# GMLC 1.3.29
# Grid Frequency Support from Distributed Inverter-based Resources in Hawaii

GRID MODERNIZATION INITIATIVE
U.S. Department of Energy

## Project Description

Hawaii leads the U.S. in the proportion of electricity provided from distributed energy resources (DERs) such as solar PV and energy storage. This leads to challenges maintaining a stable and reliable grid. This project partners with the Hawaiian Electric Companies (HECO) and key stakeholders to investigate, develop, and validate ways that DERs can support grid frequency stability on the fastest time scale (starting within a few line cycles of a frequency event). This is relevant to Hawaii today and will be relevant on the mainland U.S. in the near future as other states incorporate more DERs.

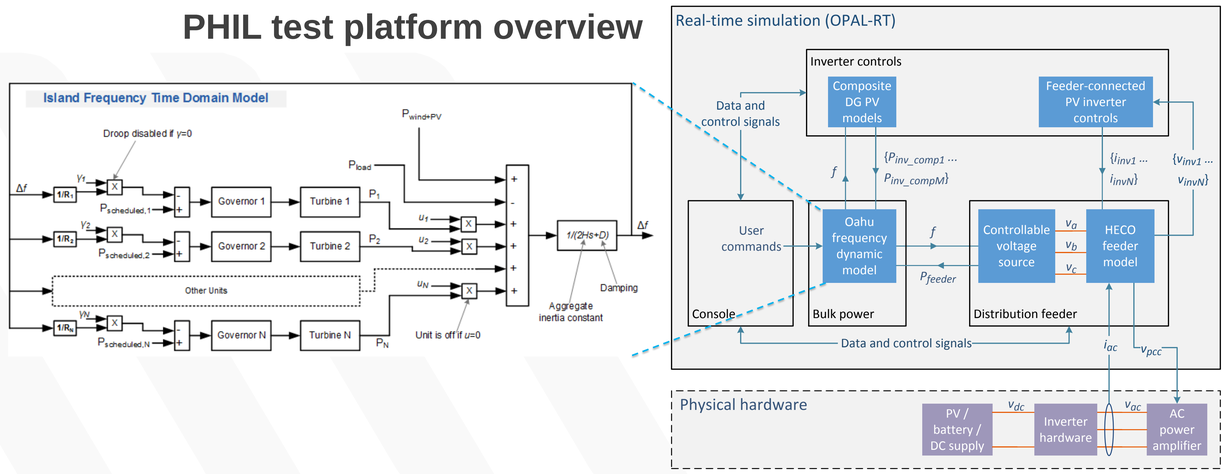
Partners: HECO, NREL (lead), SNL, Enphase, Fronius, FIGII, EEx

## Expected Outcomes

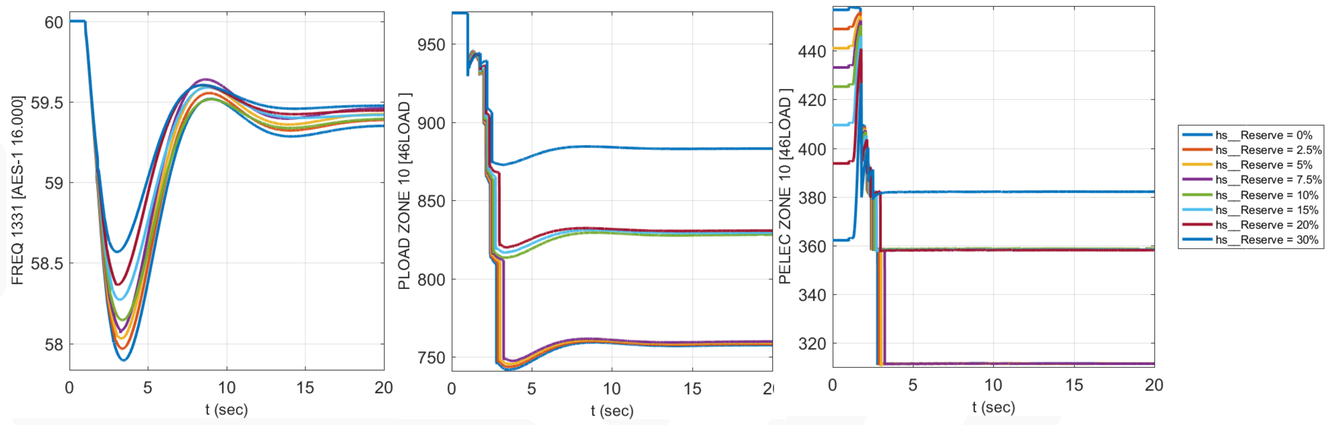
- Enable distributed PV and storage inverters to support grid frequency starting a few AC line cycles after the appearance of a frequency event.
- Characterize frequency support capabilities of existing inverters in the lab and in the field.
- Validate DER frequency support via conventional simulation (PSSE), hybrid T&D simulation, and power hardware-in-the-loop (PHIL) testing.
- Develop new models and modeling methods for DER frequency support functions.
- HECO intends to modify grid operations based on the findings of this work.
- Help ensure a reliable future electric grid.

| Significant Milestones | Date |
|---|---|
| 1.2 - Simulations of Oahu frequency events show DER-based frequency support avoids at least one load shedding event | September 30, 2016 |
| 2.4 - Prototype inverter controls for improved frequency support developed | March 31, 2017 |
| 3.4 - Initial results from PHIL testing of second inverter agree with pure simulation | March 31, 2017 |
| 4.5 - Data collection in progress for first field inverter | June 30, 2017 |
| 5.6 – Final report complete and Technical Review Committee input incorporated | September 30, 2017 |

## PHIL test platform overview




## Underfrequency event with varying levels of PV in reserve




## Progress to Date

- Draft IEEE Standard 1547 revision incorporated recommendations on speed of DER droop response from this project
- Developed custom PHIL platform for combined transmission & distribution simulation with high PV penetrations
- Publications:
  - A. Hoke, M. Shirazi, S. Chakraborty, E. Muljadi, D. Maksimovic, "Rapid Active Power Control of Photovoltaic Systems for Grid Frequency Support," *IEEE Journal of Emerging and Selected Topics in Power Electronics*, 2017

    (Online MPP estimation and PV controls for fast frequency support)
  - M. Elkhatib, J. Neely, J. Johnson, “Evaluation of Fast-Frequency Support Functions in High Penetration Isolated Power Systems,” *IEEE Photovoltaics Specialists Conference*, 2017