

**OBJECTIVE AND SIGNIFICANCE:** This project aims to develop local expertise in developing and validating modeling and control solutions for today's power grid, which increasingly integrates inverterbased resources (IBRs). The overarching technical goal is to identify the type and detail of converter models required to accurately represent power system dynamical phenomena across multiple time scales for converter-dominated power systems (CDPS). The Hawai'i power grid is an exceptional testbed for investigating the complex dynamics and transitional states between CDPS and the broader power grid. This positions the project as critically important for Hawai'i, as it is poised to drive significant progress in these areas. The initiative strategically targets these complexities, with a primary focus on enhancing the stability, efficiency, and resilience of Hawai'i's power infrastructure. This will ensure its readiness for the evolving demands of a sustainable energy future.

BACKGROUND: HNEI previously collaborated with the Natural Energy Laboratory of Hawai'i Authority (NELHA) on their microgrid analysis project, which evaluated microgrid options for NELHA's Hawai'i Ocean Science and Technology (HOST) Park. The HOST Park features the world's most extensive seawater distribution system, which relies heavily on converter-based generation and complex loads, including significant variable frequency drives (VFDs), photovoltaic (PV) arrays, and a hydrogen production facility equipped with a converter-driven electrolyzer (198 kW) and mobile storage of up to 300 kg of compressed hydrogen. These features make the HOST Park an ideal example of a CDPS integrated with the larger grid. NELHA agreed to collaborate with HNEI to use the HOST Park's power system as the case study for this project. Key project tasks include: 1) installing new power quality meters and data collection, 2) generating, calibrating, and validating baseline Root Mean Square (RMS) and Electromagnetic Transient (EMT) models, and 3) using the models to study salient dynamics of converter-based generation and loads within the HOST Park power system.

**PROJECT STATUS/RESULTS**: HNEI has made significant progress in developing a comprehensive PowerFactory model for detailed RMS and EMT studies at the NELHA Research Campus (RC) site. A major part of this effort was modeling nonlinear

loads, which involved sophisticated data analysis techniques applied to recordings from micro phase measurement units (µPMUs) installed on-site. Additionally, VFD loads and PV systems were accurately modeled using operational data from NELHA's SCADA system, supplemented by specifications from equipment datasheets. This process was essential for deriving precise parameters for harmonic sources, crucial for fine-tuning the RMS and EMT models. Also, to address the site's specific power patterns, which include 204 kW of PV inverters active during the day and idle at night, along with the continuous operation of large VFD-based pumps, two sets of models were developed: one for daytime and another for nighttime. This diurnal variation was captured to thoroughly assess the microgrid's performance under different operational scenarios. Subsequently, these models were rigorously validated against the recorded data to ensure their accuracy.

For this project, the team made several trips to the project site on the Big Island. The figure below shows a team member as he configures the final settings of the project's  $\mu$ PMUs at the site. Measurements from these meters were crucial for fine-tuning the RMS and EMT models for both daytime and nighttime operations.



Figure 1. Team member adjusting project's meters.

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