Building the Maui Smart Grid

Asia Pacific Clean Energy Summit and Expo
Power Generation & Efficiency Concurrent Session
Smart Grid Demonstrations in the Test Bed

Honolulu, Hawaii
August 13, 2012

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Clean Energy Opportunities in Hawaii are Abundant
Rapid Development of Renewable Resources Today

Wind

Solar
The Maui island Experience

72 MW of Wind Power

KWP
(30MW 2006)

KWP II
(21MW 2012)

AWE
(21MW 2013)

63,000 Customers

Daily Load Shape

Load
(MW)

24hr

200

85
Exponential Growth in PV Market
Island of Maui

Installed PV in 2011 exceeded the PV installed over the previous 10 years
(Source: Maui Electric Company, Ltd.)

Integrating High Penetrations of PV on Distribution Feeders is Today’s Challenge in Hawaii
Electrifying Transportation

- 1/3 of oil imported for ground transportation
- Driving electric vehicles are …
  - a good fit for Hawaii
  - cleaner (less CO2)
  - cheaper
  - Mitsubishi “i” @ 9 cents/mile
    (30 cents/KWh electricity)
  - Avg. Gas Car @ 20 cents/mile
    ($4/gal gas; 20 mi/gal)
Making of the Maui Smart Grid

- Maui Smart Grid Demonstration Project (2009) ~$12 M
  - US DOE funded, HNEI led project to integrate smart grid technology to achieve reduced peak load on a distribution circuit and better management of intermittent renewable energy
- Japan-US Island Grid Project (2011) ~$40 M
  - NEDO funded, Hitachi led project to integrate high levels of PV, wind energy, and EV into an island wide smart grid environment
- Smart Grid-Enabled PV Inverters (2012) ~$12 M
  - US DOE funded, HNEI led project to develop and demonstrate advanced PV inverter functionality in a smart grid environment

Three projects have partners in common and propose to share hardware, results, and lessons learned
Maui Smart Grid Demonstration Project (2009)

• Funded by US DOE with cost share from partners
• Implement advanced communications and control technologies to improve grid performance
• Demonstrate new “Smart Grid” technologies to:
  – Reduce peak demand by 15%
  – Better integrate wind and solar power
  – Improve grid reliability
  – Inform consumer demand decisions

Hawaii Natural Energy Institute
University of Hawaii at Manoa

Maui Electric Company, Ltd.

Hawaiian Electric Company

ALSTOM

SILVERSPRING NETWORKS

medb

maui economic development board, inc.
Project will Manage Distributed Energy Resources (DER) to Support Grid Operations

Advanced Metering Infrastructure
Two-way comms
Voltage monitoring
Outage detection

Distribution Management System
Aggregate DER Decision support
Volt / VAr Control
Improve visibility

Battery Energy Storage System

Home Area Network
Demand response
Monitor PV
Customer feedback

Solar PV monitoring
Smart Thermostat
In-home display

Load Control Switches

Current monitoring device

SSN Data Center
MECO Data Center
Wailea Sub Station
MECO Backhaul
GE DMS
Areva EMS

Maui Meadows
SSN Mesh

Distribution Monitoring
Current measurements

University of Hawai'i MĀNOA
Development and Demonstration of Smart Grid PV Inverters (2012)

- Enable high-penetration residential PV
- Lower grid integration costs
- Demonstrate benefits of inverter control in differing applications

Principal Investigator – Program management and analysis of benefits and impacts of intelligent inverter control capability

Technology Lead – Provide end-to-end, standards based, intelligent communications for inverter control

Inverter Technology Lead – Provide inverter with advanced grid functionality (AGF)

Services Lead – Provide system installation, training, and customer support

Co-Utility Leads – Assess capability of inverter AGF to mitigate PV variability impact on distribution feeder and provide other utility benefits
Solution Architecture

**Utility Back Office Systems**

Inverter Management & Control Software
- Provision inverter on network
- Manage PV Production Data
- Send control signals to inverter
- Monitor status of inverter

Customer IQ
- Utility web portal
- Customer can see net bill impact & solar production

Inverter Management & Control Software
- Silver Spring Networks
- Network Interface Card
- SEP 2.0 over 2.4 GHz ZigBee
- 900 MHz utility smart grid network
- Retrieve PV production data
- Send inverter control signals through network

**Smart Grid Network**

Silver Spring Networks Access Point
- 900 MHz

Smart Meter
- Utility owned
- Home’s primary meter

Based on Fronius IG Plus V Inverter
- Advanced Grid Functionality (examples)
  - Remote generation curtailment
  - Remote control of reactive power supply
  - Low voltage ride through

Customer IQ
- Utility owned
- Home’s primary meter
Japan – United States Smart Grid Demonstration Project (2011)

Other supporting partners:
- Nissan Motor Co., Ltd.
- Advanced Energy Company
- U.S. Verizon Gr.
- Okinawa Electric Power Co.
Integrate Renewables and Transform the Maui Grid

Kihei area:
- Substation (Distribute)
- μDMS
- EV Energy Control Center

Wailea area:
- Wind Farms
  - KWP (30MW)
  - KWP II (21MW)
  - AWE (21MW)

63,000 Customers

Daily Load Shape

Rapid EV chargers to be provided by Hitachi via NEDO funded project

Wind Farms

EMS EVECC

Rapid EV chargers to be provided by Hitachi via NEDO funded project
Bottom Line

- Paradigm shift - energy insecurity  ➔ energy security
- Total energy cost (electricity & transportation) lowered and stabilized using renewable energy in place of oil
- Hawaii is an ideal working ‘lab’ to prove concepts and learn lessons about advanced energy technologies
- Hawaii as a national and international leader
  - Increasing energy independence
  - Reducing fossil-fuel use
  - Limiting greenhouse gases

Opportunity for Hawaii to Establish a Clean Energy Economy
Mahalo!
(Thank you)

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• Established in 1907
• 3 universities & 7 community colleges
• Over 53,000 students
• Manoa is the largest and main research campus
  – 14,000 undergraduate students
  – 6,000 graduate students
Hawaii Natural Energy Institute (HNEI)

- Organized research unit in School of Ocean and Earth Science and Technology, University of Hawaii at Manoa
- In existence since 1974. Established in statute in 2006 with mandate to develop renewable sources of energy and to demonstrate and deploy efficient energy end-use technologies

Program Objectives
- Research and development of new energy technologies
- Testing and evaluation of emerging technologies
- Research to support renewable energy deployment
- Energy assessments and policy development
- Develop and manage research partnerships to leverage investment in Hawaii
- Contribute to STEM and workforce development

HNEI programs are multi-disciplinary efforts with strong collaboration and cost share from industry
HNEI Program Areas

- **Hydrogen:**
  - Hawaii Hydrogen Power Park
- **Fuel Cells:**
  - Testing and systems optimization
- **Photovoltaics:**
  - Thin film solar cells, deployment, testing, and analysis
- **Electrochemical Power Systems:**
  - Batteries and electric vehicles
- **Ocean Resources:**
  - Seabed methane hydrates, ocean thermal and wave energy
- **Biofuels and biotechnology:**
  - Biomass conversion - solid, liquid and gaseous fuels
  - Biofuels fit-for-use
- **Grid Analysis and Smart Grids**
- **Technology Validation, Energy Assessment and Policy**