



Hawai'i Natural Energy Institute Research Highlights

Grid Integration

Validation of Synthetic Historical Solar Data on O'ahu

OBJECTIVE AND SIGNIFICANCE: As Hawai'i's power system increasingly relies on weather-dependent generating resources like solar photovoltaics (PV), accurate solar production profiles are of particular importance for estimating power purchase agreement (PPA) levels and for conducting resource adequacy assessment. With the high penetration of battery energy storage systems on O'ahu, accurate estimation of solar is critical to ensure sufficient availability to meet peak demand.

In this project, the HNEI/Telos Energy team used 25-years of solar data from the National Solar Radiation Database (NSRDB) to produce O'ahu site-specific solar production profiles for the existing utility-scale solar plants. The electricity production was calculated based on the plant specific configurations and location-specific modeled weather parameters. These modeled solar profiles were then compared against the actual operations of five existing solar plants using hourly generation data provided by the Hawaiian Electric Company.

KEY RESULTS: This analysis compared modeled solar production to reported solar production for the five utility-scale solar plants that have been operational for multiple years on O'ahu.

Results indicate that the synthetic profiles overestimate solar production at both the monthly and annual levels for four of the five plants. Figure 1 presents the annual energy of simulated and reported solar production averaged across each year the plant was operational.

Plant Name	Plant Capacity (MWac)	Avg Simulated Annual Energy (GWh)	Avg Actual Annual Energy (GWh)	% Difference
Kawailoa Solar	49	122.1	75.8	61%
Waipio PV	46	109.7	84.6	30%
Lanikuhana Solar	14.7	34.3	28.8	19%
West Loch	20	49.0	38.0	29%
Waianae	27.6	63.6	62.8	1%

Figure 1. Average annual output for simulated and actual plant production.

Excluding Kawailoa Solar¹, for which unique curtailment constraints may apply, the synthetic data

overestimated solar production by between 1-30% over the 2019-2023 period. These results are preliminary, but warrant further investigation using detailed plant performance and ground-based measurements.

Other operating issues, such as outages or panel misalignment (for single axis tracking systems), may contribute to the differences. Initial discussions with developers of the NSRDB dataset revealed that the synthetic solar data struggles to capture the development of clouds over a region like O'ahu or other the Hawaiian Islands. Small islands, in general, present a challenge where microclimatic conditions can be difficult to replicate using meteorological re-analysis methods employed by National Renewable Energy Laboratory (NREL) to produce the NSRDB.

Additional information on plant specific performance factors and site-specific ground-based measurements are being pursued to complete the validation.

BACKGROUND: In 2020, the HNEI/Telos team conducted a preliminary validation of NSRDB based solar plant simulations using production data from five existing solar plants: Kalaeloa Solar 2 (5 MWac), Kalaeloa Renewable Energy Park (KREP) (5 MWac), Wai'hono (6.5 MWac), Wai'ananae Solar (27.6 MWac), and Aloha Solar 1 (5 MWac) sites. In total, these sites represented 49.1 MWac of installed solar capacity.

This comparison was finite due to the limited overlap of the synthetic NSRDB and actual plant production, restricting the comparison to only a 5-month period in 2018. As shown in Figure 2, the 5-month period (July to December 2018) showed good alignment between the existing plants and the simulated data. However, these plants are smaller than the more recent utility-scale solar deployments, had no tracking systems, and operated with low inverter loading ratios (low DC overbuild relative to AC).

¹ Kawailoa Solar shares an interconnection with the 69 MW Kawailoa wind plant. Kawailoa solar is curtailed before Kawailoa wind.

Plant Name	Plant Capacity (MWac)	Avg Simulated Annual Energy (GWh)	Avg Actual Annual Energy (GWh)	% Difference
Kalaeloa Solar 2	5	5.4	5.4	-1%
KREP	5	4.1	4.0	3%
Waihono	6.5	5.7	5.8	-2%
Waianae Solar	27.6	34.2	31.3	9%
Aloha Solar I	5	4.8	4.5	7%

Figure 2. Comparison of capacity factors of simulated and actual solar production for the July to December 2018 period.

While limited in scope, this initial assessment showed good alignment between simulated and actual solar data. However, due to the increasing penetration of solar plus storage and its importance to resource adequacy, this analysis was revisited in 2025.

PROJECT STATUS/RESULTS: This project is ongoing as the HNEI/Telos team renews efforts to acquire additional data on site-specific solar performance. The goal is to determine whether the discrepancy in solar production between synthetic and reported data is due to underlying meteorological data issues (e.g., not capturing midday cloud cover), operational issues, or issues associated with reporting. Once the issue is determined, corrections will be made available for public and utility use.

Key charts for each of the five solar sites in Figure 1 are shown below. On each chart, a black line indicates what the expected output (capacity factor) expected based on the associated PPA. This is an important metric since underperformance relative to the PPA results in a higher cost to the consumer since the “missing” energy must be supplied by other sources.

Lanikuhana Annual Performance

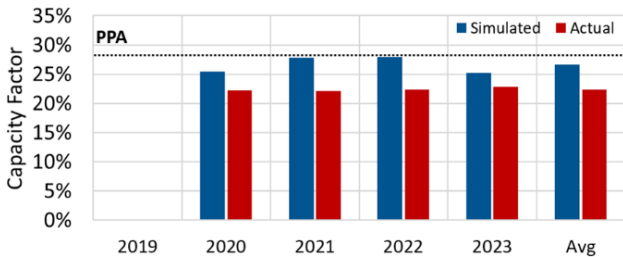


Figure 3. Lanikuhana annual capacity factor for simulated, actual, and expected production based on the PPA.

Waipio PV Annual Performance

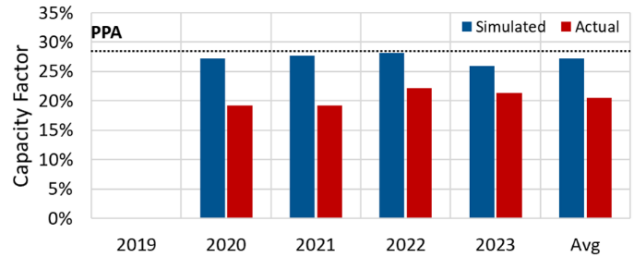


Figure 4. Waipio PV annual capacity factor for simulated, actual, and expected production based on the PPA.

Kawailoa PV Annual Performance

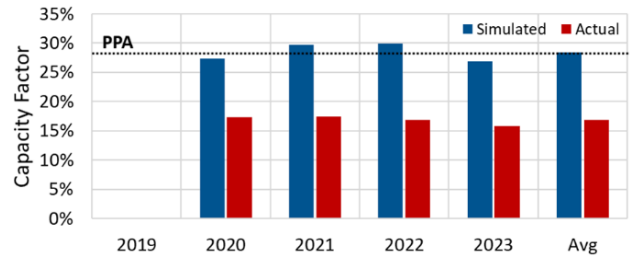


Figure 5. Kawailoa PV annual capacity factor for simulated, actual, and expected production based on the PPA.

West Loch Annual Performance

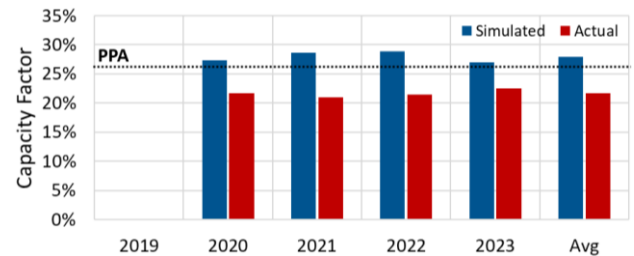


Figure 6. West Loch annual capacity factor for simulated, actual, and expected production based on the PPA.

Wai‘anae Annual Performance

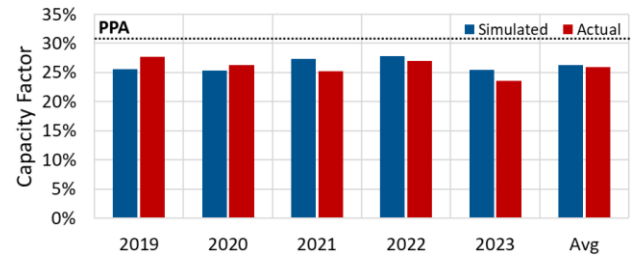


Figure 7. Wai‘anae annual capacity factor for simulated, actual, and expected production based on the PPA.

Except for Wai‘anae (Figure 7), the simulated annual capacity factors are well above the reported data.

It is important to note that differences between modeled and reported performance are not limited to the HNEI modeling. Based on the reported outputs, the plants also significantly underperform relative to the PPA contract terms. While some of this underperformance is attributable to curtailment, HECO reports for 2023 indicate an O‘ahu fleet-wide curtailment of renewable energy of only 3%, or 22,491 MWh. Excluding Kawailoa PV, the remaining four plants experience average actual production ~19% lower than expected based on PPAs. Kawailoa PV was on average 38% lower than it’s PPA amount. This is a strong indication that other factors are contributing to the differences.

While more data is required to confirm the noted behavior, this initial review clearly indicates that the synthetic data for the current utility-scale plants overstates solar production potential. This has significant implications for not only for production cost and resource adequacy modeling, but on actual ratepayers’ costs. Overstating the availability of low-cost solar may then result in understating the need for storage or thermal generation to meet resource adequacy needs.

Given the importance of solar plus storage assets to O‘ahu’s future resource procurements and meeting statewide RPS goals, HNEI continues to pursue collaboration with HECO and relevant solar developers to ensure that synthetic solar data are properly calibrated to reflect actual solar conditions and resource performance is better reflected in energy system models.

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