



Hawai'i Natural Energy Institute Research Highlights

Grid Integration

Assessing Dynamic Response of Converter-Dominated Power Systems

OBJECTIVE AND SIGNIFICANCE: This objective of this project is to develop and strengthen local expertise in modeling and validating advanced solutions for today's power grid, which increasingly integrates inverter-based resources (IBR). The overarching goal is to determine the level of model detail required to accurately represent the dynamic behavior of converter-dominated power systems (CDPS), thereby improving their stability assessment and control design across multiple time scales.

BACKGROUND: The Hawai'i power grid is an exceptional testbed for investigating the complex dynamics and transitional states between CDPS and the broader power grid. The effort also encompasses high-fidelity electromagnetic transient (EMT) modeling and sequence-domain analysis to capture fault behavior more accurately, including grounding effects, protection interactions, and other key dynamics in converter-dominated systems. Together, these activities are enhancing the stability, efficiency, and resilience of Hawai'i's power infrastructure and helping ensure its readiness for a sustainable energy future.

The Natural Energy Laboratory of Hawai'i Authority's (NELHA) Hawai'i Ocean Science and Technology (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 (VFD), photovoltaic (PV) arrays, and a hydrogen production facility equipped with a converter-driven electrolyzer (198 kW). These characteristics make the HOST Park an ideal example of a CDPS integrated with the larger grid.

PROJECT STATUS/RESULTS: NELHA collaborated with HNEI to use the HOST Park's power system as a case study for this project. Key tasks include installing power-quality meters and collecting field data; developing and validating baseline root-mean-square (RMS) and EMT models; and using these models to study dynamic interactions among converter-based resources and loads. Building on these efforts, the modeling work has been extended to include sequence-domain analysis for evaluating fault response, voltage unbalance, and protection coordination under both grid-connected and islanded conditions. These studies provide critical insights into

the behavior of converter-dominated microgrids and support efforts to improve their dynamic stability and resilience.

HNEI has developed a comprehensive PowerFactory model for detailed RMS and EMT studies of the NELHA Research Campus microgrid. Nonlinear loads were modeled using μ PMU data, while VFDs and PV systems were parameterized from SCADA records and equipment specifications. Figure 1 shows the SEL-735 monitoring system configured at the NELHA Research Campus to collect high-resolution validation data. Separate daytime and nighttime models were created to capture PV generation and diurnal load effects, both validated against field measurements.



Figure 1. SEL-735 power quality meters (top) and communication interface (bottom) configured at the NELHA Research Campus.

Building on this foundation, HNEI conducted sequence-domain EMT simulations to evaluate fault responses, grounding behaviors, and protection coordination under grid-connected and islanded conditions. This expanded analysis provides valuable insights into the dynamic performance, fault behavior, and protection coordination of converter-dominated systems, supporting future improvements in modeling standards, control strategies, and operational guidelines across Hawai'i's renewable-rich grids.

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