Hawaiʻi Natural Energy Institute Research Highlights

Grid Integration & Energy Efficiency

DER Aggregation and Control with High Penetration Solar + Storage

OBJECTIVE AND SIGNIFICANCE: Over the past decade, the Oʻahu power grid has integrated significant amounts of solar PV, with over 550 MW of uncontrollable and unobservable distributed (rooftop) PV and 190 MW of utility-scale PV currently installed. As a result of the limited room available on the grid for uncontrolled assets, there is significant focus on controllability of all assets, including the distributed systems. However, recent developments that include large amounts of battery storage and new options for grid flexibility, have created new opportunities to integrate distributed rooftop PV at the system level without real-time control. The objective of this study is to quantify the level of control needed for additional DER based on system (not circuit) hosting capacity constraints.

KEY RESULTS: Preliminary results of this recently initiated analysis indicate that there is no appreciable difference in system curtailment or operating costs between DER (distributed PV + batteries) deployed with full real-time utility control and a simple time-of-day control system without direct management. The implications for this finding are far-reaching and have potentially large impacts on the design of future DER programs across the state. Specifically, simple passive and autonomous controls at the customer level appears to provide sufficient grid support to allow additional distributed PV deployment, without the need for costly communications, control systems, and payments for DER grid services.

Because of the implications of this preliminary analysis in directing future DER policy, particularly on Oʻahu's power system, future work is planned to address questions such as:

- Do existing programs effectively incentivize the "No Utility Control" systems?
- Do transportation electrification, TOU rates, or demand-side management change the fundamental finding?
- Do these preliminary results hold for higher amounts of system-wide PV, approaching the 100% RPS?
- How might distribution circuit-level constraints impact the analysis? What about operational reserve requirements?
- How would this result be impacted by lower levels of utility scale storage than Oʻahu's planned system?

It's important to note that this analysis did not evaluate coordination and control of DER that might be required for circuit-level hosting capacity constraints at specific locations. This is another topic for future work.

BACKGROUND: In 2018, the PUC approved fifteen utility-scale hybrid solar and storage (solar + storage) projects. These projects, often referred to as Stage 1 and Stage 2 resources, total approximately 670 MW solar and 3,538 MWh of storage statewide that includes up to 415 MWac solar and 1,781 MWh of hybrid storage on Oʻahu, as well as what will become one of the largest standalone battery storage systems anywhere in the world: the 185 MWac and 565 MWh Kapolei storage system. The projected renewable energy use on Oʻahu, based on the RPS definition, through the Stage 2 projects is shown in Figure 1.

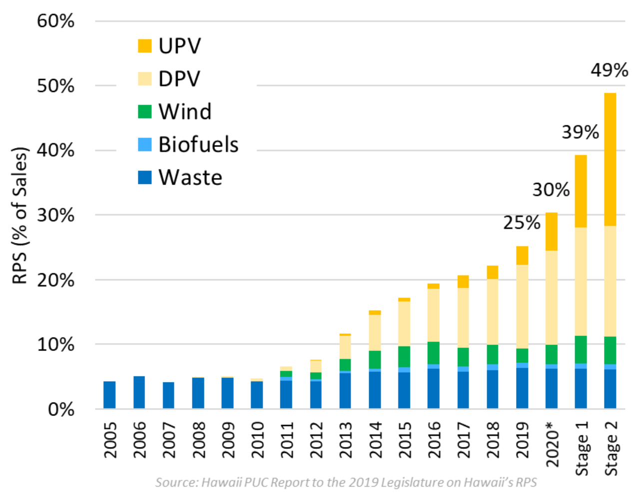

Figure 1. Oʻahu RPS Growth 2005-2020, and Stage 1 + 2.

These changes are taking place against the backdrop of other significant changes to the grid that could enable further economy-wide decarbonization. Most notably are the retirement of the AES coal plant, the largest fossil fuel-based generator on the Oʻahu grid, and the addition of the standalone Kapolei battery that can charge during the day using surplus solar resources. These storage systems, both the PV connected and the stand-alone Kapolei BESS, can also provide grid services that were traditionally provided by the steam oil fleet. As a result, the grid will soon be significantly more flexible than a traditional system. At the same time, transportation and other end uses are being electrified, leading to a more dynamic and changing demand side.

PROJECT STATUS/RESULTS: In this work, analysis was conducted to evaluate the need for aggregation and control of additional distributed solar + storage (DER) deployments. To quantify this value, a series of production cost grid simulations were conducted at increasing solar penetrations, increasing by 100 MWac blocks of installed distributed solar capacity. Each PV block was added with two different storage capacity configurations. The production cost models simulate grid operations across all 8,760 hours per year and incorporate fluctuating loads, solar, and wind resources. The remaining grid resources, including thermal generation and battery energy storage, are economically scheduled to serve load in a least-cost manner subject to utility defined operational limitations and transmission constraints. If the underlying generation mix does not have ample flexibility (either storage to charge using surplus solar or ability of thermal generators to cycle offline) solar may be curtailed and unused.

The benefits of DER aggregation and control were evaluated by simulating two bookend scenarios (Figure 2).

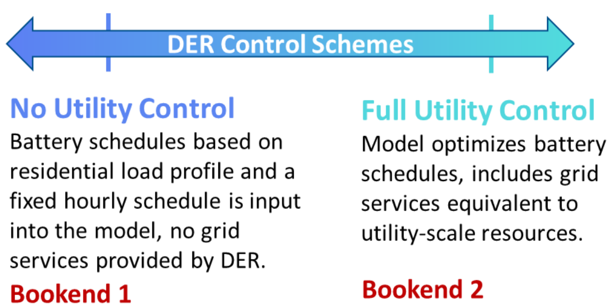

Figure 2. Overview of DER control schemes.

As additional PV is added to the grid, not all of it can be accepted, even when combined with the storage configurations that were evaluated. The resulting incremental solar curtailment, assuming full control, with increasing solar deployment is provided in Figure 3. Results are shown assuming two storage configurations and at two DER Control Schemes.

The results indicate that there are no differences in curtailment between cases with full utility control and when systems follow a fixed profile. This is because there is ample flexibility on the remaining utility-scale hybrid solar + storage resources to adjust to the static DER profile. In addition, the results showed no appreciable difference in total system generation cost because there was no change in oil-fired generation and grid services were already saturated by the utility-scale storage systems.

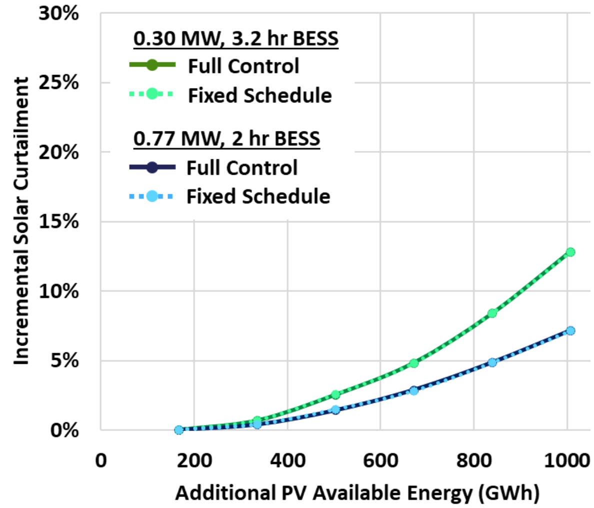

Figure 3. Curtailment of solar resources with and without utility control.

These results support two key conclusions:

1. There is no need for direct communication and control of DER resources to avoid system curtailment if behind the meter storage shifts energy out of the middle of the day via a simple rules-based approach; and
2. There is no economic benefit of DER control and coordination once there is sufficient utility-scale storage resources available on the system. The flexibility and grid service benefits saturate once a certain amount of battery storage is installed.

This finding indicates that programs to require or compensate DER resources for coordination and control may not be necessary once sufficient grid scale storage is available to the system operator. Well-designed tariffs and autonomous response of DER to grid conditions may be sufficient for further DER integration, but additional research is underway to validate this initial finding.

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