Hawai‘i Natural Energy Institute Research Highlights

Energy Policy & Analysis

Clean Firm Needs

OBJECTIVE AND SIGNIFICANCE: This study was intended to inform ongoing procurement and proposed legislation for both variable and firm renewable energy. It seeks to determine the minimum amount of firm power that the system would require at various levels of wind, solar, and storage additions. This will also inform decisions on whether to integrate more variable renewable energy today, considering that these decisions may shut the door on future options. This information can be used to determine characteristics of future systems to inform decisions on oil-fired power plant retirements, procurement of new resources, and to show how robust the system can be with variable renewable energy and storage alone.

KEY RESULTS: The results of this study help frame the ongoing discussions, debates, and planning related to the role of firm renewable energy. The findings indicate that on O‘ahu, even with very high penetration of energy from variable renewable energy and storage grid (e.g. over 70% by energy), there is a need for firm capacity of 600-750 MW. While the need for capacity remains, the use of these systems decreases significantly as the penetration of the variable generation increases. In this future clean energy system, these resources would run sparingly. However, when they do run, it could be for multiple consecutive days at a time. This detailed analysis of firm energy need will help identify potential resources to provide this unique grid service and help inform recommendations for policymakers, regulators, and grid planners related to the long-term role of firm renewables.

BACKGROUND: Despite the growth in wind, solar, and battery technologies over the past ten years, there is increased interest in firm renewable energy technologies in Hawai‘i and the power industry in general. This is being driven by several factors, including resource saturation, resource diversity, reliability, and agricultural and forestry sector objectives.

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% of renewable energy be generated by firm renewable energy and imposed limits on any one type of renewable energy source. While these laws are not in statute today, there is continued interest in firm renewable energy and likely the topic of future legislative sessions.

In addition, on March 1, 2022, Hawaiian Electric issued a request for proposals (RFP) seeking proposals to acquire 500 to 700 megawatts of energy from 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.”

The RFP also states that the objective of the firm renewable procurement is to ensure that “sufficient firm capacity must be available during periods of low wind and solar production. Modernizing the ageing fossil fuel generation fleet (some of which are over 75 years old) by adding new renewable firm generation is consistent with decarbonization goals and policies as new firm generators will be installed alongside significant quantities of low-cost renewables to ensure reliability and resilience, resulting in overall reductions in carbon emissions.”

PROJECT STATUS/RESULTS: 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. The analysis was first conducted for the island of O‘ahu, and later expanded to evaluate needs statewide.

In order to quantify potential firm renewable needs, the study team developed a simplified screening methodology that was verified with robust probabilistic resource adequacy and detailed

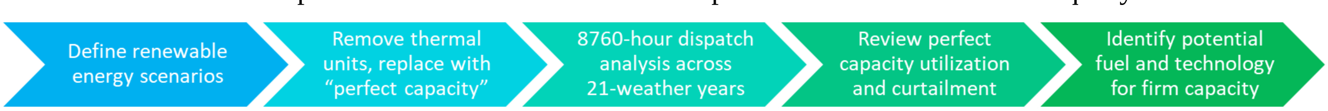

Figure 1. Five-step screening methodology to calculate firm renewable needs.

operational modeling of a specific resource mix. The screening methodology was conducted in a five-step process (Figure 1 on the previous page).

The study team developed a limited number of potential future variable-renewable resource mixes able to provide up to 90% of the island's energy needs. This was done by varying the amount of solar + storage and offshore wind resources in 1,000 GWh per year intervals. These scenarios were then evaluated without the existing oil capacity on the system to estimate the remaining amount of capacity and energy needed after maximizing the use of the solar, wind, and battery energy storage. These firm energy additions were assumed to be always available and perfectly flexible allowing them to operate in a manner which would minimize the total capacity additions while meeting the needs of the system.

The scenarios and perfect 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 21-year period, creating dispatch profiles for nearly 184,000 hours of chronological operations (Figure 2).

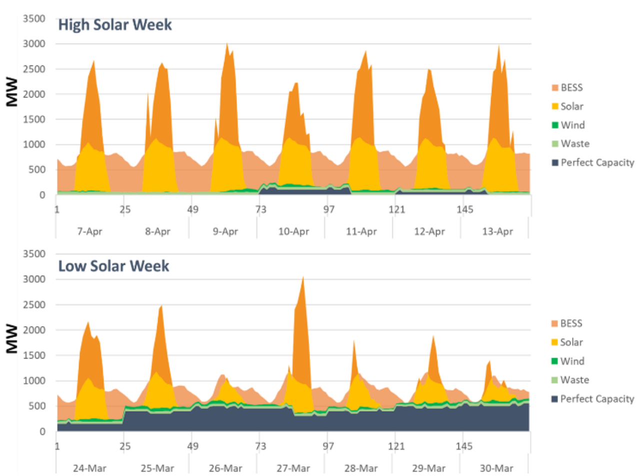

Figure 2. Representative high and low solar weeks and the need for firm renewables.

The results of the simulations were then evaluated to quantify system performance and firm renewable capacity needs. In particular, the metrics evaluated included the amount of curtailment of variable wind and solar resources, as well as the utilization of the perfect capacity resource. For the perfect capacity resource, particular attention was given to the maximum dispatch of the unit which implies the overall capacity need. Operational metrics like number of starts, ramp needs, operating hours, and capacity factor by incremental block were also evaluated. Cost metrics were also incorporated as proxy values for the perfect capacity resource – as if it was provided by the existing oil-fired generating mix or a future firm renewable resource mix.

Results of the analysis are provided in Figure 3 on the following page which compares two resource portfolios at various levels of variable renewable energy. Only the maximum dispatch of the perfect capacity resource is shown, illustrating the aggregate *capacity* need of 500-750 MW, depending on the amount of variable renewable energy and battery energy storage on the system. These values can be used as a proxy for the firm renewable resource needs of the system. This clearly shows the relationship between increasing variable renewables and storage capacity to the diminishing needs for firm renewable capacity.

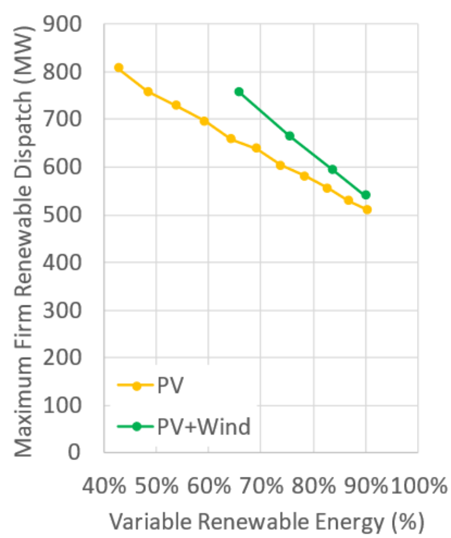

Figure 3. Firm capacity needs at increasing levels of variable renewable energy.

However, the analysis also investigated that even at very high penetrations of variable renewable energy – reaching almost 95% of annual energy – there is still a substantial need for firm capacity of between 500 and 700 MW. This is approximately 50% of the system's peak demand and emphasizes the point discussed previously that there are diminishing returns associated with additional variable renewable energy at high penetrations.

The analysis was also repeated at various levels of electric vehicle integration. The results indicate that a 20% increase in EV charging during peak demand periods would only increase the firm renewable requirement by approximately 50 MW, which would increase to an approximately 250 MW increase in the 60% EV peak charging scenario. In addition, the differences between the charging profiles were relatively modest. While daytime charging is slightly better than peak demand or overnight charging profiles, there is relatively little difference between the time of charging and the additional firm renewable capacity needed.

The reason for this is twofold; first the system is largely energy constrained rather than capacity constrained. As a result, the firm renewable needs are largely driven by low wind and solar days rather than hourly demand. Second, there is a significant amount of grid battery energy storage assumed in these portfolios, and thus plenty of flexibility to move energy from one time of day to another. Overall, while EV adoption rates would change the total amount of renewable energy needed to reach the state's renewable energy targets, but the timing of EV charging has a relatively modest impact on overall firm renewable needs for reliability.

The analysis concluded with an evaluation of specific firm renewable technologies that may play a role in meeting the system's firm capacity needs. This included a review of biomass and biodiesel, geothermal, OTEC, hydrogen, and long duration storage resources. Each resource was discussed based on technical potential, feasibility, and land use considerations.

This study is intended to be a preliminary analysis of the potential firm renewable needs for the future O‘ahu system and to help inform proposed legislation and utility procurements. In the light of the Hawai‘i State Legislature's efforts (through SB 2510) to require a minimum amount of firm renewable energy, ongoing work will be continued by HNEI to inform on the appropriate levels of firm renewables that may be required. A more complete reporting of these results is expected prior to the start of the 2023 legislative session. 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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