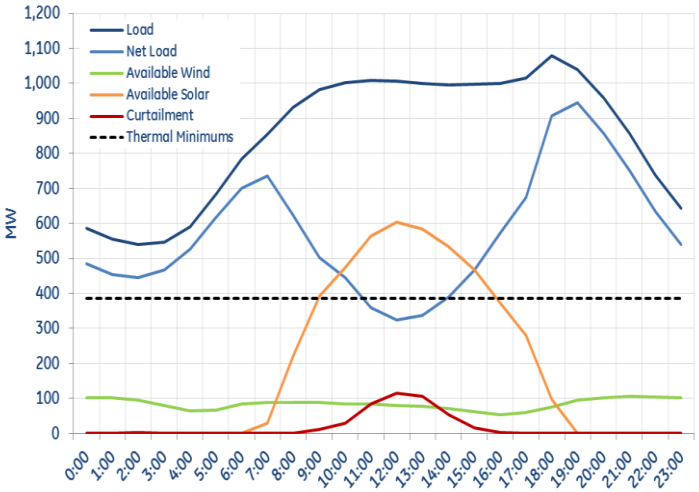
Energy Transformation through Grid Modernization



ASEAN Smart Grid Congress 5
Johor Bahru, Malaysia
December 3-4, 2019

by

Richard Rocheleau
Hawaii Natural Energy Institute
University of Hawaii at Manoa

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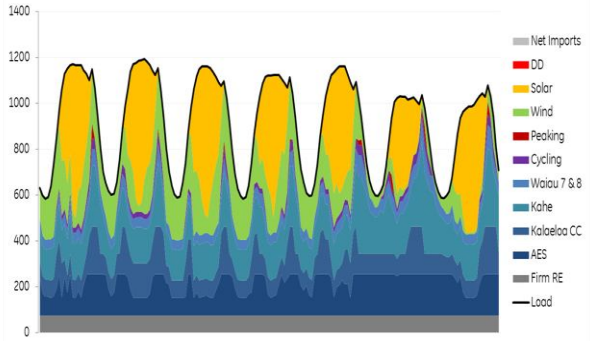
Hawaii Natural Energy Institute (HNEI)

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



- **Technical and policy support to facilitate Hawaii's 100% clean energy goals.**
- **Research, development, testing, and deployment of advanced energy technology using Hawaii as a test bed**
- **Partnerships with organizations throughout Asia-Pacific to enhance reliability, stability and resilience of energy systems**

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Hawaii's Transition to Resilient Renewable Energy

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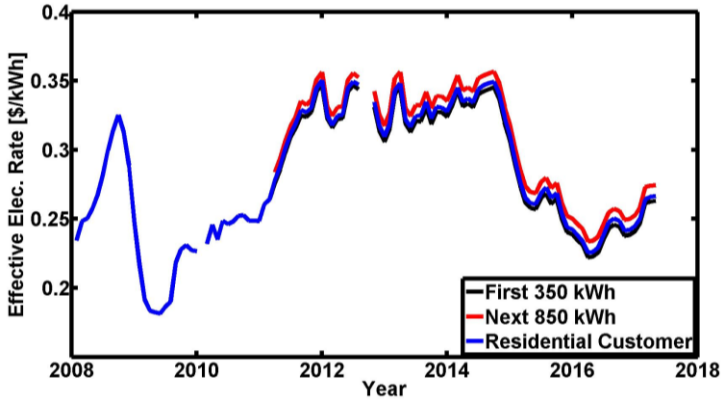
Drivers of Hawaii Energy Transformation

Energy Security - Hawaii depends on imported oil for almost all its energy needs, including over 60% of its electricity generation



Economic Risk – Hawaii has some of the highest and most volatile electricity prices in the United States

Global climate change – recent HI legislation and court decisions require HPUC to consider GHG in decision making

Hawaii's Electrical Systems

Six unique islands, four electric companies

- **No indigenous fossil fuels**
- **Each island has its own unique generation mix and renewable resources**
  - **Peak loads range from 5 to 1200MW**
  - **Variable renewables (wind and solar) are the most widely available**
- **No interconnections between islands**

Aggressive Clean Energy Goals and Policies

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

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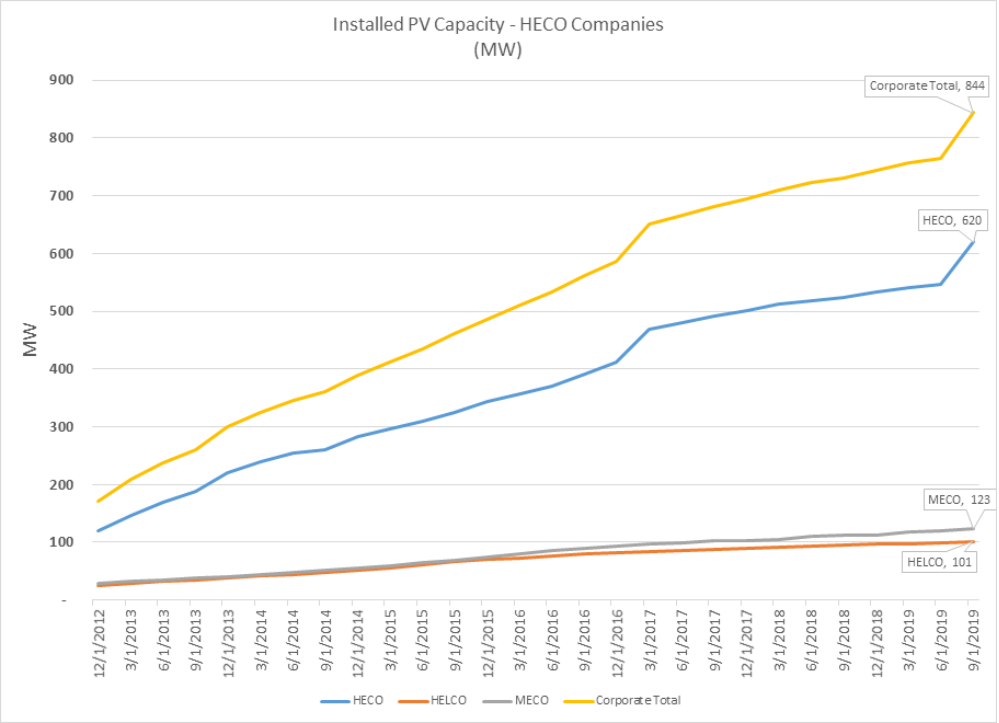
Hawaii's "Early" Energy Transition

- **Hawaii Clean Energy Initiative (2008)**
  - Partnership between Hawaii, US Dept of Energy and utility
  - Mandated aggressive renewable energy goals (RPS)
  - Established NEM and generous state tax credits

- Early development was primarily **utility scale wind.**

- Rising electricity rates and decreasing solar costs combined with existing policies led to rapid growth of **rooftop solar**



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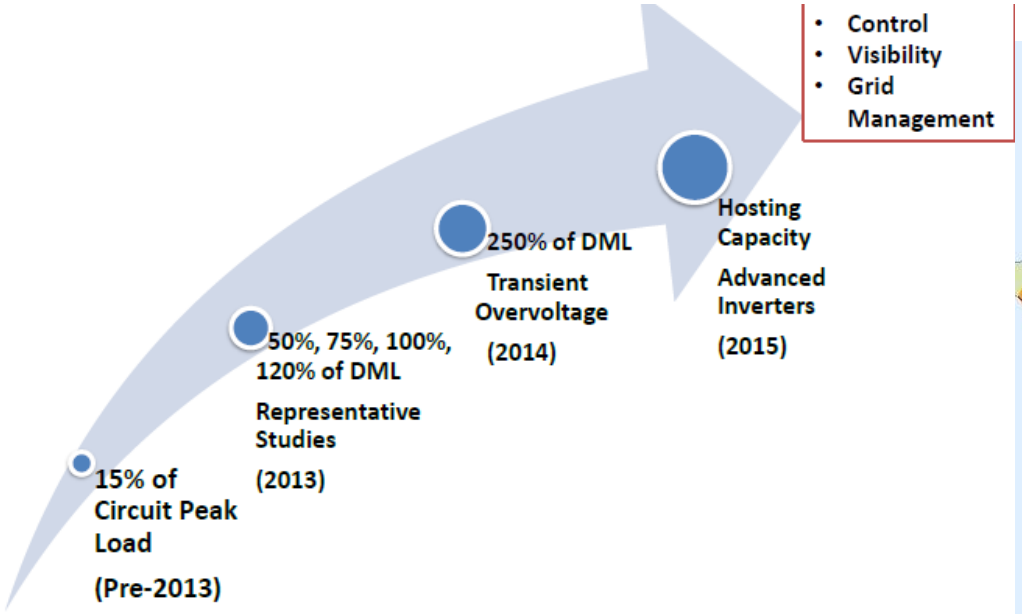
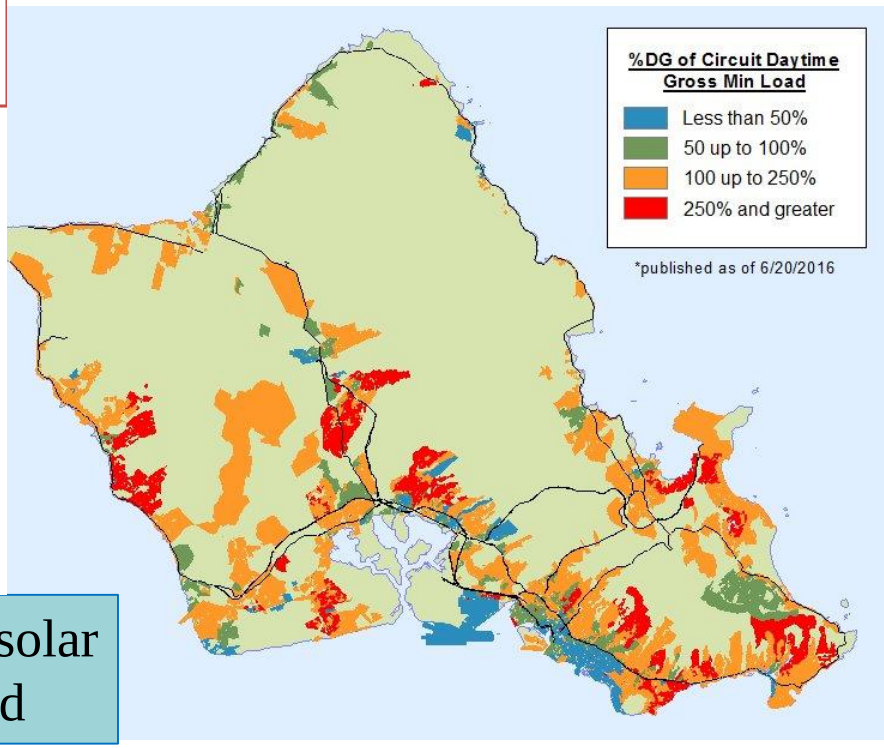
High Penetration of Distributed PV

- Interconnection rules evolved as utility and regulators gained experience
- Rules on advanced inverters to manage transient overvoltage allowed very **high circuit penetration** of rooftop solar
- Continual modification of grid operations mitigated system level barriers -– unit cycling, reduced minimum run, faster ramping
- By 2015, **system constraints** led to NEM being replaced with less favorable tariffs – grid no longer served as 'free' storage





By 2016 many circuits experiencing solar at 250% of minimum daytime load

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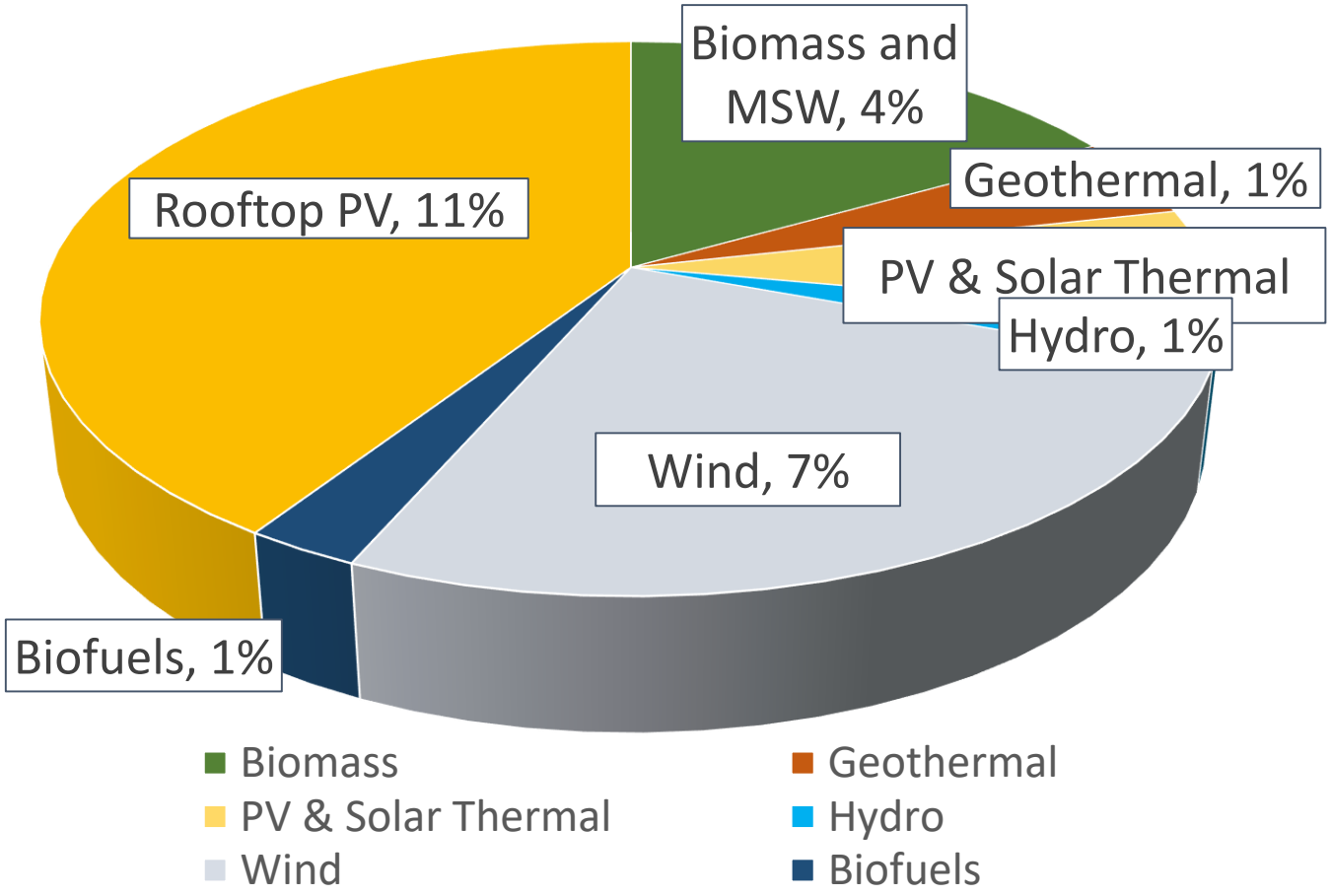
Hawaiian Electric 2018 RPS Status Report



By 2018, 27% of island energy provided by renewables with rooftop PV the single largest contributor

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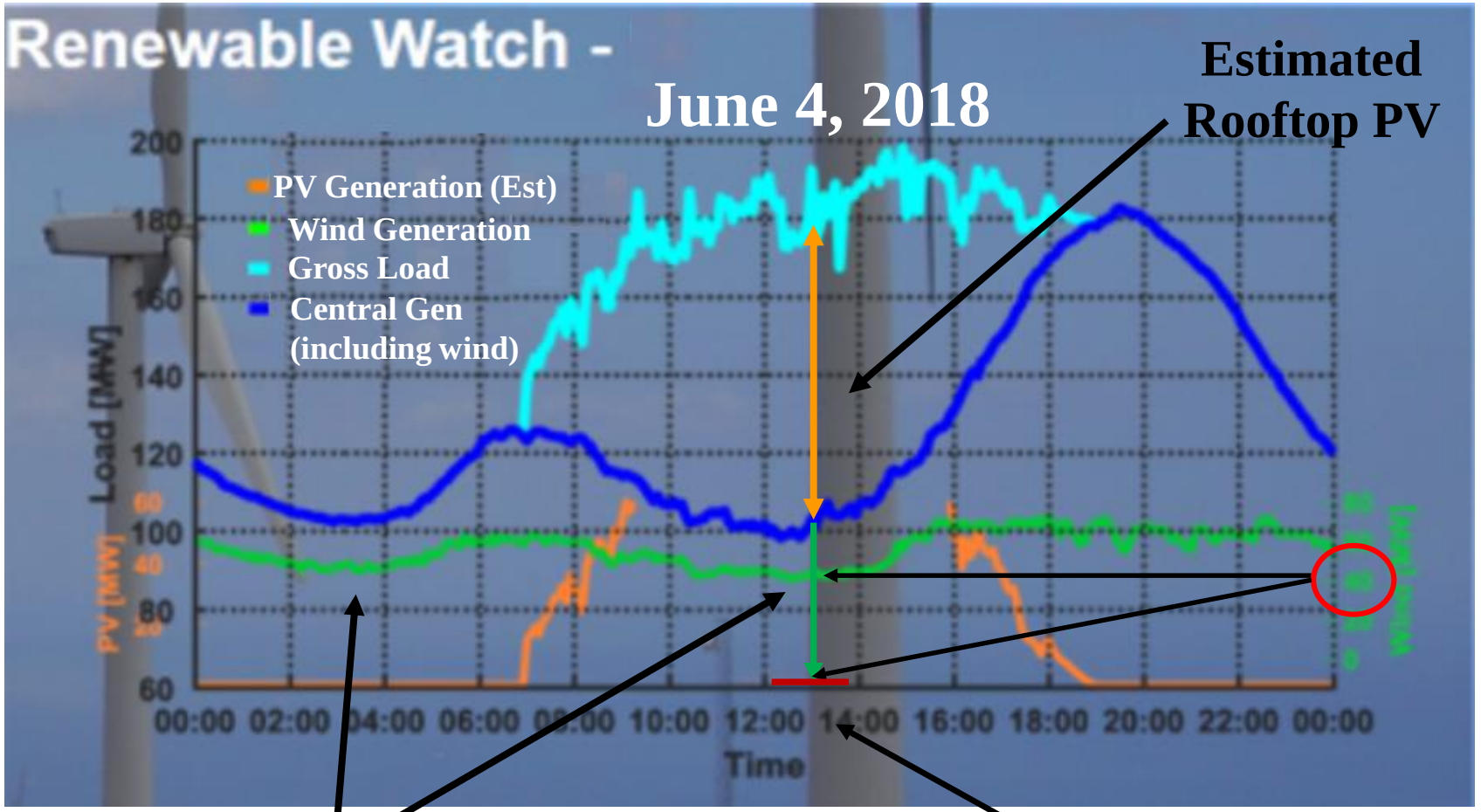
Maui Grid Operation: June 4, 2018



Wind Curtailment
Observed at night and mid-day

Midday Operations

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

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

Dispatchable Renewable Generation (2019)

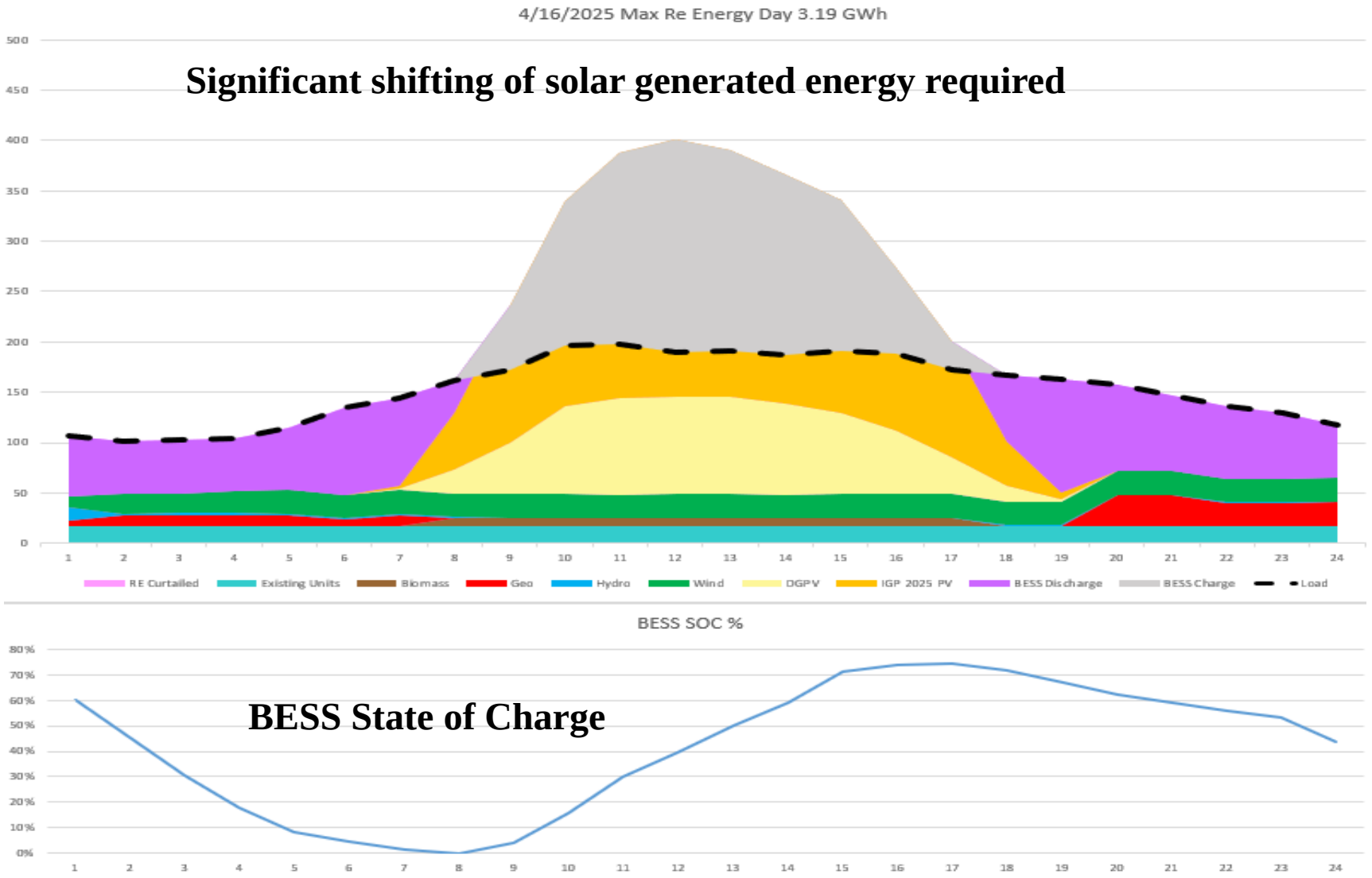
- **Phase 1 – seven contracts, expected completion 2022**
  - 275MW of PV coupled with 1100 MW-hr of Li-ion battery storage
  - $.08 - $.12 per kwh based on guaranteed utility payment and facility's energy potential.
  - Developer at risk for system availability.
  - Utility responsible for dispatch
  - Battery cycling limited to equivalent one per day
- **Phase 2 -RFP due 2020, estimated completion 2025**
  - 2,040,000MWh dispatchable variable renewables for utility dispatch
  - 200 MW storage for capacity needs
  - 108 MW storage for contingency

Estimated available renewable at completion of Phase 2

Oahu - 50%, Maui – 82%, Big Island* - 76%

Big Island Post Stage 2 Energy Mix

(assuming Stage 2 met by solar/storage)



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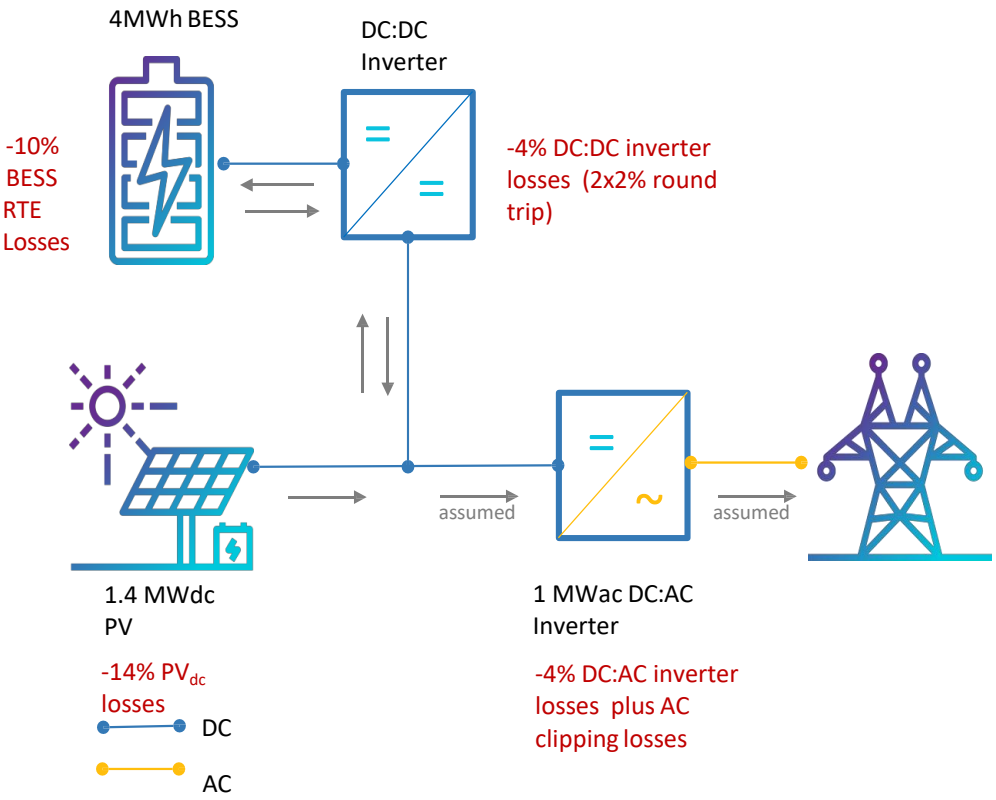
PV-Storage Operating Strategies



PV array oversized relative to inverter yields very high capacity factors (> 25%)

- What is most efficient dispatch of PV-storage system
- Can batteries load shift but also provide grid services
- How do we manage BESS to work with future smart grids – EV, demand response, more distributed solar, retirement of thermal generation
- Can PV-storage fully replace capacity resources currently provided by thermal generation
- What is value of short term and multiday solar forecasting

Ongoing "Smart Grid" Activities

- **Integrated Grid Planning** – PUC approved process intended to improve coordination across distribution, transmission & generation resources
- **Performance-Based Regulation**: new rate recovery structure to consider customer experience and societal outcomes in determining utility compensation.
- **Advanced Transportation**: Increase customer options and align transportation with state energy goals. Is electrification the best objective?
- **Resilience**: Modify Hawaii energy system for better response to natural disasters

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- **Distributed storage and real-time voltage control :** New measurement methods and control technologies needed to allow continued growth of distributed PV
- **Grid Services -** Utility can no longer rely only on conventional generators to provide grid services. New tariff structures for grid services being developed.
- **Loss of inertia:** What are the operational constraints and safety limitations for grids dominated by inverter-based generation. What new technologies are needed
- **Data Management -** Advanced metering infrastructure, data management system, and communications & controls network are critical

Hawaii is just beginning its evolution to Smart Grids

Asia Pacific Partnerships and Opportunities

Asia Pacific Regional Energy Systems Assessment APRESA

HNEI program to support development of resilient renewable energy systems in the Asia Pacific including capacity building, technology options, operating strategies, and policy enhancements

Funded by the Office of Naval Research

Export lessons learned from the Hawaii experience

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Vietnam Electricity and Renewable Energy Authority of Vietnam (EREA, MOIT)

MOU signed October 25, 2019

- Purpose is to establish a framework to identify, research, and analyze issues of the renewable energy policy, strategy, and deployment in Vietnam.
- Potential activities
  - Research and analysis to support national policy decision making
  - Training of key energy institutions and decision makers
  - Exchange program

National Institute for Science,Technology, Policy and Strategic Studies (VISTI, MOST)

Agreement executed August 26, 2019

- Objectives
  - Map the innovation system in renewable energy in Vietnam including identification of actors and the relationship among them
  - Conduct an analysis of the policy to support development of the innovation system in renewable energy in Vietnam.

- Joint effort between VISTI and HNEI

Electricity Generation Authority of Thailand

MOU signed February 28, 2018

- Purpose is to establish the framework to identify, research, and analyze barriers to the electricity generation from renewable energy development and grid integration challenges in Thailand
- HNEI and EGAT have initiated a renewable integration assessment of the EGAT power system considering increasing levels of renewable energy resources over the next five to ten-year horizon.
- HNEI conducted hands on training with EGAT planning engineers focused on new tools and methods needed to perform renewable integration analysis.

Chulalongkorn University, Faculty of Engineering

Renewed on January 1, 2019

- Purpose is to establish a framework for multi-year collaboration that leads to enhanced resilience and reliability of energy while enabling a clean energy transition through grid modernization and the advancement of smart grid initiatives
- Projects (planning underway)
  - **Thailand Regional Solar Forecasting** – Collaboration in support of EGAT to develop algorithms and ICT infrastructure to demonstrate regional solar forecasting
  - **Chulalongkorn Smart Campus Project** – HNEI's Advanced Real-time Energy Monitor System (ARGEMS) being deployed in support of Chula's smart grid integration project.
  - **Provincial Electricity Authority of Thailand Collaboration** – Collaboration to develop a capacity building program focused on smart grid technologies for PEA engineers. Workshops scheduled in Hawaii in March and July 2020

Other APRESA Activities

Universiti Teknologi Mara (UiTM): Negotiations ongoing to finalize MOU supporting information and personnel exchange

AdiCET, Chiangmai Rajabhat University: Negotiating agreement to support regional biomass/bioenergy assessments and support processing of waste for energy

Center for Regional and Urban Studies, HoChiMinh City: Collaboration to design and implement a public solar photovoltaic demonstration project in one or more public parks to raise public awareness of the feasibility and benefits of renewable energy (Agreement executed April 2019)

International Best Practices for Renewable Portfolio Standard (RPS) Policies, 2019: At request of the Government of Vietnam, HNEI partnered with the US National Renewable Energy Laboratory to examine effective RPS policies globally https://www.nrel.gov/docs/fy19osti72798.pdf

Other Memorandum of Understanding

Naresuan University (December 9, 2018)

Chiang Rai Rajabhat University (January 23, 2019)

MAHALO

For more information, contact:

Rick Rocheleau
Hawaii Natural Energy Institute
1680 East-West Road, POST 109
Honolulu, Hawaii 96822

Office: (808) 956-8346
Mobile: (808) 389-9944
E-mail: rochelea@hawaii.edu
Website: www.hnei.hawaii.edu

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University of Hawai'i at Mānoa