Smart Grid Inverters for High-Penetration PV Applications

Hawaiʻi Natural Energy Institute

The Hawaiʻi Natural Energy Institute (HNEI) is leading a team of recognized energy industry leaders working to develop enhanced capability smart inverters and to demonstrate improved operational performance, control and visibility. Validation of performance will be accomplished by deploying and evaluating smart inverters on operating utility distribution feeders in two locations with very high penetration of rooftop photovoltaics (PV) -- Maui, Hawaiʻi and Washington DC. This project will demonstrate that these smart grid-enabled inverters can address critical distribution-level barrier issues caused by high penetrations of distributed PV systems.

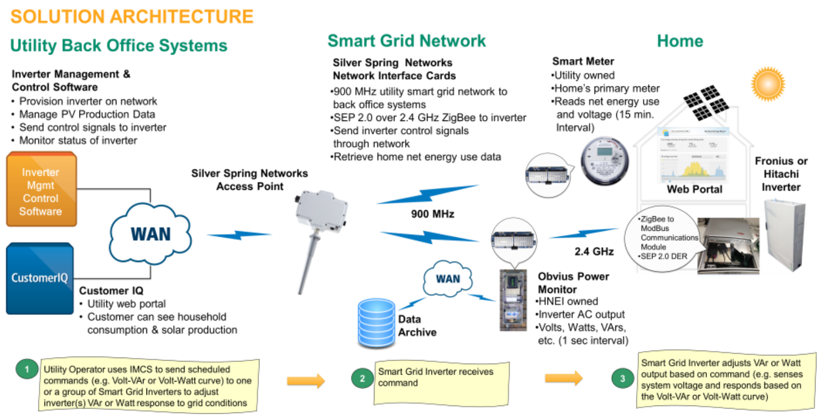

Figure 1. Project technology and solution architecture.

Challenge & Significance

Hawaiʻi has seen recent rapid growth in PV deployments in which the installed total MW of distributed rooftop PV has roughly doubled year over year across the islands. This rapid growth in residential rooftop PV has resulted in circuit level penetrations well in excess of 100% of daytime minimum load on numerous circuits in Hawaiʻi. In the Washington DC networked distribution system, increases in PV penetration have been limited by the utility PEPCO due to concern for power backflow and related misoperation of network protection devices, a serious reliability issue. Demonstrating that smart grid-enabled inverters can address critical distribution-level barrier issues may enable utilities to approve more residential rooftop PV systems, thereby increasing their potential contribution to our collective renewable energy portfolio.

Status & Accomplishments

- Deployed advanced function inverters and integrated them with inverter control software via standards-based communications to enable remote access and control.
- A network of data collection devices are deployed on the target distribution feeder to capture high resolution (1 sec.) synchronized inverter and feeder performance data.
- A detailed model has been constructed for the Maui distribution circuit targeted for smart inverter deployment, from the substation 69-12kV transformer

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Period of Performance:

2011-2015

Major Partners:

- Silver Spring Networks, Inc.
- Fronius USA LLC
- Hitachi Ltd.
- SMA America LLC
- Maui Electric Company, Ltd.
- PEPCO Holdings, Inc
- Rising Sun Solar Electric

Funding:

- US Department of Energy
- Office of Naval Research

down to the single phase feeders, service transformers, customer home loads, and rooftop PV systems with smart inverters.

- Smart inverter deployments are underway with 20 recruited residential volunteers in Maui.
- An advanced function inverter has been deployed at the Watershed House in Maryland (the University of Maryland's winning entry in the 2011 Solar Decathlon competition) which was purchased by PEPCO for public education of sustainability and clean energy technologies.

Project Detail

The HNEI led consortium, which includes a world class team with significant smart grid solutions expertise and experience, a sizable share of the PV inverter market, and PV system sales and installation experience, will demonstrate smart inverters supplied by three industry leading manufacturers, Fronius, Hitachi and SMA. The inverters and communications protocols have been developed and lab tested to evaluate advanced inverter control capabilities in various programmed scenarios. The project has completed full end-to-end testing of the control system, field communications systems, and inverters using a pre-deployment installation at Maui Electric. The team is installing 20 new and retrofit smart inverters at Maui residences to test the feasibility of using inverters to mitigate voltage fluctuations caused by the intermittency of PV systems and control PV system power output with the curtailment capability. The Maui grid has less than 200 MW total daytime demand with 55 MW of installed rooftop PV.

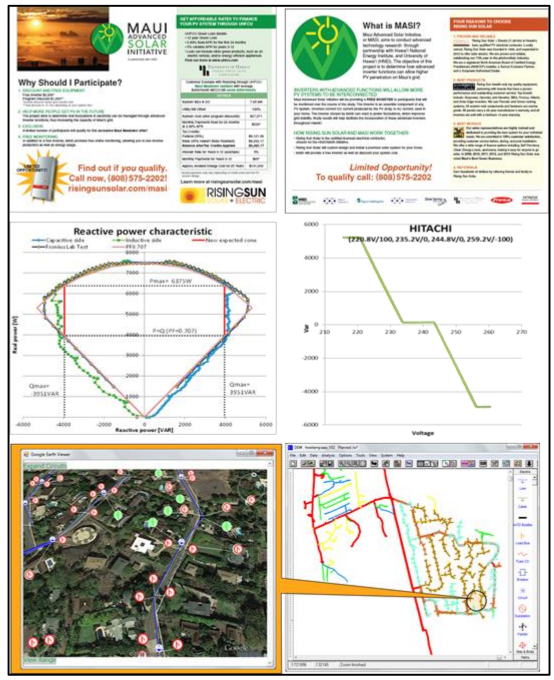

Figure 2. Volunteer recruitment materials, inverter testing and distribution feeder modeling.

At PEPCO, the project team will use the curtailment function of the inverters to study their ability to prevent back feeding and mis-operation of protective devices in an underground secondary network. At both demonstration sites, a smart meter mesh communication network is utilized for communication and control of the inverters. A detailed model of the affected Maui distribution feeder using the DEW/ISM power system modeling application is complete and the project team is utilizing the model to simulate the smart inverters and their impact on the grid to develop control strategies for the inverters. These strategies will then be implemented in the field and their actual impact on the grid measured by the power system monitors. This measured data will then be used to validate and update the results from the model. This iterative process will be used to fine tune the inverter control strategies.