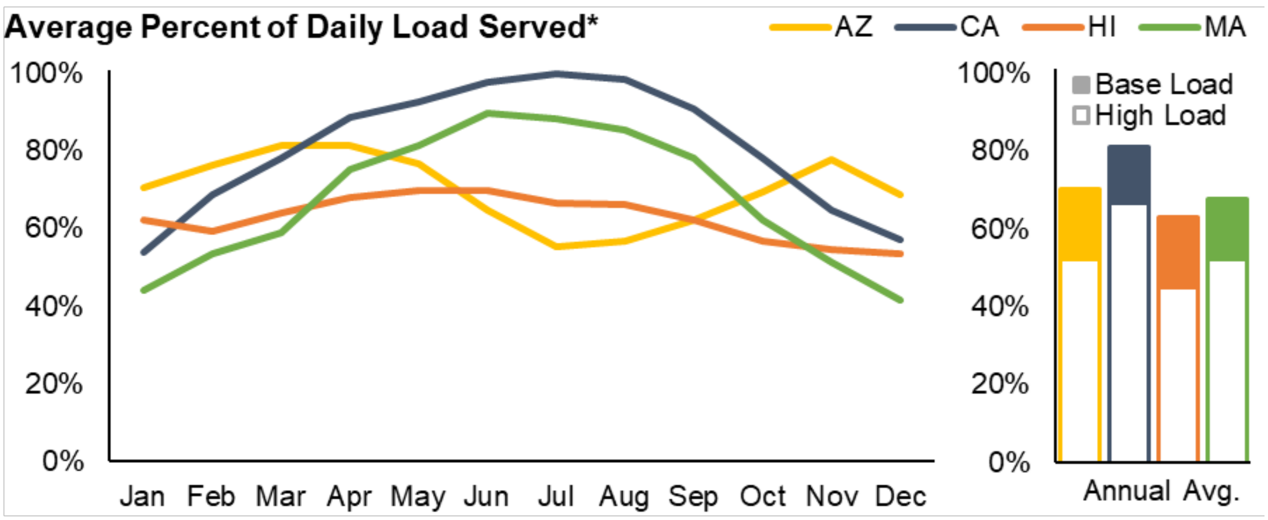

Figure 6. Percent of residential customer load that could be served by BTM PV+storage, given typical system sizing

Conclusions

The findings above and in the full report suggest a number of broad themes:

- BTM solar+storage is growing, at least within the residential sector, but is still a small part of the broader solar market
- The supply-side of the market is fairly concentrated in terms of both manufacturers and installers, though a significant share of PV installers has entered the solar+storage space, at least to some limited extent
- Installed prices for BTM battery systems have generally risen or remained flat over the past few years; increasing adoption can't be attributed to falling retail costs
- Deployment drivers are locationally specific (e.g., specific rate structures, incentive programs, natural disaster threats)

- Deployment trends partly reflect the underlying economics, but there are also some apparent disconnects (e.g., lower attachment rates for non-residential than residential, divergent attachment rates across regions with similar payback, un-economic adoption in some markets)
- Those apparent disconnects may partly reflect other sources of value beyond the direct financial benefits—including potential customer reliability benefits from backup power during outages