Hawai‘i Natural Energy Institute Research Highlights

Energy Policy & Analysis

O‘ahu Grid Reliability

<u>Objective and Significance</u>: The AES Hawai‘i coal plant, the largest power plant on O‘ahu retired on September 1, 2022. This retirement decreased the amount of dispatchable fossil capacity available to the utility by more than 10%. Throughout 2021 and 2022 the HNEI-Telos Energy team conducted extensive reliability analysis of the retirement to brief HECO, the Hawai‘i Public Utilities Commission (PUC), and the Governor's Power Past Coal Task Force on the impacts of project delays, cancellations, and other events. The objective of this ongoing study is to evaluate the ability of proposed solar + storage resources to provide the required energy needed while also maintaining grid reliability amid generation shifts. The results of this work are expected to have important implications for power system planning and policy for O‘ahu, and in particular, informing stakeholders on the implications of future fossil fuel plant retirements.

<u>Key Results</u>: Stochastic analysis, using the tools developed by the HNEI-Telos Energy team and reported last year, are being used to assess capacity reliability risks associated with the AES retirement, updates for utility plans, and possible impacts due to delays in project schedules, and new trends in HECO's generator outage rates (-), the recent failure of Kahe 4 (-), project delays (-), and load (+). Analysis shows that with the retirement of AES in September with only one replacement resource available (Mililani I, 39 MW), O‘ahu is currently in a supply deficit until other Stage 1 and 2 solar + storage resources become available.

However, recent trends in the O‘ahu peak load which are still approximately 100 MW lower than pre-pandemic levels, mitigate much of the reliability risk through the end of 2022 and early 2023.

With the ever-changing delivery schedules due to both local issues, such as interconnection requirement studies, permitting, and global shipping delays, this work is ongoing and will continue until sufficient resources are deployed to ensure capacity needs are met.

<u>Background</u>: As the Hawai‘i grid transitions to renewables, including higher percentages of variable renewable energy, these new resources are required to provide not only energy, but also to provide capacity and other grid services currently provided by fossil generation. Current utility plans call for combining solar with battery storage resources allowing solar energy to be shifted from the middle of the day, when there is surplus renewable generation, to other times of the day including the evening peak-load hours that occur after the sun has set. The inclusion of storage into these systems offers the opportunity for them to provide grid services, one of which is capacity – or the ability to provide energy when it is required for reliability. The first test of this strategy occurred with the retirement of the AES coal plant in September 2022.

In 2020, SB 2629 was enacted which bans coal-fired generation in Hawai‘i after 2022, ensuring the AES retirement. The objective of this ongoing study, requested by the PUC, is to evaluate the ability of the planned Stage 1 and Stage 2 utility scale solar + storage plants to provide the capacity resources needed to ensure reliable grid operations now that the AES coal plant is retired.

The Stage 1 and 2 solar + storage projects were originally proposed to be completed in 2022, prior to or concurrent with the AES retirement. However, as of November 2021, several of these projects are encountering delays, pushing their delivery dates to beyond the legislatively mandated AES coal facility retirement. At the end of 2022, only one of the projects is online and operating, with the remaining projects not expected before April 2023. As a result, the power system is currently in a supply deficit.

Since the completion of the 2021 analysis, numerous events and trends occurred on O‘ahu that required a re-evaluation of O‘ahu's grid reliability:

1. Continued project delays across most of the Stage 1 and Stage 2 projects. The primary AES capacity replacement (185 MW standalone KES BESS) is now delayed until May 2023, and other solar + storage projects are delayed until Q3 or Q4 of 2023;
2. The Kahe 4 (90 MW) oil generator was removed from service due to equipment failure in July 2022. This plant is not expected back online until late Spring 2023 at the earliest while repairs take place;
3. There was a notable increase in HECO's forced outage rates during 2020 and 2021, due to both

aging of existing thermal units and modification of operations during COVID; and

4. Oʻahu peak load dropped noticeably during the pandemic and has not yet recovered. It remains below the forecasted level, mitigating some of the reliability risk.

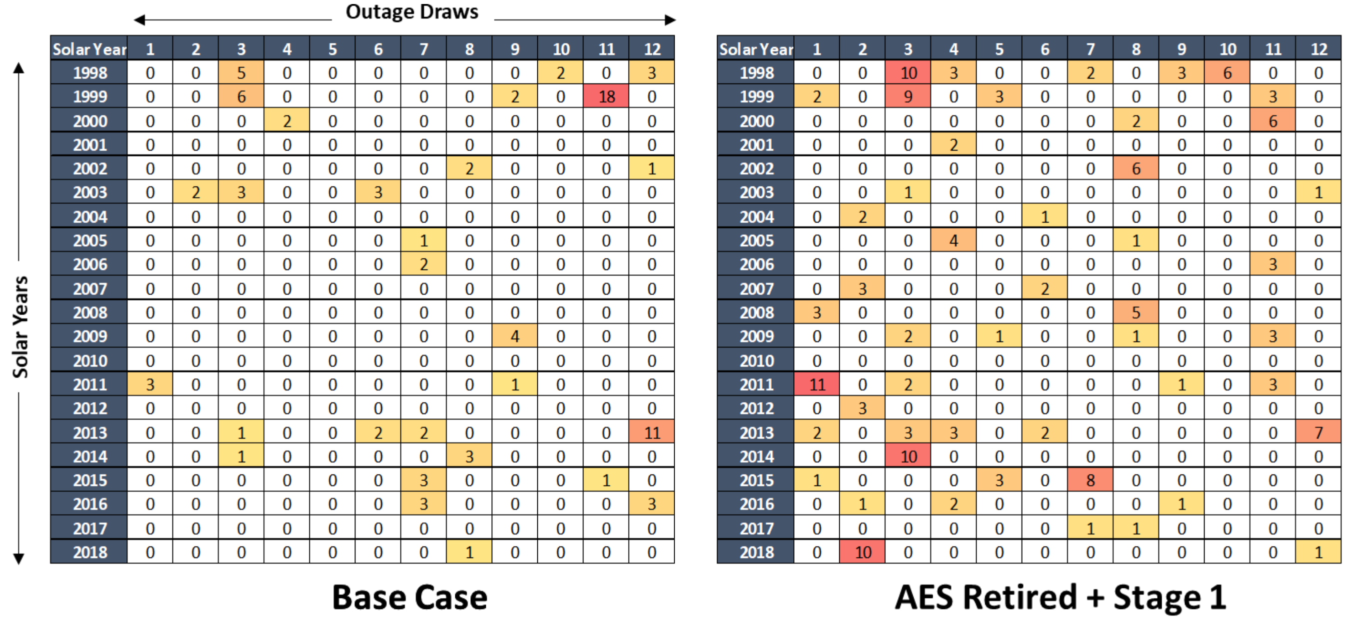
Given these changes, the PUC requested a refresh of the 2021 reliability analysis to evaluate system reliability through the end of 2022 and 2023.

Novel stochastic modeling methodologies, developed by HNEI and Telos Energy and summarized in Appendix A1 in HNEI's Report to the 2021 Legislature, that accurately account for the chronological operations of storage, solar variability, and generator outages are being utilized to determine if the proposed solar + storage systems can maintain reliability in the coming year. These models are being used to identify key timelines as well as to assess the viability of other mitigating measures such as DER and the proposed rescheduling of HECO generator maintenance. The methodology developed by HNEI and Telos Energy is now also being deployed in HECO's Integrated Grid Planning (IGP) process.

PROJECT STATUS/RESULTS: The stochastic methodology is being used to evaluate the reliability the Oʻahu grid, following the AES coal plant retirement assuming different buildouts of utility-scale solar + storage resources. Each case is analyzed across 1,008 random draws (replications) of chronological dispatch, representing 21 years of solar data and 48 unique outage draws for each year of solar data. The output of each analysis includes the number (probability), the magnitude, and the duration of capacity shortfall events that might occur when there are not enough available resources to serve load. An example of this process is provided in Figure 1.

This methodology was repeated across 27 cases which evaluated a range of three solar + storage levels: 39 MW (Mililani), 89 MW (+Waiawa & West Oʻahu), and 139 MW (+Hoʻohana); three peak load levels: 1085 (2022 data), 1150 (IGP), and 1215 MW (2017-2019 data); and three forced outage rates: 7.5 (2015-2019), 11 (midrange), and 15% (2020, 2021). Each of these cases was evaluated with and without the Kapolei battery for a total of 54 scenarios.

Unlike the results provided in 2021 which were predicated on a single estimate of forced outage rates, system load, and replacement schedules, this analysis was reported in a manner that allowed a user to select any level of solar, forced outage, and load plus KES operability for any given month to calculate key resource adequacy metrics (LOLE, LOLH, EUE, etc.). **The resulting customizable tool was provided to key stakeholders participating in the Governor's Powering Past Coal Task Force** to



Solar Year	1	2	3	4	5	6	7	8	9	10	11	12
1998	0	0	5	0	0	0	0	0	0	2	0	3
1999	0	0	6	0	0	0	0	0	2	0	18	0
2000	0	0	0	2	0	0	0	0	0	0	0	0
2001	0	0	0	0	0	0	0	0	0	0	0	0
2002	0	0	0	0	0	0	0	2	0	0	0	1
2003	0	2	3	0	0	3	0	0	0	0	0	0
2004	0	0	0	0	0	0	0	0	0	0	0	0
2005	0	0	0	0	0	0	1	0	0	0	0	0
2006	0	0	0	0	0	0	2	0	0	0	0	0
2007	0	0	0	0	0	0	0	0	0	0	0	0
2008	0	0	0	0	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0	4	0	0	0
2010	0	0	0	0	0	0	0	0	0	0	0	0
2011	3	0	0	0	0	0	0	0	1	0	0	0
2012	0	0	0	0	0	0	0	0	0	0	0	0
2013	0	0	1	0	0	2	2	0	0	0	0	11
2014	0	0	1	0	0	0	0	3	0	0	0	0
2015	0	0	0	0	0	0	3	0	0	0	1	0
2016	0	0	0	0	0	0	3	0	0	0	0	3
2017	0	0	0	0	0	0	0	0	0	0	0	0
2018	0	0	0	0	0	0	0	1	0	0	0	0

Base Case

Solar Year	1	2	3	4	5	6	7	8	9	10	11	12
1998	0	0	10	3	0	0	2	0	3	6	0	0
1999	2	0	9	0	3	0	0	0	0	0	3	0
2000	0	0	0	0	0	0	0	2	0	0	6	0
2001	0	0	0	2	0	0	0	0	0	0	0	0
2002	0	0	0	0	0	0	0	6	0	0	0	0
2003	0	0	1	0	0	0	0	0	0	0	0	1
2004	0	2	0	0	0	1	0	0	0	0	0	0
2005	0	0	0	4	0	0	0	1	0	0	0	0
2006	0	0	0	0	0	0	0	0	0	0	3	0
2007	0	3	0	0	0	2	0	0	0	0	0	0
2008	3	0	0	0	0	0	0	5	0	0	0	0
2009	0	0	2	0	1	0	0	1	0	0	3	0
2010	0	0	0	0	0	0	0	0	0	0	0	0
2011	11	0	2	0	0	0	0	0	1	0	3	0
2012	0	3	0	0	0	0	0	0	0	0	0	0
2013	2	0	3	3	0	2	0	0	0	0	0	7
2014	0	0	10	0	0	0	0	0	0	0	0	0
2015	1	0	0	0	3	0	8	0	0	0	0	0
2016	0	1	0	2	0	0	0	0	1	0	0	0
2017	0	0	0	0	0	0	1	1	0	0	0	0
2018	0	10	0	0	0	0	0	0	0	0	0	1

AES Retired + Stage 1

Figure 1. Example of Loss of Load Hours by Solar Years and Outage Draw.

allow for ongoing evaluation of results as new data arises and timelines of resource construction projects change.

Results of the 54 evaluated cases are provided in the matrix in Figure 2, which shows the loss of load expectation (measured in average days of capacity shortfall in a year) across a range of solar + storage replacement, load levels, forced outage rates, and with and without the KES battery. Higher numbers, highlighted in yellow and orange, represent conditions with high risk.

			Low PV	Mid PV	High PV
No KES	Low Load	Low FOR	**0.18**	**0.04**	**0.02**
		Mid FOR	0.59	**0.24**	**0.15**
		High FOR	2.09	0.85	0.38
	Mid Load	Low FOR	0.71	**0.25**	**0.12**
		Mid FOR	1.95	0.75	0.34
		High FOR	6.02	2.60	1.37
	High Load	Low FOR	2.23	0.85	0.40
		Mid FOR	5.72	2.56	1.25
		High FOR	15.21	7.47	4.01
KES	Low Load	Low FOR	**0.01**	**0.00**	**0.00**
		Mid FOR	**0.05**	**0.03**	**0.02**
		High FOR	**0.21**	**0.12**	**0.06**
	Mid Load	Low FOR	**0.04**	**0.02**	**0.01**
		Mid FOR	**0.19**	**0.09**	**0.09**
		High FOR	0.71	0.43	**0.26**
	High Load	Low FOR	**0.20**	**0.08**	**0.04**
		Mid FOR	0.66	0.43	**0.27**
		High FOR	2.25	1.37	0.83

Figure 2. LOLE (days per year) for 2023 evaluated across 54 scenarios.

One example of the results converted into a monthly forecast is provided in Figure 3. This was developed assuming the current schedule of replacement resources (as of November 2022), and load returning to pre-pandemic levels by Fall of 2023.

These results indicated that resource adequacy risk will remain elevated relative to historical norms (Reference Point) until replacement resources start coming online in April 2022. By Fall 2023, reliability is at or below historical norms, even with a large return of load, in all cases but the high forced outage rates.

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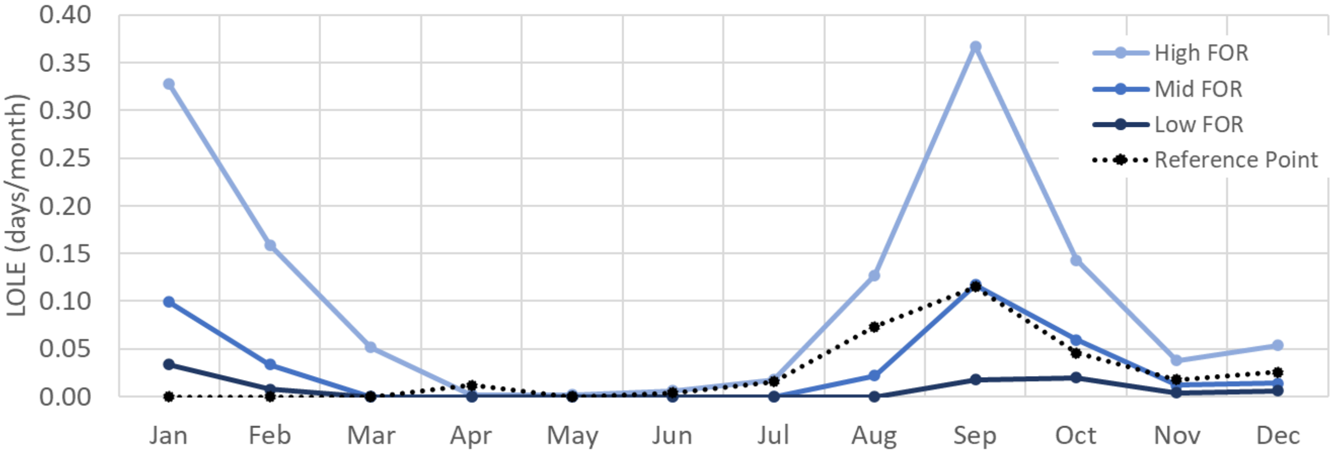

Figure 3. Expected monthly loss of load expectation based on current proposed schedules and returning load.