Hawai‘i Natural Energy Institute Research Highlights

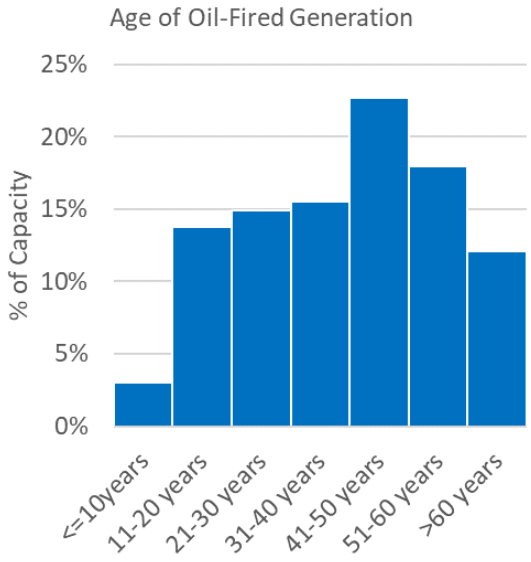
Energy Policy & Analysis

Capacity Value of Storage with High Penetration of PV and Storage

OBJECTIVE AND SIGNIFICANCE: The objective of this analysis was to evaluate the ability of battery energy storage to reliably replace the aging fossil-fired generation fleet in Hawai‘i. Specifically, this analysis quantified the capacity value and resource adequacy benefits that energy limited resources provide to the grid to answer the question, “can solar and battery energy storage replace the capacity value of thermal generation?” As the Hawai‘i grids integrate additional solar + storage resources, the capacity value metric will be a primary factor in the ability to retire the thermal generating fleet.

KEY RESULTS: The results of this analysis indicate that storage systems can provide capacity for reliability, supporting efforts to retire fossil generation. This is based on stochastic resource adequacy simulations using GE Multi-Area Reliability Software (GE MARS) to evaluate system reliability under hundreds of combinations of load, weather, and generator outages. However, as seen in the “**Grid Reliability with AES Retirement**” project summary for the retirement of AES, while storage can provide an effective one-to-one replacement at modest levels of penetration, this work found that the efficacy of storage to provide firm capacity saturates with increasing penetration of storage or solar + storage.

BACKGROUND: The average age of the oil-fired[1] power plants in Hawai‘i is 40 years with at least one being over 80 years old, arguably the oldest operational fossil power plant in the U.S. Many of the plants are now operating well past their original design life. As the grid transitions to increased wind and solar energy, these plants are used less for energy, but are still being relied on to provide grid services and capacity, especially during periods of low wind and solar production. These plants are also being operated differently, cycling more often and ramping more regularly. The combination of aging infrastructure and increased flexibility demands are leading to increasing generator outages and required maintenance.



At some point, these generators will need to be retired and replaced with newer technology. While wind and solar can replace their energy contributions, a better understanding of their ability to provide capacity benefits is needed for long term planning.

Energy storage, either standalone or paired with solar, is increasingly being used in Hawai‘i and across the industry to provide firm capacity and other grid services. Many of these systems are currently planned for deployment in Hawai‘i. However, because storage is an energy limited resource and hybrid solar + storage projects are dependent on variable solar energy resources, these resources do not necessarily provide the same nameplate capacity benefits as fossil generation.

PROJECT STATUS/RESULTS: To evaluate the energy storage capacity value, referred to as the effective load carrying capability (ELCC), a series of Monte-Carlo resource adequacy simulations were conducted using the GE MARS. This analysis evaluates generator outages across hundreds of random draws to determine the expected amount of availability capacity and quantifies the number of unserved energy events. Storage resources with different hourly capacities were then added to the system. Load was then added to the system until the original reliability level was achieved. The amount of load added, relative to the amount of storage, determines

[1] Includes low-sulfur fuel oil, diesel, and dual-fueled (diesel and biodiesel) generating units.

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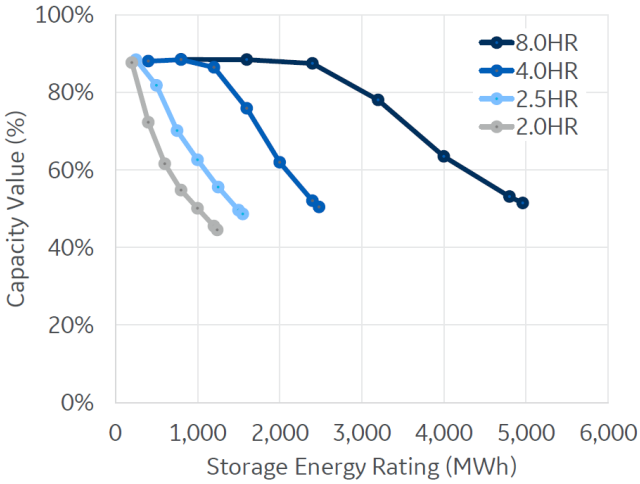
the capacity value of the resource.

While early storage additions can effectively replace thermal capacity, as illustrated in "Grid Reliability with AES Retirement", the results of this analysis illustrate that the capacity value of storage saturates as penetration increases.

- With increasing storage and load shifting, the net-load curve starts to flatten, and each subsequent reduction in peak load requires an increasing duration of response, as illustrated in the figure below.
- The state of charge of the storage can vary depending on daily variability of the solar resource.
- At high penetrations, system risk shifts to periods of low solar output, which could last multiple day because of anomalous, but well-understood and historic, weather patterns.



This limits the role storage can have on the system as a firm capacity resource as well as its ability to fully replace the need for conventional thermal generation. However, full capacity credit until 30% of peak load can still provide valuable near-term opportunities for storage to replace aging fossil capacity. To further retire and replace aging capacity, it will require either longer duration storage resources, a larger portfolio of storage and demand response, or other forms of renewable generation.

This work has produced the following publication: 2019, D. Stenclik, et al., "**Energy Storage as a Peaker Replacement: Can Solar and Battery Energy Storage Replace the Capacity Value of Thermal Generation?**", IEEE Electrification Magazine, Vol. 6, Issue 3, pp. 20-26.

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