Federal Energy Regulatory Commission

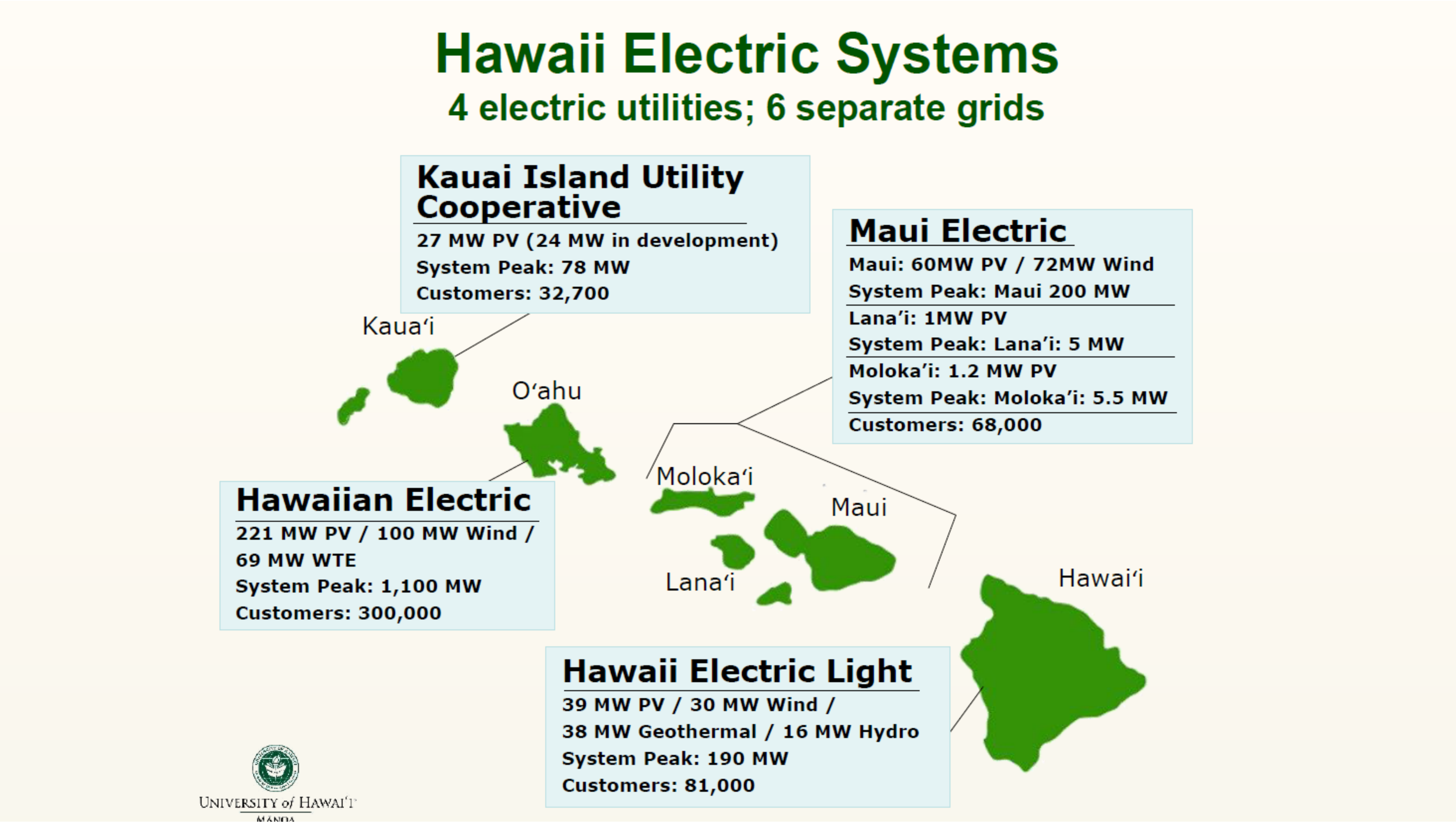
# RELIABILITY TECHNICAL CONFERENCE

# “PANEL II: EMERGING ISSUES–PART II”

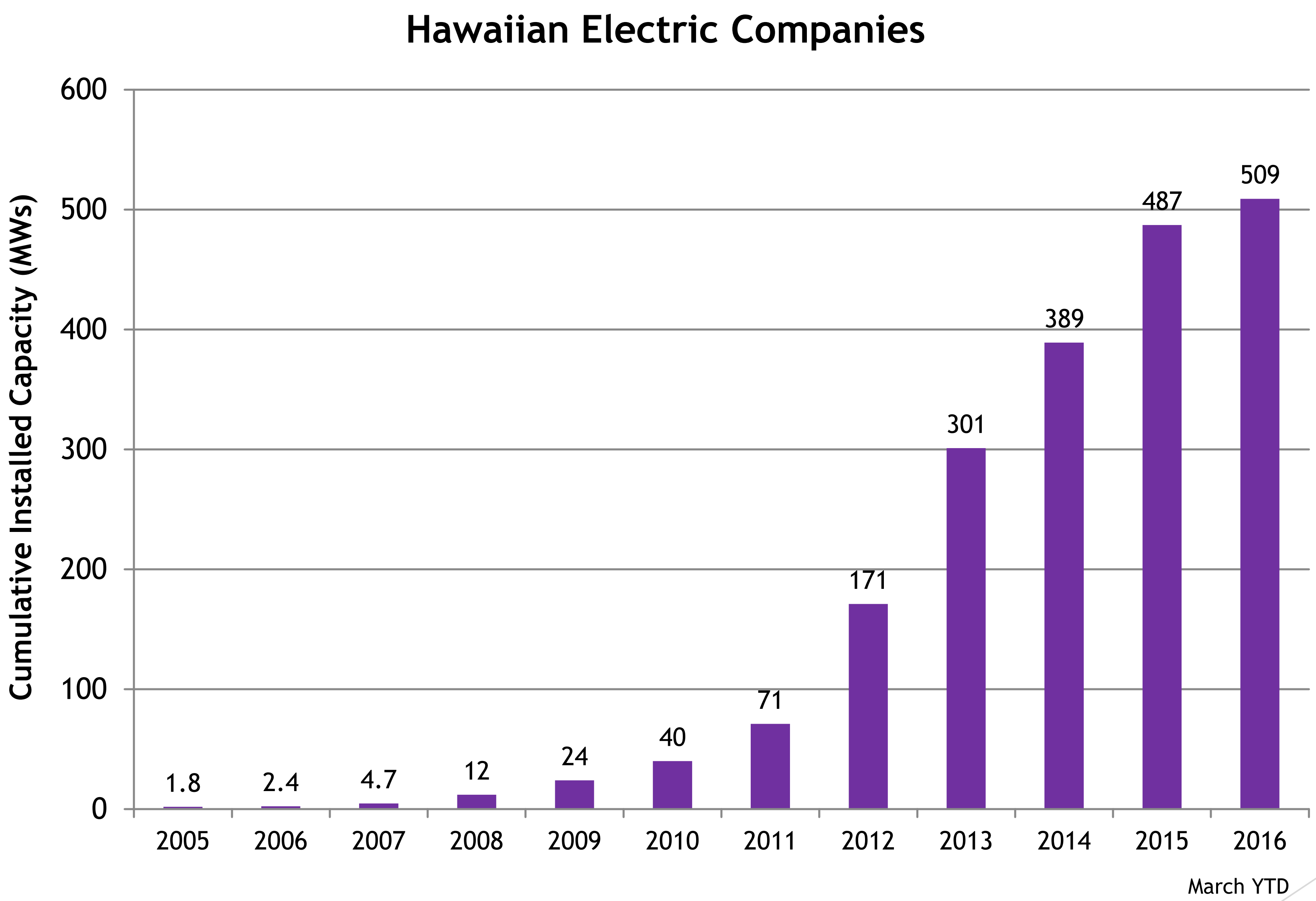
Lorraine H. Akiba, Commissioner

Hawaii Public Utilities Commission

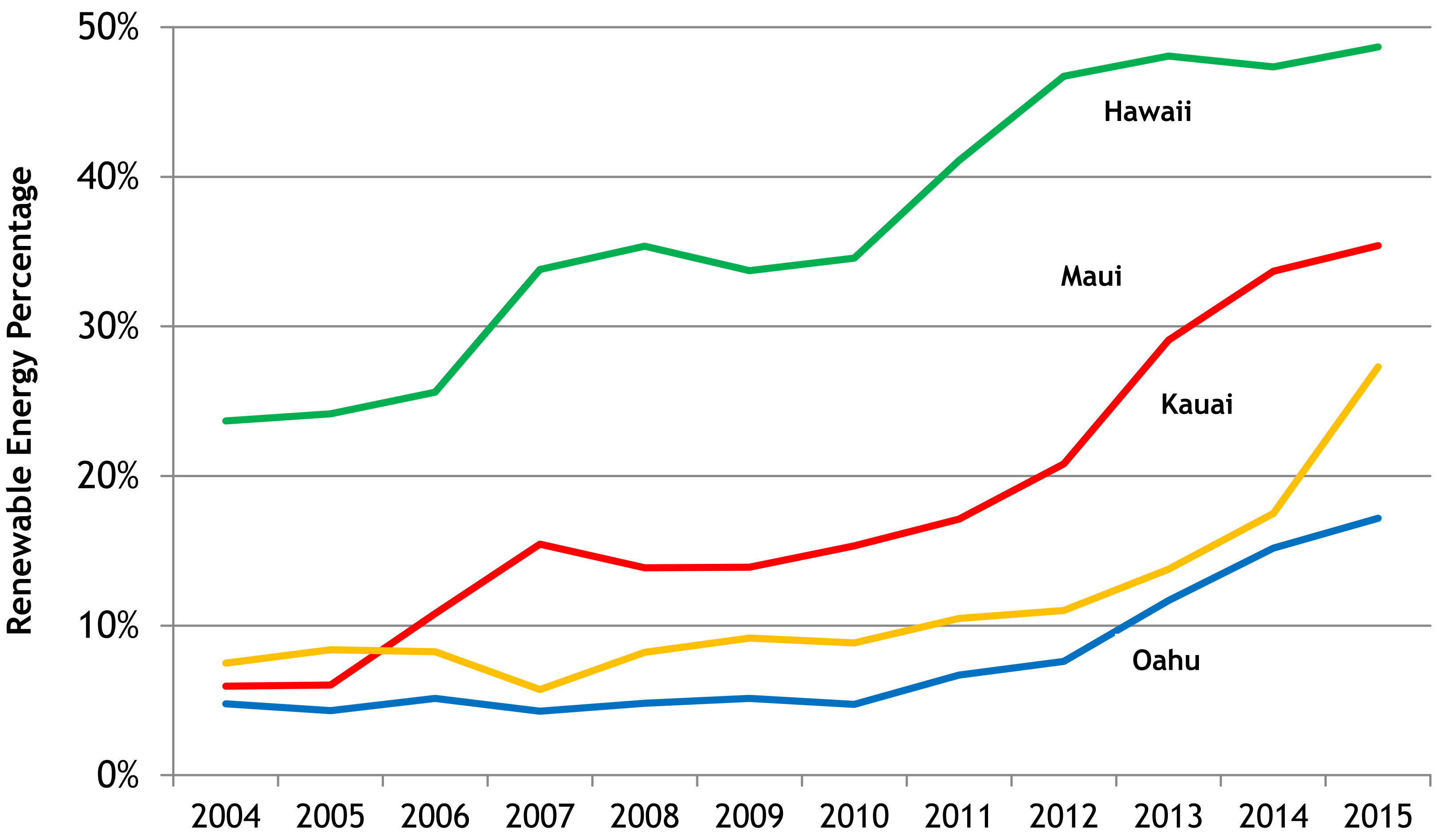
June 1, 2016


Hawaii Electric Systems
4 electric utilities; 6 separate grids
Kauai Island Utility Cooperative
27 MW PV (24 MW in development)
System Peak: 78 MW
Customers: 32,700
Maui Electric
Maui: 60MW PV / 72MW Wind
System Peak: Maui 200 MW
Lana'i: 1MW PV
System Peak: Lana'i: 5 MW
Moloka'i: 1.2 MW PV
System Peak: Moloka'i: 5.5 MW
Customers: 68,000
Kaua'i
O'ahu
Moloka'i
Maui
Lana'i
Hawai'i
Hawaiian Electric
221 MW PV / 100 MW Wind /
69 MW WTE
System Peak: 1,100 MW
Customers: 300,000
Hawaii Electric Light
39 MW PV / 30 MW Wind /
38 MW Geothermal / 16 MW Hydro
System Peak: 190 MW
Customers: 81,000
UNIVERSITY of HAWAI'I
MĀNOA

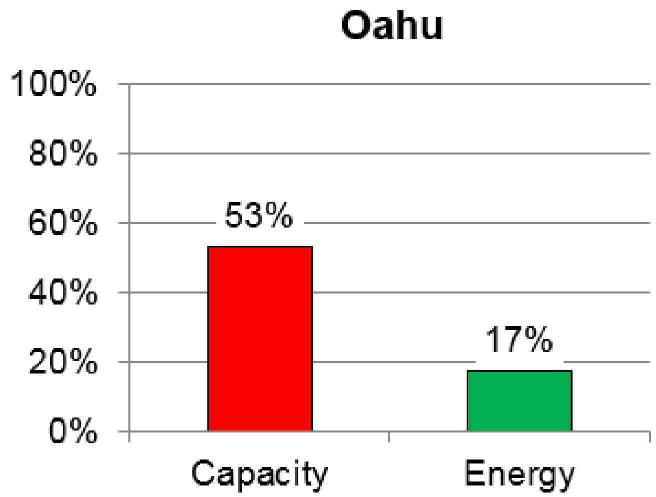
# Hawaii's Distributed Solar PV Capacity Growth

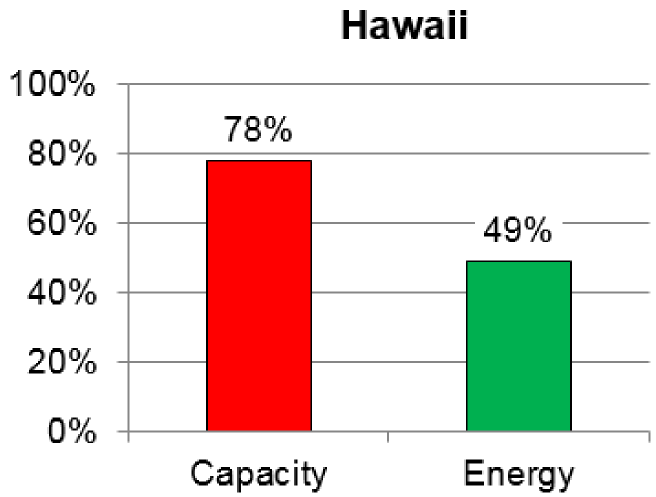


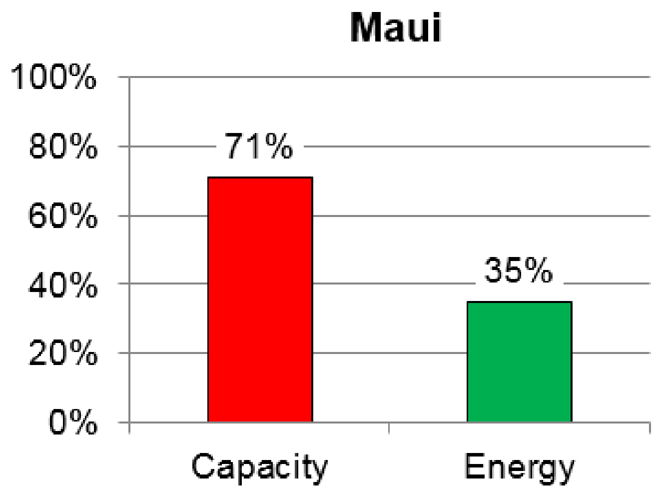
# Hawaii’s Renewable Energy Trends

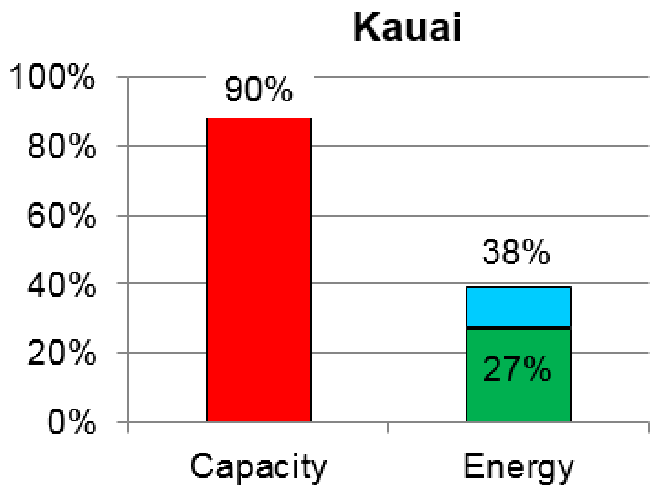


# Total Renewable Capacity vs Energy Penetration -- 2015



# System Level Challenges Related to Solar PV

"Notwithstanding expansion of distribution circuit capacity to accommodate more solar PV systems, **system level reliability, curtailment and operational challenges** on each island grid, not individual distribution circuit penetration levels, **will ultimately become the binding constraint**, and thus limit the cumulative amount of customer solar PV capacity that can be interconnected to, and the amount of energy that can be exported onto, the grid."

"These technical, economic and operational challenges are not well understood publicly, yet have important ratepayer implications."

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Hawaii Public Utilities Commission Order No. 32053 in Docket No. 2011-0206, dated April 28, 2014

# System Level Challenges Related to Solar PV (continued)

a) "[C]onventional generators, which currently provide dispatchable power and ancillary services, would be displaced during the daily solar output period."

b) "[L]arge amount of solar PV capacity can create major daily operational challenges for island grids ... [i]f the island grid lacks sufficient quick-start generation, other flexible load-following generation capacity, or large-scale bulk energy storage resources, it may not be possible to serve major morning ramp-down and late afternoon ramp-up of net system load requirements."

c) "[T]he unscheduled and uncontrolled export of excess [distributed] solar energy onto the grid, could eventually create curtailment risks for existing and future utility-scale solar PV, wind, and other renewable energy projects …"

d) "[L]imited industry knowledge about the impact of operating an isolated island power grid with large quantities of total energy being supplied by electronically-coupled resources, for extended periods of time"

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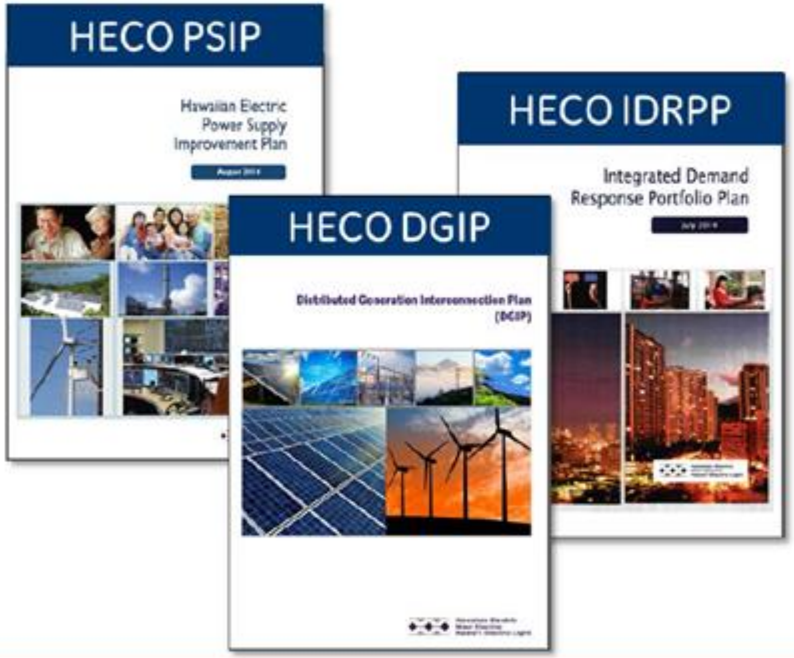
Hawaii Public Utilities Commission Order No. 32053 in Docket No. 2011-0206, dated April 28, 2014

# What's Happening in Hawaii…

## Hawaii's Renewable Portfolio Standard

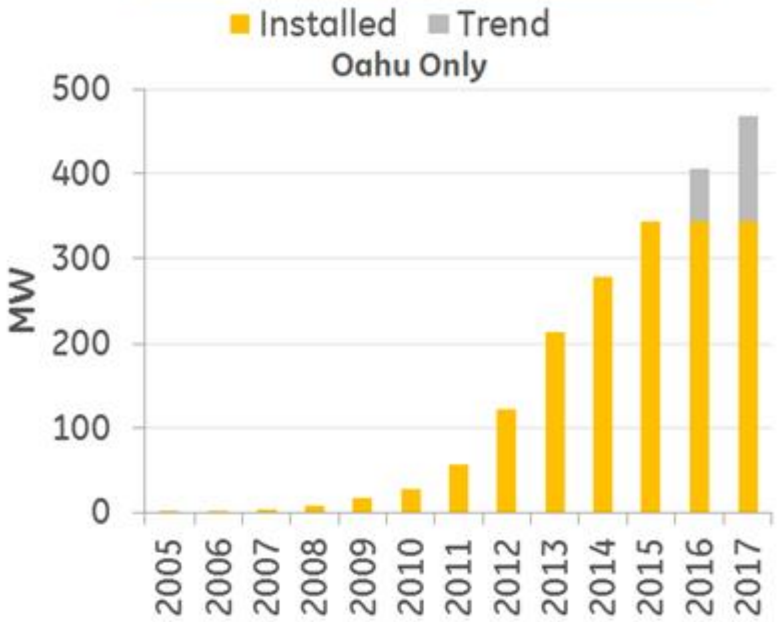
- 30% by 2020
- 40% by 2030
- 70% by 2040
- 100% by 2045




## Rapid Growth of Distributed PV

5x growth in 5-years

>30% of single family homes




Focus on the integration of variable renewable resources due to the fast growth and unique grid challenge, complexities warrant independent engineering & economic studies

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

# Why is Grid Stability Important?

- 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


**Novel solutions are required to maintain grid stability with high wind and solar penetration**

HNEI
Hawai'i Natural Energy Institute

# Why is Hawaii Unique?

## A shared experience with other islanded power systems

### Large Single Contingency

**Must be prepared for the loss of AES coal plant, which can be up to 30% of the grid's supply**

### Low Number of Synchronous Generators

**Oahu has few synchronous generators online and available to provide primary frequency response**

### Isolated grids

**Islands cannot rely on neighbors during emergency events for support**

### High Level of Renewable Penetration (DPV especially)

**High renewable penetration displaces conventional generation and some of the ancillary services they provide.**

Novel solutions are required to maintain grid stability with high wind and solar penetration

# Key Findings and Observations

- ✓ Developed a methodology to evaluate system risk at all hours
- ✓ In Scenario 2, wind and solar generation represents 22% of annual load, with times of instantaneous penetration at 70%
- ✓ Increased renewables can reduce the contingency severity; highlighting the alignment of economic and stability objectives
- ✓ Both generator and load contingencies are manageable with up to 700 MW of DPV, 150 MW of CPV, and 125 MW of wind
  - ✓ Grid strength still needs to be evaluated
- ✓ Frequency response from both utility-scale and distributed renewables can avoid curtailment

# Key Findings and Observations (Generator Trip)

**Increased DPV penetration up to 700 MW (with frequency ride-through enabled) does not erode grid stability to a *generator trip event* with the assumptions evaluated in this study.**

- ❑ Based on the simulations, the grid was able to survive all of the generator contingency events evaluated, even in the most challenging hours of operation
- ❑ While the expected frequency response in some hours may have been reduced when adding 300 MW of DPV, the net result when evaluating the entire year of operations is a slight improvement in system frequency response to a generator contingency.
- ❑ DPV reduces the net load on feeders that are part of the load-shedding system, which decreases the effectiveness of load-shedding to stop rapid declines in frequency.
- ❑ The reduced AES output during times of high wind and solar output reduces system risk.

# Key Findings and Observations (Load Trip)

**With increased renewables, system risk shifts to loss of load contingencies. Absent mitigations, increasing DPV from 400 MW in Scenario 1 to 700 MW in Scenario 2 will significantly erode system stability due to loss of load contingency events.**

- ❑ Many more hours when frequency excursions could approach over-frequency protection actions
- ❑ Greater dependence on thermal units to quickly reduce output to very low levels
- ❑ Utility scale renewables and DPV can contribute to the grid's frequency response with over-frequency governor action
- ❑ Due to their power-electronic interfaces, wind & solar response times can be faster than thermal units
- ❑ Grid performance improves dramatically when renewable resources share over-frequency governing with thermal units

# Next Steps & Ongoing Analysis

- Higher renewable penetration to achieve RPS targets (40% - 60%)
  - ✓ Evaluate proposed grid upgrades at higher penetration level
- Incorporate mitigations and grid modernization efforts
  - ✓ Energy storage
  - ✓ Electric vehicles
  - ✓ Fast acting demand response
  - ✓ Smart inverters
  - ✓ UFLS schemes
  - ✓ New operating practices (unit cycling, spinning reserve adjustments, etc.)
- Evaluate other facets of grid stability
  - ✓ Transmission faults
  - ✓ Grid strength

# Mahalo!

For any questions, please contact:
Lorraine.H.Akiba@hawaii.gov
(808) 586-2020

Lorraine H. Akiba, Commissioner
Hawaii Public Utilities Commission