Photovoltaic Distributed Generation
Hawaii Case Study

GridSTART
Grid System Technologies Advanced Research Team

Marc M. Matsuura
Sr. Smart Grid Program Manager, Grid***START***

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

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University of Hawai'i Manoa

Solutions to Facilitate Successful RE Integration on the Distribution System

Asia Clean Energy Forum

June 5, 2018
Manila, Philippines

New *Regulatory Compact*

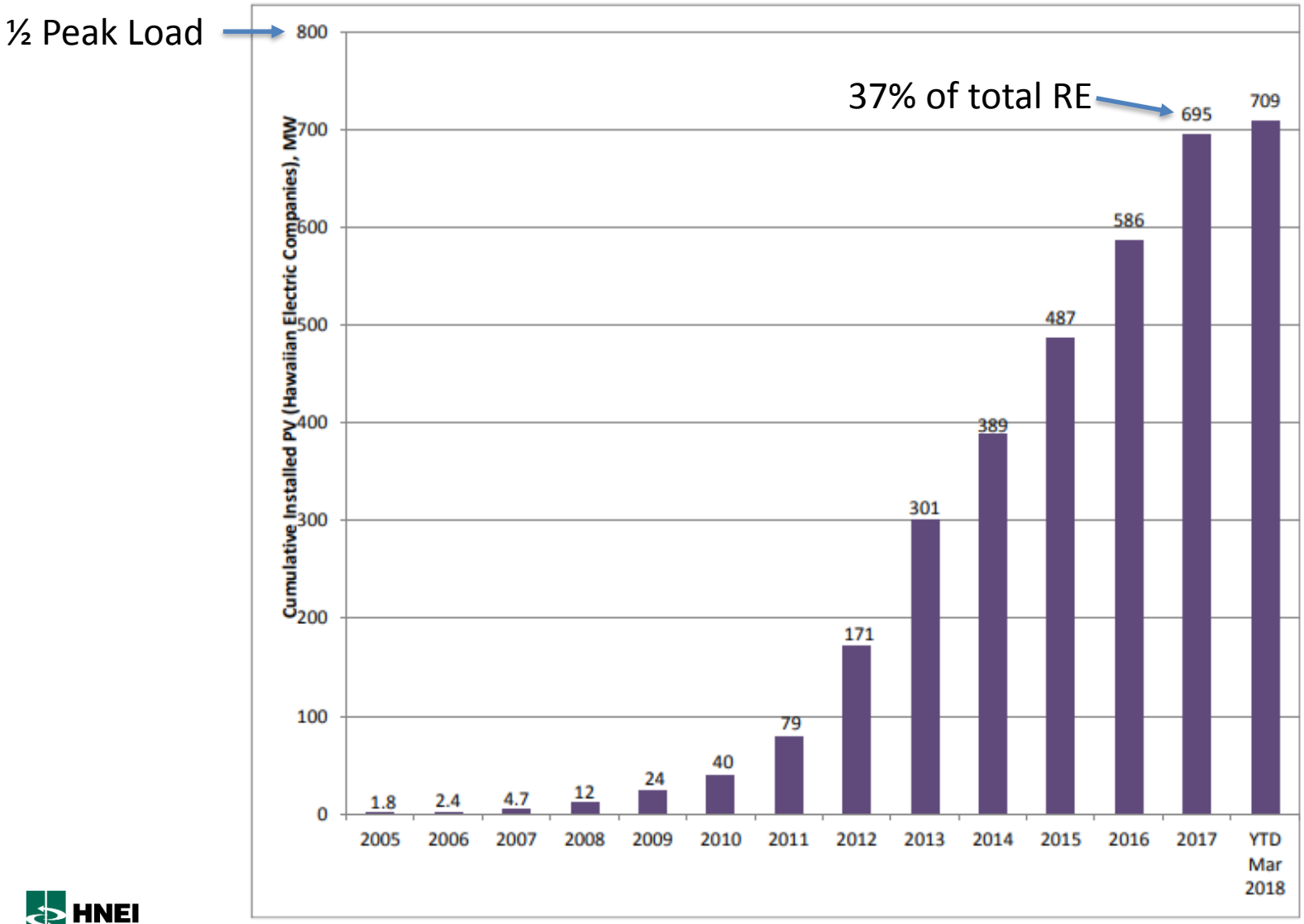
- Government policy set to ***drive*** clean energy action
  - Renewable & Energy Efficiency Portfolio Standards
  - Net Energy Metering & Feed-in Tariffs
- Financially sound utility needed to ***implement*** the policy
  - *Why?*
  - RE projects must be *"bankable"* (utility is contract counter-party)
- But, these policies ***reduce*** energy sales for the utility … so what's in it for the utility?
- New regulatory compact ***aligns*** utility's business interest
  - Utility rates "decoupled" from energy sales (utility ensured to recover it's costs even if sales declining)
  - Investment in grid renewal encouraged (utility earns on CapEx)

Hawaii State Capitol

Hawaiian Electric offices

Installed PV Capacity - HECO Companies

(2005 to 3/2018)



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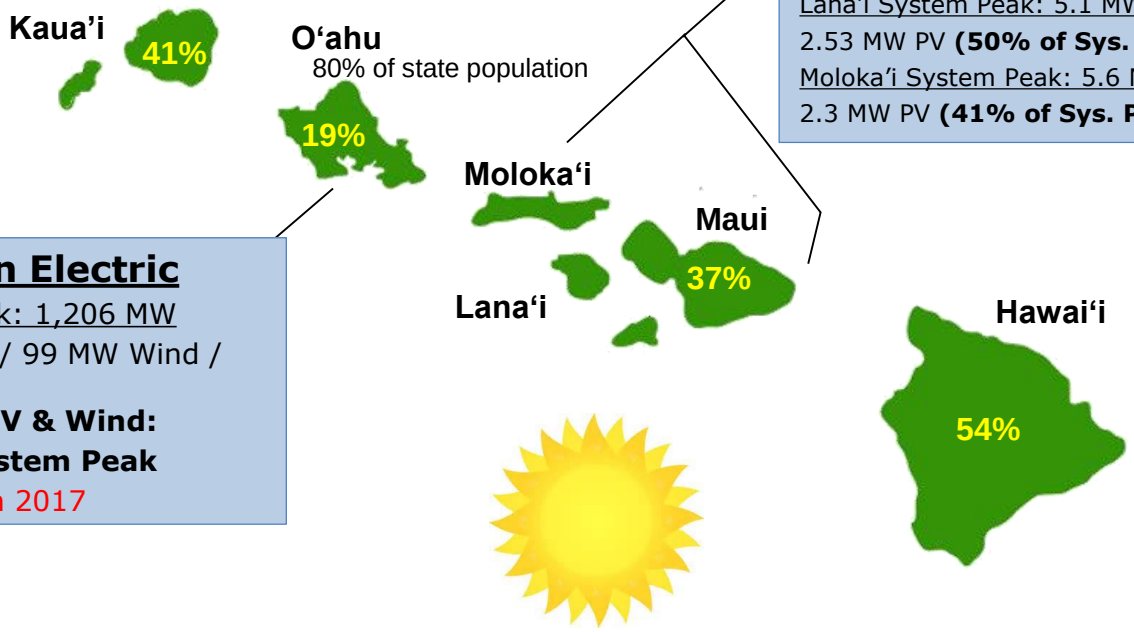
Hawai‘i Electric Systems –

4 Electric Utilities; 6 Separate Grids; % Renewable Energy

Kaua‘i Island Utility Cooperative
System Peak: 78 MW
65.6 MW PV / 7 MW Biomass / 9 MW Hydro
Installed PV: 84% of System Peak
41.7% RE in 2016

Maui Electric
Maui System Peak: 202 MW
100 MW PV / 72 MW Wind
Installed PV & Wind:
85% of Sys. Peak
34.2% RE in 2017
Lana’i System Peak: 5.1 MW
2.53 MW PV **(50% of Sys. Peak)**
Moloka’i System Peak: 5.6 MW
2.3 MW PV **(41% of Sys. Peak)**



Hawaiian Electric
System Peak: 1,206 MW
512 MW PV / 99 MW Wind / 69 MW WTE
Installed PV & Wind:
50% of System Peak
20.8% RE in 2017

Hawaii Electric Light
System Peak: 192 MW
92 MW PV / 30 MW Wind /
38 MW Geothermal / 16 MW Hydro
Installed PV & Wind:
64% of System Peak
56.6% RE in 2017

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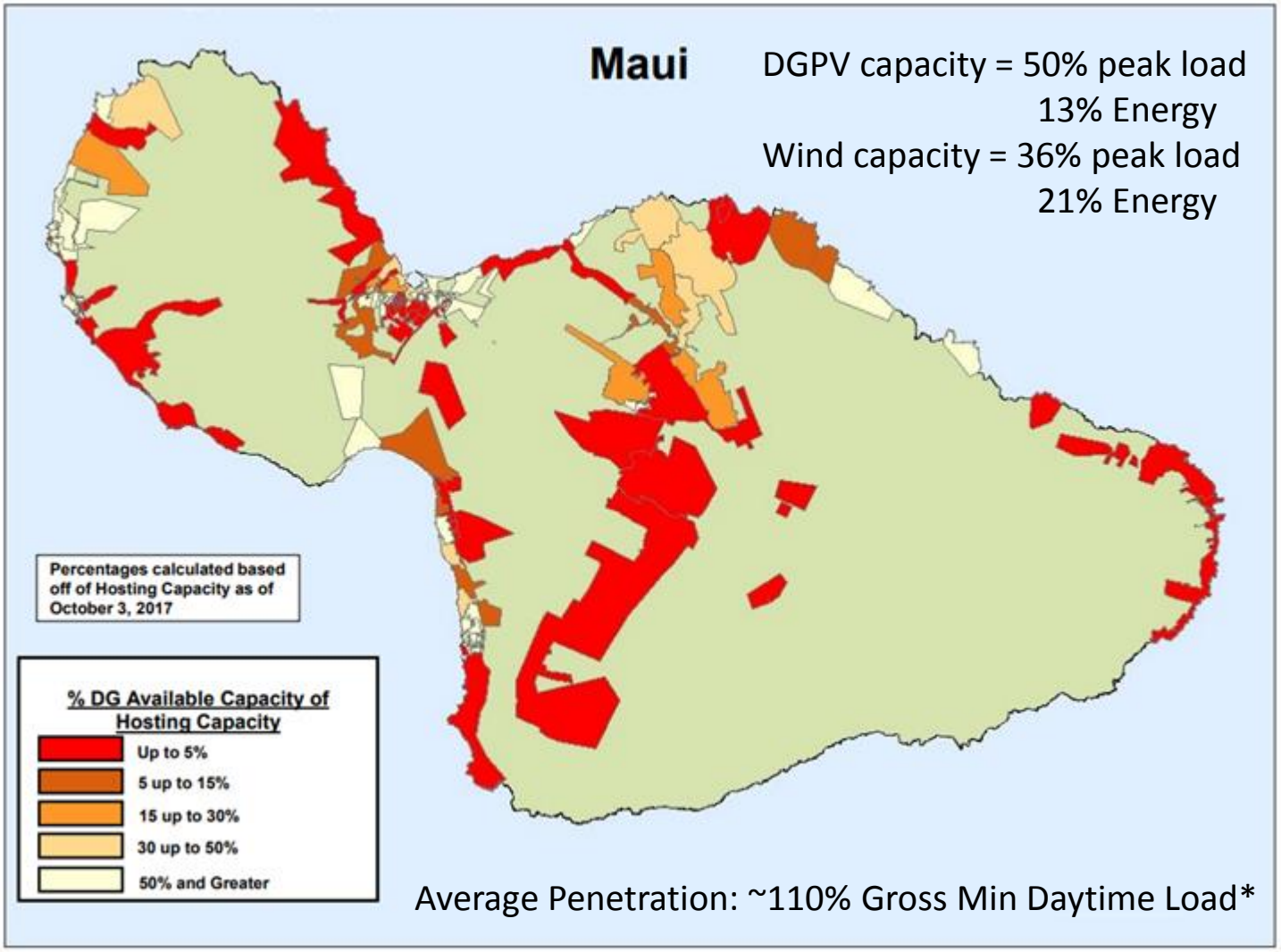
Distributed PV Circuit Penetrations



*GMDL = Net min load + 75% of installed PV capacity

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Why is DG PV So Popular in Hawaii

Federal Incentives

30% of the cost of Solar systems with no cap. *Extended to 2019 (Ramps down through 2020 to 26%, then in 2021 to 22%)*

State Incentives

35% of the actual cost or $5,000 per system, whichever is less. No expiration date

Average Price of Residential Electricity (EIA)

	State	Mar-18
1	North Dakota	9.65
2	Washington	9.65
3	Louisiana	9.79
4	Idaho	9.99
5	Nebraska	10.25
	.	
	.	
46	New Hampshire	19.93
47	Rhode Island	20.22
48	Connecticut	21.04
49	Alaska	21.47
50	Massachusetts	22.49
51	Hawaii	32.05
	U.S. Average	12.99

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Why is DG PV So Popular in Hawaii

The average Hawaii resident spends about 0.37 per kilowatt-hour (kWh) and uses about 515 kilowatts (kW) per month. With an average month's electric bill totaling $190.36 it definitely makes sense to see if you can save money on power.

Key Solar Facts – Averaged for Hawaii

Average savings per year: $3,539.18 ($294.93 per month)

Estimated time for the system to pay for itself: 6 years, 0 months

Is solar worth it in Hawaii? Based on the price of electricity in Hawaii (an average of 0.37 per kW) and high amounts of sun (8% more than average) compared to other states, solar power is 238% more cost effective than the rest of the nation.

Our final opinion: **solar panels are an obvious financial choice in Hawaii**.

Source: Decisiondata.org

DG PV Programs

Customer Grid-Supply Plus (CGS Plus) systems must include grid support technology to manage grid reliability and allow the utility to remotely monitor system performance, technical compliance and, if necessary, control for grid stability.

Smart Export customers with a renewable system and battery energy storage system have the option to export energy to the grid from 4 p.m. – 9 a.m. Systems must include grid support technology to manage grid reliability and system performance.

Customer Self-Supply (CSS) is intended only for private rooftop solar installations that are designed to not export any electricity to the grid. Customers are not compensated for any export of energy.

X **Customer Grid-Supply (CGS)** participants receive a PUC-approved credit for electricity sent to the grid and are billed at the retail rate for electricity they use from the grid. The program remains open until the installed capacity has been reached.

X **Net Energy Metering (NEM)** is closed to new applicants.

Standard Interconnection Agreement (SIA) is designed for larger customers who wish to offset their electricity bill with on-site generation.

DG PV Programs

Program	Grid Export Rate*	Battery Storage Required?	Grid Export Window	Controllable?	Wireless Availability Required?
Customer Grid-Supply Plus	10 cents/kWh	No	Daylight	Yes	Yes
Smart Export	15 cents/kWh	Yes	4 p.m. to 9 a.m.	No	Yes
Customer Self-Supply	N/A	No, but usually installed	N/A	N/A	No
SIA	N/A	No	N/A	No	No

Qualified Inverter Lists

Hawaiian Electric
Maui Electric
Hawai'i Electric Light

QUALIFIED GRID SUPPORT UTILITY INTERACTIVE INVERTERS AND CONTROLLERS MEETING MANDATORY FUNCTIONS SPECIFIED IN RULE 14H

(EQUIPMENT THAT MEETS CUSTOMER GRID SUPPLY AND STANDARD INTERCONNECTION AGREEMENT (SIA))

Technology Type:	Manufacturer:	HI SRD Certification	Model:
Inverter	Apparent Energy	No Information Submitted	SG424 (120V/208V/240V)
Inverter	Canadian Solar	No Information Submitted	CSI-36KTL-CT (DSP FW Ver 0.30)
Inverter	Chilicon Power LLC	No Information Submitted	CP-250-60/72-208/240-MC4-MTC (FW 232 or greater)
Inverter	Chilicon Power LLC	No Information Submitted	CP-250-60-208/240-MC4 (FW 232 or greater)

https://www.hawaiianelectric.com/Documents/clean_energy_hawaii/list_of_advanced_legacy_equipment.pdf

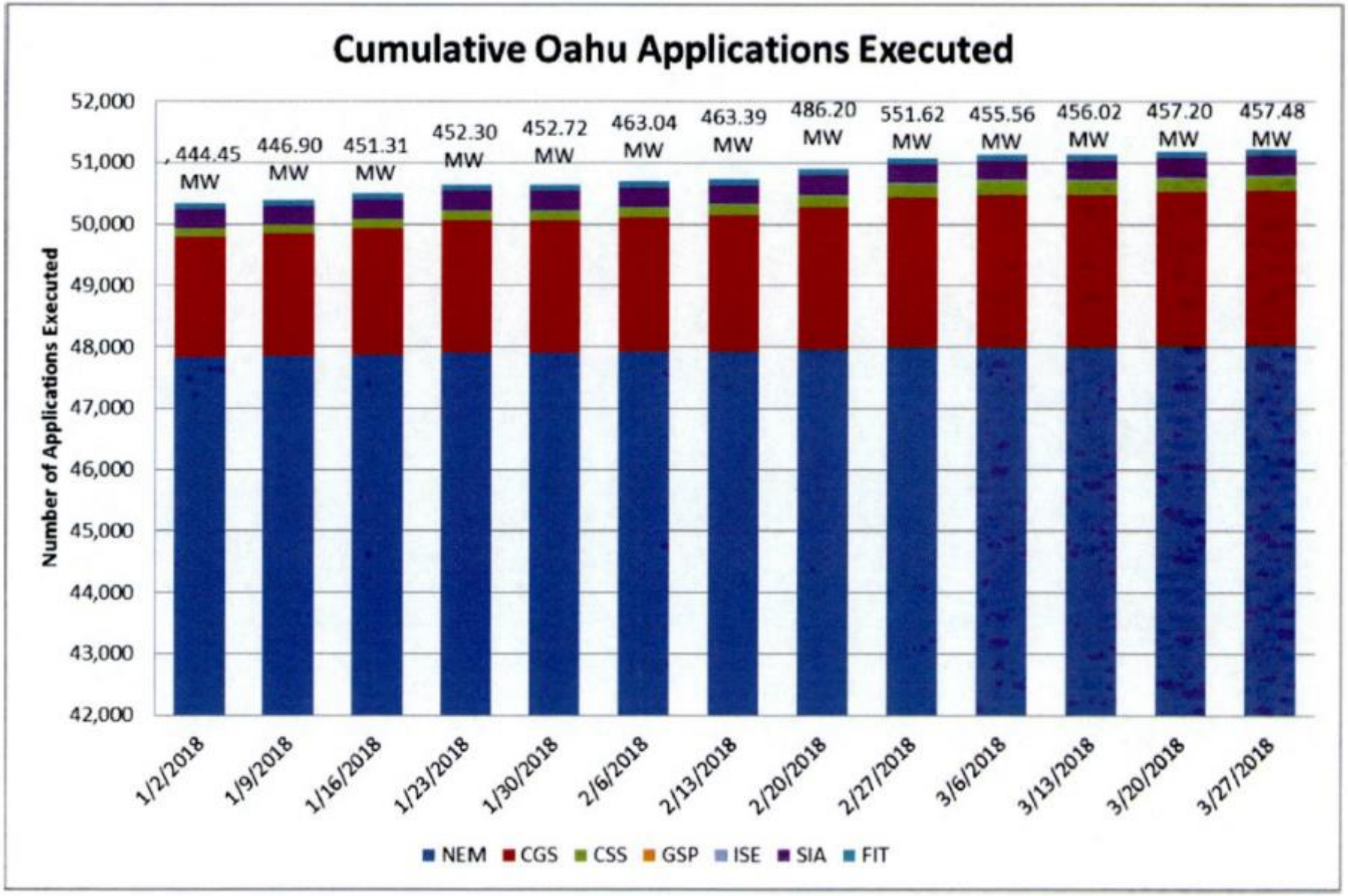
Evolution of Circuit Penetration Limits (Why is the utility being a roadblock?)

"How much distributed generation can you add before you need to do an expensive Interconnection Requirements Study?"

- 15% of Peak Load
  - Utility "Rule-of-Thumb" for synchronous generation
    - Historically, utilities only measured circuit peaks for planning
- 30% of minimum daytime load (MDL)
  - The actual issue is the generation at minimum load
- 120% of MDL
  - "Typical" distribution circuit modeling showed no issues until the circuit penetration levels reached 120% of the MDL where transient over voltages (TOV) were a concern.

Evolution of Circuit Penetration Limits (Why is the utility being a roadblock?)

- 250% of MDL
  - Modeling studies determined TOV levels were acceptable if new inverters could trip within 1-cycle if its terminal voltage reached 120% pu voltage. TOV trip requirement added to interconnection Requirements
- Individual Hosting Capacity Limit
  - Based only on steady-state power flows (Thermal and Voltage limits) and flicker limits.
  - Actual inverter testing determined that TOV was not an issue if inverters met the TOV requirements
  - "Advanced" Inverter capabilities are now required to expand Hosting Capacity Limits
  - Load Tap Changer settings need to be reviewed with distribution voltage monitoring
  - Emergency configurations need to be assessed



940 Applications Executed in the first quarter of 2018

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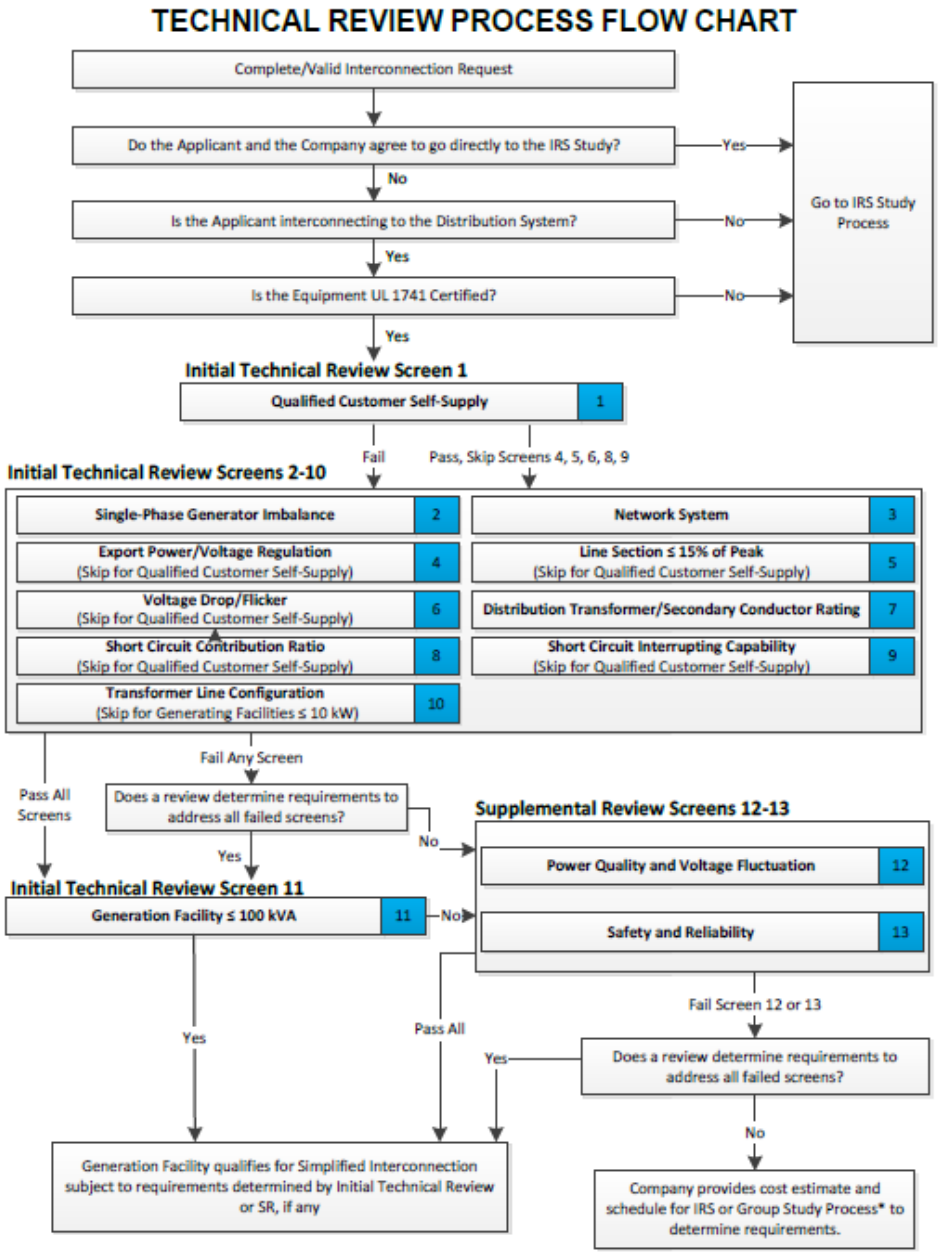
Rule 14



* "Group Study Process" may include a consolidated IRS or a proactive utility determination of interconnection requirements covering multiple Generating Facilities.

And then there's the system limits…

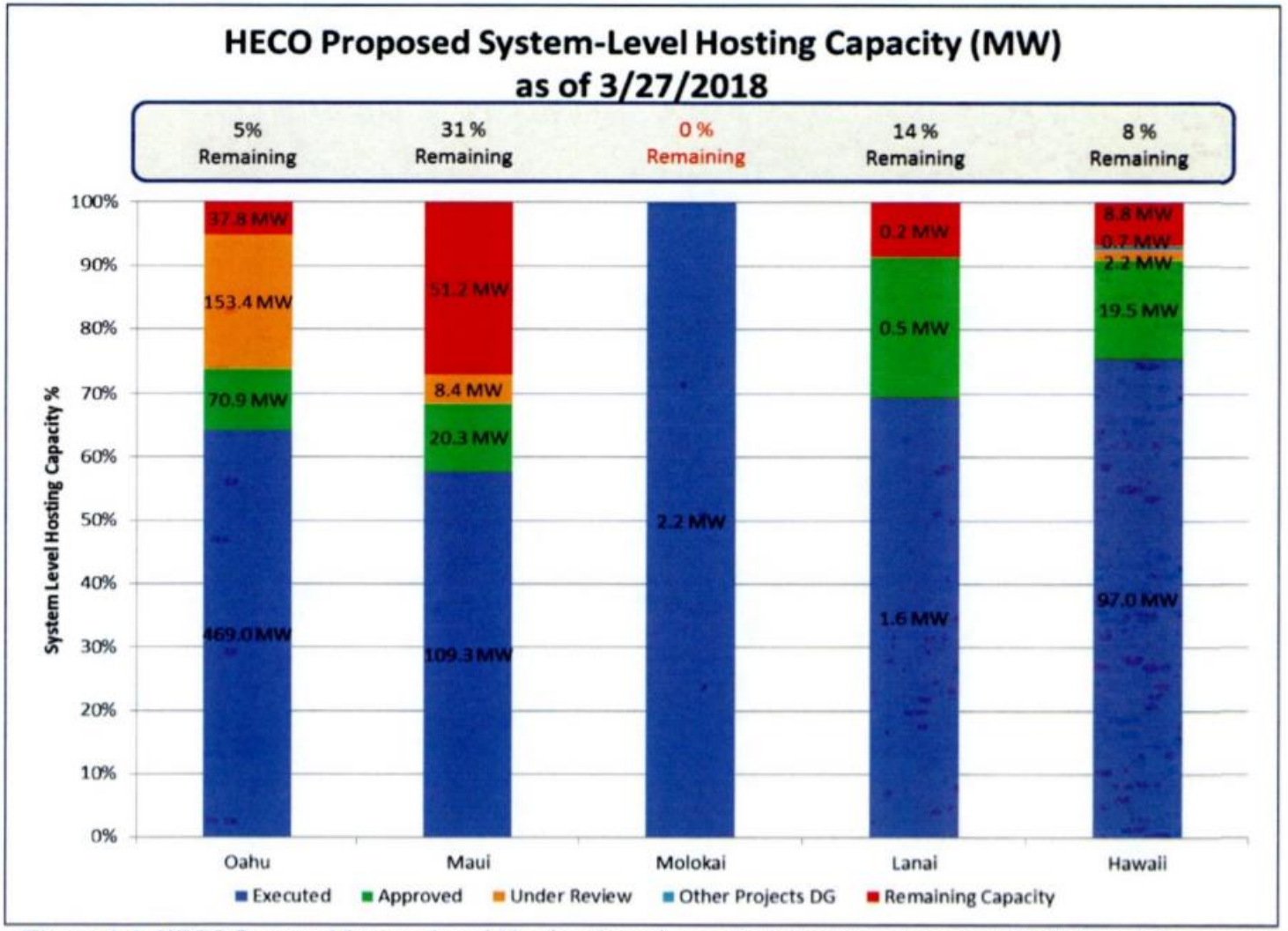


Figure 1-1. HECO Proposed System-Level Hosting Capacity as of 3/27/2018 (excludes controllable/curtailable capacity).

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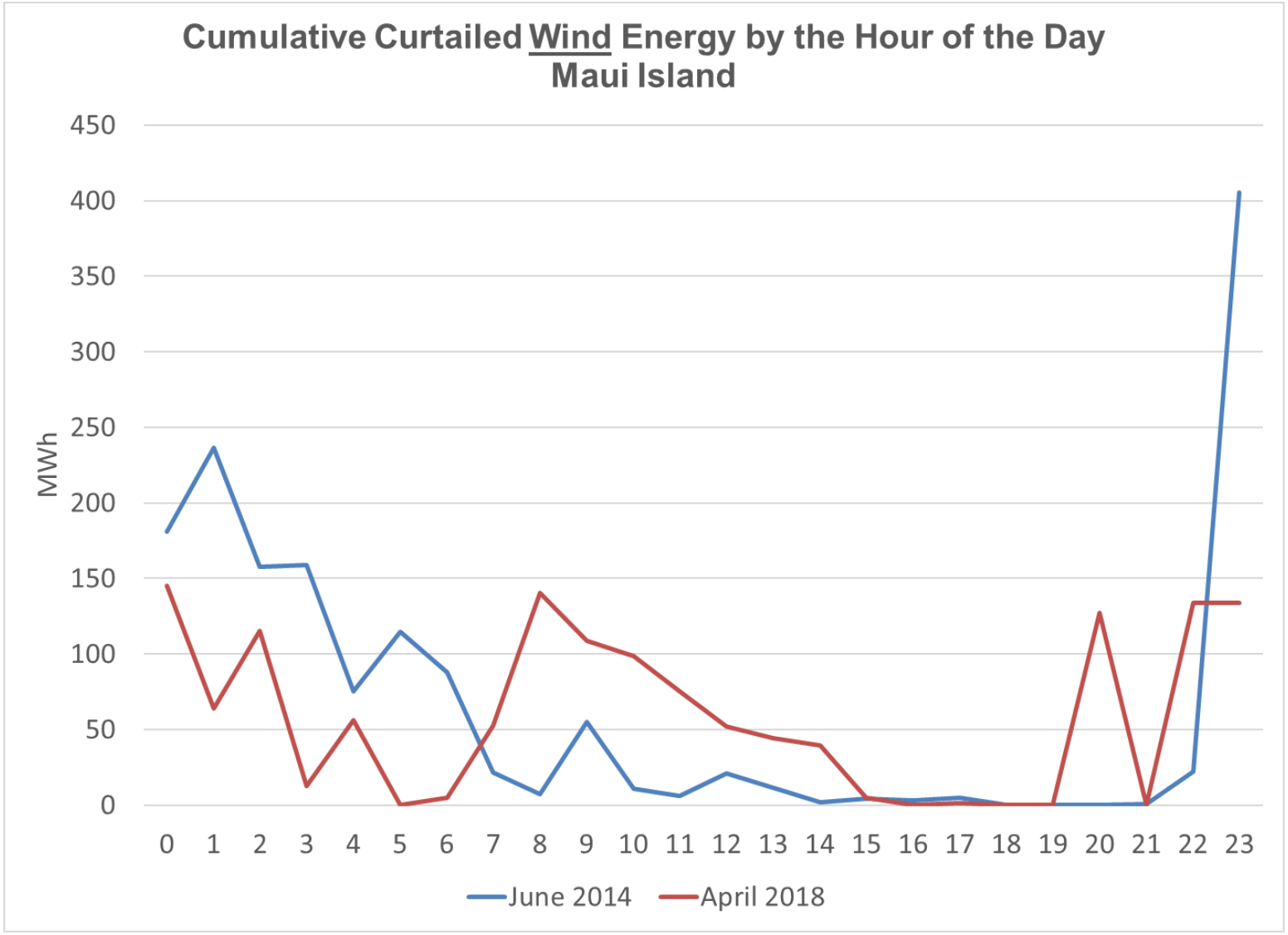
Is This a Limit?

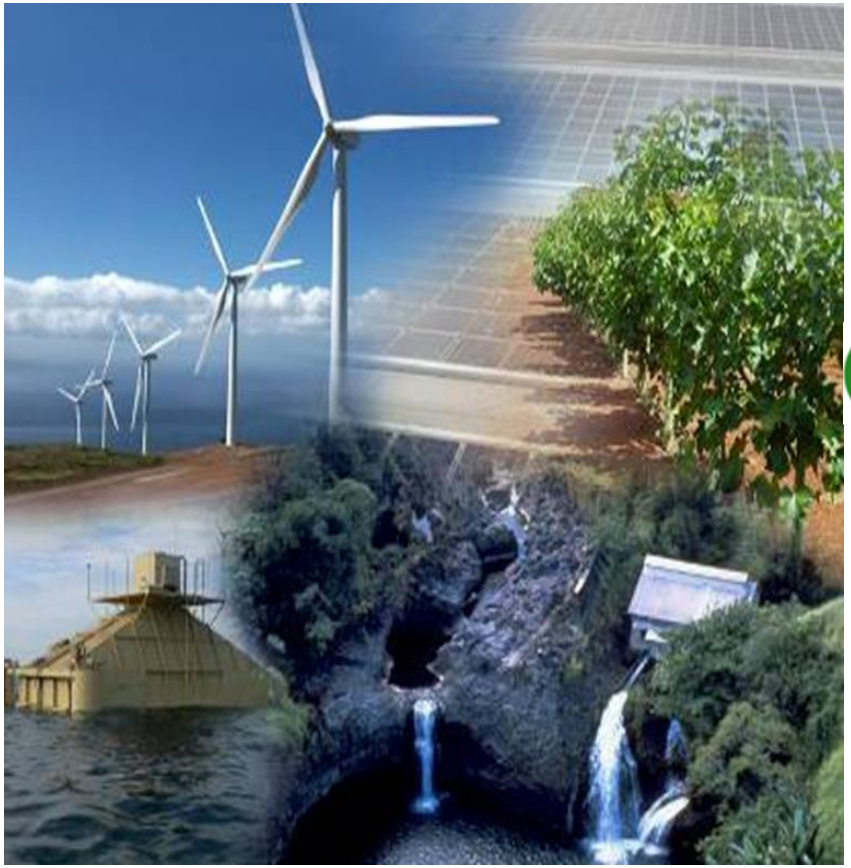


Key Messages

- Hawai‘i has made great strides in the integration of distributed PV
- Those strides came through a combination of significant subsidies and solving real technical and process roadblocks
- Policy facilitates change
- Change takes time and needs to be monitored to match technical capabilities and right size subsidies and energy mix.

Mahalo!

(Thank you)



For more information, contact:

Marc Matsuura
Sr. Smart Grid Program Manger
Office: (808) 956-7050
E-mail: marc.matsuura@hawaii.edu

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