Hawai‘i Natural Energy Institute Research Highlights

Grid Integration

Clean Firm Resource Needs in Hawai‘i

OBJECTIVE AND SIGNIFICANCE: HNEI is conducting analysis to quantify the need for firm dispatchable generation on Hawai‘i’s grids as the penetration of variable renewables increases. The results of this study help frame the ongoing discussions, debates, and planning related to the role of dispatchable firm capacity. The objective is to inform ongoing procurement and proposed legislation for both variable and firm renewable energy. This study sought to determine the minimum firm capacity required by the system to ensure adequate resource availability at various levels of wind, solar, and storage additions. The findings provide valuable insights into the characteristics needed in future systems. They can inform decisions on oil-fired power plant retirements and guide the procurement of new energy resources.

KEY RESULTS: The findings of this analysis indicate that on O‘ahu, even in a very high variable renewable energy and storage grid, there will be a need for firm capacity of 600-750 MW. This number will increase if load increases significantly such as via the adoption of EV. In this future clean energy system, these resources would run more sparingly as the variable generation increases but are necessary for reliability. When the firm resources are in operation, they may need to run at significant levels for several consecutive days, making it difficult, if not impossible, to address reliability issues exclusively relying on battery storage or demand response. Today, this grid service is provided by the existing HECO oil plants. These plants are aging and becoming less reliable. At some point, they will need to be retired and replaced with other forms of firm renewable energy. Given lead times for development of new generation, these decisions need to be considered in the near future.

The analysis for O‘ahu was extended to each of the other islands to compare the total firm capacity need and operational characteristics of these resources. Results indicate that firm capacity needs are approximately 50% of peak load on all islands.

Preliminary results also indicate that flexibility from these resources could be important, especially when uncertainty in solar forecasting is considered. Additional work is being conducted to determine operational considerations for new firm resources and reserve strategies to ensure reliability.

BACKGROUND: In the 2022 legislative session, the Hawai‘i State Senate and House of Representatives introduced a series of bills that sought to promote, and in some cases mandate, increased adoption of firm renewable energy. For example, HB 1611 and SB 2510 proposed to establish a state energy policy that requires at least 33.3 percent of renewable energy be generated by firm renewable energy. These bills also proposed to limit the percentage of any one type of renewable energy source to 45 percent of all generation for each island except for geothermal generated energy. It was unclear if the intent of this requirement was to limit the percentage of distributed PV and utility-scale PV to 45 percent, but since some of the islands already have high levels of these resources, it could have prevented the installation of additional solar systems. These bills were approved by both the Senate and the House but later vetoed by the governor. While these laws are not in statute today, there remain important questions about the need for firm renewable energy and potential solutions to address that need. These are likely to be the topic of future legislative sessions.

On March 1, 2022, Hawaiian Electric Company issued a request for proposals (RFP) seeking to acquire 500 to 700 megawatts of firm renewable generation resources on O‘ahu with a targeted online date between 2029 and 2033. According to HECO, “While solar and wind energy resources will help us hit our near-term clean energy milestones, we’ll also need firm renewable resources available for customers when the sun isn’t shining, or the wind isn’t blowing.”

Given the recent legislative actions and proposed firm renewable procurements by the utility, HNEI conducted a series of analyses to identify the amount of firm renewable capacity that may be required in Hawai‘i.

PROJECT STATUS/RESULTS: HNEI’s analysis of resource adequacy was first conducted for O‘ahu, and the methodology was later extended to the islands of Kaua‘i, Maui, Moloka‘i, Lāna‘i, and Hawai‘i.

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To quantify potential firm renewable needs, the study team developed a simplified screening methodology and then verified the results with robust probabilistic resource adequacy and detailed operational modeling of specific resource mixes. The screening methodology was conducted in a five-step process.

The study team evaluated several potential future resource mixes with differing amounts of solar, storage, and wind with variable renewable energy contributing up to 90% of the energy resource mix. These scenarios were then evaluated assuming any firm dispatchable resources were highly flexible to estimate the capacity and energy needed to ensure reliability after accepting all the solar, wind, and battery energy storage that the system could accept.

The scenarios and flexible capacity resources were modeled across 21-years of weather resources (which represented historical weather conditions from 1998-2018) for the solar and offshore wind resources. The model was evaluated across all hours of the year in the 25-year period, creating dispatch profiles for nearly 184,000 hours of chronological operations. The firm capacity requirements for one week of high solar resource and one of low solar resource are shown in Figure 1.

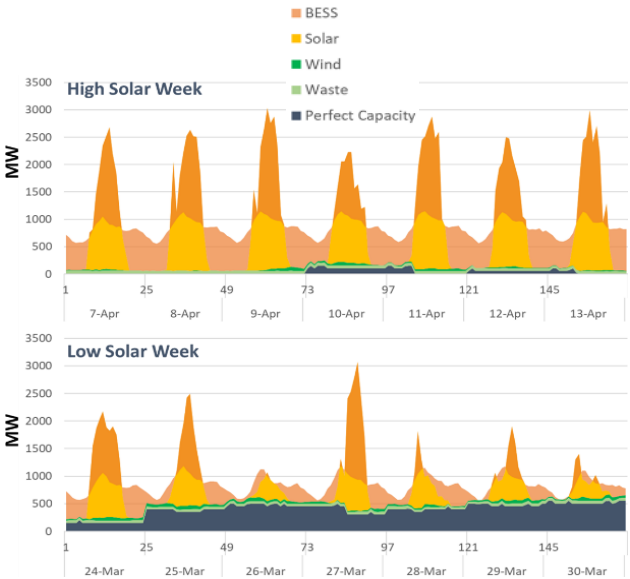

Figure 1. Representative high and low solar weeks and the need for firm renewables.

The analyses yielded the amount of curtailment of variable wind and solar resources, as well as the utilization of the firm-flexible capacity resource. Particular attention was given to the maximum dispatch of the firm-flexible units, which implies the capacity need. Operational metrics like number of starts, ramp needs, operating hours, and capacity factor by incremental block were also evaluated.

Results of the analysis are provided in Figure 2, showing the maximum firm-flexible capacity requirement as a percentage of peak load (y-axis) at varying levels of solar and storage builds (x-axis). These values can be used as a proxy for the firm renewable resource needs of the system.

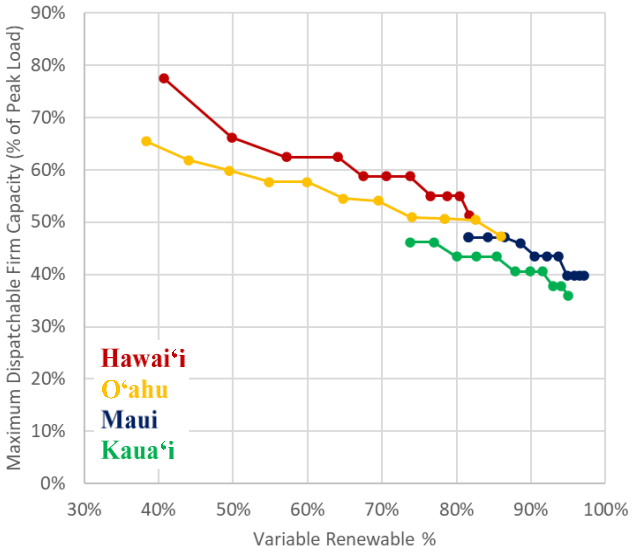

Figure 2. Minimum firm capacity needs by island at increasing levels of variable renewables.

The analysis found that even at very high penetrations of variable renewable energy, there is still a substantial need for firm capacity. With 70% of the annual energy demand met by variable resources, the system still requires firm-flexible capacity of approximately 60% of the system's peak demand. While higher levels of variable generation reduce this requirement, there are diminishing returns associated with the additional variable renewable energy at high penetrations and the additional cost of increasing curtailment.

In 2024, the HNEI project team updated this analysis to evaluate the impacts of solar forecast accuracy and the operating flexibility of the new firm resources on the maximum capacity required to maintain reliability. Quantifying this flexibility need and

gaining community acceptance of the results is critical given the lead time for new generation resources.

This new study is evaluating three types of firm resources: 1) baseload resources which are unable to cycle on or off or load follow; 2) inflexible resources which have significant startup/shutdown times and limited ramp rates; and 3) fully flexible resources that could start/stop and ramp quickly. An illustration of these three configurations and the impact on one week of operations is provided in Figure 3.

Results of this analysis indicate that when forecast errors of solar resources are introduced, quick-start flexible resources are more effective at meeting the firm energy needs. Without highly flexible firm generation, early firm unit commitments are required, introducing the likelihood of increased curtailment or resource adequacy shortages, depending on the accuracy of the solar and wind forecast.

Today, there are limited low-emission resources available to provide dispatchable firm capacity, and each has operational limitations and cost/availability issues that must be considered. While identifying the optimal firm flexible technology is not part of this analysis, the large capacity needs identified shows the need for more attention to this issue. HNEI is initiating a number of studies, some in concert with the Hawai‘i Energy Policy Forum, to address the options.

This study is intended to be a screening analysis of the firm renewable capacity needs for future Hawai‘i grids to help inform legislation and utility procurements. This work will be presented to the Hawai‘i Energy Policy Forum to initiate a broader discussion of these grid needs. In addition, as the utility’s Stage 3 RFP and Firm Renewable RFP continue to progress, additional analysis can be conducted on specific portfolios and resource types.

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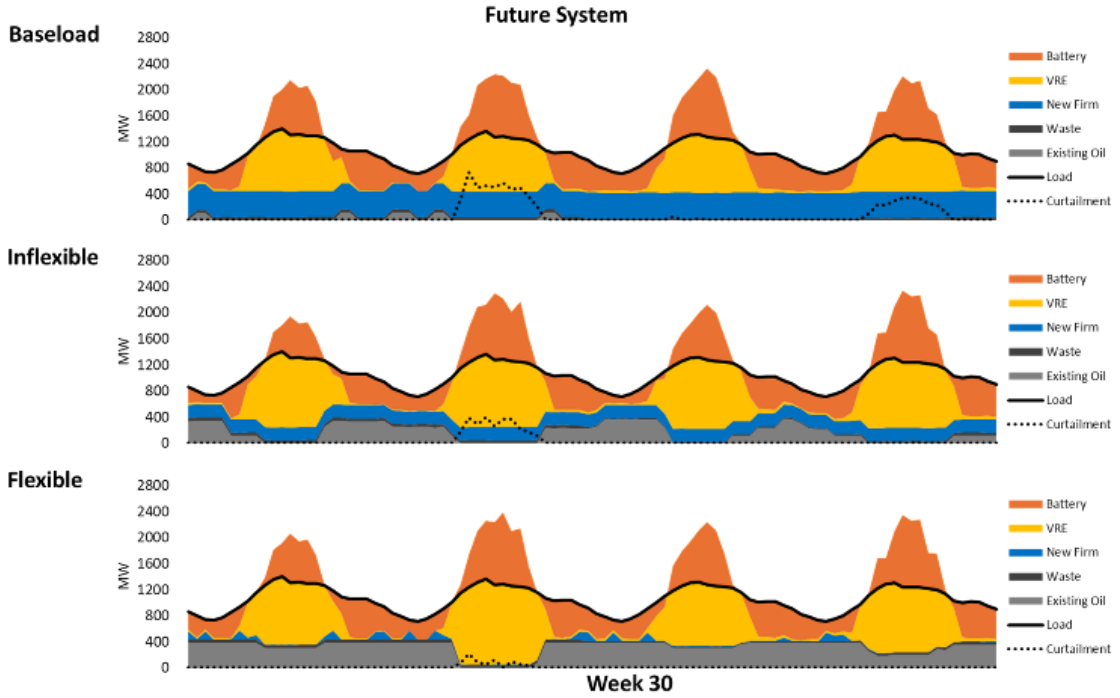

Figure 3. Weekly dispatch of system with baseload (top), inflexible (middle) and flexible (bottom) firm resources.