Hawaii Natural Energy Institute

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Rick Rocheleau, Director
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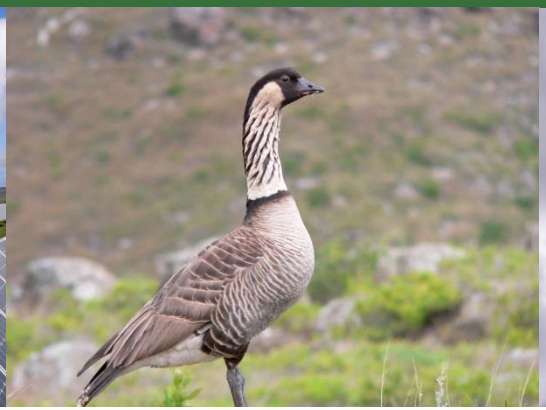


APEC Expert Group on New and Renewable Energy Technologies

HNEI Overview & Hawaii Energy Policy

March 20, 2018

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

HNEI Overview

Hawaii Natural Energy Institute (HNEI)

Organized Research Unit in School of Ocean and Earth Science and Technology

Founded in 1974, established in statute in 2007 (HRS304A-1891)

- Conduct RDT&E to accelerate and facilitate the use of resilient alternative energy technologies; and to reduce Hawaii's dependence on fossil fuels.
- Programs characterized by partnerships with local, national and international organizations.
- Diverse staff includes engineers, scientists, lawyers; students and postdoctoral fellows; visiting scholars

Areas of Interest

- **Alternative Fuels**
- **Electrochemical Power Systems**
- **Renewable Power Generation**
- **Building Efficiency**
- **Transportation**
- **Grid Integration**
- **Policy & Innovation**

Core Functions

- **Research & Development**
- **Testing and Evaluation**
- **Analysis**
- **State Energy Policy Support**
- **Workforce Development**

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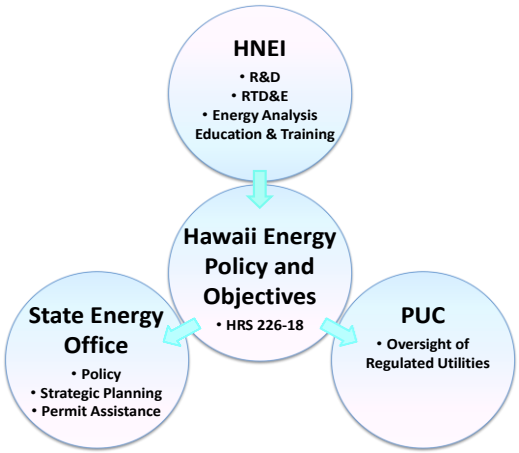
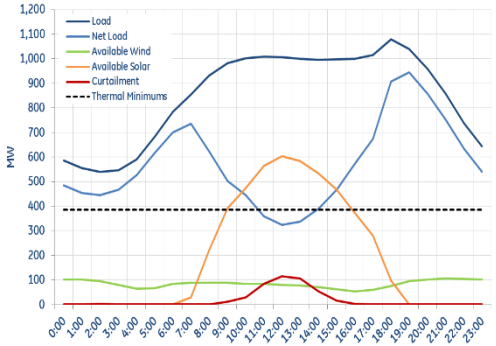
HNEI Major Programs & Funding



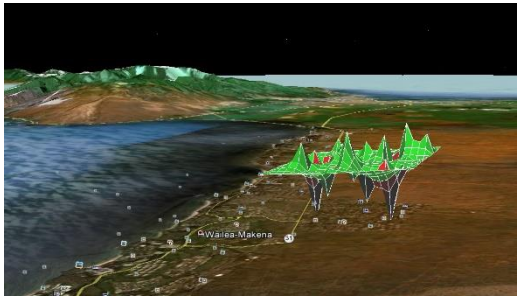


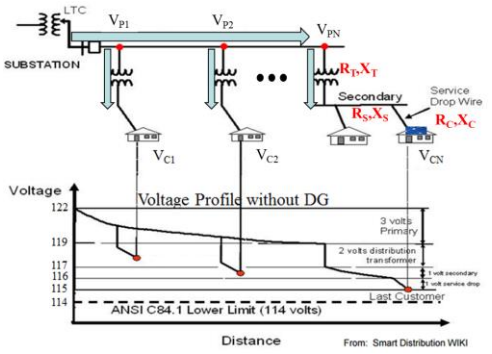
Hawaii Energy Systems Development Special Fund

- Analysis to inform policy,
- T&E of Hawaii relevant technologies
- Economic analysis

Asia Pacific Research Initiative for Sustainable Energy Systems

RDT&E of advanced energy technology

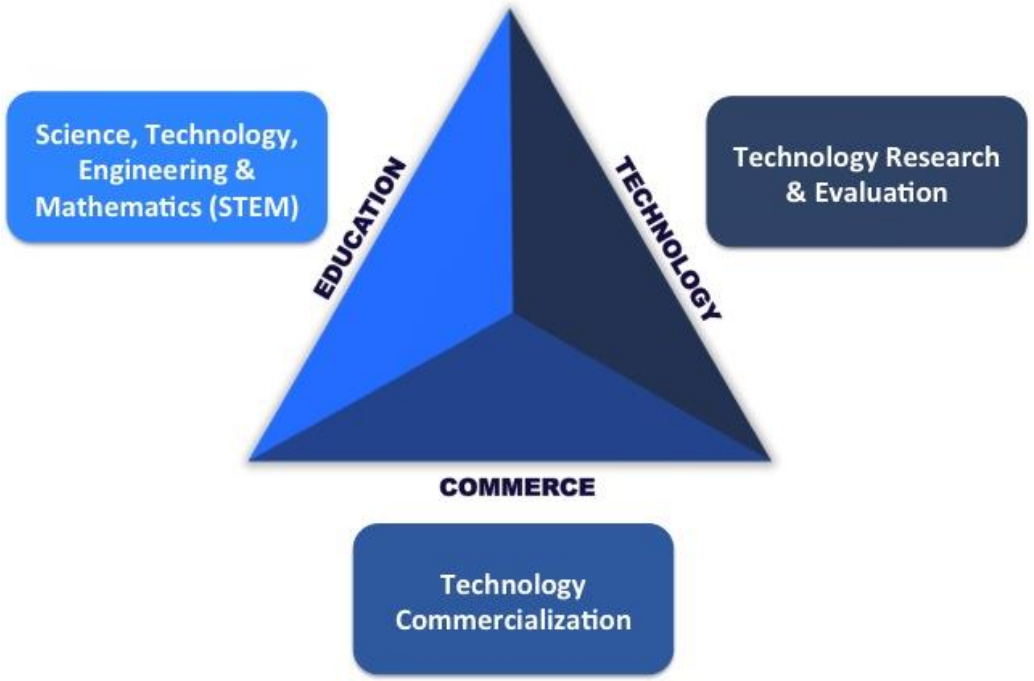




Asia Pacific Regional Energy System Assessment

Support enhancement of energy reliability and resiliency in locations of US interest throughout the Asia-Pacific region

HNEI is Key Performer for Technology Research and Evaluation in Support of ONR's APTEP



- APTEP links HNEI research initiatives to other innovation and commercialization focused efforts e.g. Elemental Excelerator
- APRESA provides opportunity to extend research, innovation and commercialization to the Asia-Pacific region

Asia Pacific Technology and Education Partnership (APTEP) promotes commerce and partnerships in the Asia-Pacific region through advancements in alternative energy research, technology development and education.

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

Grid System Technologies Advanced Research Team

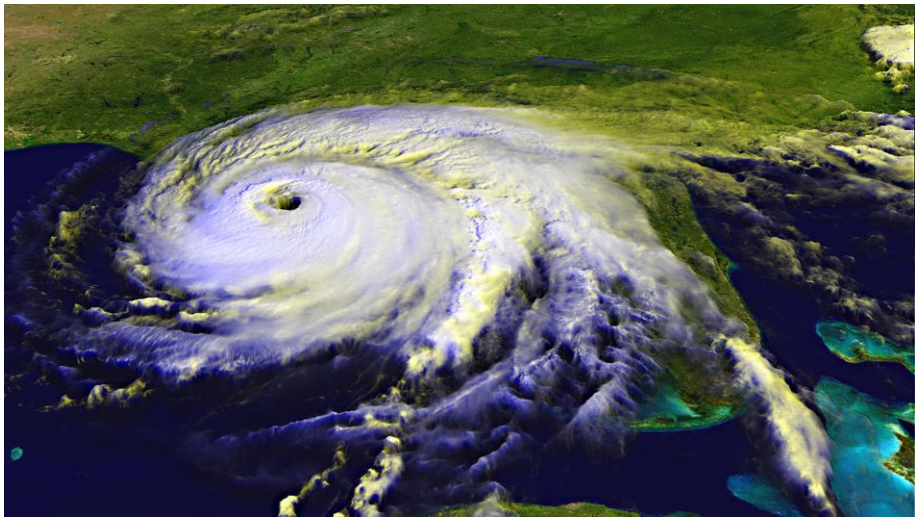
Established to develop and test advanced grid architectures, new technologies and methods for effective integration of renewable energy resources, power system optimization and enabling policies.

- Serves to integrate into the operating power grid other HNEI technology areas: biomass and biofuels, fuel cells and hydrogen, energy efficiency, renewable power generation
- Strong and growing partnerships with national and international organizations including Asia-Pacific nations.

Lead for many public-private demonstration projects

Hawaii Energy Policy

GLOBAL CLIMATE CHANGE
Vital Signs of the Planet



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Hawaii's Isolation Poses a Serious Challenge ….

In 2008 nearly 90% of Hawaii's energy is met using *fossil fuels*

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

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

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

US Dept of State Geographer
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Data SIO, NOAA, U.S. Navy, NGA, GEBCO

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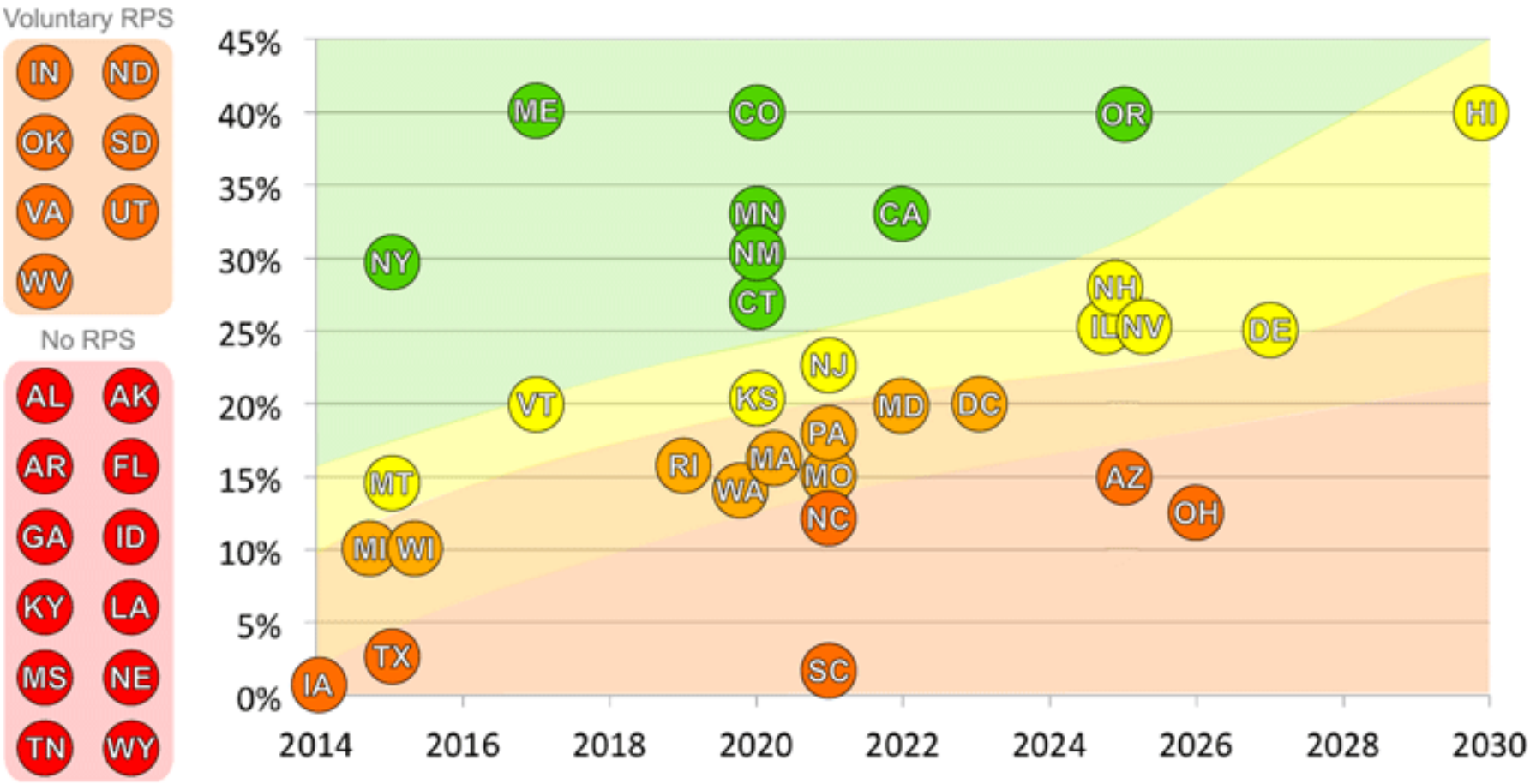
United States Renewable Portfolio Standards



Courtesy of SolarPowerRocks.com

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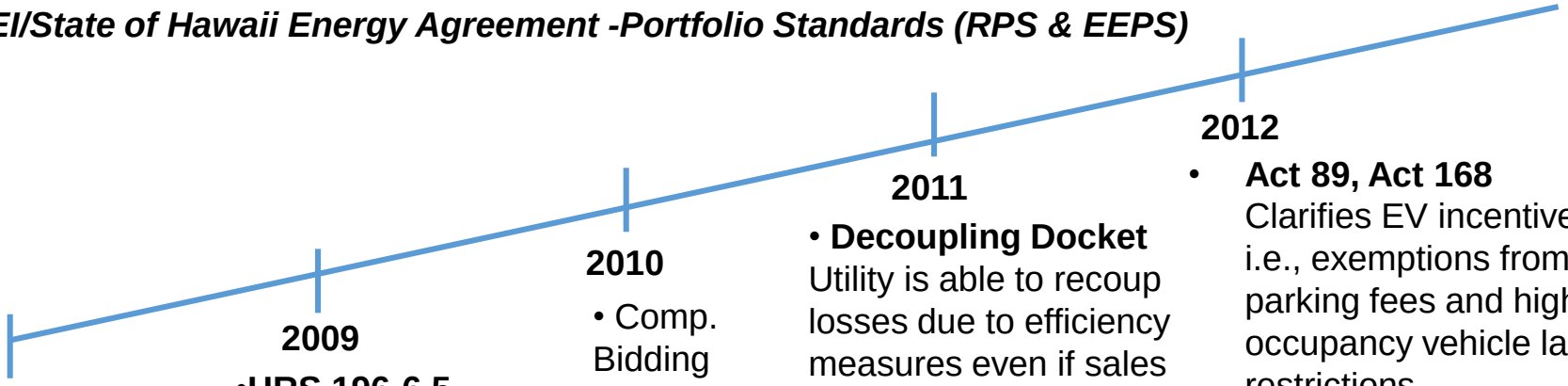
Hawaii's Energy Transformation Policies

INITIAL FIVE YEAR DRIVERS

-HEI/State of Hawaii Energy Agreement -Portfolio Standards (RPS & EEPS)



2008

- **Energy Agreements** – USDOE-Hawaii & Hawaii-HECO
- **Act 208** establishes Energy Security Special Fund

2009

- **HRS 196-6.5** new home solar hot water heating mandate
- **Act 155** revised RPS to 25% by 2020, 30% by 2030; created EEPS (4300 GWh reduction by 2030); allowed EPC contracting, public building benchmarking

2010

- Comp. Bidding Framework Docket
- Act 73: Created $1.05 "Barrel Tax" for HCEI

2011

- **Decoupling Docket** Utility is able to recoup losses due to efficiency measures even if sales decline
- **Act 10:** Clarifies RPS includes RE delivered to utility from customer sited grid connected systems

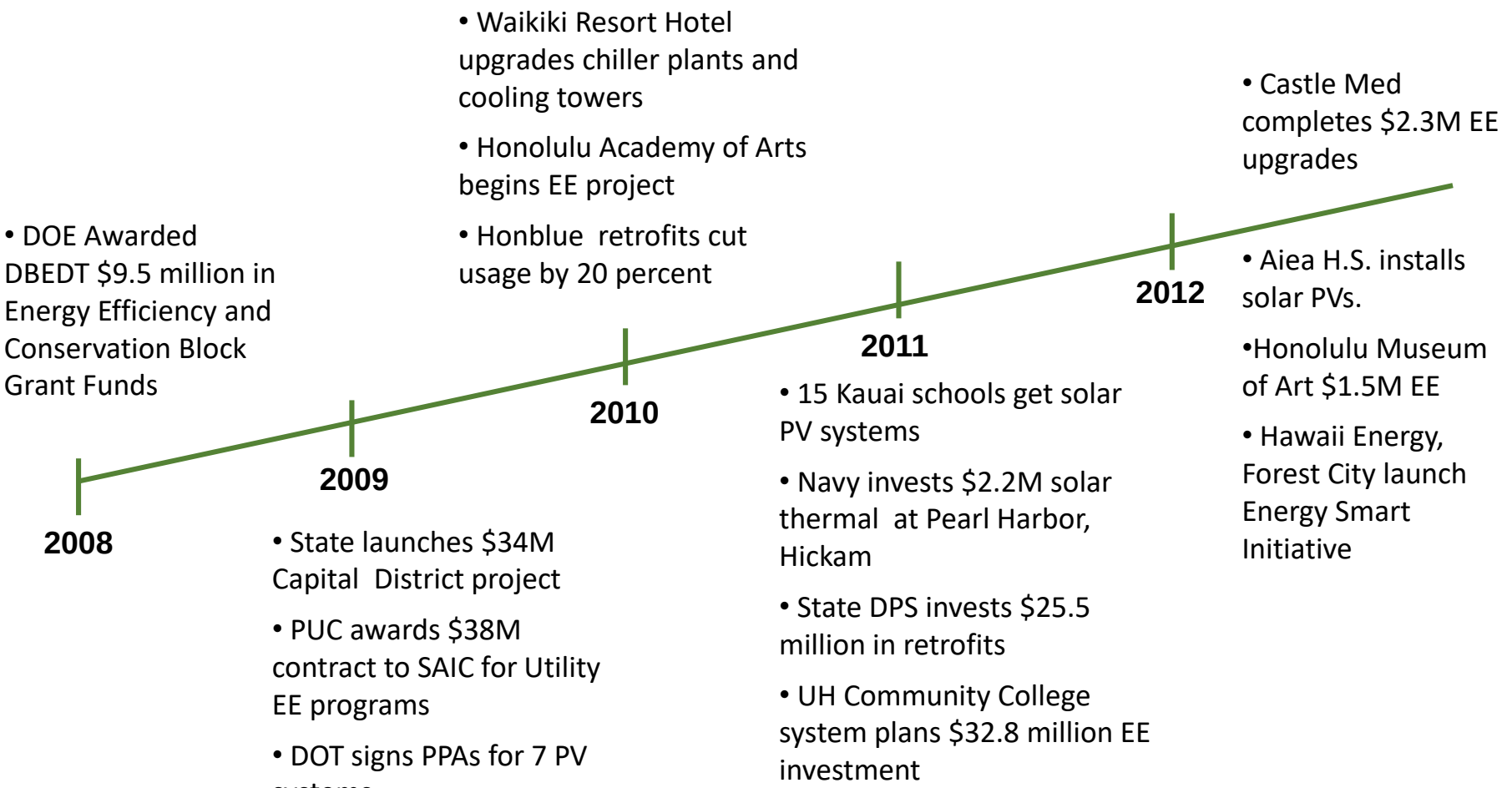
2012

- **Act 89, Act 168** Clarifies EV incentives, i.e., exemptions from parking fees and high occupancy vehicle lane restrictions
- **Act 97, Act 193** permits geothermal resource development on state lands; exempts geothermal exploration from EA/EIS requirements

Regulatory Proceedings

- Intragovernmental Wheeling (opened in 2007)
- HECO Feed-in Tariff (opened in 2008)
- HECO Rule 14H (opened in 2010)
- Implementation of Reliability Standards (opened in 2011)
- Integrated Resource Planning (opened in 2012)

Energy Efficiency Accomplishments



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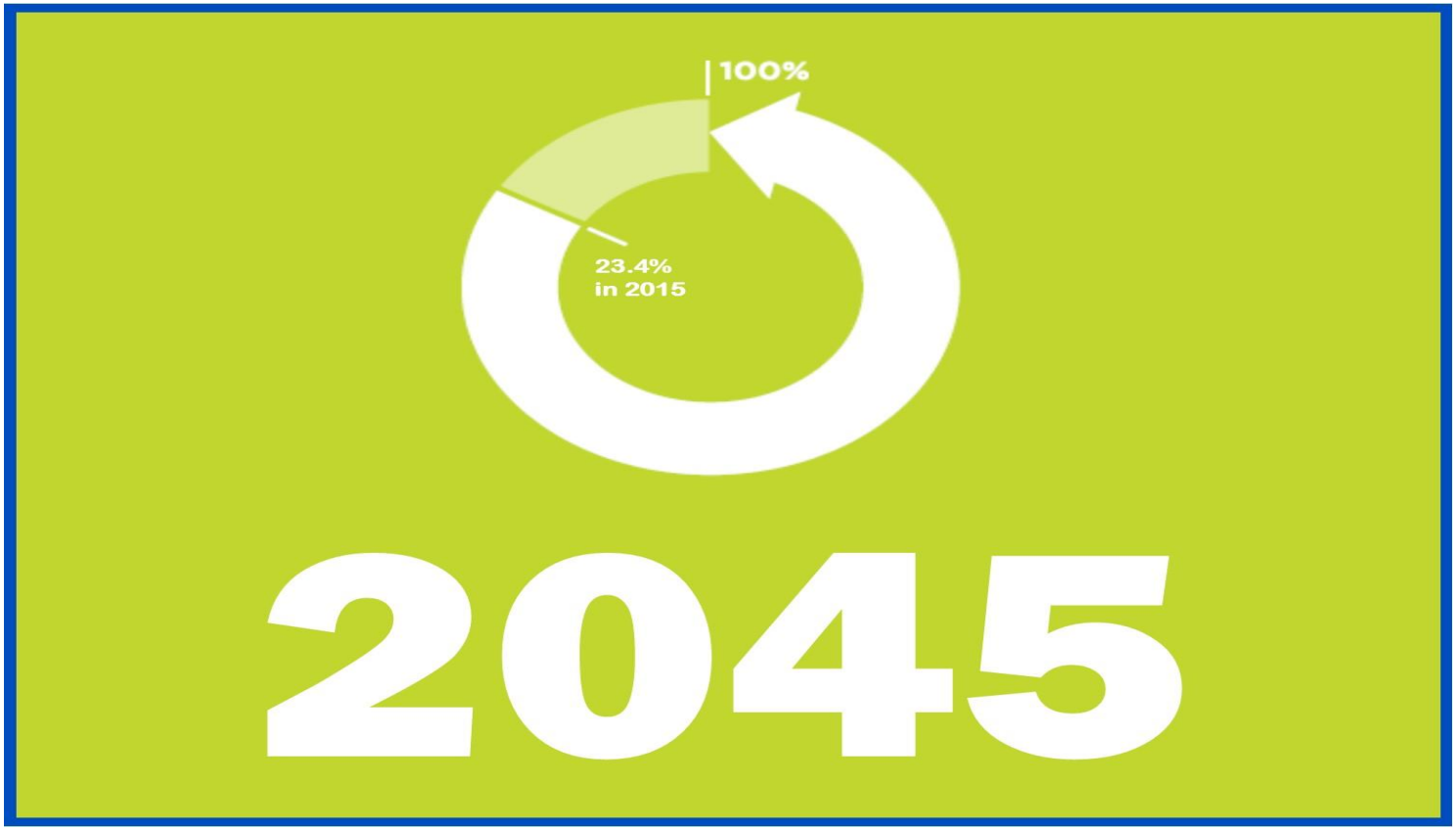
Policy Highlights (2013-2016)

- **Act 97 (2015)** 100% RPS (electricity sector) by 2045
- **Act 99 (2015)** Net zero energy requirement for University of Hawaii
- **Act 100 (2015)** Community-based renewable energy program
- **Act 185 (2015)** Applies barrel tax to other fossil fuels like natural gas as follow-up to ending sunset on source of funding under **Act 107 (2014)**
- **Act 201 (2015)** Repayment for clean energy improvements via electricity bill
- **Act 164 (2014)** State Building Code adoption streamlined & strengthened
- **Act 37 (2013)** Authorizes PUC policy to accelerate retirement of utility fossil generation



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RPS (PUC-Utilities-HSEO)

EEPS (PUC-HSEO)

Regulatory (PUC)

Analysis (HNEI)

RD&D/Innovation (HNEI & EEx)

- 100% RPS
- 4,300 GWh
- Dockets
- Advisory
- Test Bed

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THE WALL STREET JOURNAL.

“there’s no better place to look than Hawaii”

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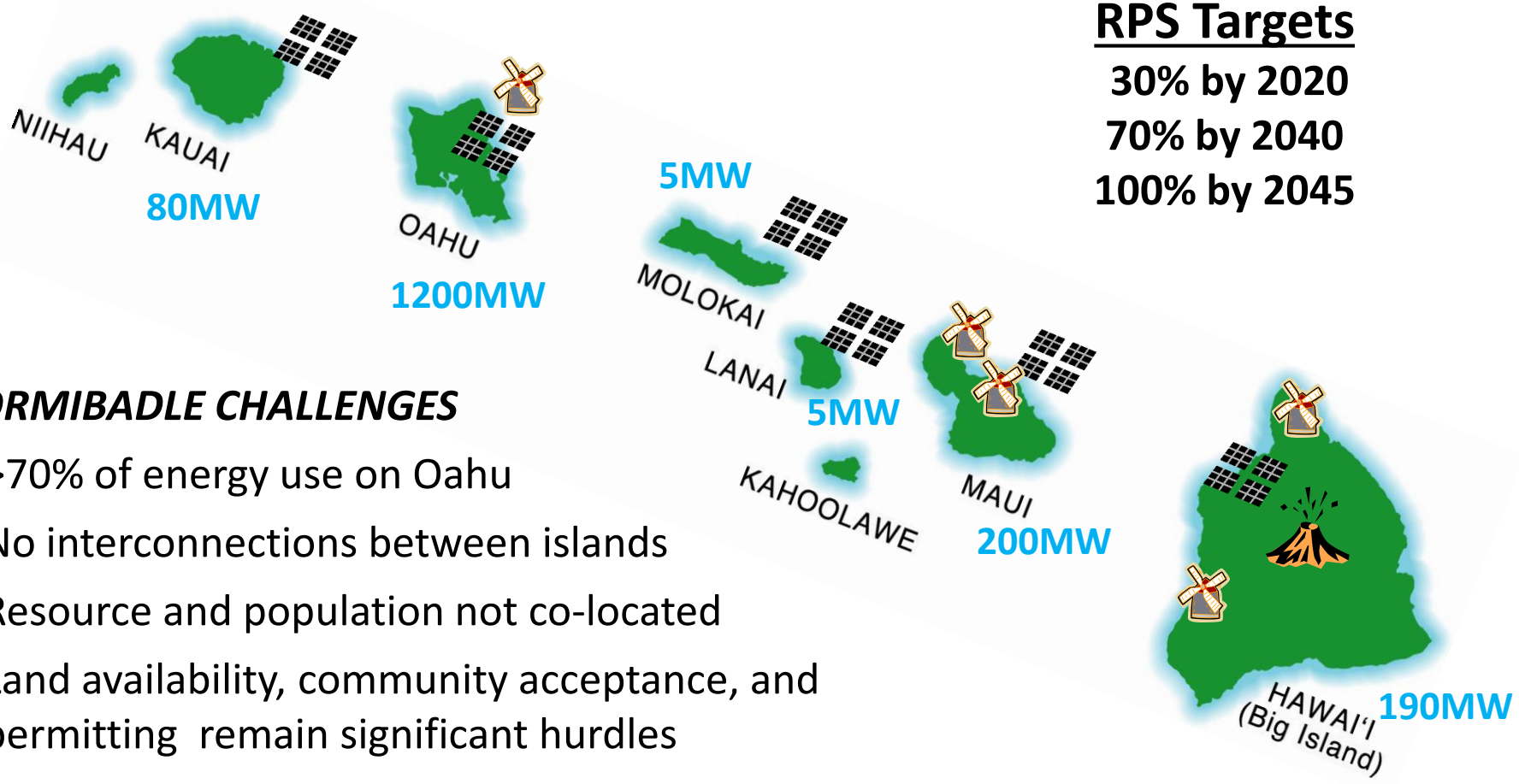
Affecting Change on Six Isolated Grids



RPS Targets

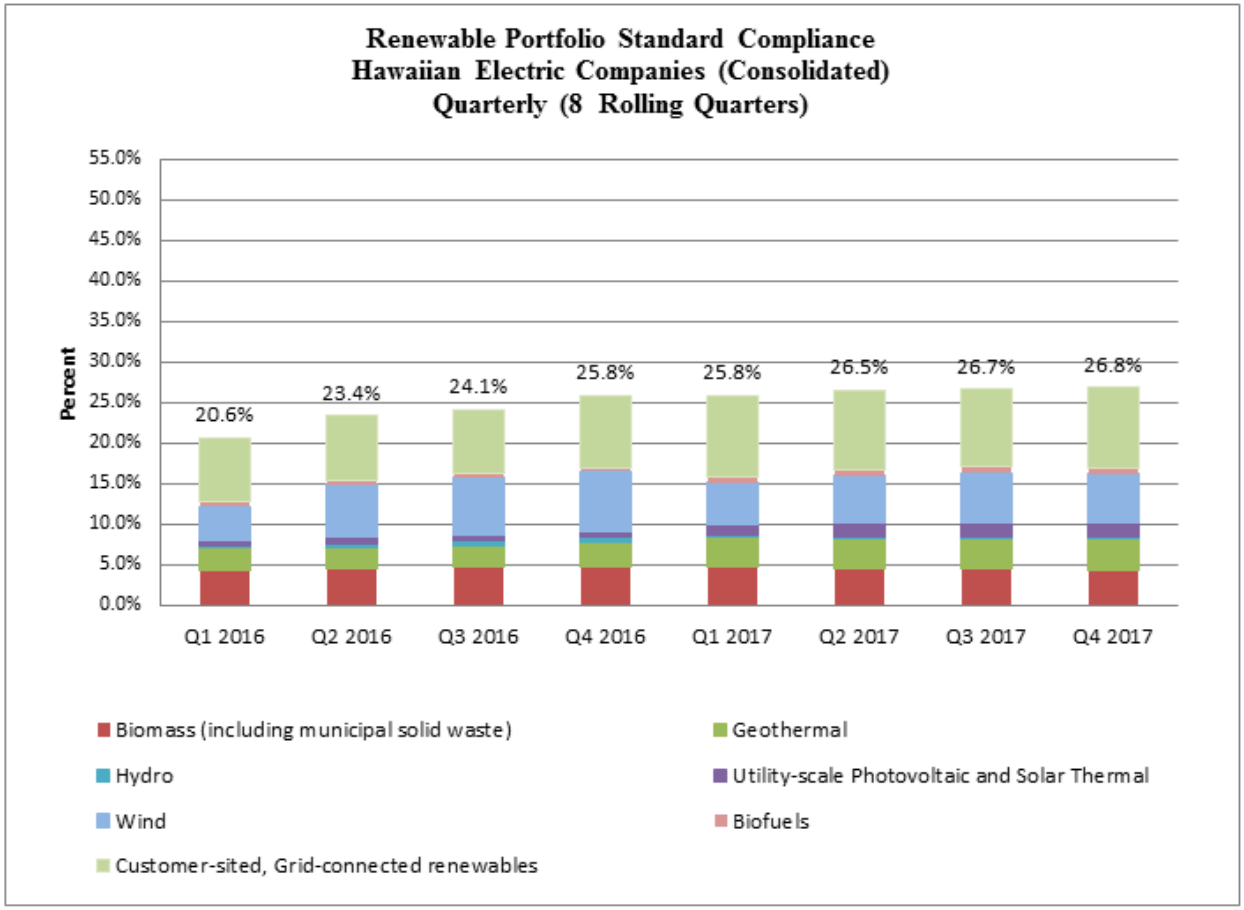
30% by 2020
70% by 2040
100% by 2045

FORMIBADLE CHALLENGES

- >70% of energy use on Oahu
- No interconnections between islands
- Resource and population not co-located
- Land availability, community acceptance, and permitting remain significant hurdles

Meeting RPS goals requires innovation and community commitment

Hawaiian Electric Companies (Consolidated)



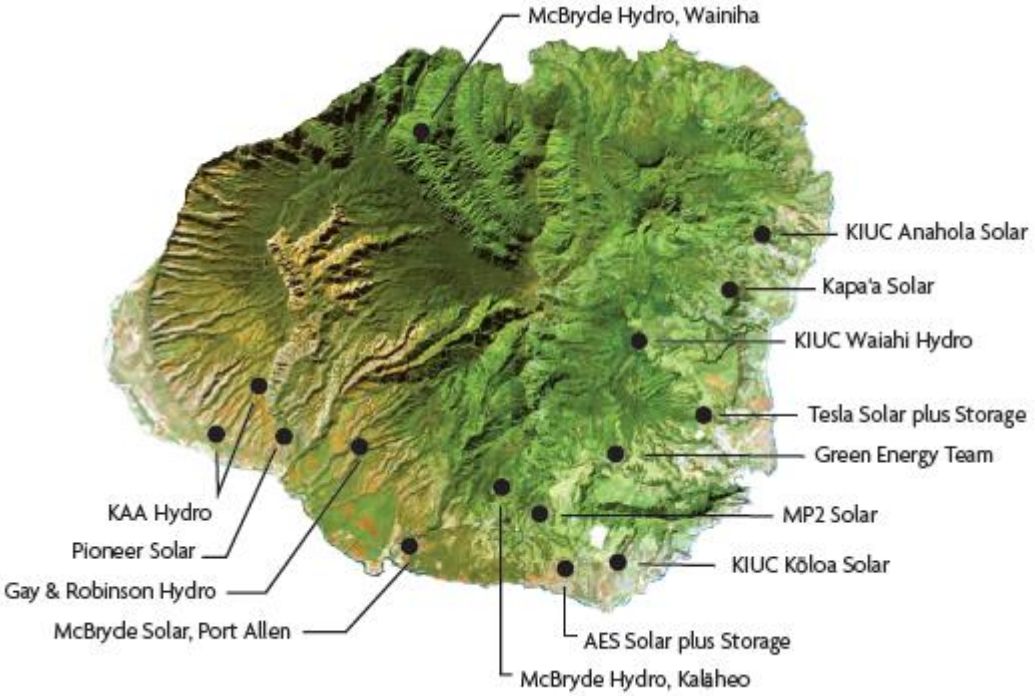
27% Consolidated

21% HECO (Oahu – Honolulu)

57% HELCO (Hawaii Island)

34% MECO (Maui, Molokai, Lanai)

Kaua'i's Renewable Energy Projects



	Type	MW	% of Sales
Active In Use			
KIUC, Kōloa	Solar	12.0	5.0
KIUC, Anahola	Solar	12.0	5.0
Green Energy Team	Biomass	7.0	11.4
McBryde, Port Allen	Solar	6.0	2.7
McBryde, Wainiha	Hydro	4.0	3.6
KIUC, Waiahi	Hydro	1.5	2.0
McBryde, Kalāheo	Hydro	2.0	1.0
Gay & Robinson, Olokele	Hydro	1.3	0.9
KAA, Waimea/Kekaha	Hydro	1.5	0.9
Pioneer, Waimea	Solar	0.3	0.1
Kapa'a Solar	Solar	1.0	0.4
Tesla Energy Storage	Solar	13.0	5.0
MP2, 'Ōma'o	Solar	0.3	0.1
Customer Solar	Solar	22.0	4.5
Under Construction/Permitting			
Gay & Robinson, Olokele	Hydro	6.0	4.2
AES Lawai	Solar	20.0	11.0
Customer Solar	Solar	5.0	1.0
Under Consideration			
Westside Pumped Hydro Storage	Hydro	12.0	7.0
Solar plus Storage	Storage	12.0	7.0

Total Renewable Energy in Service 2017

83.9 MW/42.6%

Potential Renewable Energy in Service 2025

138.9 MW/72.8%

Unsubsidised clean energy world records, April 2016

Solar PV

Country:	Coahuila Mexico
Bidder:	Enel Green Power
Signed:	March 2016
Construction:	2019
Price:	US$ 3.60 c/kWh

Onshore wind

Country:	Morocco
Bidder:	Enel Green Power
Signed:	January 2016
Construction:	2018
Price:	US$ 3.0 c/kWh

Offshore wind

Country:	Denmark
Bidder:	Vattenfall
Signed:	Dec 2015
Construction:	2019
Price:	US$ 5.3 c/kWh

Source: Bloomberg New Energy Finance; ImagesSiemens; Wikimedia Commons

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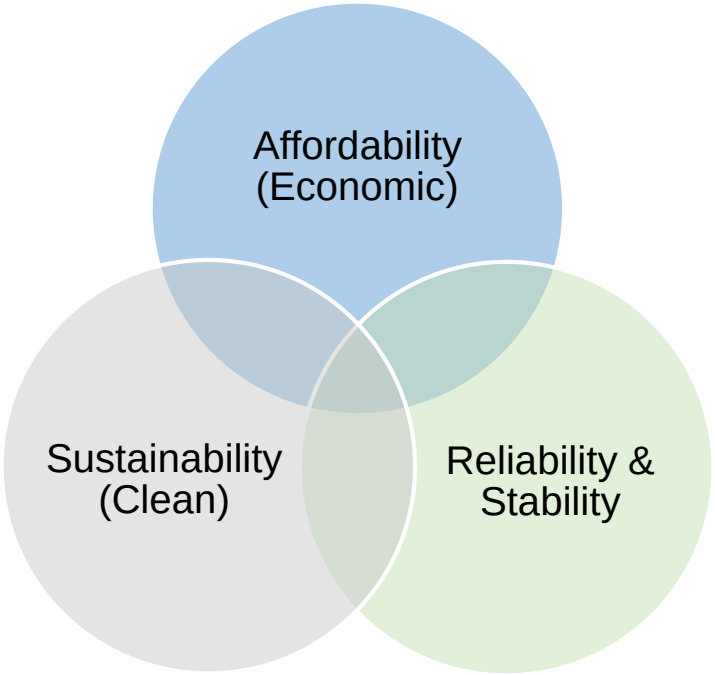
Three Pillars of Power System Planning & Operations

Don’t take reliability and stability for granted!

- Customers want their electricity to be affordable, clean, and reliable … all are important
- Part of a comprehensive analysis for power system planning
- Responds to emergency (contingency) events, not normal operations
- Important at different time scales of system operation; seconds to minutes



Island Grid Analysis Accomplishments

Studies have been used to inform State energy policy & utility operations

- Analyses cited in PUC decisions
- Recommendations for utility operations have been adopted
- Informed decision-making (e.g. Maui wind expansion)

Developed innovative analytical techniques & tools

- New methods to assess system risk across all hours of year
- Integrating analyses across multiple time-scales to better understand high-penetration renewable grids

Ongoing Studies

- Integrating transportation with the power grid
- In-depth understanding of use & value of storage
- Assess new technologies & operating strategies to ensure grid reliability, stability & power quality

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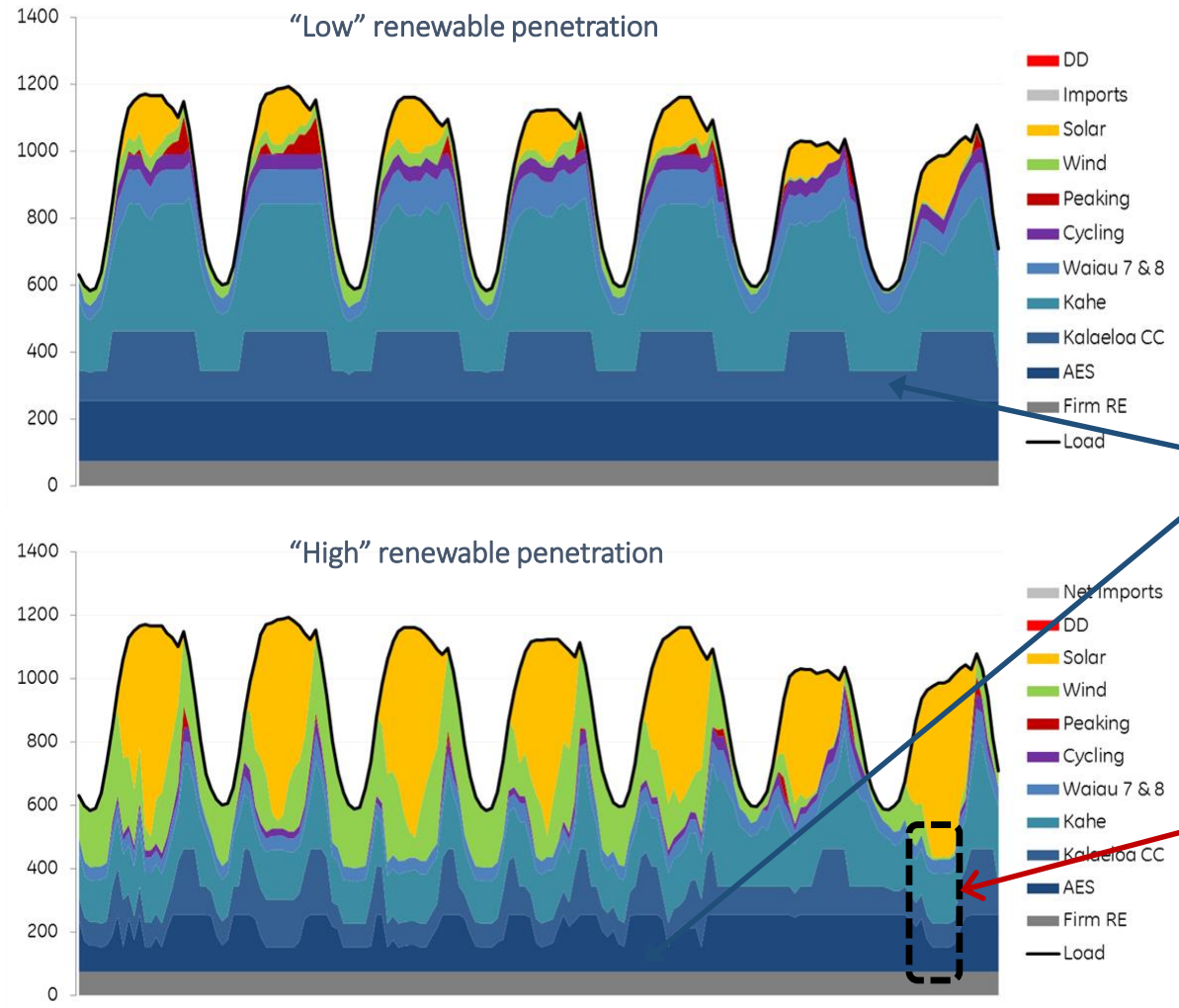
Modeling Variable Renewable Effects



A WEEK OF OPERATION

Generation-load balance essential for frequency control

Increased cycling of baseload units to accommodate intermittency

Curtailment occurs when all dispatched thermal units are at minimum power and cannot cycle off

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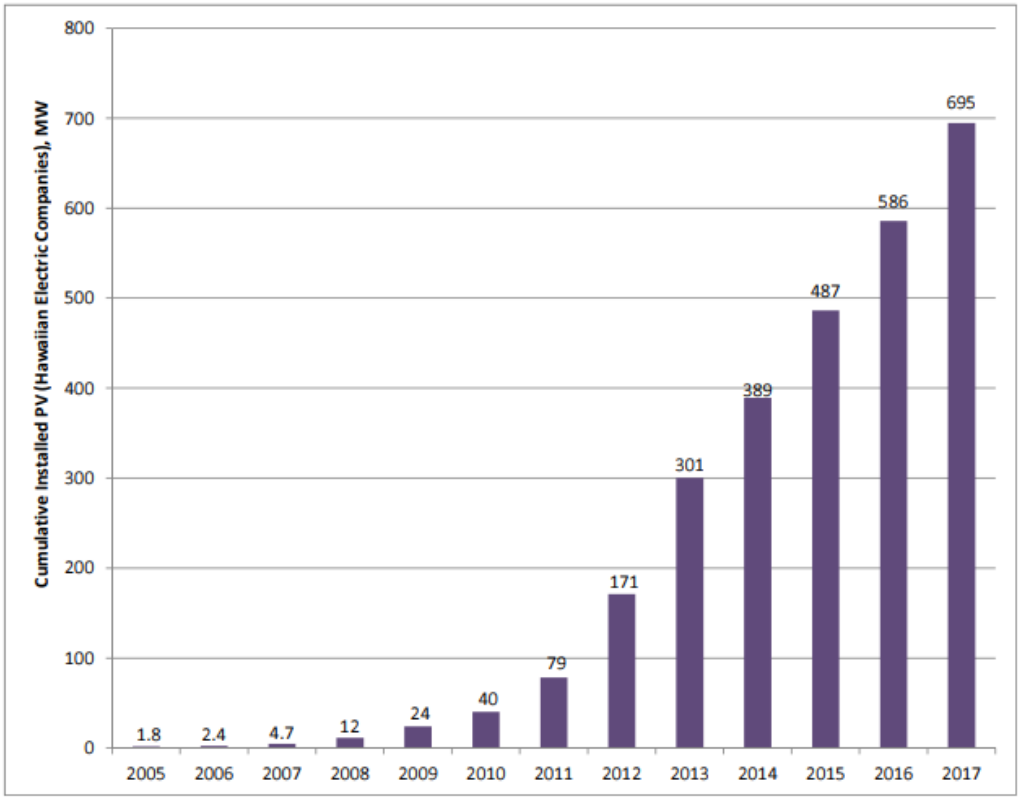
Cumulative Installed PV -- As of Dec 31, 2017

	Number of PV Systems			PV Capacity, MW		
	Number	% Residential	% Commercial	Capacity	% Residential	% Commercial
Hawaiian Electric	50,268	96%	4%	502	54%	46%
Hawai'i Electric Light	11,895	94%	6%	90	65%	35%
Maui Electric	12,021	92%	8%	103	62%	38%
Total	74,184			695		



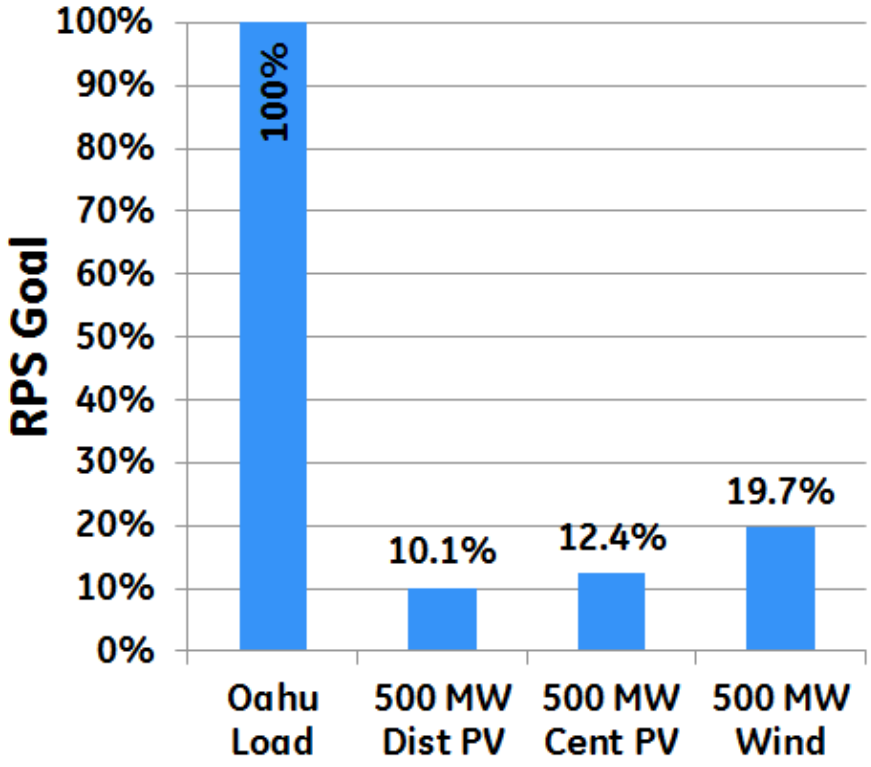
Data subject to change

Hawaiian Electric
Maui Electric
Hawai'i Electric Light

Fast Growth of Distributed PV can Challenge System Operations

- Smaller contribution in meeting RPS
  - 500 MW of installed rooftop PV can meet only about 10% of Oahu's annual load energy

- Other grid stability & reliability requirements for further increasing Distributed Solar PV
  - Voltage & frequency ride through
  - Enabling curtailment
  - Reactive support
  - Frequency response
  - Other grid strengthening measures



500 MW of Distributed Solar PV achieved in Q4 2017

New Programs: October 2017

Smart Export Program

Program Features

- **PV + Battery:** New option for customers to install a rooftop PV system plus a battery energy storage system.
- **Smart Charging and Exporting:** Customer's battery storage system will typically charge from the PV system during the daytime (9am – 4pm) and power their home in the evening. Option to export energy to the grid during evening, overnight, and early morning (4pm – 9am).
- **Annual True-Up:** Energy export credits will be reconciled on an annual basis. Excess credits expire at the end of the year (with utility cost reduction benefiting all customers).
- **Energy Credits:** Customers will be credited on monthly bill for electricity sent to the grid during the evening, overnight, and in the early morning (4pm – 9am).

Program Capacity:		
HECO: 25 MW	HELCO: 5 MW	MECO: 5 MW
Approximately 3,500-4,500 customers may enroll in the Smart Export program throughout the HECO service territories.		

Credit Rates and Export Windows for Interim Smart Export Program for the HECO Companies			
	12 a.m. – 9 a.m.	9 a.m. – 4 p.m.	4 p.m. – 12 a.m.
O'ahu	14.97 ¢/kWh	No credit	14.97 ¢/kWh
Hawai'i Island	11.00 ¢/kWh		11.00 ¢/kWh
Maui	14.41 ¢/kWh		14.41 ¢/kWh
Moloka'i	16.64 ¢/kWh		16.64 ¢/kWh
Lāna'i	20.79 ¢/kWh		20.79 ¢/kWh
The export credit rates will remain fixed for five (5) years.			

Program Requirements

- **Application:** Streamlined interconnection application with the Hawaiian Electric Companies.
- **Smart Net Meter:** The utility installation of a Smart Net Meter that can measure the bi-directional flow of energy between the Smart Export system and the grid and ensure reliable operation.
- **Advanced Inverter:** Advanced inverters provide support to the electric grid during different types of grid disturbances. Activating these functions in new Smart Export systems will help maintain a stable and reliable grid.

Customer Grid Supply+ Program (CGS+)

Program Features

- **Direct-to-Grid:** New option for customers to install a solar PV-only system that exports energy to the electric grid during the daytime, but will need to utilize new equipment that allows the electric utility to manage power from the system when necessary to maintain a stable grid.
- **Lower Upfront Investment:** Allows for a direct to grid exporting PV system with no energy storage needed.
- **Annual True-Up:** Energy export credits will be reconciled on an annual basis. Excess credits expire at the end of the year (with utility cost reduction benefiting all customers).
- **Energy Credits:** Customers credited on monthly bill for electricity sent to the grid.

Program Capacity		
HECO: 35 MW	HELCO: 7 MW	MECO: 7 MW
Approximately 5,000-6,000 customers may enroll in the CGS+ program throughout the HECO service territories.		

Credit Rates for the CGS+ Program for the HECO Companies	
Island	**CGS+ Credit Rate**
Oahu	10.08 ¢/kWh
Hawai'i Island	10.55 ¢/kWh
Maui	12.17 ¢/kWh
Moloka'i	16.77 ¢/kWh
Lāna'i	20.80 ¢/kWh
The export credit rates will remain fixed for five (5) years.	

Program Requirements

- **Application:** Streamlined interconnection application with the Hawaiian Electric Companies.
- **Communications and Controllability:** Controllability may be provided by a third party that can send data to the utility. The third party will provide a flexible mechanism to reduce CGS+ system output while leaving the customer's load connected when needed to ensure reliable operation of the grid. Alternatively, customers may elect to have HECO install a separate smart production meter that will provide utility data collection and controllability to ensure reliable operation of the grid.
- **Advanced Inverter:** Provides support to the electric grid during different types of grid disturbances. Activating these functions in new CGS+ systems will help maintain a stable and reliable grid.

MAHALO

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