Hawai‘i Natural Energy Institute Research Highlights

Grid Integration

O‘ahu Thermal Retirement and Repower Analysis

OBJECTIVE AND SIGNIFICANCE: HECO’s steam oil plants are aging, with more than 70% of HECO’s generation fleet now over 30-years old. A significant fraction of that generation, over 700 MW, is scheduled to retire over the next fifteen years (Figure 1). New firm resources must be introduced to maintain reliability as we continue to transition to a solar dominant system.

This study analyzes how much of the existing thermal fleet can be retired while preserving reliability across various portfolios of solar and short duration battery storage, with and without additional firm thermal capacity or long-duration energy storage (LDES). Results will provide context to discuss alternative solutions to maintaining system reliability in the face of a changing O‘ahu generating fleet.

KEY RESULTS: Previous analysis showed that O‘ahu extended will require considerable thermal capacity on the grid to ensure reliability during periods of low renewable resource generation. For example, the retirement of Waiau Units 3-8 would require additional solar, sufficient to provide an additional 2500 GWh per year—beyond the Stage 2 deployments, to maintain reliability if no replacement or repowering takes place. This is much higher than projected solar deployment in this approximately 5-year timeframe. However, the 250 MW proposed repower of Waiau units along with the commissioning of the Pu‘uloa plant would be sufficient to allow for the full retirement of the existing Waiau units plus partial retirement of Kahe (Units 1 and 2).

The analysis also found that the addition of Pu‘uloa and a partial repower of Waiau could maintain reliability over the next several years while creating optionality for other more fuel efficient combined cycle power plants or liquefied natural gas (LNG) fuel options that may have longer development timelines.

BACKGROUND: Over the past several years, the community has expressed concern over O‘ahu’s electric system reliability, driven in part by the retirement of the AES coal plant and the delays and cancellations in the deployment of the Stage 1 and Stage 2 utility scale solar plus storage systems that were expected to help offset the impact of retiring fossil units. As more of the state’s aging steam oil fleet approaches the end of its operating life, evidenced by the plan to retire Waiau and Kahe generating units in the coming years, the system must maintain reliability while continuing to adhere to decarbonization plans.

In 2024, Hawaiian Electric (HECO) completed the Integrated Grid Planning (IGP) process and identified the need for up to 500-700 MW of new firm resources, which informed the Stage 3 request for proposals (RFP). HECO is currently proposing a retirement and replacement plan for the Waiau by 2030 and the majority of Kahe between 2035-2040 (Figure 1). Timely action is essential to avoid reliability gaps.

Under the Stage 3 RFP, two firm resources were selected to bolster reliability on O‘ahu: a repowering of Waiau with six new combustion turbines (approximately 42 MW each) and the Pu‘uloa reciprocating engine project providing roughly 100 MW at Joint Base Pearl Harbor-Hickam (JBPHH). These projects are currently under review by the Hawai‘i Public Utilities Commission (PUC).

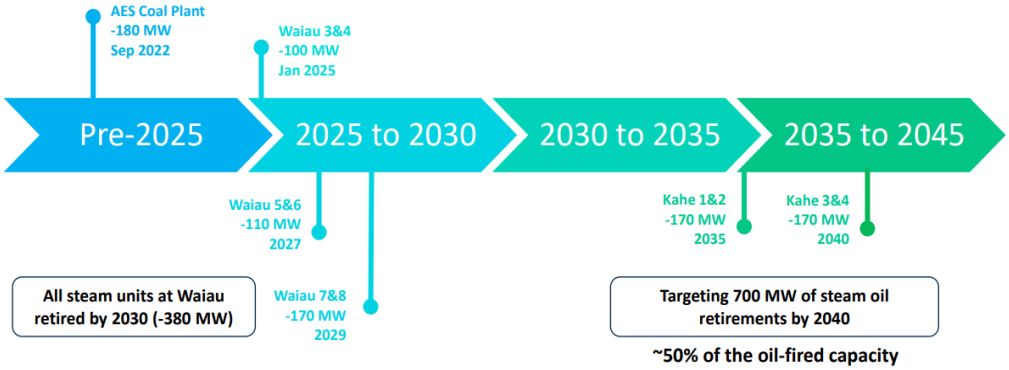

Figure 1. Proposed timeline for Waiau and Kahe power plants.

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In parallel, stakeholders have expressed interest in alternatives such as LDES, and how firm resources should fit within broader decarbonization priorities. In addition to the proposed repowering, the Governor and the Hawai‘i State Energy Office are pursuing a policy of LNG that would necessitate different repowering options for O‘ahu.

PROJECT STATUS/RESULTS: HNEI conducted a series of probabilistic resource adequacy analyses to identify various combination of resources sufficient to maintain reliability during O‘ahu’s transition. Analysis utilized detailed power system models incorporating 26-years of hourly historical weather, HECO’s 2026 planned maintenance, and simulated forced generator outages to evaluate reliability of a future power system with incremental retirements of the Waiau and Kahe units.

All scenarios modeled included incremental solar and storage buildouts up to 2500 GWh beyond what is expected when the Stage 2 projects are completed.

Three portfolios were evaluated: the incremental addition of solar plus storage only; additional solar and storage plus 350 MW of new combustion turbine and/or reciprocating engine generation, and additional solar plus storage plus 350 MW of 100-hour LDES capacity.

For each portfolio and scenario, the system’s loss of load expectation (LOLE), expected unserved energy, and other resource adequacy metrics were calculated to determine the reliability of the system at different stages of retirement. Minimum requirements to ensure loss of load expectation below 0.1-0.2 days per year were identified.

Figure 2 shows LOLE, measure in days per year, for various additions of solar (columns) and different increments of retirement (rows) assuming no repower or new generation is added to the system. The green blocks represent combinations of solar and retirement that exceed current LOLE, while numbers in yellow are approximately at the historical criterion used by HECO in previous planning cycles. Red values (and all boxes below red) represent an unreliable outcome.

	Plant Name	Cumulative Retirement	Current PV+BESS	+500 GWh PV+BESS	+1500 GWh PV+BESS	+2500 GWh PV+BESS
Incremental Retirement		0				
	AES	180				
	W3-4	274	0.21	0.04		
	W5-6	382	0.95	0.24	0.01	
	W7	466		0.91	0.10	0.03
	W8	551			0.47	0.12
	K1	635				0.37
	K2	720				
	K3	805				
	K4	889				
	K5	1024				
	K6	1159				

Figure 2. LOLE at varying levels of renewable buildout and thermal retirements with no additional firm capacity.

Based on these results, if solar and storage are the only new resources added, approximately 2,500 GWh of additional capacity is needed to sustain reliability, corresponding to approximately 70% RPS, if Waiau Units 3-8 are retired. However, even at this full build-out, the system could not reliably retire any Kahe units.

The analysis was repeated with the same solar scenarios plus a build or repower of 350 MW of firm capacity, which could include the proposed repower of Waiau Units 3-8 and the JBPHH (Pu‘uloa) units. These results (Figure 3) indicate that the proposed repowering provides sufficient reliability through the Waiau retirements, even with no additional solar and storage beyond the Stage 2 projects. Additional simulations, not shown in the tables, indicates that completion of the Pu‘uloa plant and a partial repower of Waiau (approximately 100 MW) would meet LOLE criteria and offer potential flexibility for the repower of the remaining Waiau units.

	Plant Name	Cumulative Retirement	Current PV+BESS	+500 GWh PV+BESS	+1500 GWh PV+BESS	+2500 GWh PV+BESS
Incremental Retirement		0				
	AES	180				
	W3-4	274				
	W5-6	382				
	W7	466				
	W8	551				
	K1	635				
	K2	720	0.10	0.01		
	K3	805	0.28	0.08		
	K4	889	1.41	0.31	0.04	
	K5	1024		1.94	0.29	0.08
	K6	1159			1.51	0.36

Figure 3. LOLE at varying levels of renewable buildout and thermal retirements with 350 MW thermal capacity additions.

Alternatively, as shown in Figure 4, 350 MW of 100-hour LDES could provide grid reliability through the Waiau retirement without new generation. With LDES in place, the system could reliably retire Waiau Units 3-8 with completion of the Stage 2 solar and storage. Additional discussion of the potential for use of LDES is included in the "**Multi-Day Energy Storage for Oʻahu Reliability**" project summary.

	Plant Name	Cumulative Retirement	Current PV+BESS	+500 GWh PV+BESS	+1500 GWh PV+BESS	+2500 GWh PV+BESS
Incremental Retirement		0				
	AES	180				
	W3-4	274				
	W5-6	382				
	W7	466				
	W8	551	0.01			
	K1	635	0.42	0.05		
	K2	720		0.58	0.03	
	K3	805			0.24	0.03
	K4	889				0.26
	K5	1024				
	K6	1159				

Figure 4. LOLE at varying levels of renewable buildout and thermal retirements with 350 MW 100-hour LDES.

This analysis indicates that, under HECO's current retirement schedule, solar and storage are unlikely to be deployed in sufficient quantity or on the timeline necessary to maintain reliability and resource adequacy to allow the retirement of the Waiau units. This shortfall underscores the critical importance of repowering Waiau, as delaying a decision on technology, scale, or fuel type increases the likelihood of near-term reliability challenges and constrains the system's operational flexibility.

A repowering strategy of approximately 250 MW at Waiau, combined with the development of the Puʻuloa plant, would provide sufficient firm capacity to enable retirement of Waiau's existing units and could also support the potential retirement of Kahe Units 1 and 2, depending on actual load growth.

Given the later timeframe proposed for the Kahe retirement, a partial repower of Waiau could meet near term reliability needs while creating additional options for firm generation that requires longer lead time to develop. For example, repowering the remaining Waiau with a high-efficiency combined cycle configuration would reduce reliance on Kahe and other aging, lower-efficiency generators, lower fuel consumption and emissions, and potentially extend the remaining useful life of the Kahe units by shifting them into more limited operational roles. This option, as opposed to a full repower, may also make conversion of some units to LNG more cost effective, while preserving near term reliability.

While Hawaiʻi would realize meaningful reliability benefits under any capacity additions or fuel choice, the system will only capture these advantages if decisions are made promptly and implementation milestones are met. Timely action remains essential to ensuring that repowering efforts strengthen system reliability, reduce overall emissions, and align with the State's long-term transition objectives.

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