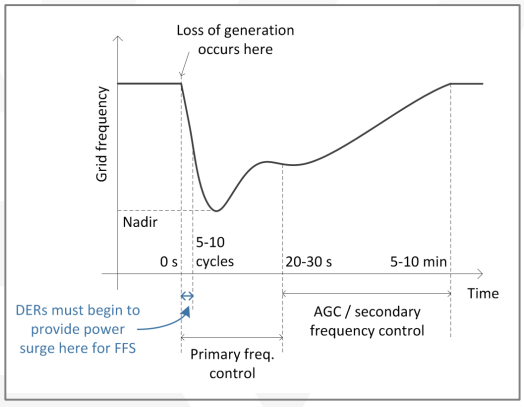
Grid Frequency Support from Distributed Inverter-Based Resources in Hawaii

CHALLENGE

Hawaii leads the nation in the portion of its electricity that is produced from distributed solar photovoltaics (PV). This high level of PV penetration, in combination with Hawaii's small size and geographical isolation, is forcing Hawaiian electric utilities to confront emerging grid reliability and safety issues much sooner than their continental counterparts. For example, the sudden loss of a major generator or a downed transmission line could cause some distributed PV systems to also shut down as a safety response, potentially exacerbating the change in the grid's electric frequency and causing a loss of grid stability. In addition, PV systems have displaced some of the conventional generators whose inertia and governor controls help to stabilize the grid.

PV systems installed in Hawaii. (Courtesy: SolarCity)



Grid frequency in response to system disturbance.

APPROACH

To tackle the engineering challenges that emerge with the growing number of distributed energy resources (DERs)—such as rooftop PV—the Hawaiian Electric Companies (HECO) are partnering with a team led by the National Renewable Energy Laboratory (NREL) to study the use of fast, DER-based frequency support to ensure grid stability. By configuring DERs to quickly modulate their output after an unexpected event, grid frequency can potentially be better maintained. The goal of the project is to investigate, develop, and validate ways that distributed PV and energy storage can

At-A-Glance

PROJECT LEADS

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PARTNERS

- Hawaiian Electric Companies (HECO)
- Enphase Energy
- Fronius USA
- Forum on Grid Integration Issues
- Energy Excelerator

BUDGET

$1.17 million

DURATION

April 2016 – September 2017

TECHNICAL AREA

Devices and Testing

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support grid frequency stability on the fastest time scale (starting within milliseconds of the occurrence of an event that affects grid frequency), and without negatively affecting the distribution systems to which the devices are connected.

The project team will accomplish several tasks:

- Analyze the impact of DER-based frequency support by simulating both over-frequency and under-frequency events in a variety of HECO grid scenarios. The project will also develop and validate new control methods that improve inverter-based frequency support capabilities and performance.
- Power-hardware-in-the-loop testing at NREL will reveal the ability of real hardware inverters to respond to disruptions in grid frequency in an environment that mimics the HECO power system. The team will also field test PV inverters in Hawaii to better understand their responses to real grid frequency events.
- The project team will compare the data gathered from the simulations, power-hardware-in-the-loop testing, and field testing to inform their final results. The project's final report, reviewed by a panel of experts, will collect lessons learned and provide recommendations on the use of DERs for grid frequency support.

EXPECTED OUTCOMES

The project will develop new control methods to improve inverter-based frequency response and new models to evaluate DER-based frequency support. The project will also test the frequency support functions of PV and battery storage in the field and in the lab.

By studying presently available PV and storage inverters in an environment that emulates HECO's actual distribution and transmission system, this project should help HECO—and potentially other utilities—make better use of fast, DER-based frequency support to maintain grid stability.

LAB TEAM

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Sandia National Laboratories

Launched in November 2014 under the U.S. Department of Energy's Grid Modernization Initiative, the GMLC is a strategic partnership between DOE Headquarters and the national laboratories, bringing together leading experts and resources to collaborate on national grid modernization goals. The GMLC's work is focused in **six technical areas** viewed as essential to modernization efforts:

Devices and Testing | Sensing and Measurements | Systems Operations and Control
Design and Planning | Security and Resilience | Institutional Support