



# Hawai'i Natural Energy Institute Research Highlights

## Grid Integration

### Load and PV Data Synthesis

**OBJECTIVE AND SIGNIFICANCE:** The objective of the research activity was to synthesize a full set of disaggregated solar photovoltaic (PV) and customer load data from a limited number of field measurements to enable realistic distribution feeder modeling and state analysis for circuits with high distributed PV penetration. Actual field metered measurements of customer load and PV system production is very limited today, yet effective circuit power flow modeling requires the representation of the individual time-varying energy production and demand profiles at all electrical buses. This work is crucial in the development and testing of distributed control algorithms for distributed energy resources on an entire feeder with high penetration of distributed PV systems.

**BACKGROUND:** Under the earlier U.S. Department of Energy (DOE) funded Maui Advanced Solar Initiative, HNEI deployed approximately sixty (60) distribution-level power monitoring devices to capture high resolution data at key nodal points located at distribution service transformers, PV inverters, and residential homes. In conjunction, a detailed electrical model was developed as shown in Figure 1. The rooftop PV systems and customer loads are marked with green and red circles, respectively. This feeder serves approximately 800 customers, with a total installed rooftop PV capacity of approximately 2 MW and a daytime minimum feeder load of 975 kW, a PV penetration level of more than 200%.

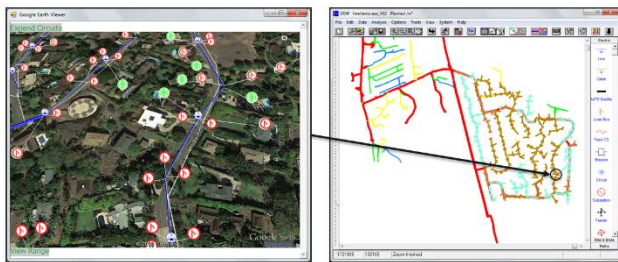


Figure 1. Maui Meadows distribution circuit.

**PROJECT STATUS/RESULTS:** HNEI GridSTART developed a data-driven method (DDM) to estimate the instantaneous output of the behind-the-meter (BTM) rooftop PV sites with high temporal resolution, which allows more insights into the fluctuation of PV output. The PV output is estimated from a statistical regression model where a Minimum Redundancy Maximum Relevance (MRMR) algorithm is applied to preselect the optimal

composite of the reference PV systems. The performance of the proposed method is compared with the spatial interpolation method (SIM) and a model-based method (MBM). Figure 2 is the map of the 18 monitored PV sites in the Maui Meadows neighborhood.

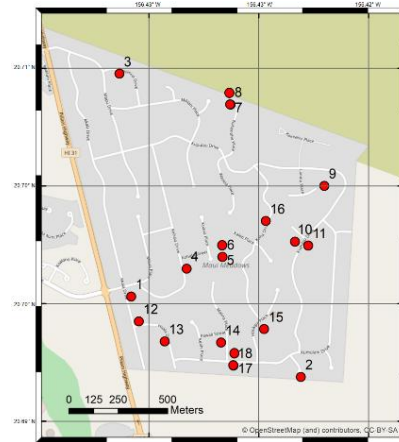


Figure 2. Map of the 18 monitored PV systems (red circles) in the region of Maui Meadows, Hawaii. Map source: OpenStreetMap.

The BTM PV output estimation algorithms are tested on a randomly selected PV system with one-week data (January 7, 2017 to January 13, 2017, time period of each day from 6:00 am to 6:00 pm). To quantify the performance of the three methods, the error is evaluated using the Mean Bias Error (MBE) and the Root Mean Squared Error (RMSE). The estimation results of these three methods are shown in Figure 3.

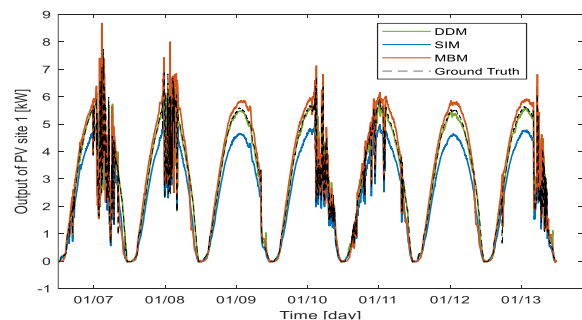


Figure 3. Estimation results of PV site 1 within a 1-week period.

The paper “A Data-Driven Method for Estimating Behind-the-Meter Photovoltaic Generation in Hawaii” was published in IEEE PES ISGT NA, 2021.

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