Hawaii's Energy Transformation

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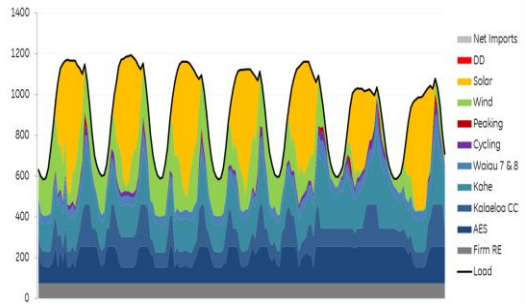
Hawaii Natural Energy Institute (HNEI)

Organized Research Unit in School of Ocean and Earth Science and Technology at the University of Hawaii at Manoa
Founded in 1974, established in statute in 2007 (HRS304A-1891)

- **Research, development, deployment, and testing of advanced energy technologies using Hawaii as test bed**

- **International partnerships to enhance reliability, stability and resilience of energy systems in Asia-Pacific region**



- **Technical and policy analyses to inform decision makers on cost effective pathways to 100% clean energy goals.**

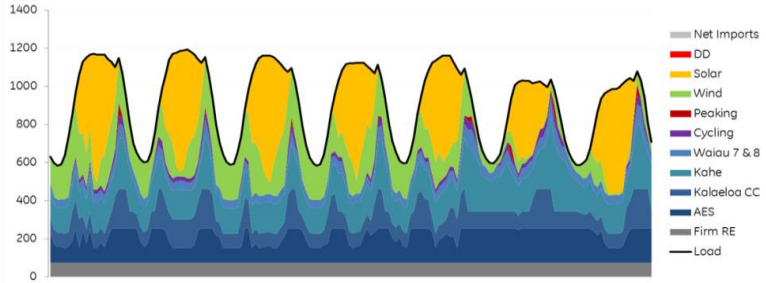
HNEI: Sample Research Areas

Ocean Energy (Navy Wave Energy Test Site)

Sustainable Fuels (FAA)

Community Energy & Microgrids

Battery Energy Storage



Grid Analysis

Hydrogen Technology (Generation, Storage, Unmanned Vehicles, Field Validation

Comfort, Health and Building Efficiency

Asia-Pacific Regional Analysis

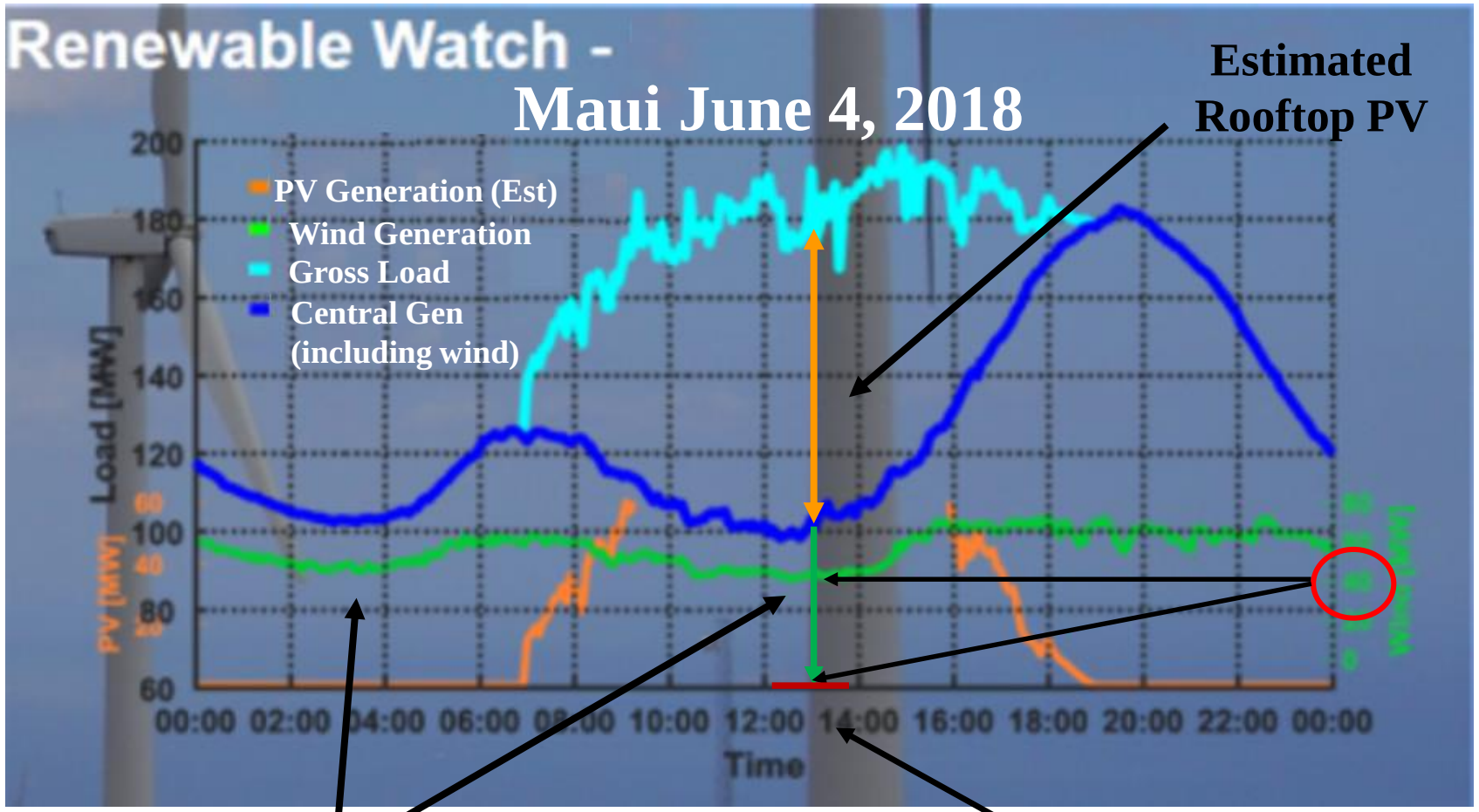
Hawaii Energy: A Historical Perspective

- Six isolated grids from 5 to 1200 MW
- No interconnections between islands
- Oil dominant generation (historically)
- Each island has its own unique generation and resource mix
- Over 70% of energy use on one island - Oahu

Renewable Energy History

- Long history of bioenergy from sugar plantations
- 2005 – 2013: Utility scale wind developed on most major islands
- 2011 - 2017: Aggressive state policies (net metering and tax credits), high oil prices, and decreasing technology costs accelerated roof-top solar
- 2017 –2019: Slower deployment of rooftop solar due to daytime saturation (duck curve)
- 2019 – PV with storage became cost effective in Hawaii

Saturation of Rooftop PV Penetration



Wind Curtailment

- Can occur at night and mid-day
- Automatically adjusted every 4 sec

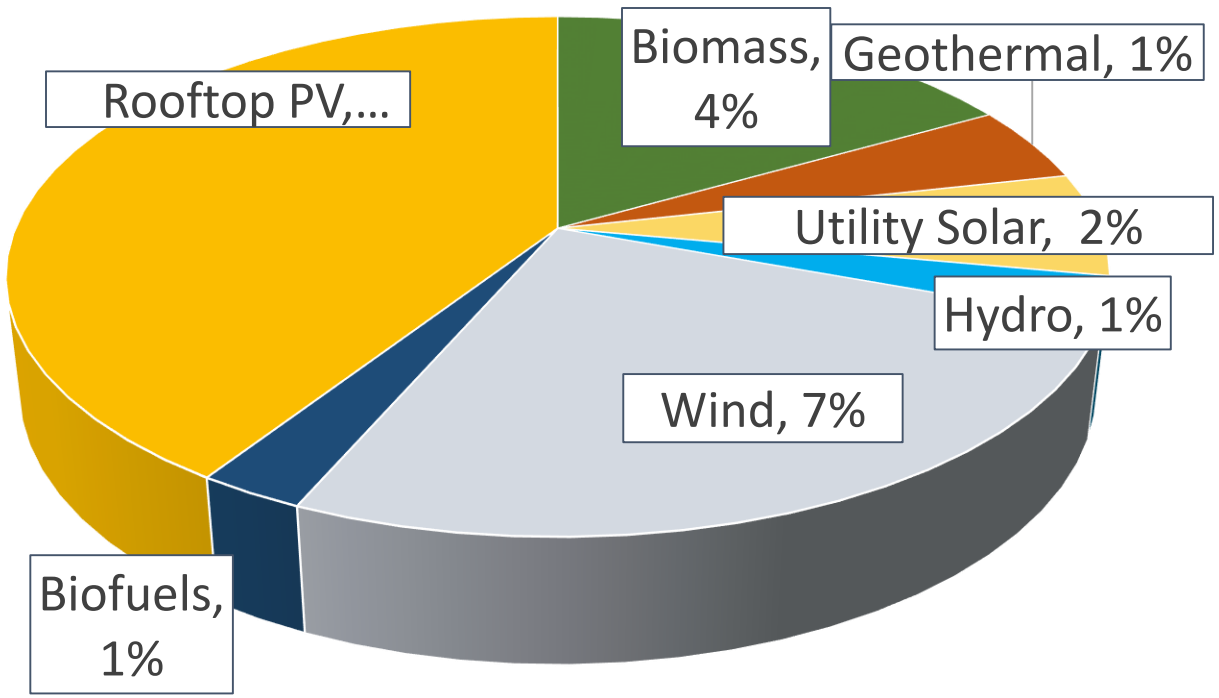
Midday

- 80MW PV ~ 45% of total load
- 40MW wind ~ 22% of total load
- 60 MW thermal dispatch – utility required minimum

Source: https://www.mauielectric.com/clean-energy-hawaii/integration-tools-and-resources/renewable-watch

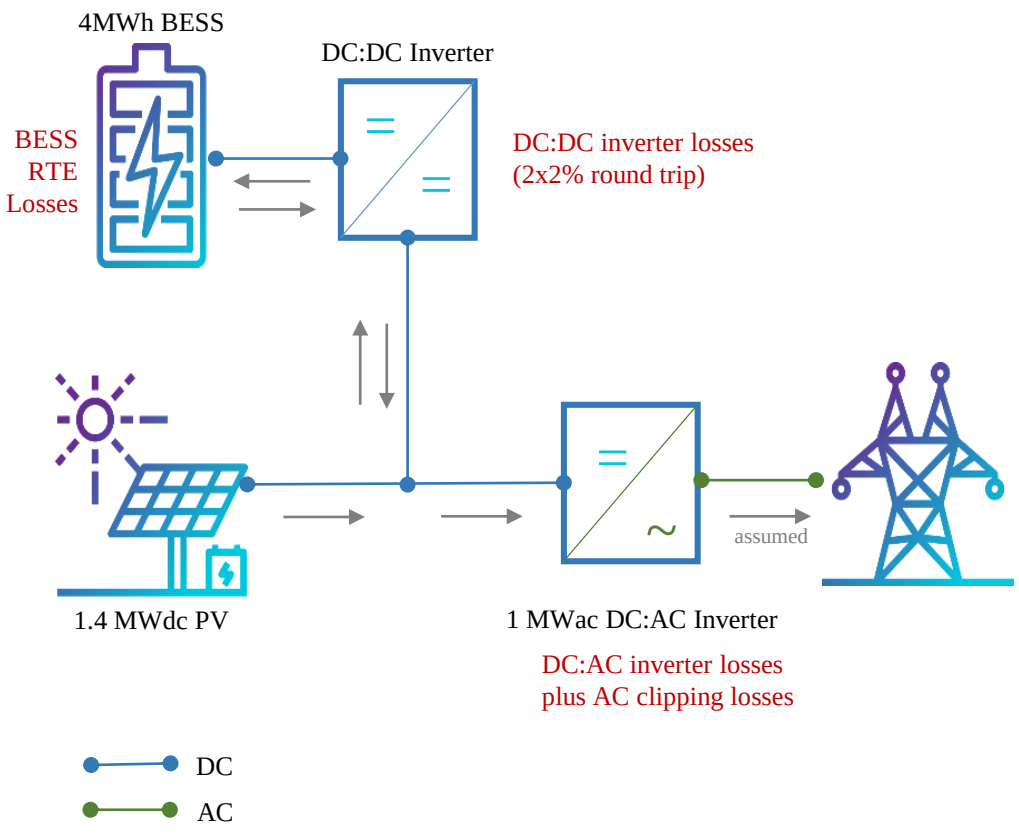
27% of Electricity from Renewable Sources by 2018

(Hawaiian Electric RPS Status Report)



- **Advanced inverters interconnection requrirements allowed very high circuit penetration - up to 300% of minimum daytime load**
- **By 2018 rooftop PV was the largest RE generation source**
- **Deployment of distributed solar slowed by new tariffs**

2019– Utilities Solicit Proposals for “Dispatchable” Renewables



- **Multiple PPAs approved allowing utility scale PV with integrated battery energy storage (BESS)**

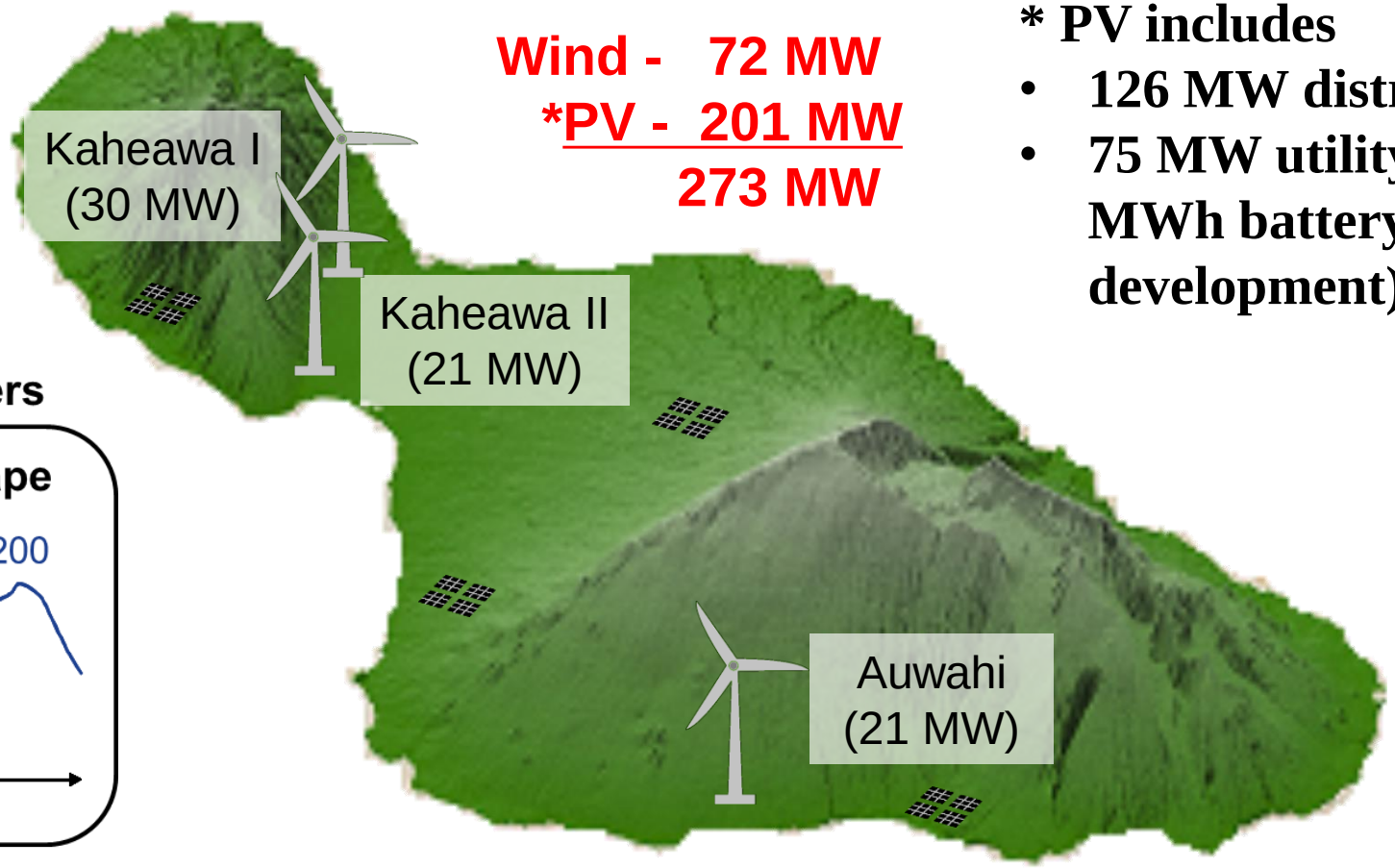
- DC PV “oversized’ relative to inverter interconnection
- BESS DC or AC coupled to PV array

- High capacity value - system nameplate sized by inverter rating
- BESS charged by PV to maximize tax credits
- BESS cycling limited by PPA

- IPP provided with fixed monthly payment based on expected system performance
- Utility responsible for economic dispatch of PV-BESS system

Policy and Economics Drive all Islands to High Levels of Variable Renewable Generation

Maui Island - *Model for High Solar and Wind Penetration*

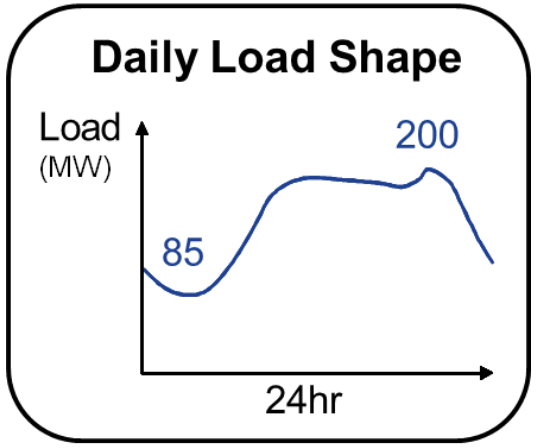


Wind - 72 MW
***PV - 201 MW**
273 MW

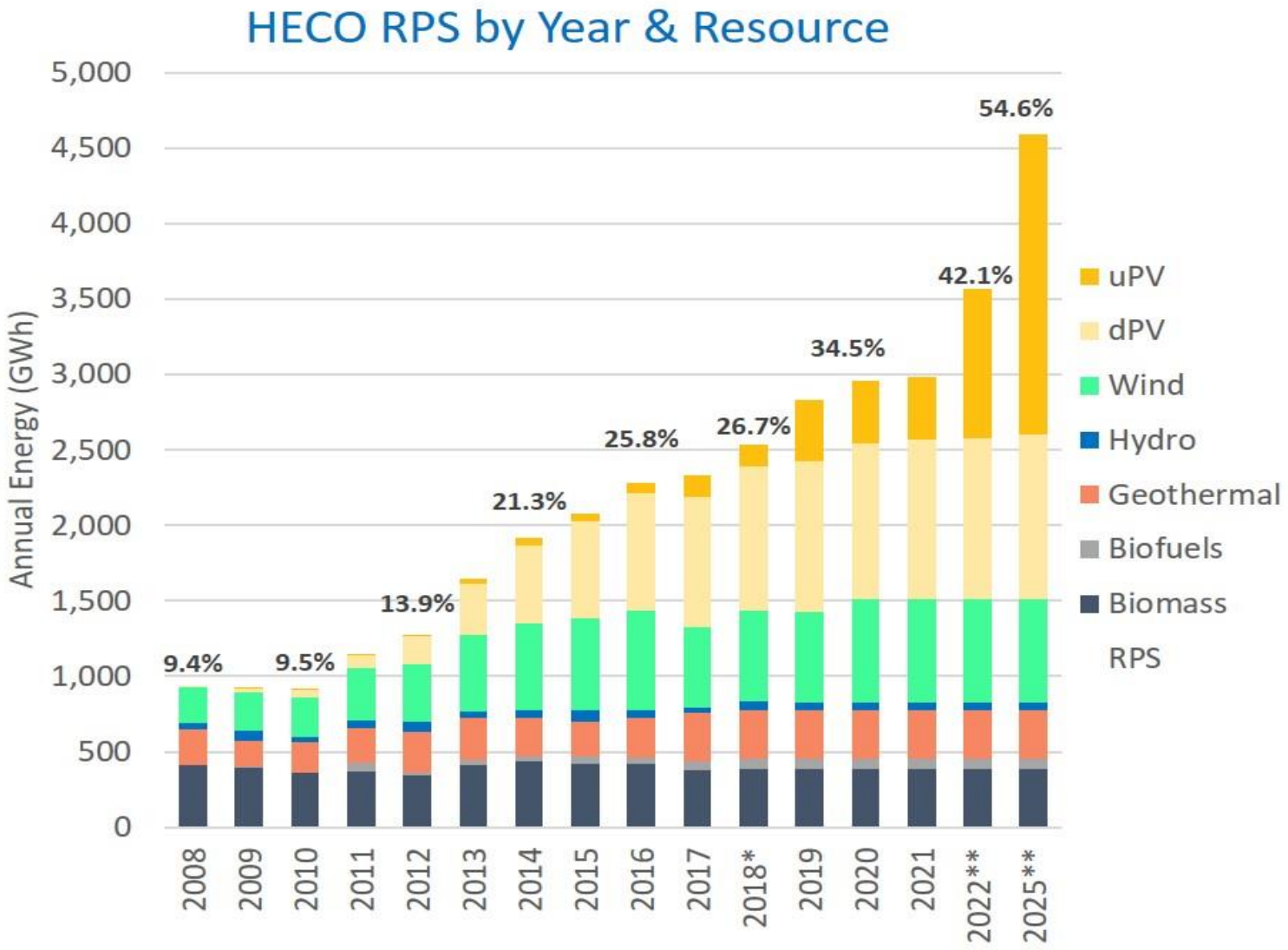
*** PV includes**

- **126 MW distributed (rooftop) PV**
- **75 MW utility scale PV with 300 MWh battery storage (under development)**

63,000 Customers



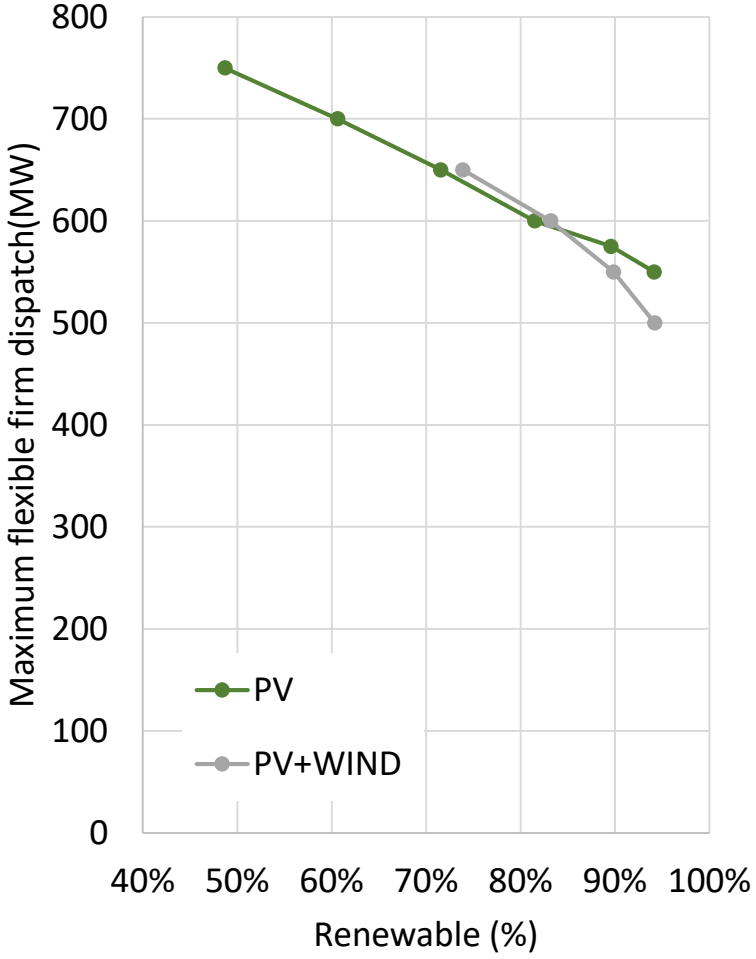
Energy Production is undergoing a Transformational Change



How do we maintain reliability (capacity) with these changes

Models show need for dispatchable capacity remains significant even at high variable penetration levels

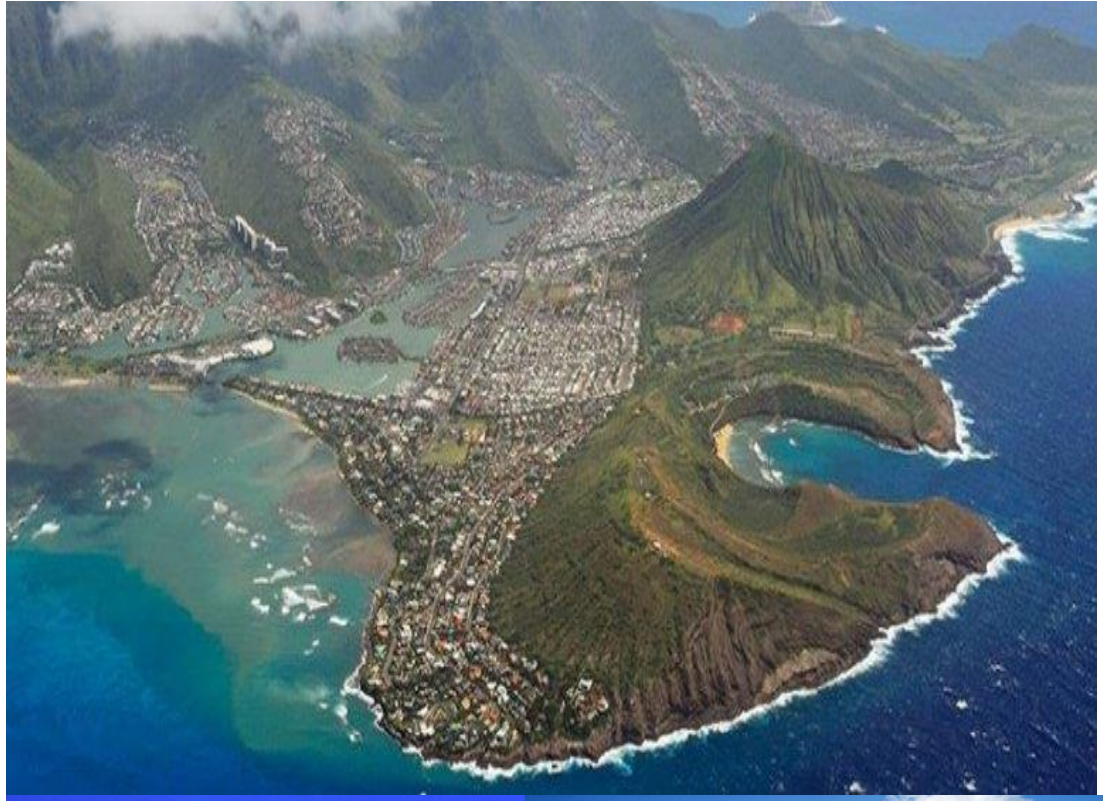
Flexible Firm Resource Max Dispatch



Flexible Firm Resource Capacity Factors

Portfolio Pathway	Variable Renewable (%)	Flexible Firm Capacity Factor			
		0 - 200 MW	201 - 400 MW	401 - 600 MW	601 - 800 MW
PV	70%	85%	42%	5%	0.1%
	80%	65%	19%	1%	0.0%
	90%	37%	8%	0.5%	0.0%

- Between **500 and 700 MW** (of 1500) of *flexible* firm capacity is needed to maintain reliability in a 70-90% variable renewable portfolio
- Actual firm capacity likely to be even higher when existing unit flexibility and outage rates are considered.
- *Options for firm flexible renewables to meet 100% goal not readily identifiable. Options may include biomass, biofuels, demand response, long duration storage or hydrogen?*



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