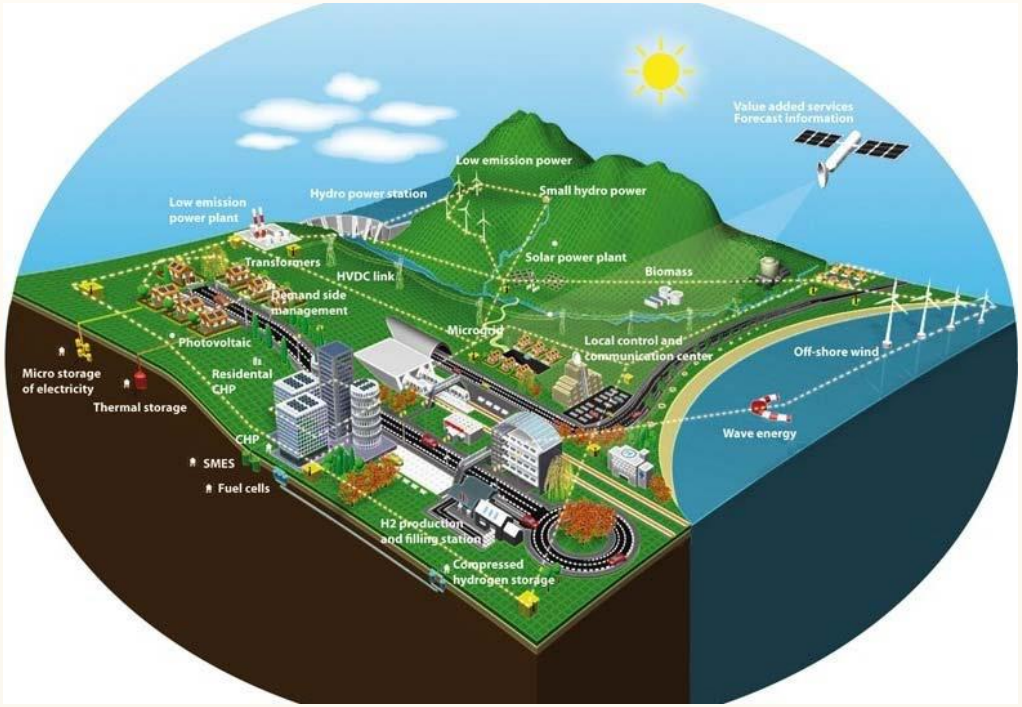
Hawaii's Renewable Energy Future

"The Maui Smart Grid – An Energy Technologies & Applications Showcase"



Leon R. Roose, Esq.
Principal & Chief Technologist

GridSTART
Hawai'i Natural Energy Institute | University of Hawai'i

Grid System Technologies Advanced Research Team

HNEI
Hawai'i Natural Energy Institute
School of Ocean and Earth Science and Technology
University of Hawai'i at Mānoa

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Hawaii Natural Energy Institute
School of Ocean & Earth Science & Technology
University of Hawaii at Manoa
1680 East-West Road, POST 109
Honolulu, Hawaii 96822

The Second International Symposium on Open Energy Systems

Sponsored by

Okinawa Institute of Science and Technology Graduate University

OIST

Okinawa, Japan
February 2-3, 2015

Hawaii is Paradise Found

Admitted to US: 1959

- 50th and last U.S. State

Total Land Area: 10,931 sq mi

- 43rd in Nation

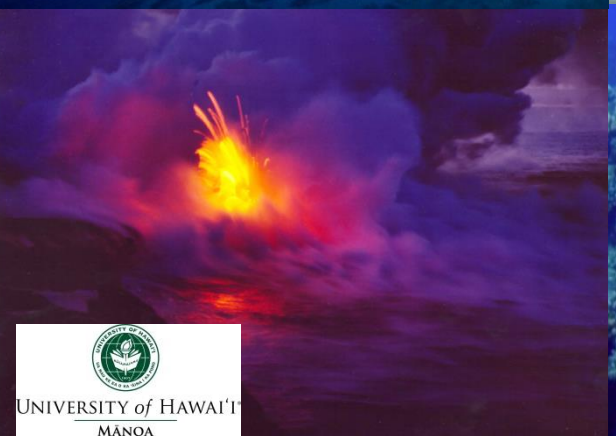
Population: 1.4 million

- 40th in Nation, 12.3% incr. in past decade

Median Household Income (2013): $68,020

- 4th in Nation



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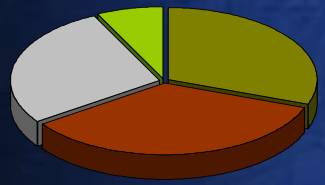
But, it's the Most Isolated Population Center on Earth

Nearly 90% of Hawaii's energy is met using *fossil fuels*

100% of the crude oil for the State is *imported*



JET FUEL	34%
ELECTRICITY	32%
GASOLINE/ MARINE FUEL	27%
OTHER	7%

***Threat* to Hawaii's:**

- **Security**
- **Economy**
- **Environment**

High Energy Cost Drains the Island Economy

High Cost of Service

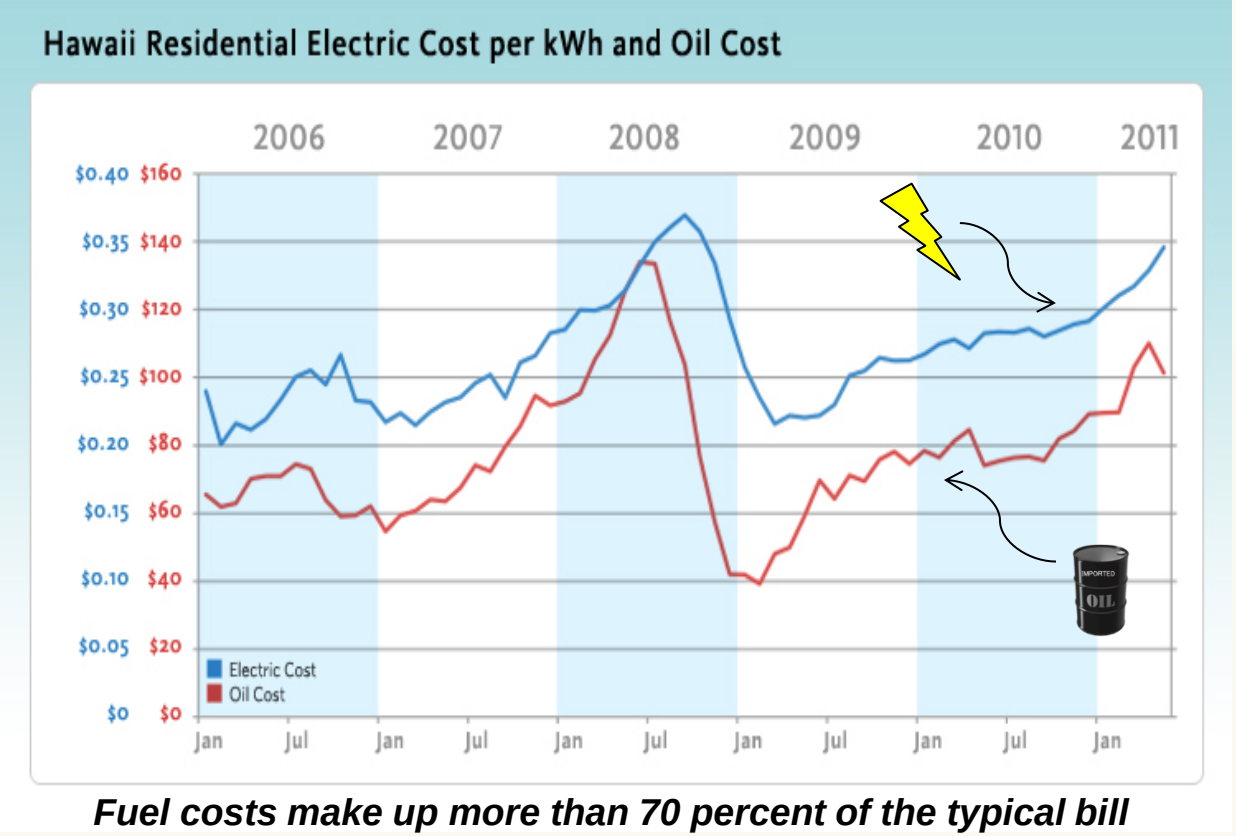
Hawaii ranks #1 in U.S. electric energy costs:

46.4 cents/kWh	Molokai
46.3 cents/kWh	Lanai
42.2 cents/kWh	Hawaii
37.8 cents/kWh	Maui
34.6 cents/kWh	Oahu

(Avg. residential rates for **2013**)

11 - 12 cents/kWh U.S. avg.

Source: Hawaiian Electric Company



Fuel costs make up more than 70 percent of the typical bill

High Electricity Price and Volatility Linked to Cost of Oil

Renewable Energy Aimed to "Break the Link" and Lower Cost

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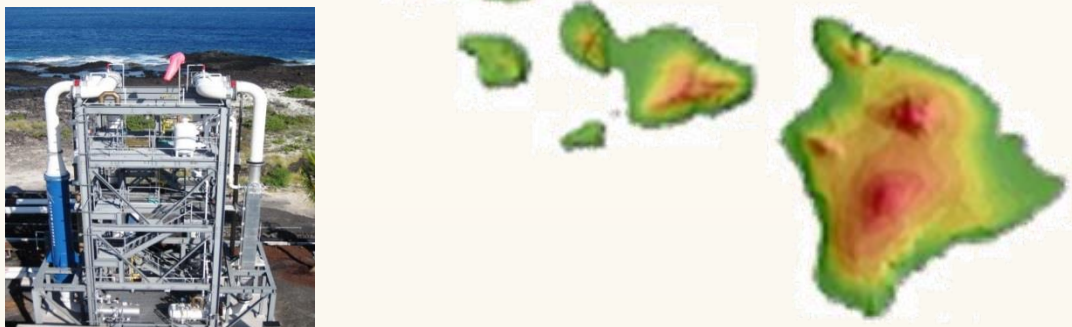
Opportunity for Sustainability in Hawaii is Abundant



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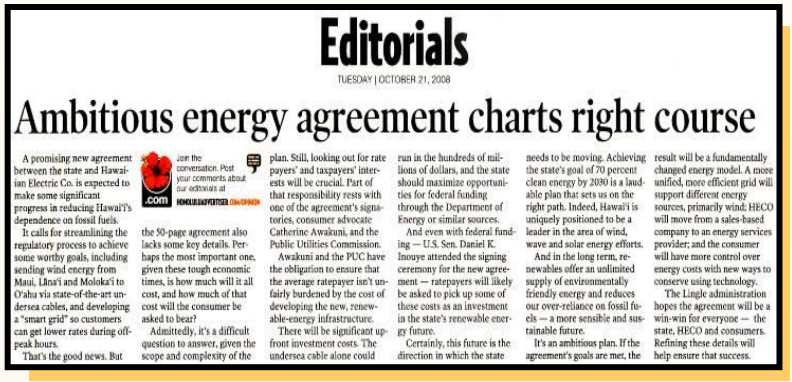
Hawaii's Progressive Leadership in Clean Energy Policy



Editorials

TUESDAY | OCTOBER 21, 2008

Ambitious energy agreement charts right course

A promising new agreement between the state and Hawaiian Electric Co. is expected to make some significant progress in reducing Hawai'i's dependence on fossil fuels.

It calls for streamlining the regulatory process to achieve some worthy goals, including sending wind energy from Maui, Lāna'i and Moloka'i to O'ahu via state-of-the-art undersea cables, and developing a "smart grid" so customers can get lower rates during off-peak hours.

That's the good news. But the 50-page agreement also lacks some key details. Perhaps the most important one, given these tough economic times, is how much will it all cost, and how much of that cost will the consumer be asked to bear?

Admittedly, it's a difficult question to answer, given the scope and complexity of the plan. Still, looking out for ratepayers' and taxpayers' interests will be crucial. Part of that responsibility rests with one of the agreement's signatories, consumer advocate Catherine Awakuni, and the Public Utilities Commission.

Awakuni and the PUC have the obligation to ensure that the average ratepayer isn't unfairly burdened by the cost of developing the new, renewable-energy infrastructure.

There will be significant up-front investment costs. The undersea cable alone could run in the hundreds of millions of dollars, and the state should maximize opportunities for federal funding through the Department of Energy or similar sources.

And even with federal funding — U.S. Sen. Daniel K. Inouye attended the signing ceremony for the new agreement — ratepayers will likely be asked to pick up some of these costs as an investment in the state's renewable energy future.

Certainly, this future is the direction in which the state needs to be moving. Achieving the state's goal of 70 percent clean energy by 2030 is a laudable plan that sets us on the right path. Indeed, Hawai'i is uniquely positioned to be a leader in the area of wind, wave and solar energy efforts.

And in the long term, renewables offer an unlimited supply of environmentally friendly energy and reduces our over-reliance on fossil fuels — a more sensible and sustainable future.

It's an ambitious plan. If the agreement's goals are met, the result will be a fundamentally changed energy model. A more unified, more efficient grid will support different energy sources, primarily wind; HECO will move from a sales-based company to an energy services provider; and the consumer will have more control over energy costs with new ways to conserve using technology.

The Lingle administration hopes the agreement will be a win-win for everyone — the state, HECO and consumers. Refining these details will help ensure that success.

Hawai'i Powered
Hawai'i Clean Energy Initiative

Hawaii Clean Energy Initiative (HCEI)

The State of Hawaii, US DOE, and local utility launched HCEI in January 2008 to transform Hawaii to a 70% clean energy economy by 2030:

- ***Increasing Hawaii's economic and energy security***
- ***Fostering and demonstrating Hawaii's innovation***
- ***Developing Hawaii's workforce of the future***
- ***Becoming a clean energy model for the U.S. and the world***

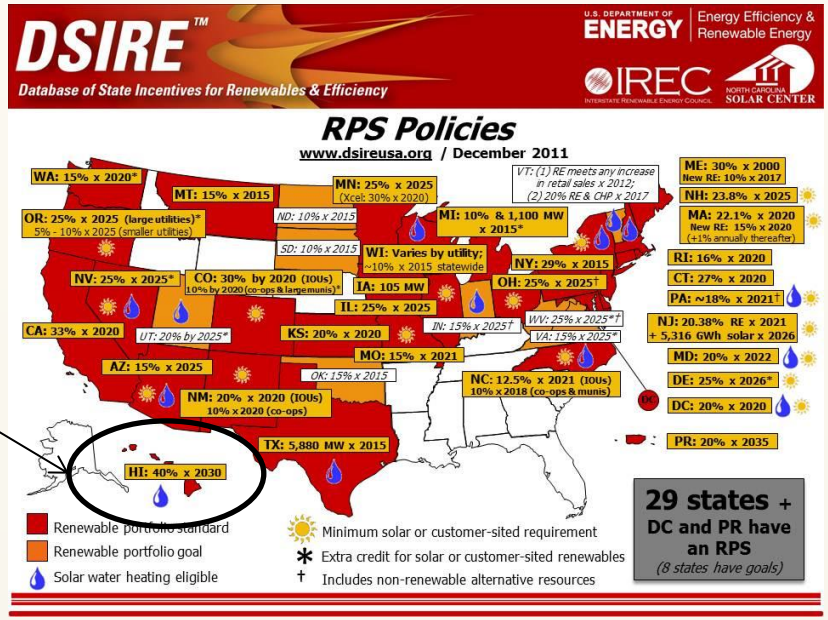
Strong Hawaii Policies

Highest RPS Target in the United States

40% by 2030
(2015 - 15%; 2020 - 25%)

Other key policies:

- **Tax incentives**
- **Net metering**
- **Feed in tariffs**



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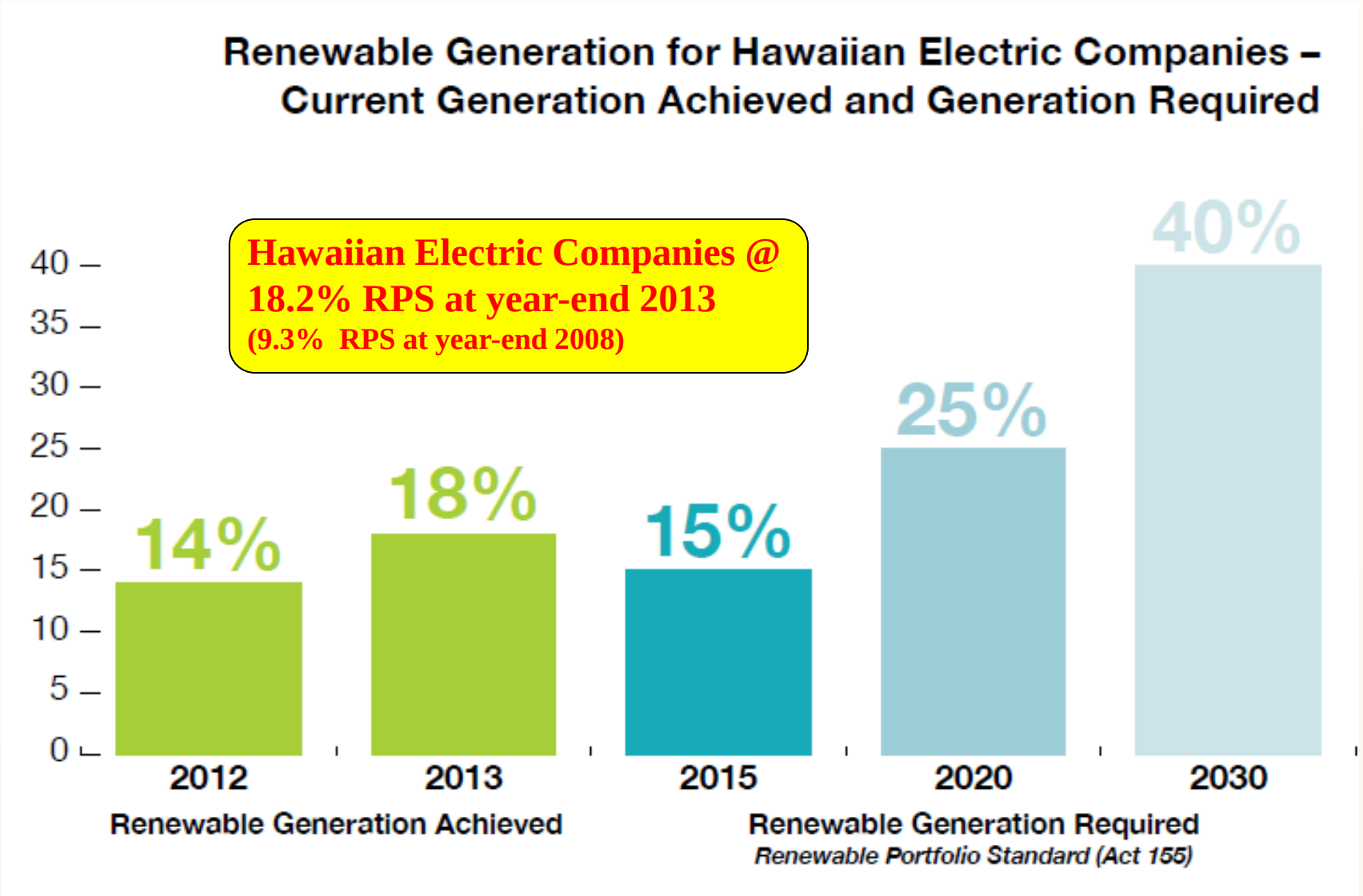
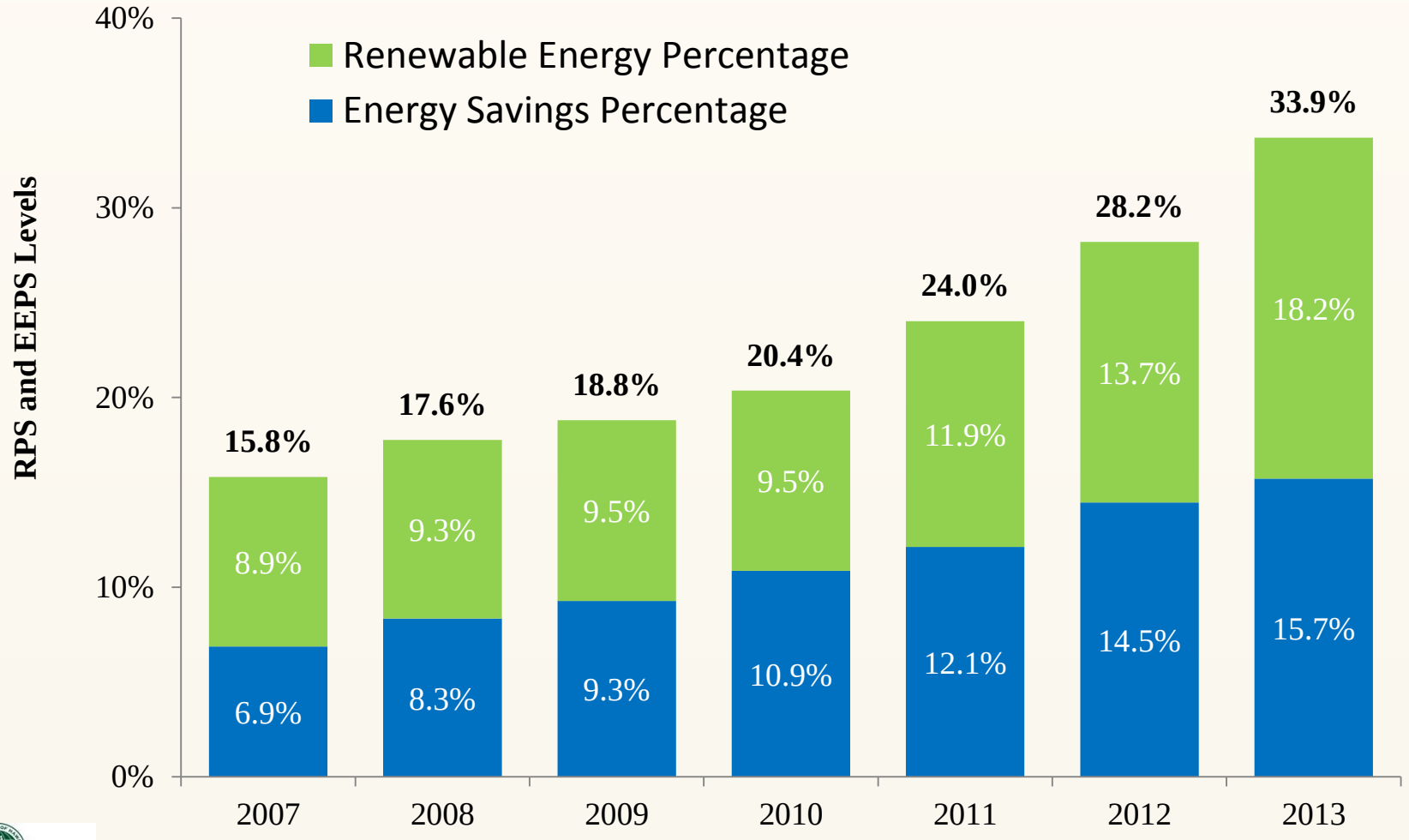
Exceeding Hawaii RPS Goals

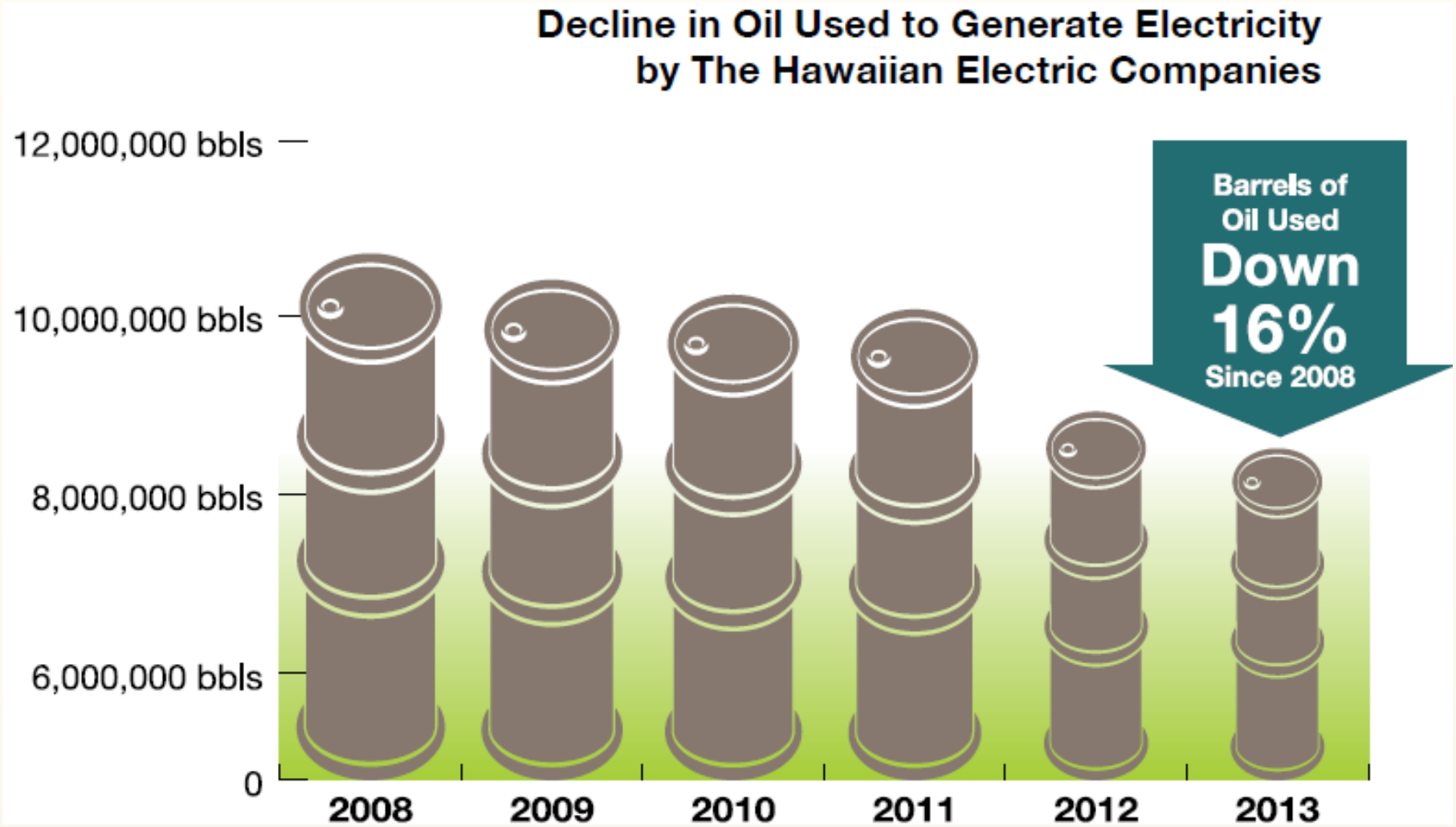


Source: Hawaiian Electric Companies 2013 Clean Energy Update Report

The Complete HCEI Scorecard - Combined Energy Efficiency Portfolio Standards (EEPS) and RPS Advances



Hawaii's Significant Reduction in Oil Imports



Source: Hawaiian Electric Companies 2013 Clean Energy Update Report

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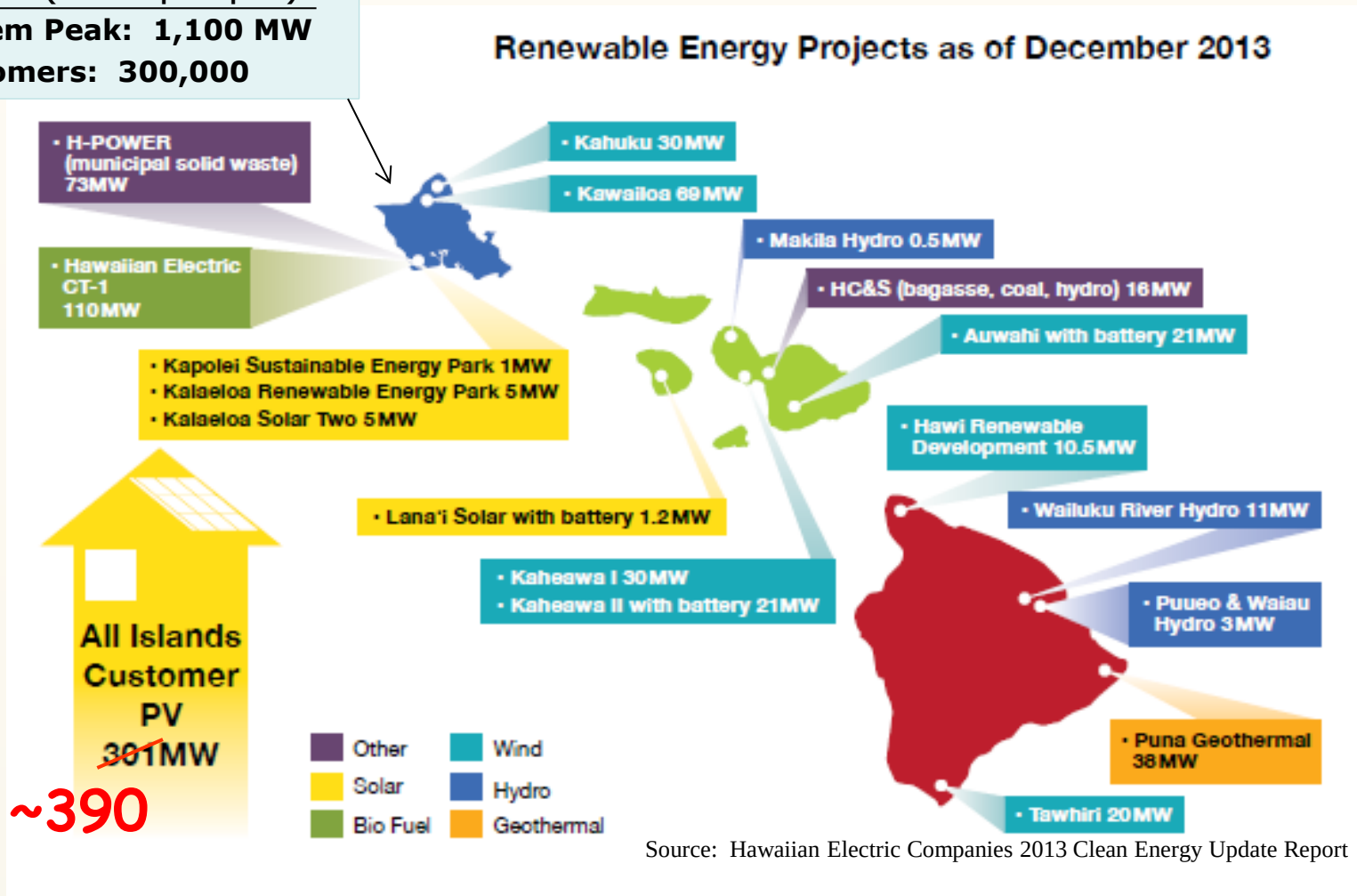
Hawaii's Renewable Energy Projects

"Clean Energy, Lower Bills"

Oahu (~1M people)
System Peak: 1,100 MW
Customers: 300,000



Source: Hawaiian Electric Companies 2013 Clean Energy Update Report

240 MW of large-scale PV projects in development at an average cost of 15.8 cents/kWh (1/3 less than the energy cost from oil)

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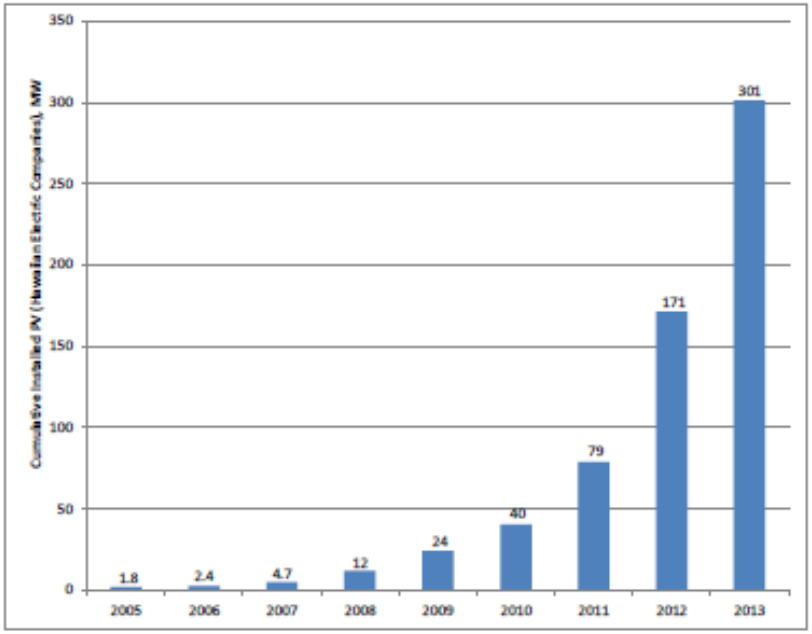
Rapid Growth in Customer Sited Solar PV in Hawaii Continued in 2014

45 MW added in first 6 months of 2014

89 MW added in 2014

Cumulative Installed PV -- As of December 31, 2013

	Number of PV Systems			PV Capacity, MW		
	Number	% Residential	% Commercial	Capacity	% Residential	% Commercial
Hawaiian Electric	29,558	97%	3%	221	65%	35%
Hawai'i Electric Light	5,355	93%	7%	38.2	59%	41%
Maui Electric	5,246	92%	8%	40.9	59%	41%
Total	40,159			301		



Data subject to change

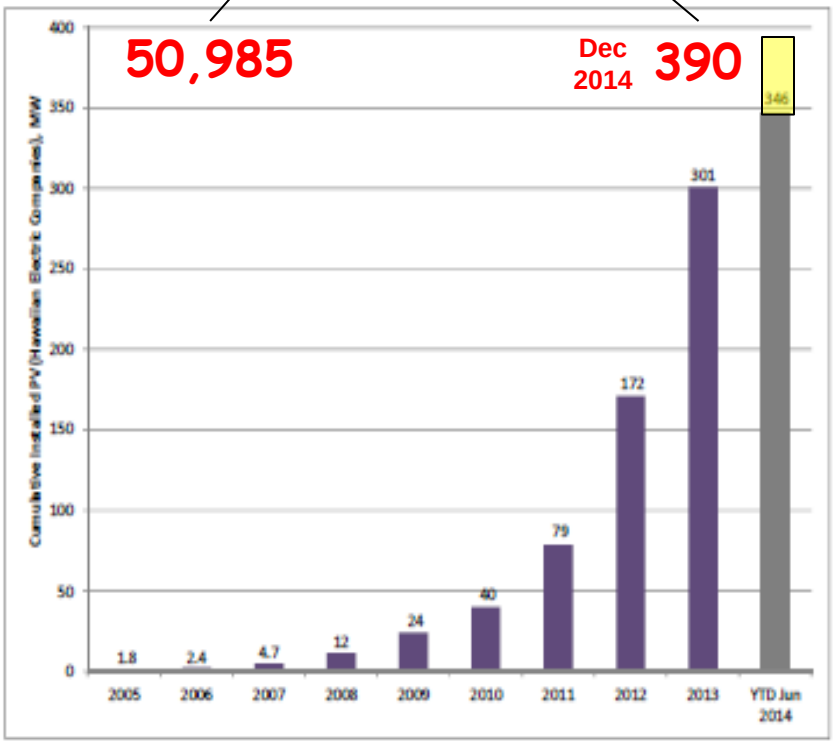
Hawaiian Electric
Maui Electric
Hawai'i Electric Light

Cumulative Installed PV -- As of June 30, 2014

	Number of PV Systems			PV Capacity, MW		
	Number	% Residential	% Commercial	Capacity	% Residential	% Commercial
Hawaiian Electric	33,861	97%	3%	254	283 67%	33%
Hawai'i Electric Light	6,231	93%	7%	44.0	52 61%	39%
Maui Electric	6,187	92%	8%	47.5	55 61%	39%
Total	46,279			346		

50,985

Dec 2014 390



Data subject to change

Hawaiian Electric
Maui Electric
Hawai'i Electric Light

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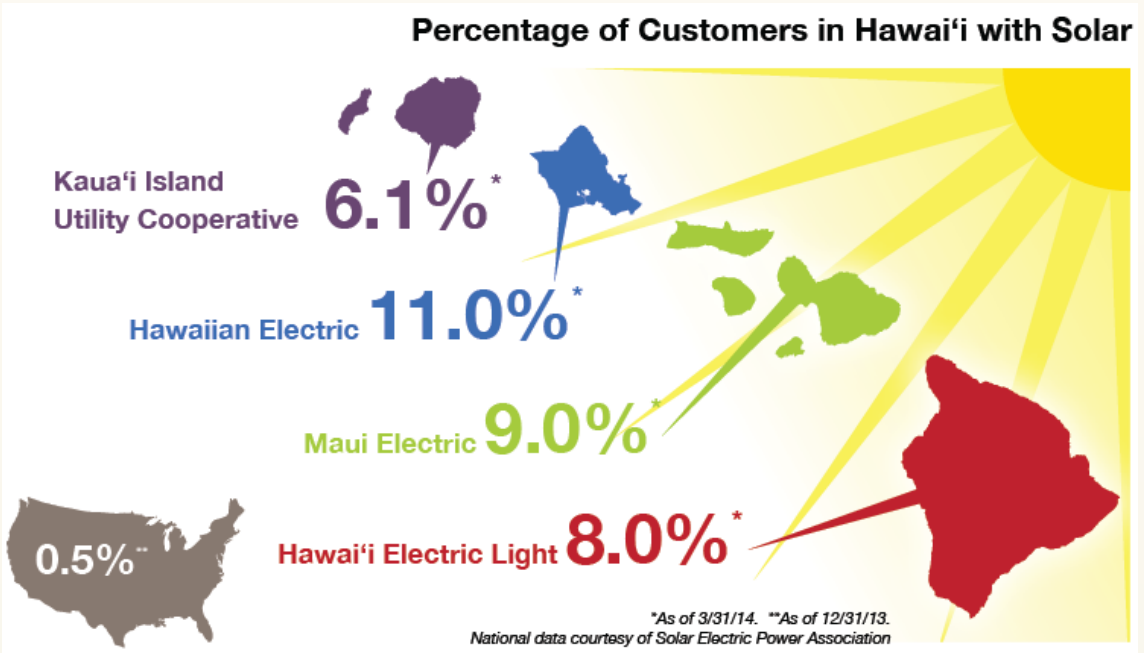
Hawaii is a PV Leader

Top 10 Solar PV States

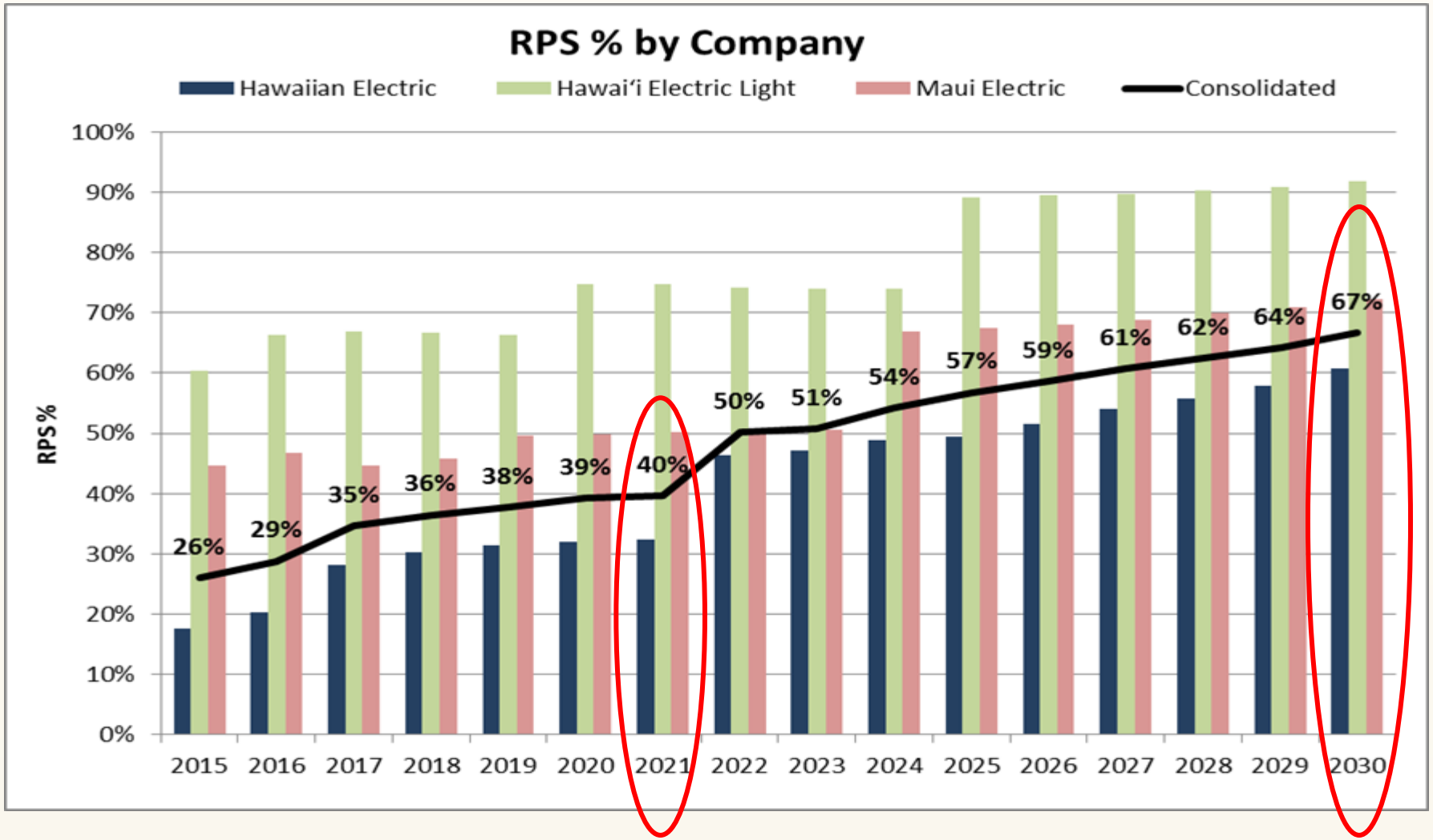
1.	Hawai'i	255
2.	Arizona	235
3.	Nevada	152
4.	California	135
5.	New Jersey	133
6.	New Mexico	123
7.	Colorado	68
8.	Delaware	68
9.	Massachusetts	67
10.	Vermont	66

Ranked by Cumulative installed
PV Capacity per Capita (DC Watts/person)
through 12/2013.
Source: Interstate Renewable Energy Council



Source: Hawaiian Electric Companies 2013 Clean Energy Update Report

Renewable Portfolio Standards (RPS) Projections



Hawaiian Electric Companies

Power Supply Interconnection Plan (PSIP)

(Filed: August 26, 2014)

Maui Island

Leading the way in Wind and Solar Power

Wind - 72 MW
PV - 55 MW
127 MW

55 MW of Distributed PV
~20 MW Pre-approved
75 MW Total

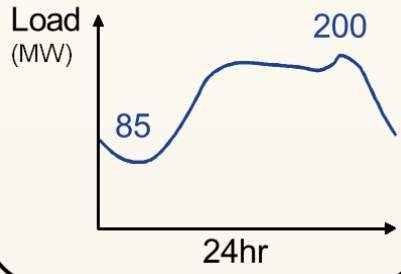
Kaheawa I
(30 MW)

Kaheawa II
(21 MW)

Auwahi
(21 MW)

63,000 Customers

Daily Load Shape



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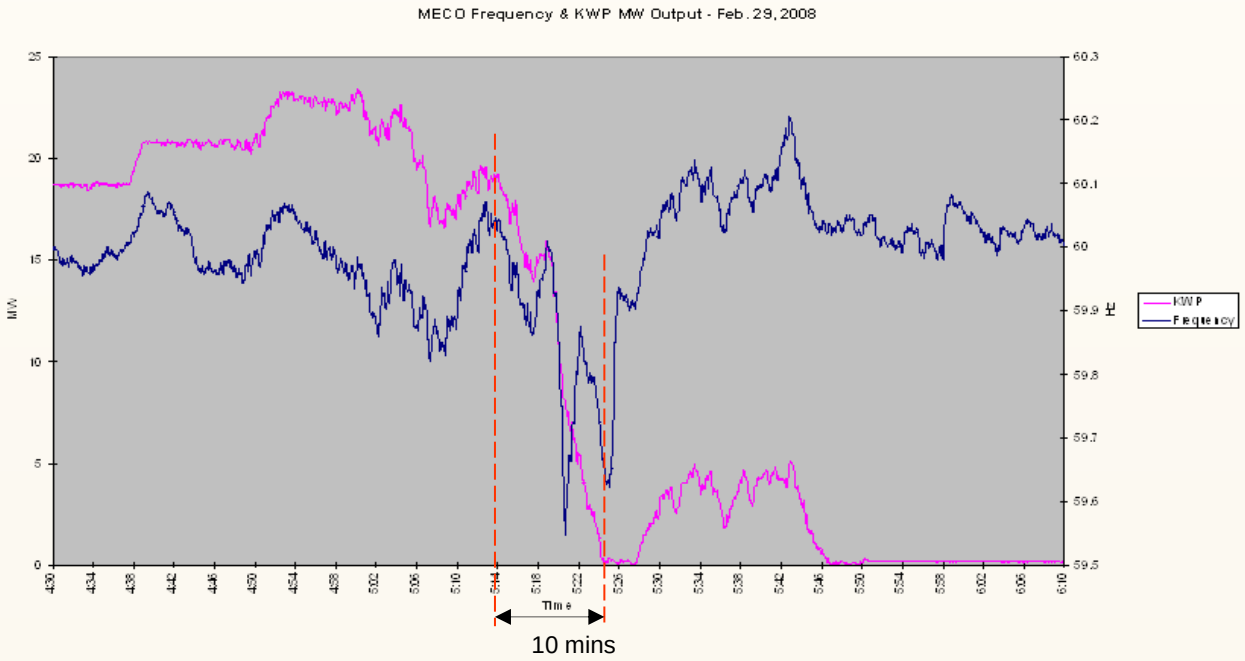
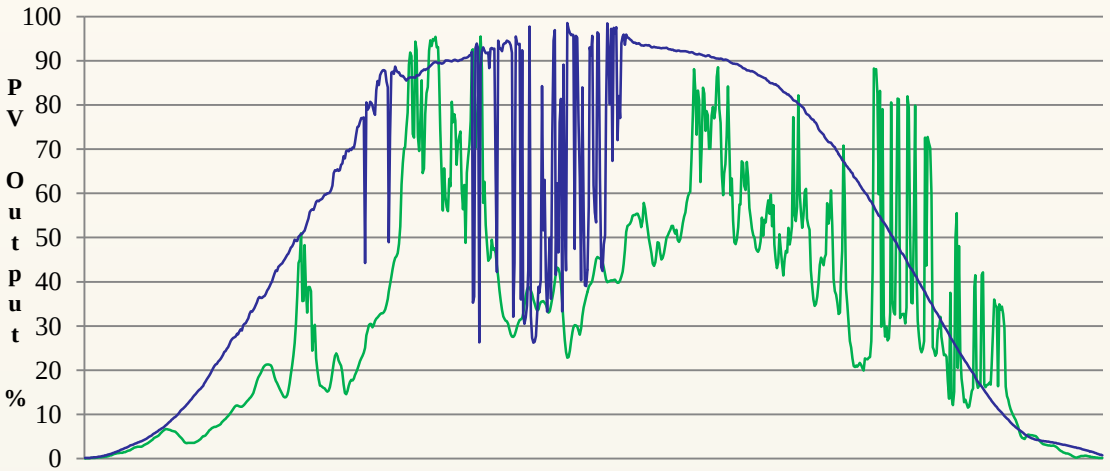
Wind and Solar Resource Intermittency and Variability



Wind Energy

Solar Energy



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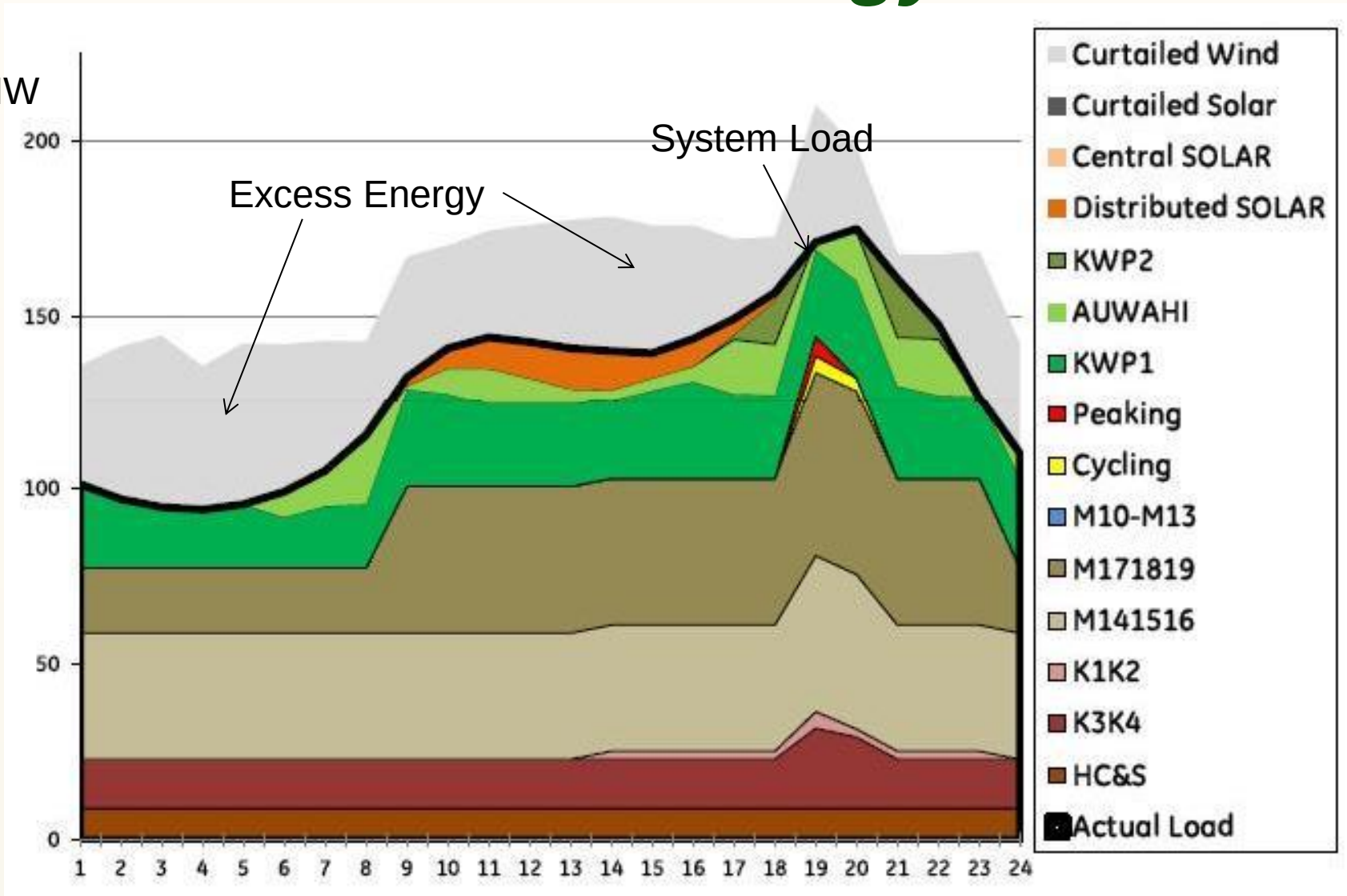
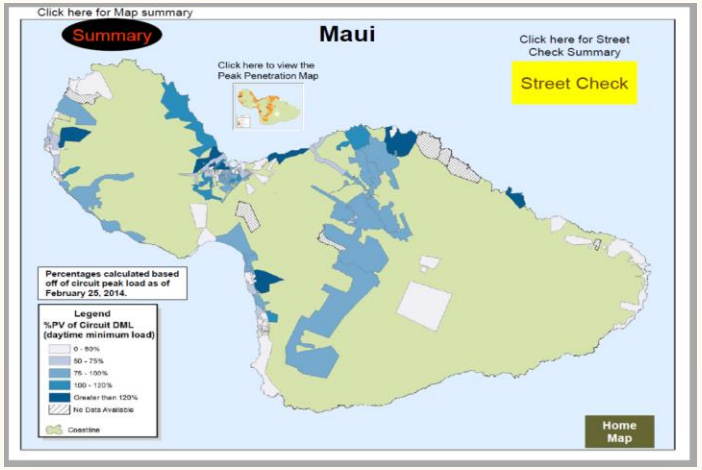
Excess Energy



Distribution Circuit PV Penetration

Grid Saturation?

Circuits where generation from distributed solar is at or above 100% of daytime minimum load



Utility	Circuits >100% Daytime Minimum Load	Total Circuits	% of Total
HECO	127	465	27%
HELCO	28	136	21%
MECO	25	136	18%
KIUC	0	35	-
Total	**180**	**772**	**23%**

Hawaiian Electric recently announced a 250% distribution circuit penetration target for distributed solar
(Jan. 20, 2015; Docket No. 2014-0192)

Maui Island Test Bed

A Model of Smart Grid Innovation & Collaboration

- **Maui Smart Grid Project** **~$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
- **Maui Advanced Solar Initiative** **~$11 M**
  - US DOE & ONR funded, ***HNEI led*** project to develop and demonstrate advanced PV inverter functionality in a smart grid environment
- **JUMPSmart Maui** **~$30 M**
  - NEDO funded, ***Hitachi led*** project to integrate high levels of PV, wind energy, and EV into an island wide smart grid environment
- **Great Maui Project** **~$20 M**
  - NEDO funded, ***Hitachi led*** phase 2 of JUMPSmart Maui project, to demonstrate EV vehicle-grid and Virtual Power Plant integration

All projects have partners in common and share hardware, results, and lessons learned

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MAUI SMART GRID PROJECT

US DOE Renewable Distributed Systems Integration (RDSI)

Hawaii Natural Energy Institute
University of Hawaii at Manoa

Maui Electric

Hawaiian Electric

medb
maui economic development board, inc.

SILVERSPRING NETWORKS

ALSTOM

COUNTY OF MAUI
STATE OF HAWAII

HNU-ENERGY
Harnessing the Power of Light

Sentech, Inc.

UNIVERSITY of HAWAI'I MAUI COLLEGE

http://www.mauismartgrid.com/maui-smart-grid-project-description/project-team

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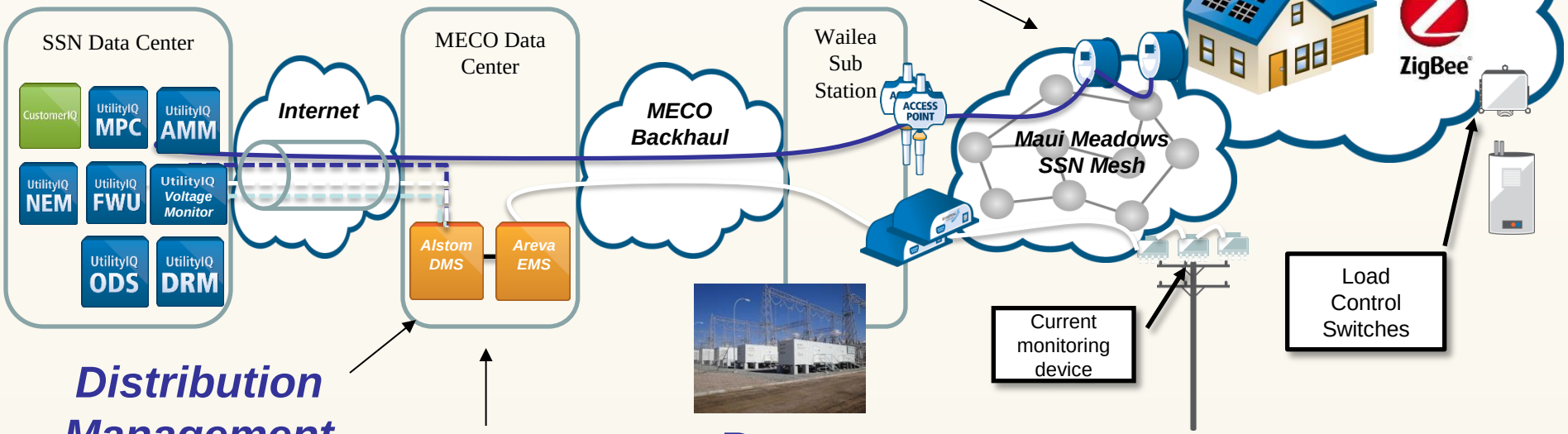
Project Manages Distributed Energy Resources to Support Grid Operations

Advanced Metering Infrastructure

Two-way comms
Voltage monitoring
Outage detection

Home Area Network

Demand response
Monitor PV
Customer feedback



Distribution Management System

Aggregate DER
Decision support
Volt / VAr Control
Improve visibility

Battery Energy Storage System

Distribution Monitoring

Current measurements

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Maui Smart Grid Project Goals Achieved

Distributed Resources for Transmission-level Support

- Reduce distribution circuit peak loading by >15%
  - By demand response, switching peak loads to energy storage, and supporting more renewable energy
- Improve service quality
  - By improved visibility, voltage monitoring, and volt/var control study mode
- Enable consumers to manage their energy use to minimize electric bills
  - By using AMI “smart meters” with customer portals
- Support grid stability
  - Through controllable loads, storage, and improved voltage/current information
- Enable greater utilization of as-available renewable energy sources
  - By providing measurement and estimation of distributed PV to the utility operator
  - By mitigating PV variability through BESS
  - By increasing minimum system load (BESS, DR), thus reducing wind curtailment

Final Project Report Completed: December, 2014

MAUI ADVANCED SOLAR INITIATIVE

OBJECTIVES

- Deploy new Smart Grid Inverters
- Utilize Inverter Management Control Software (IMCS)
- Utilize ***standards-based*** controls and communications
- Employ detailed distribution modeling and high-resolution field data to develop advanced inverter settings

HNEI Hawai'i Natural Energy Institute
School of Ocean and Earth Science and Technology
University of Hawai'i at Mānoa

GridSTART
Grid System Technologies Advanced Research Team

Research Project lead
- Project oversight, management and direction
- Smart Inverter application design; performance and data analytics

Silver Spring Networks

Communications Technology Lead
- Mesh Communication System; IMCS
- Customer Engagement via PV Customer Portal

Fronius HITACHI Inspire the Next SMA

Inverter technology leads
- Leads for communications integration into inverter
- Develop control functionality in inverter; implement control programs sent from IMCS

Maui Electric
Hawaiian Electric

Host utility in Hawaii
- Inverter operations for field pilot; performance evaluation

RISINGSUNSOLAR+ELECTRIC

Co-Services lead
- Sales, marketing, installation, project management, customer service

Pepco Holdings, Inc

Host utility in Washington DC
- Inverter operations for field pilot; performance evaluation

STANDARD SOLAR

Co-Services lead
- Sales, marketing, installation, project management, customer service

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OG&E

Inverter Testing Facility
- Site of functional requirements and inverter testing

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

Inverter Mgmt Control Software

CustomerIQ

WAN

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

Smart Grid Network

Silver Spring Networks Network Interface Cards
- 900 MHz utility smart grid network to back office systems
- SEP 2.0 over 2.4 GHz ZigBee to inverter
- Send inverter control signals through network
- Retrieve home net energy use data

Silver Spring Networks Access Point

900 MHz

WAN

Data Archive

Home

Smart Meter
- Utility owned
- Home's primary meter
- Reads net energy use and voltage (15 min. Interval)

Web Portal

Fronius, Hitachi, or SMA Inverter

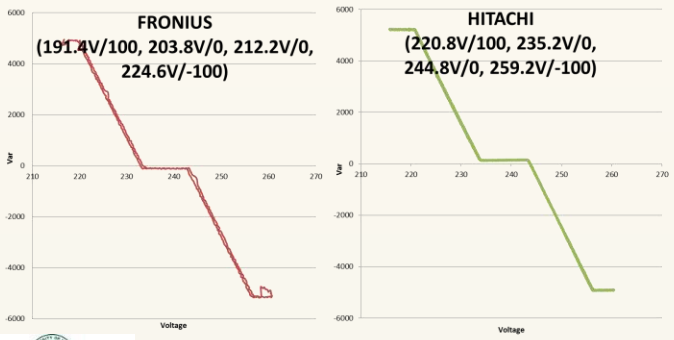
2.4 GHz

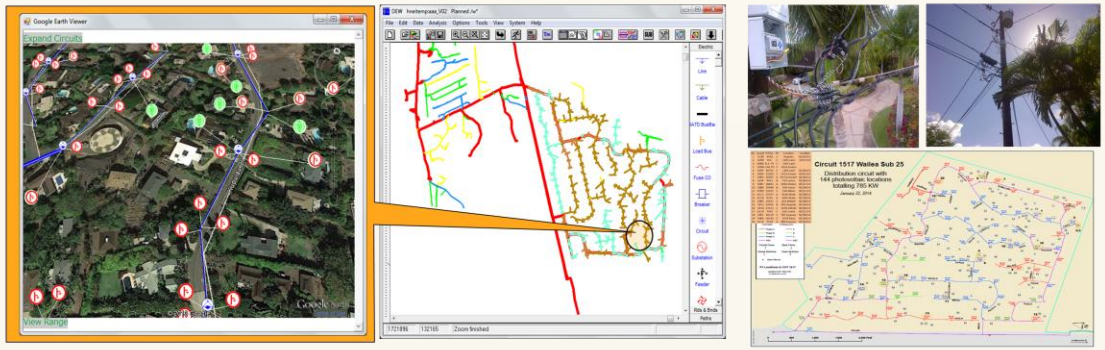
- ZigBee to ModBus Communications Module
- SEP 2.0 DER

Obvius Power Monitor
- HNEI owned
- Inverter AC output
- Volts, Watts, Vars, etc. (1 sec interval)

1. Utility Operator in IMCS creates and sends Volt-VAR or Volt-Watt curve to Smart Grid Inverter to adjust inverter VAR or Watt injections into the grid
2. Smart Grid Inverter receives curve, senses system Voltage
3. Smart Grid Inverter adjusts VAR or Watt output based on curves to respond to system fluctuations

INVERTER TESTING, DETAILED DISTRIBUTION MODELING, & FIELD PERFORMANCE ANALYTICS





U.S. – Japan Cooperation on Clean Energy Technologies

The White House

Office of the Press Secretary

For Immediate Release November 13, 2009

FACT SHEET: U.S.-Japan Cooperation on Clean Energy Technologies

President Obama and Prime Minister Hatoyama met on November 13, 2009 in Tokyo. The two leaders affirmed the intent of the United States and Japan, as the two leading global investors in energy research and development, to expand already strong cooperative activities in technology research and development to provide solutions to the challenges of global energy security and climate change. They announced initial areas for joint activities to strengthen their cooperation that include:

- Establishment of a task force that will evaluate the achievements of existing clean energy projects in Hawaii and Okinawa to enable the islands to be energy independent, including micro-grid projects, and develop activities to help the two islands share experiences and knowledge with each other;

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JUMPSmart Maui Project

A Japan – United States Smart Grid Demonstration Project

HNEI
Hawai'i Natural Energy Institute
School of Ocean and Earth Science and Technology
University of Hawai'i at Mānoa

Maui Electric

Hawaiian Electric

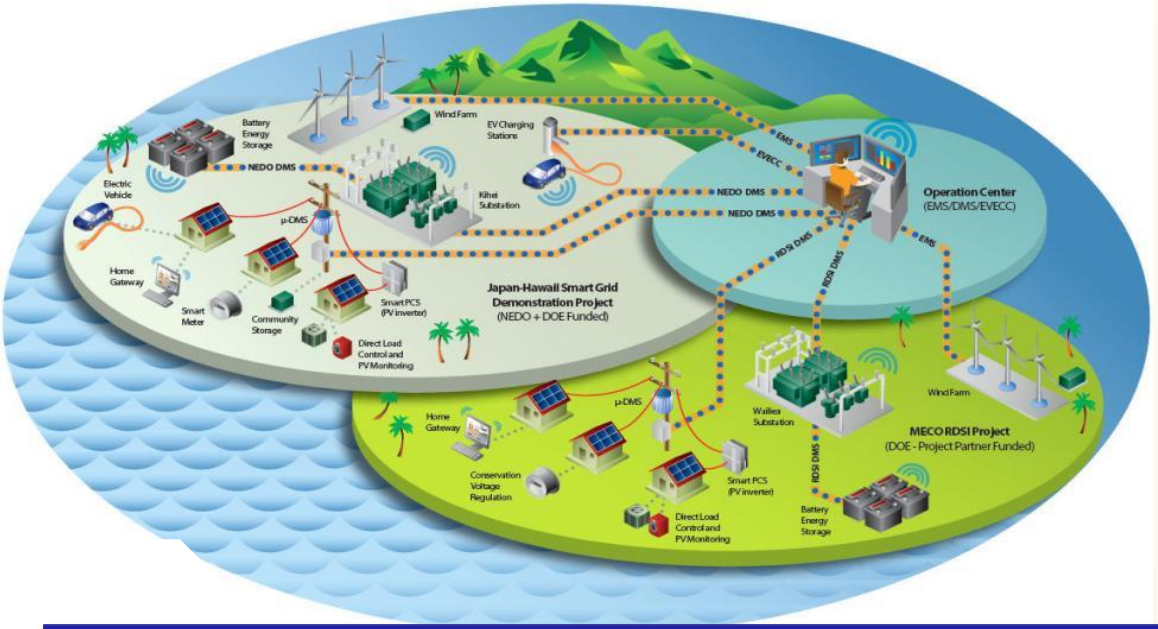
CyberDefense

University of Hawai'i Mānoa

JUMPSmart Maui Project

JUMPsmartmaui
SMART ENERGY. SMART CARS. SMART GRID.

In Maui, large scale renewable energy (72 MW of wind and 55 MW of distributed PV) has been introduced. In addition, many electric vehicles (EV) are expected soon.



Issues

- Excess Energy
- System Frequency Impact
- Distribution Line Voltage Impact

Solutions

- Integrated DMS
- μDMS &Smart PCS
- EV charger control
- Battery system
- Direct Load Control
- ICT Platform

Demonstration Objectives

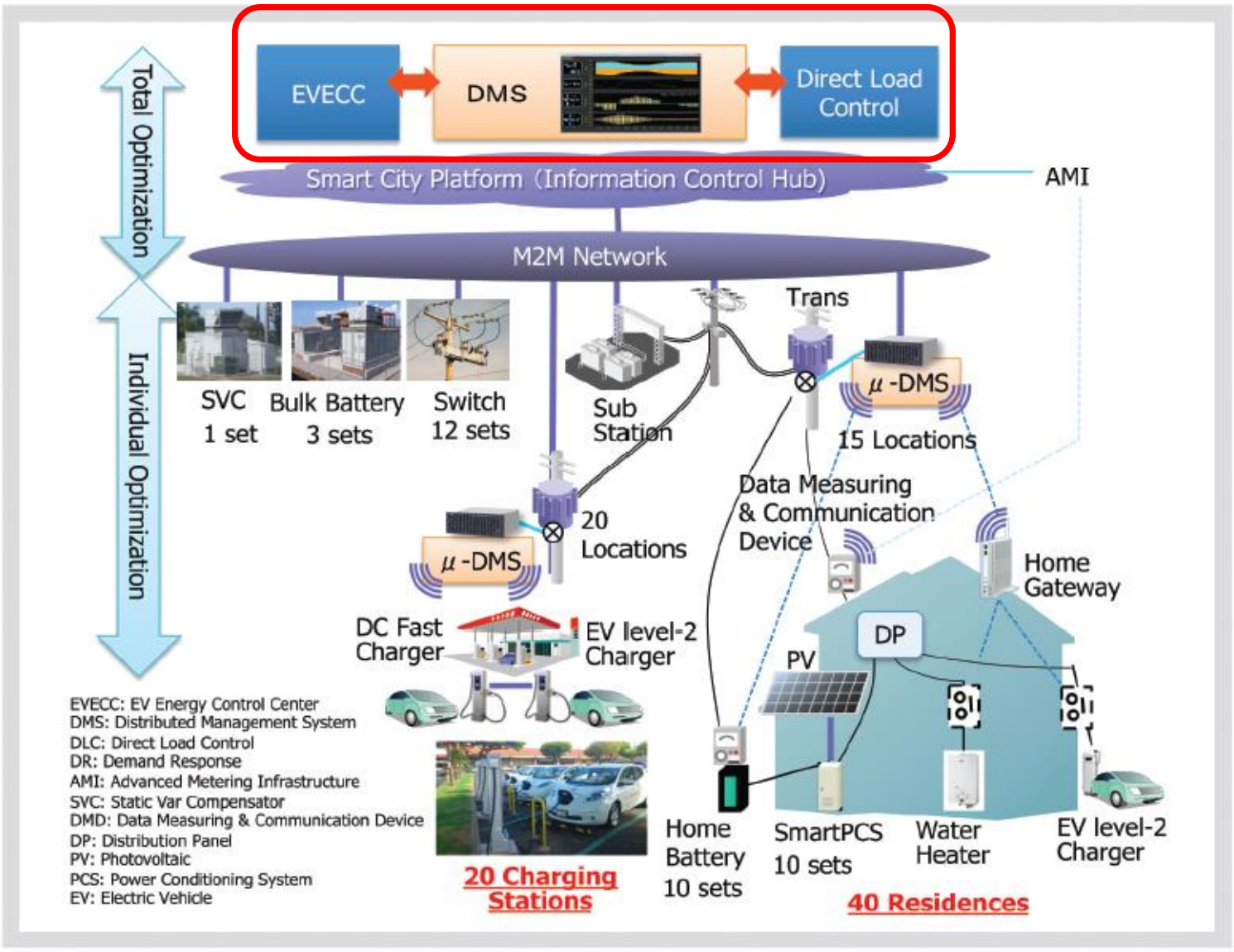
- Maximize Utilization of Renewable Energy (RE)
- Stable Supply of Electric Power
- Solution for Impact of EV & PV High Penetration

NEDO

HITACHI
Inspire the Next

UNIVERSITY of HAWAI'I MANOA

Overall View of System Configuration



EV Fast Charging Stations on Maui

JUMPsmartmaui
SMART ENERGY. SMART CARS. SMART GRID.

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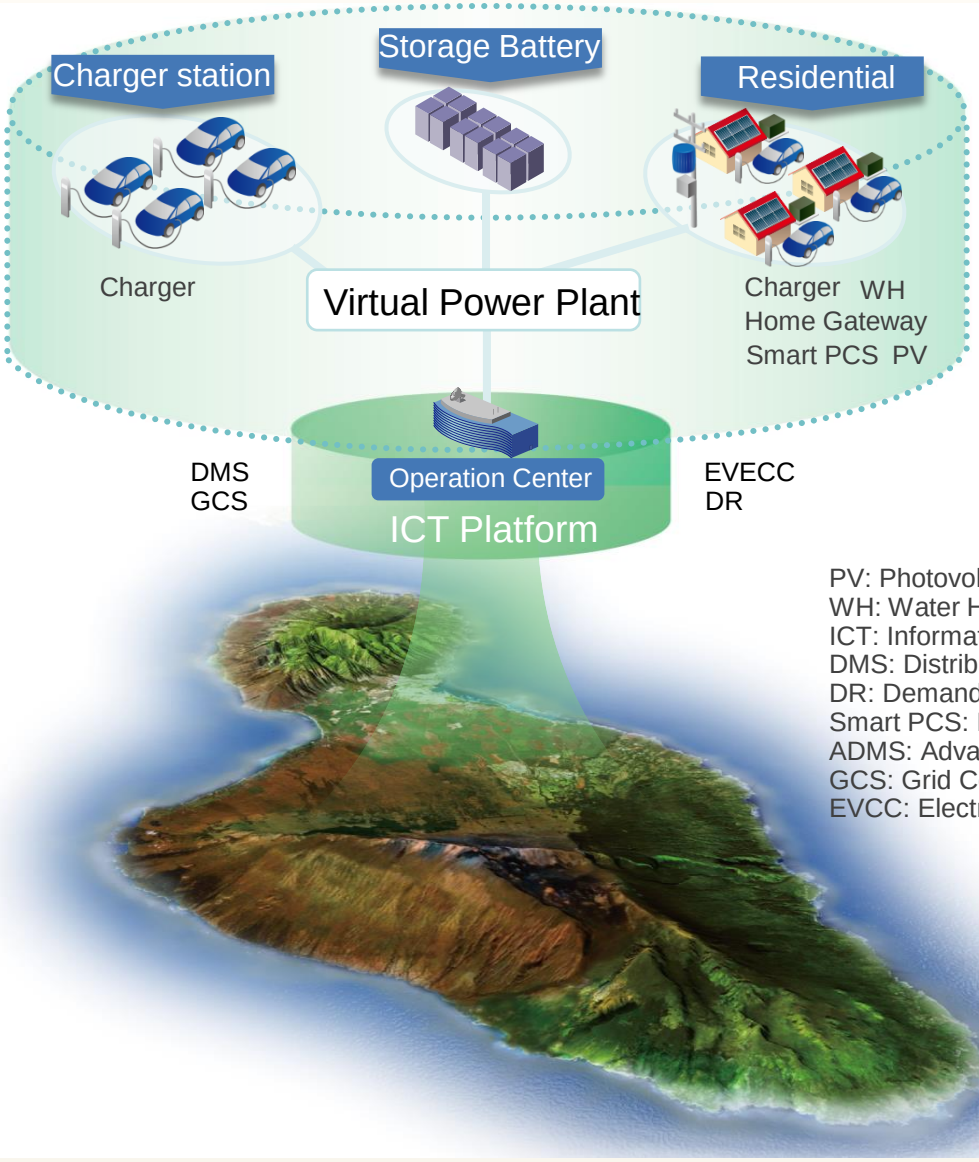
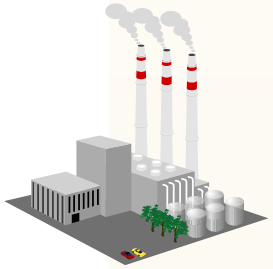
MANOA

Great Maui Project

Development of VPP solutions in Maui

Wind power Generation





Thermal Power Generation

PV: Photovoltaic
WH: Water Heater
ICT: Information Communications Technology
DMS: Distribution Management System
DR: Demand Response
Smart PCS: Power Control System
ADMS: Advanced Distribution Management System
GCS: Grid Control System
EVCC: Electric Vehicle Control Center

Evolution of a Renewed and Smarter Grid

- **International collaborations, such as the successful Japan-US partnership in smart grid technology development on Maui island, serve as a crucial catalyst to drive smart energy technology evolution**
- **Hawaii is an ideal 'test bed' to prove concepts and learn lessons about smart energy technologies in action that will …**
  - √ **Increase energy independence**
  - √ **Achieve affordable and stable energy costs**
  - √ **Limit greenhouse gases**

All Keys to Delivering a Sustainable Energy Future

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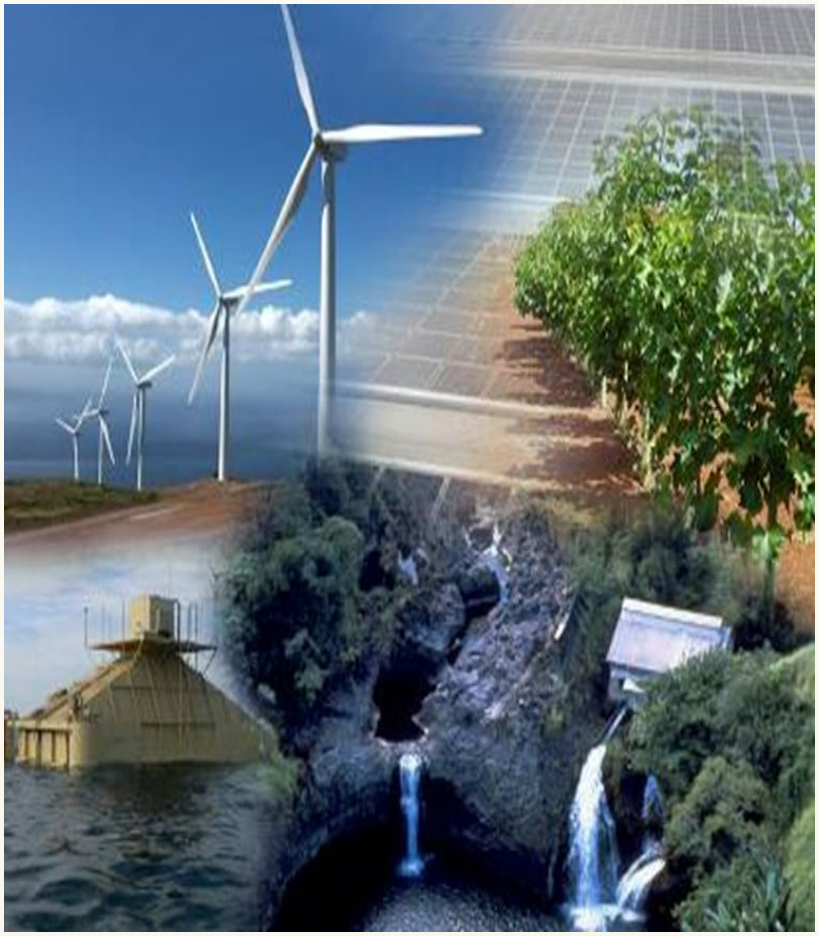
Mahalo!

(Thank you)



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