



# Hawai'i Natural Energy Institute Research Highlights

## Grid Integration & Energy Efficiency

### Long Duration Storage Modeling

**OBJECTIVE AND SIGNIFICANCE:** In Hawai'i and across much of the country, significant attention is being given to identifying the need and amount of clean firm renewable energy required for a 100% clean electricity grid. While much attention has been afforded to hydrogen and/or biodiesel resources to fill this need, recent developments in long duration, multi-day battery energy storage may be another option to provide sufficient firm renewable capacity to bridge extended periods of low solar and wind resource. To evaluate this potential, the HNEI-Telos team conducted a limited evaluation to determine whether long-duration storage can provide the required resource adequacy and capacity.

**KEY RESULTS:** Preliminary analysis has identified two key findings. The first is that multi-day battery energy storage requires new modeling techniques. Such methods that are currently being developed by HNEI-Telos and the broader industry. The second is that, despite the long duration of discharge capability, the multi-day storage will likely be constrained to charge during periods of tight-supply – thus diminishing the efficacy of providing comparable firm capacity benefits as a thermal resource.

**BACKGROUND:** Under other tasks, the HNEI-Telos team has conducted significant analysis to quantify the amount of clean firm resources necessary to maintain reliability in a high renewable power system. This analysis was conducted using generic assumptions associated with a “perfect capacity” resource that is always available when needed (see [“Clean Firm Needs”](#) project summary).

To date, all of the battery storage systems being integrated in Hawai'i are relatively short duration, capable of providing their rated output for only a few hours. Early battery adoptions on O'ahu, Maui, and the Big Island were less than 30-minutes in duration, providing only grid services to balance fluctuations in wind output. More recent battery additions were 4-hour resources, often combined with solar projects, and added the ability to shift solar generation from mid-day to overnight periods.

However, new storage technologies are under development across the power industry that are advancing the capabilities associated with longer duration batteries. Most notably, Form Energy is

currently offering a 100-hour iron battery storage product – potentially allowing for surplus renewable generation to shift across days or even weeks.

In 2022, HECO initiated its Stage 3 procurement process and specifically requested bids for 500-700 MW of firm renewable resources. This procurement, however, specifically *excludes* the option for multi-day battery storage projects regardless of their duration because of requirements around fuel storage and recharging constraints.

This analysis was conducted to understand the technical capabilities of multi-day storage resources, to develop new modeling methods, and to understand whether or not multi-day battery storage provides similar characteristics as a thermal resource with liquid fuel capabilities.

**PROJECT STATUS/RESULTS:** The HNEI-Telos team is currently conducting the multi-day storage analysis and anticipate having final results to share with relevant stakeholders in early 2024. Initial analysis was conducted to develop new methodologies for evaluating multi-day storage resources. This was required to overcome modeling challenges associated with foresight and predictability of multi-day storage needs.

Without foresight of the need included in the model, the battery will discharge completely and will not recharge because round-trip efficiency losses are so high. However, with perfect foresight, the model over-optimizes the long-duration storage, perfectly aligning future state of charge with grid needs. For example, the battery will charge in the days and weeks leading up to a period with sustained low renewable output and high generator outage conditions. Both outcomes misrepresent the capabilities of multi-day storage.

As a result, a new methodology was developed incorporating different forecast “look-ahead” periods in the model combined with a new constraint that requires the multi-day storage to be at or above a certain state of charge at all times, unless it is needed for grid reliability. This additional energy reserve ensures that the multi-day storage is available when needed, but does not overstate the predictability of when those events may occur. The HNEI-Telos team

is currently testing different levels of these model parameters and collaborating with multi-day storage technology providers in industry to ensure the modeling process is robust.

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*Contact:* Richard Rocheleau, [rochelea@hawaii.edu](mailto:rochelea@hawaii.edu)

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Initial results suggest that the multi-day storage does not provide comparable benefits for reliability when compared to a thermal, liquid-fuel generating resource. This is because the future O’ahu grid is highly energy constrained and there may be extended periods of time where the multi-day storage cannot recharge. This increases the potential for an event where the battery storage cannot recharge and redeploy fast enough to be available for subsequent grid reliability events. The energy challenge is amplified by low round-trip efficiency associated with current multi-day battery technologies.

Additional research is being conducted to adjust modeling constraints to properly reflect grid operations with multi-day storage and the evaluation of multiple grid portfolios with various solar and thermal resources to understand if multi-day storage can be integrated alongside other firm renewable resources.

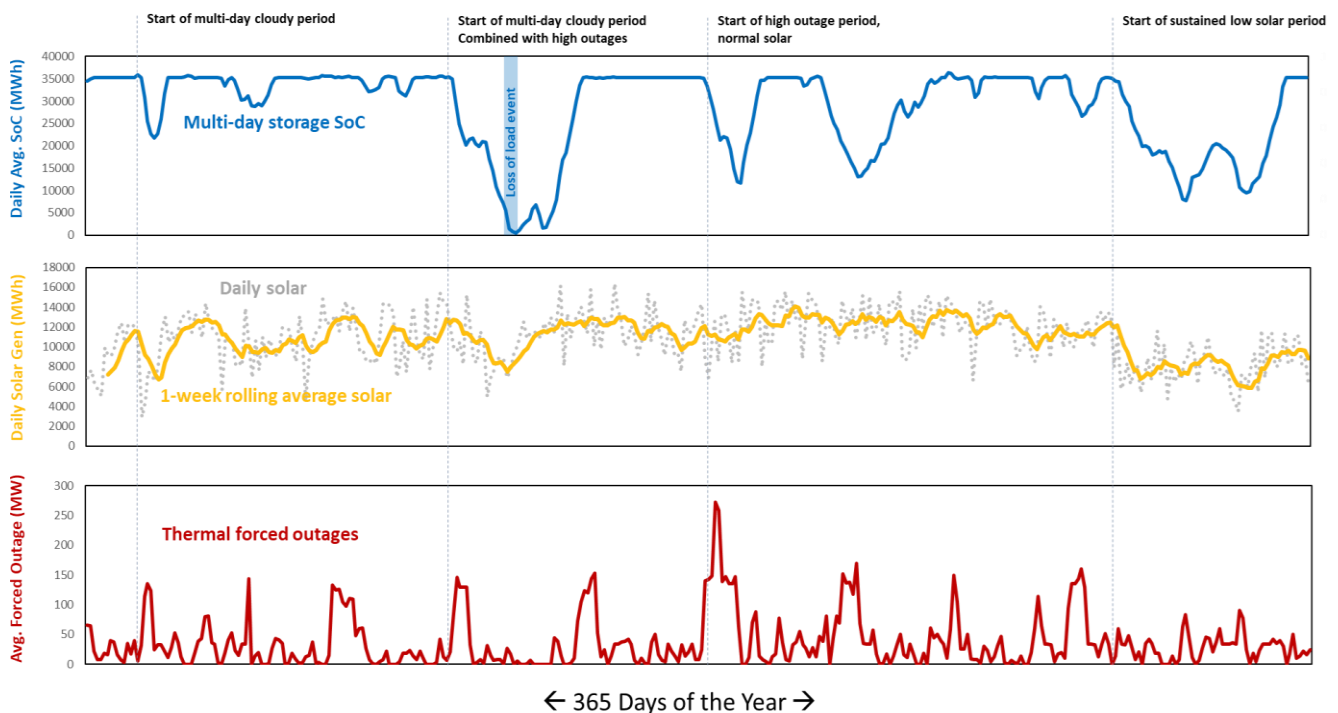


Figure 1. Modeling of multi-day battery storage state of charge (top) against O’ahu solar resource (middle) and thermal generator outages (bottom), with loss of load events highlighted.