ENERGY TRANSITION INITIATIVE
Islands

Playbook Lesson Learned
Phase 2: Assessing Opportunity Pathways

High Penetration Solar Distributed Generation Study on Oahu

In 2008, the Hawai‘i Clean Energy Initiative (HCEI) set a goal of reaching 70% clean energy by 2030. In order to complement energy efficiency targets, the state of Hawai‘i developed requirements to generate 40% of its energy from renewable resources by 2030.

In support of HCEI and the 40% renewable resource goal, the U.S. Department of Energy (DOE) and the Hawai‘ian Electric Company (HECO) focused on developing strategies to allow increased photovoltaic (PV) penetration levels on distribution systems, laying the foundation for integrating high levels of distributed PV. These studies relied on the expertise of the National Renewable Energy Laboratory, General Electric, BEW Engineering, and others.

The rooftop solar PV on Hawai‘i's Mauna Lani Bay Hotel generates 75 kW of electricity. *Photo from SunPower, NREL 06430*

Challenge

The main objective of the project was to construct, calibrate, and validate one high penetration renewable generator distribution feeder circuit on Oahu's electricity grid to understand the impact on the entire electric power system.

Solution

To start the effort, the team developed a low-voltage electricity distribution circuit model incorporating high penetration levels (more than 15% of the annual peak load) of PV, including data from the substation to the end-use load as well as PV inverter characteristics. The study expanded upon a previous one by enhancing the model's ability to identify the impact on technical performance and operations on Oahu's electricity grid.

During the course of the study, the team evaluated critical issues and mitigation strategies for achieving increased penetration of PV on the HECO electricity grid, including:

- Levels of PV installation protection schemes and how they were impacted
- Reverse power flow impacts on feeder circuits
- Capacitor operations, load tap changers, and voltage regulation on feeders.

At the conclusion of the study, systems planning improvements and modifications, as well as strategic options for mitigation, were presented to HECO. The identified solutions were also coupled as potential reasons to make changes to interconnection rules such as *HECO–Hawai'ian Electric Rule No. 14H–Interconnection of Distributed Generating Facilities Operating in Parallel with The Company's Electric System*.

Although the results of the study and final recommendations were valid only for the particular feeder analyzed, the methodology was replicable on other feeders. Thanks to a standardized process detailing the considerations the utility should review—whether at a single site level or a cluster level—future studies can employ the same methodology.

Key Takeaway: Studies Find High Levels of Wind and Solar Attainable

The project discussed here was part of a larger, more comprehensive effort by DOE and the Hawai'ian utilities to identify ways to increase wind and solar penetration across the islands. Two studies were conducted over the course of several years, each reviewing various scenarios.

Engaging Stakeholders Leads to Better Studies, Integrated Planning

As part of several studies conducted in 2009 that looked at ways to integrate more solar and wind on the Hawai'ian Islands (including the high penetration solar study mentioned here), the HCEI leadership team convened key stakeholders from the beginning of the project. For two studies in particular, the Oahu Wind Integration Study and the Hawai'i Solar Integration Study, a technical review committee (TRC) was developed. TRC members were regional, national, and international technical experts with substantial experience in power systems, renewable energy, direct-current cable systems, island grids, and wind and solar integration. TRC members provided a technical review of each study's methods, assumptions, preliminary results, gaps, overlaps, data needs, and timelines at in-person meetings during each project. Each TRC reviewed the studies and made recommendations, but the Hawai'ian utilities had final decision-making authority for their projects and next steps.

The Oahu Wind Integration and Transmission Study was meant to help stakeholders, especially the utility and the State, understand the costs and operating impacts of significant amounts of wind power on their island grids, and plan for future transmission to accommodate this power. The Hawai'i Solar Integration Study detailed the effects of high penetrations of solar and wind energy on the technical operations of the Maui and Oahu grids. Because those two islands already had significant wind and solar power feeding their electricity grids, the utilities on each island wanted to understand how to better operate their systems with more renewable and distributed energy. Both studies found that although renewable generation changes grid dynamics, these resources can be successfully integrated with the right approach.

The studies described here helped decision makers anticipate and plan for this high-penetration solar reality. Today, Hawai'i has one of the highest penetrations of distributed solar in the United States with 1 in 10 homes using solar.

This lesson learned is one of many provided in the Energy Transition Initiative Islands Playbook—an action-oriented guide to help island communities successfully initiate, plan, and complete a transition to a clean energy system and eliminate dependence on imported fuels. See the full Islands Playbook at **www.eere.energy.gov/islandsplaybook**.

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The Energy Transition Initiative leverages the experiences of islands, states, and cities that have established a long-term vision for energy transformation and are successfully implementing energy efficiency and renewable energy projects to achieve established clean energy goals. Through the initiative, the U.S. Department of Energy and its partners provide government entities and other stakeholders with a proven framework, objective guidance, and technical tools and resources for transitioning to a clean energy system/economy that relies on local resources to substantially reduce reliance on fossil fuels.