Maui Smart Grid Demonstration Project

Managing Distribution System Resources for Improved Service Quality and Reliability, Transmission Congestion Relief, and Grid Support Functions

Executive Summary

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1. SUMMARY

The Maui Smart Grid Project (MSGP) is under the leadership of the Hawaii Natural Energy Institute (HNEI) of the University of Hawaii at Manoa. The project team includes Maui Electric Company, Ltd. (MECO), Hawaiian Electric Company, Inc. (HECO), Sentech (a division of SRA International, Inc.), Silver Spring Networks (SSN), Alstom Grid, Maui Economic Development Board (MEDB), University of Hawaii-Maui College (UHMC), and the County of Maui. MSGP was supported by the U.S. Department of Energy (DOE) under Cooperative Agreement Number DE-FC26-08NT02871, with approximately 50% co-funding supplied by MECO.

The project was designed to develop and demonstrate an integrated monitoring, communications, database, applications, and decision support solution that aggregates renewable energy, other distributed generation (DG), energy storage, and demand response technologies in a distribution system to achieve both distribution and transmission-level benefits. The application of these new technologies and procedures will increase MECO's visibility into system conditions, with the expected benefits of enabling more renewable energy resources to be integrated into the grid, improving service quality, increasing overall reliability of the power system, and ultimately reducing costs to both MECO and its customers.

The project had seven primary objectives for applying advanced technologies to the MECO grid in the scope of the project. Distribution-level benefits include:

- D-1: Reduce a distribution system's peak grid energy consumption.
- D-2: Improve voltage regulation and power quality on the selected distribution feeder.
- D-3: Demonstrate that the architecture of the demonstration project is compatible with additional distribution management system functions, customer functions, and legacy systems.
- D-4: Develop and demonstrate solutions to significant increases in distributed solar (photovoltaic systems) technologies.

At the transmission level, the solution will enable coordination of the operation of distributed energy resources (DER) to make the distribution system dispatchable, providing benefits of:

- T-1: Provision for management of short-timescale intermittency from resources elsewhere in the grid, such as wind energy, solar energy, or load intermittency.
- T-2: Provision for management of spinning reserve or load-following regulation.
- T-3: Reduction of transmission congestion (through curtailment of peak load).

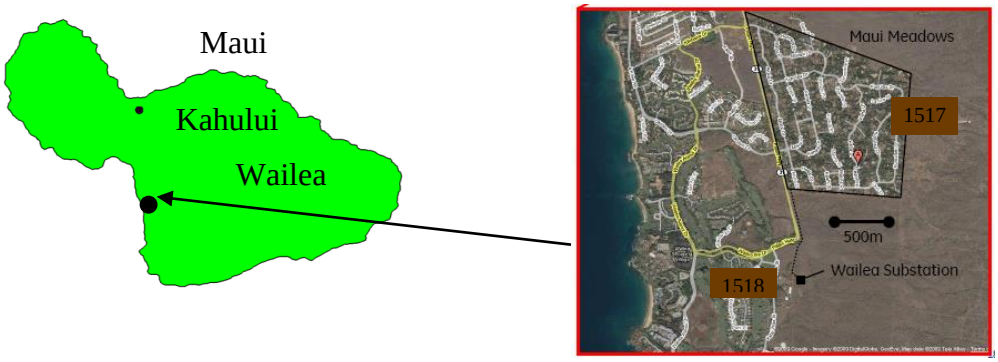
Maui, as is true of all of Hawaii, is seeing a tremendous increase in distributed and grid-level renewable energy installations. Operating the grid with high penetrations of as-available renewable energy resources is proving increasingly difficult. There are especially concerns about maintaining the reliability and stability of the grid, maintaining customer voltages within tariff specifications, and determining the amount of operating reserves needed to support the as-available renewable energy resources cost effectively. "Smart grid" technologies and functionality have the potential to address these issues, but before a system-wide "rollout" of a smart grid, MECO desired to obtain more familiarity with costs, capabilities, and operating procedures through a pilot demonstration. Determining appropriate functionality for Advanced Metering Infrastructure (AMI) is especially key. So-called "smart meters" offer many

capabilities to consumers, but before MECO invests in an AMI system, it wanted to determine which of the myriad AMI functions will deliver real value to its customers.

At the beginning of the project, the project team identified key issues and questions:

- Improving visibility into the distribution system; evaluation of methods to acquire, transmit, process and display the information; data resolution and latency requirements. Specific goals included:
  - Data on customer voltages, resulting in better power quality
  - Understanding the impacts of distributed photovoltaic (PV) systems on service voltages
  - Load research – understand how consumption information and PV system installations impact residential energy use
- Determining the amount of PV energy supplied by distributed generation on the system
- Use of Demand Response (DR) to reduce peak load and mitigate variations of as-available renewable energy resources
- Experience with specification, installation, and operation of a Battery Energy Storage System (BESS), including smoothing variability from renewable energy generators and loads
- Identifying "Smart Grid" functions, especially "smart meter" functionality, of most value to MECO customers (in preparation for system-wide smart meter rollout)
- Improved volt/var management
- Determine MECO training and staffing requirements for smart grid implementation and operation (meter shop, installers, system operators, etc.)
- Integration of AMI, DR and Distribution Management System (DMS) together with MECO's Supervisory Control and Data Acquisition (SCADA)/ Energy Management System (EMS)
- Insight into specification, procurement, and testing of smart grid systems for MECO and the other Hawaii utilities

The project demonstrated new technologies in South Maui, on two distribution circuits fed by a transformer at MECO's Wailea substation.



The MSGP implemented:

- Advanced Metering Infrastructure (AMI)
- PV system metering

- DR of water heaters and air conditioner thermostats
- In-Home Display (IHD) of energy use
- BESS of 1 MW with 1 MWh usable storage capacity
- Distribution Management System (DMS) for voltage support and reactive power management

Primary project roles were:

- HNEI: project management, specification of capabilities, data collection and analyses
- MECO: supplied BESS; project implementation, testing, commissioning, operations
- MEDB: continuing consumer outreach and education
- SLIM: workforce training; energy use analysis
- SRA/Sentech: functional specification and system integrator
- SSN: supplied AMI, PV metering, DR, and IHD systems
- Alstom Grid: supplied DMS

The project accomplished its objectives. It was successful in providing MECO with an opportunity to evaluate the capability of several advanced systems and technologies to resolve issues faced by MECO and its customers: high energy costs, the need to manage high penetrations of as-available renewable energy, and constraints on expanding the power system to serve load growth. The customer outreach and education activities proved especially valuable: while the proponents of the "smart grid" often cite the information and choices that smart meters offer the consumer, this demonstration project showed MECO what information customers *really* wanted, and how they wanted it presented. A significant accomplishment of the project was obtaining customer input *before* any system-wide implementation. For example, the project showed that customers would indeed utilize the information provided by smart meters to reduce their energy consumption.

The project spanned a period when the number of new PV installations in Hawaii was doubling every year. From a grid operation perspective, the higher than expected penetration of PV revealed new requirements for monitoring and control of distribution system assets and load flow simulation models. "Lessons learned" in this demonstration have already been applied to subsequent projects: HNEI's Maui Advanced Solar Initiative (MASI), and HECO's distribution voltage optimization project.

MECO has already acted on the visibility it gained into the Maui Meadows distribution feeders to adjust tap changer settings and improve voltage support for its customers. Distribution transformers MECO buys in the future will have additional voltage adjustment capabilities that will allow a response to the conditions observed during the project that resulted from high penetrations of PV.

This project afforded MECO its first opportunity to operate a large BESS, giving experience for specifying, installing and commissioning future BESS projects. This is important, as energy storage is proving to be an essential asset for supporting high penetrations of as-available renewable energy sources. The project showed that a BESS is effective for load management, enabling it to smooth variations in loads and renewable energy output. The BESS also demonstrated capability for providing regulation and for shifting times of demand on MECO's generators. Charging the BESS during nighttime hours uses electricity generated by wind turbines, reducing their curtailment due to excess energy conditions.

The project showed both BESS and DR technologies can be effective in reducing peak loads on the MECO system and of individual substations. The experience gained in this project will help MECO integrate distributed and renewable energy resources (PV, wind) with the operation of its central generators and transmission system. The result will be the ability to support larger amounts of as-available renewable energy resources, improved system stability, higher reliability of supply and lower costs for Maui Electric customers.

The project was funded in part under the American Recovery and Reinvestment Act of 2009. From that perspective, the technology demonstration directly invested in and strengthened Maui's electrical infrastructure. Local workers were educated in energy auditing, equipment installations, and smart grid technologies; this not only gave immediate benefits to a group of jobseekers, but the workforce training developed by UHMC under this project will continue to provide clean energy workforce training on Maui. The experience gained under this project also provided MECO personnel with valuable training on distribution management, advanced metering, BESS management and system integration of renewable energy.