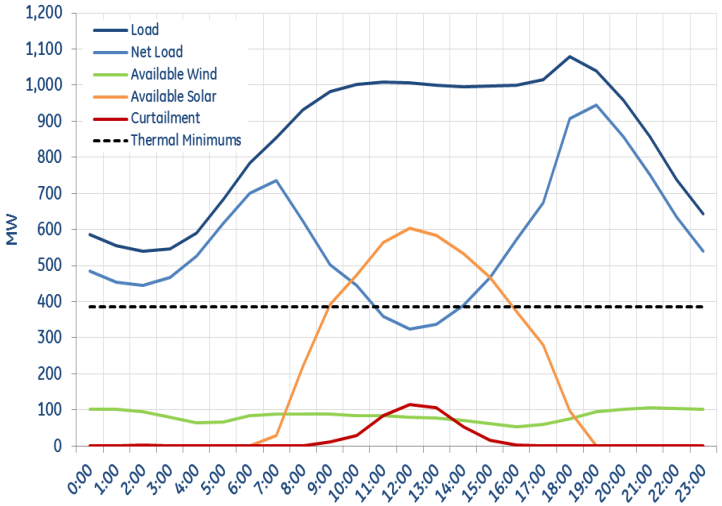
Hawai‘i Energy: Status; Issues; Storage



DOE/OE Storage Peer Review

Rick Rocheleau
Hawaii Natural Energy Institute
University of Hawaii at Manoa

September 27, 2016

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Hawaii Natural Energy Institute (HNEI)

Organized Research Unit in School of Ocean and Earth Science and Technology at University of Hawaii

- Founded in 1974, **established in statute in 2007**
- Work with government organizations to reduce state dependence on fossil fuels
- Diverse staff (~90) - engineers, scientists, lawyers; students and postdoctoral fellows, visiting scholars
- Work across many sectors of alternative energy
- Mandated by statute to support state efforts to reduce use of fossil fuels**.**
- Primary funding: DOD (ONR, NavFAC), US DOE, **State of Hawaii via barrel tax**

RDT&E; Analysis; Policy support; Education

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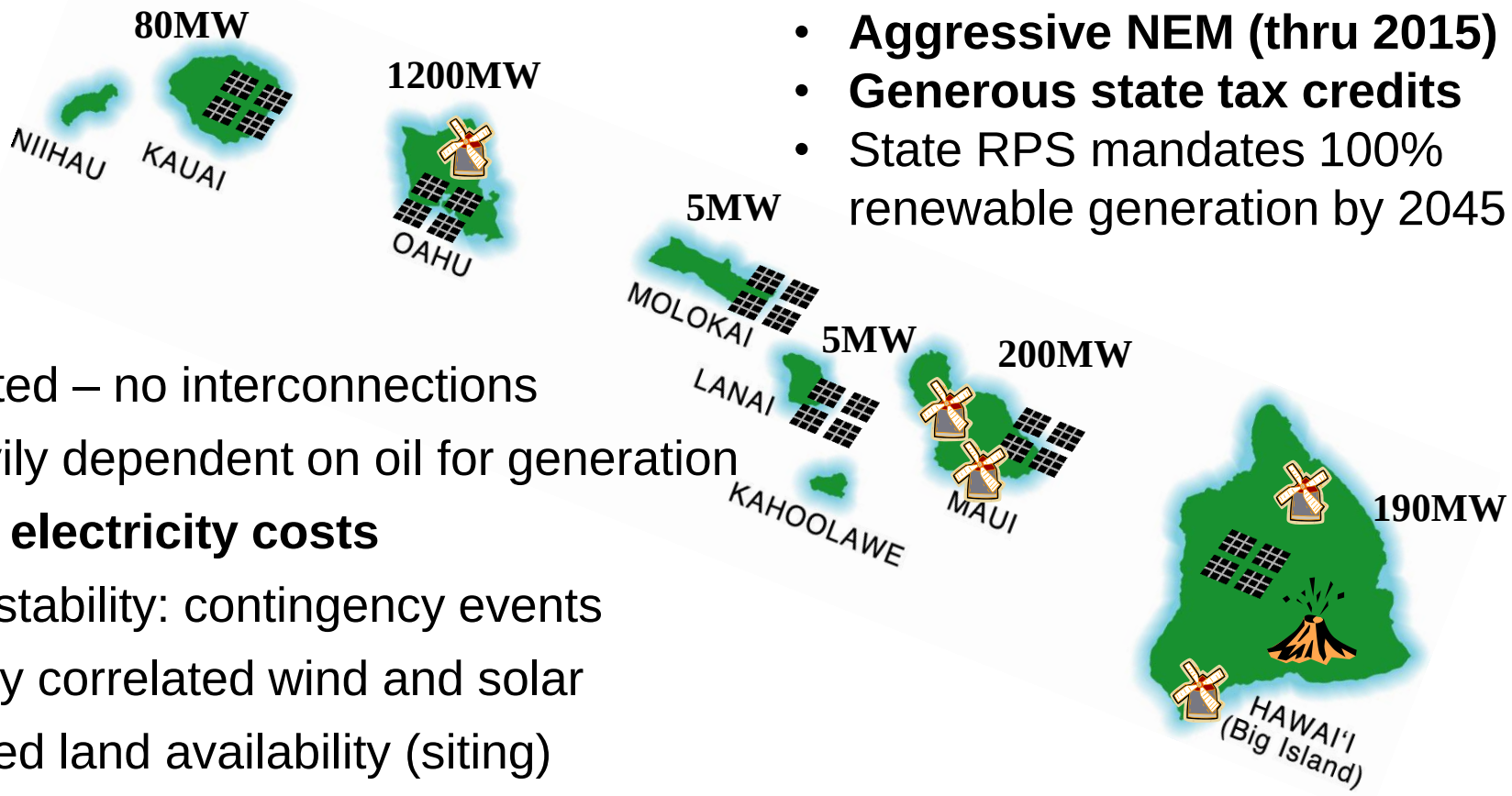
Hawai‘i: 4 electric utilities; 6 unique island grids



- **Aggressive NEM (thru 2015)**
- **Generous state tax credits**
- State RPS mandates 100% renewable generation by 2045

- Isolated – no interconnections
- Heavily dependent on oil for generation
- **High electricity costs**
- Grid stability: contingency events
- Highly correlated wind and solar
- Limited land availability (siting)

Opportunity to engage new technologies and solutions

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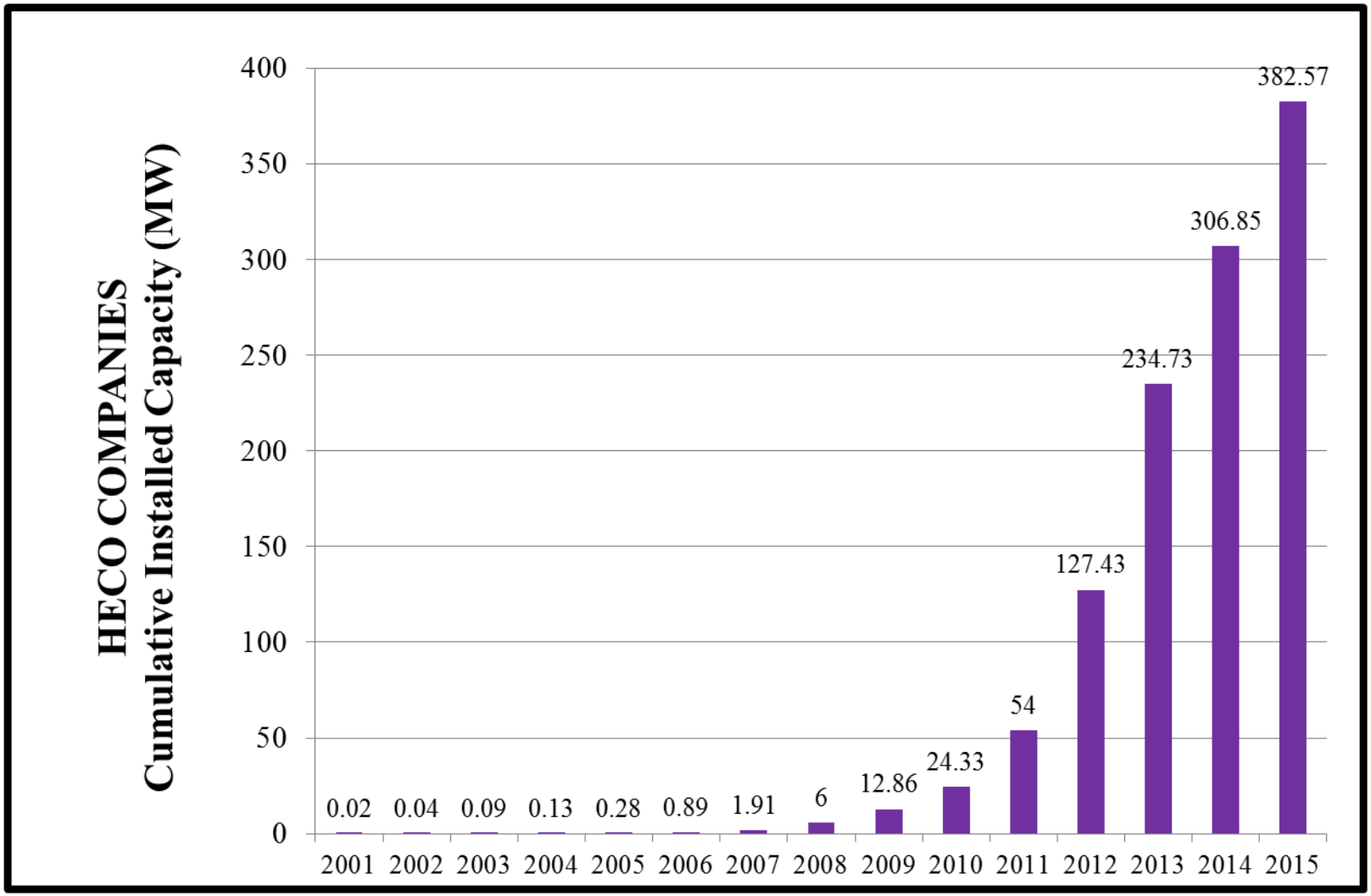
NEM policy has led to highest per capita solar in the US



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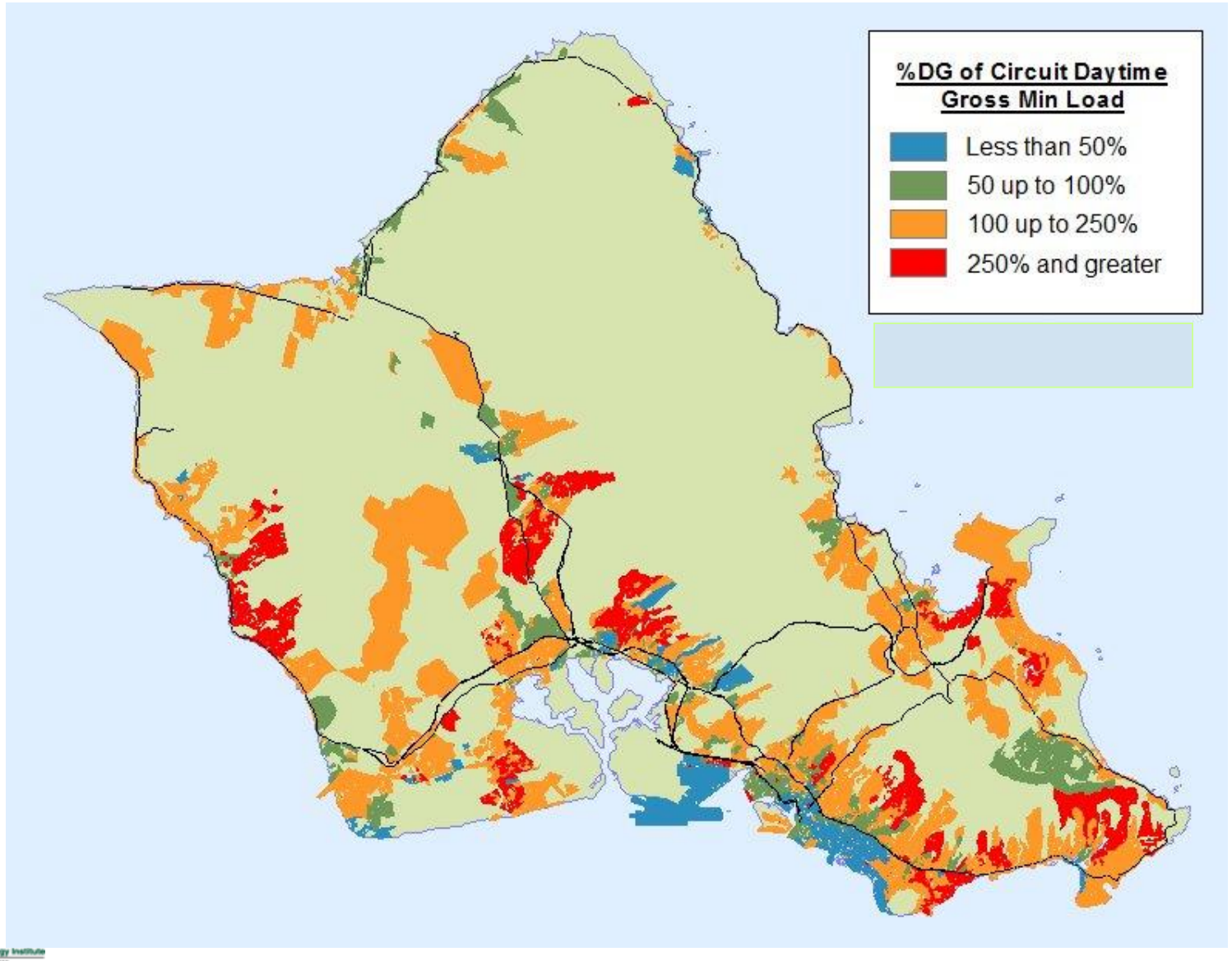
High PV Circuit Penetration Levels > 250% of daytime minimum load (Oahu)



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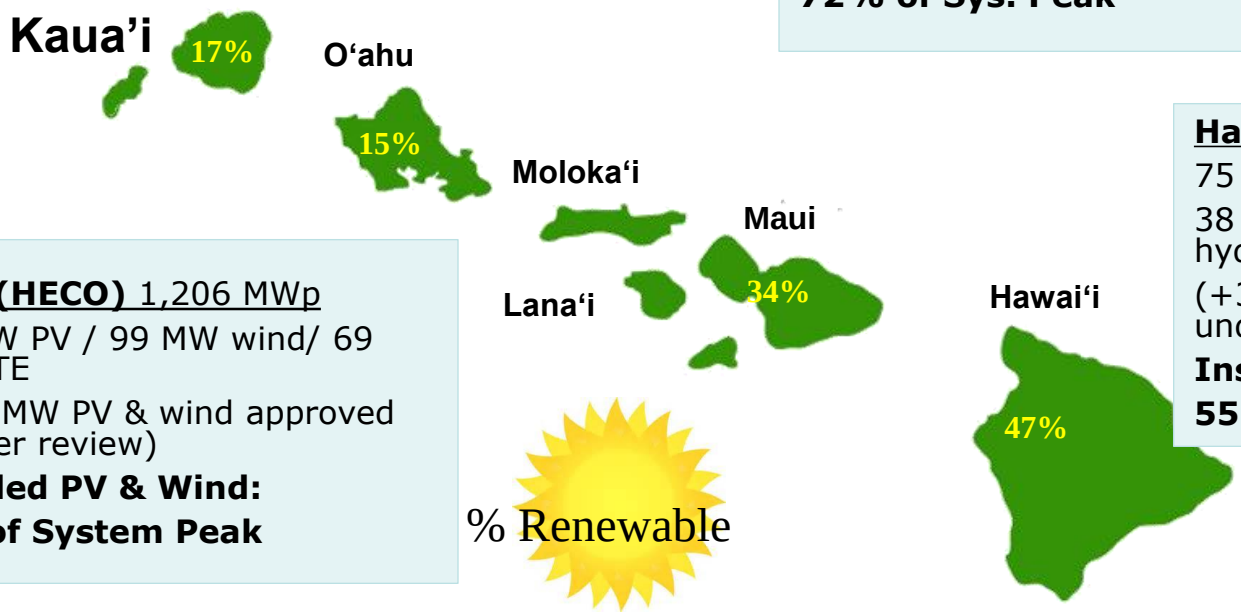
Renewable Mix and Penetration Varies by Island

Kauaʻi (KIUC): 78MWp
52.6 MW PV / 7 MW biomass / 9 MW hydro
(+6.6 MW PV under review)
Installed PV: 67% of System Peak

Maui (MECO) 202 MWp
74 MW PV / 72 MW Wind
(+40 MW PV approved or under review)
Installed PV & Wind:
72% of Sys. Peak



Oahu (HECO) 1,206 MWp
329 MW PV / 99 MW wind/ 69 MW WTE
(+227 MW PV & wind approved or under review)
Installed PV & Wind:
35% of System Peak

Hawaiʻi (HELCO) 192 MWp
75 MW PV / 30 MW wind /
38 MW geothermal / 16 MW hydro
(+31 MW PV approved or under review)
Installed PV & Wind:
55% of System Peak

Total PV (installed, approved, under review) = 835MW ~ 50% of peak. Peak occurs after solar production stops

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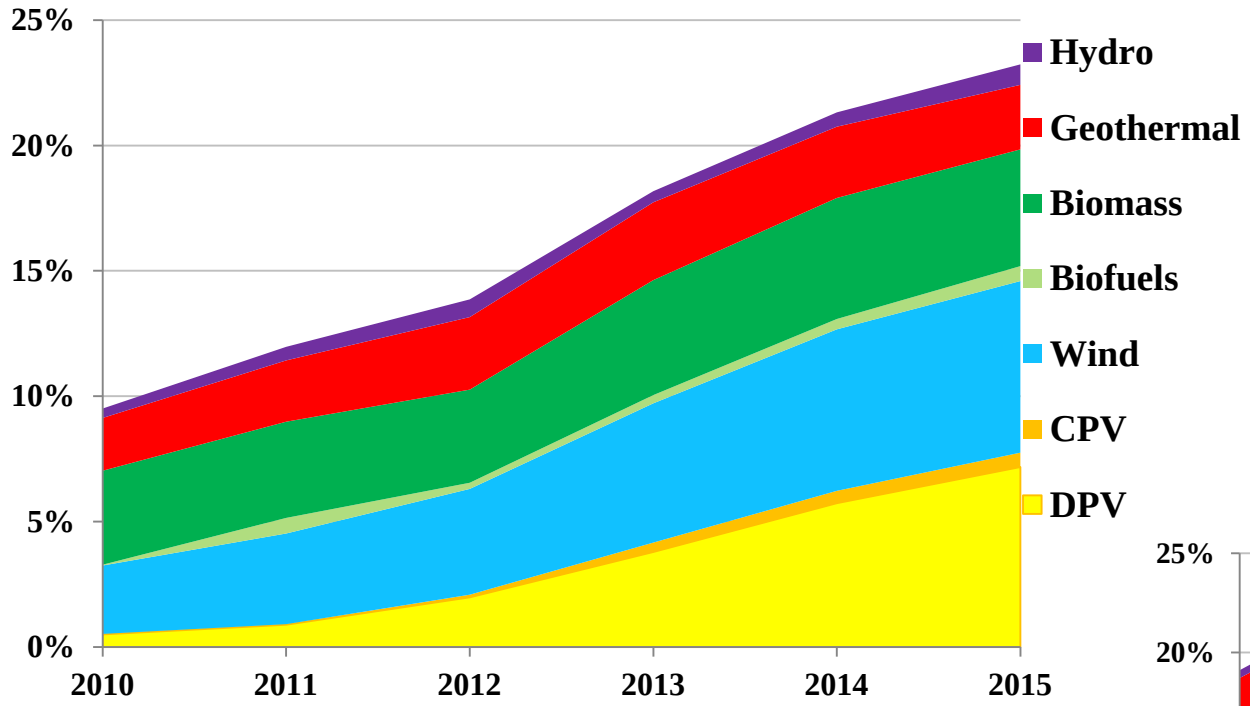
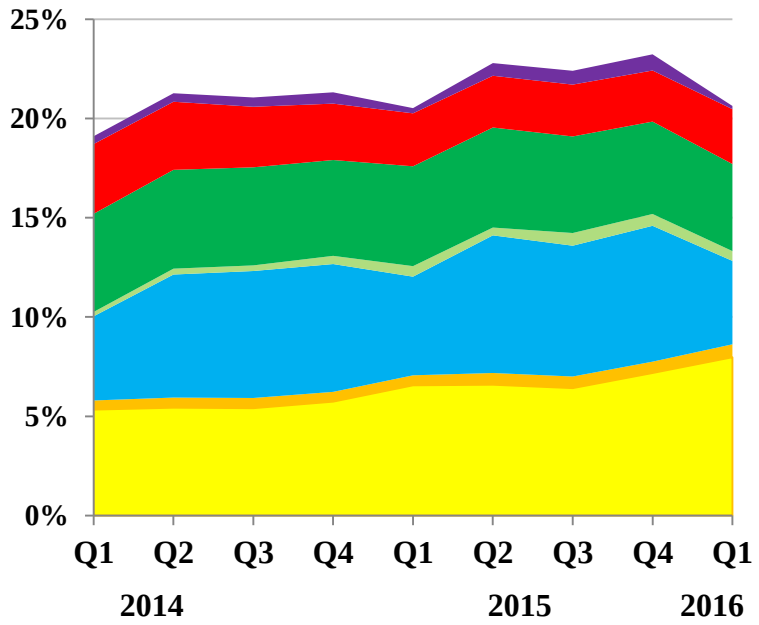
How Much More Low-hanging Fruit?

Last 5 Years



Last 9 Quarters



Source: Hawaiian Electric Key Performance Metrics, https://www.hawaiianelectric.com/about-us/key-performance-metrics/renewable-energy

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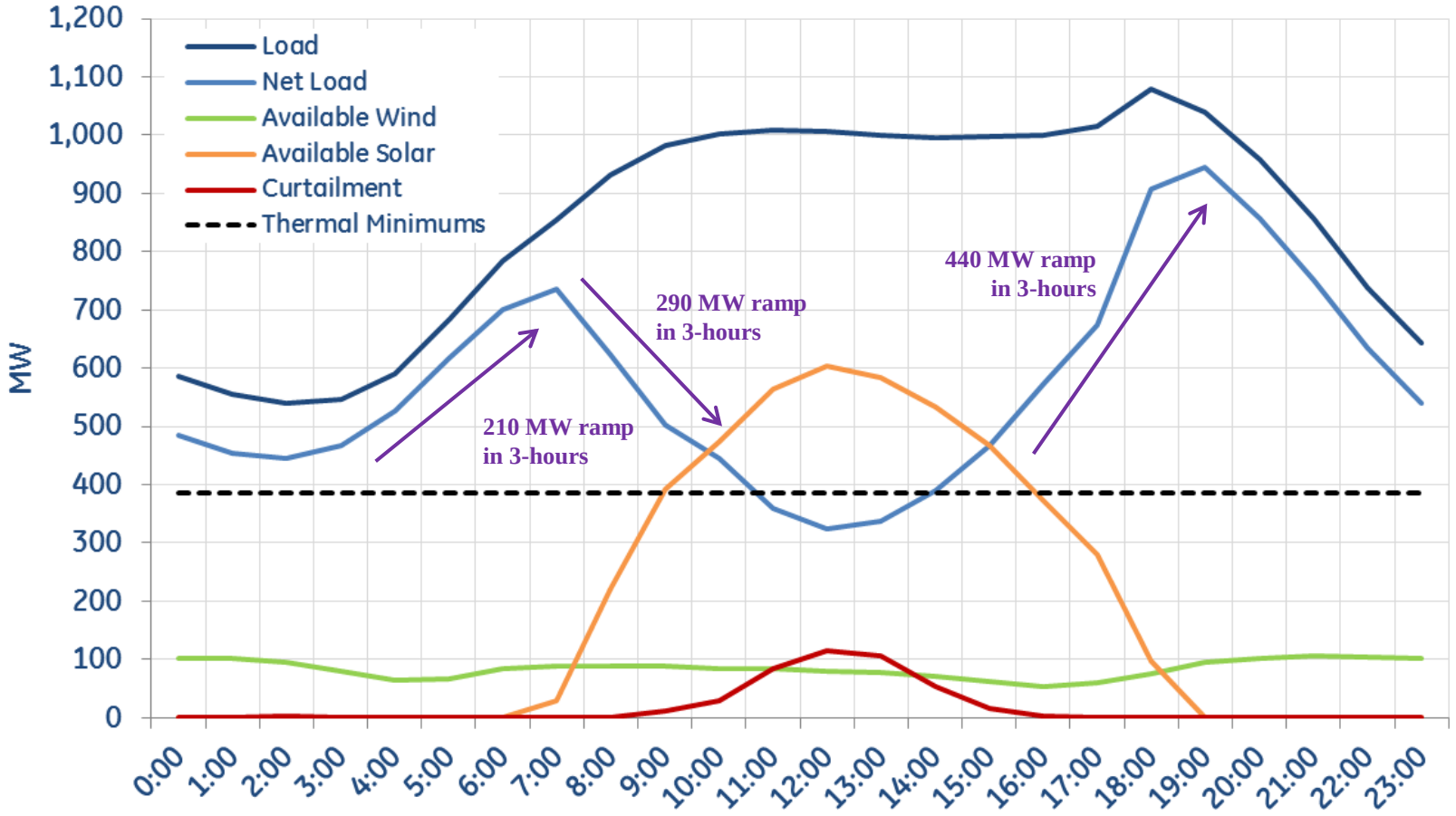
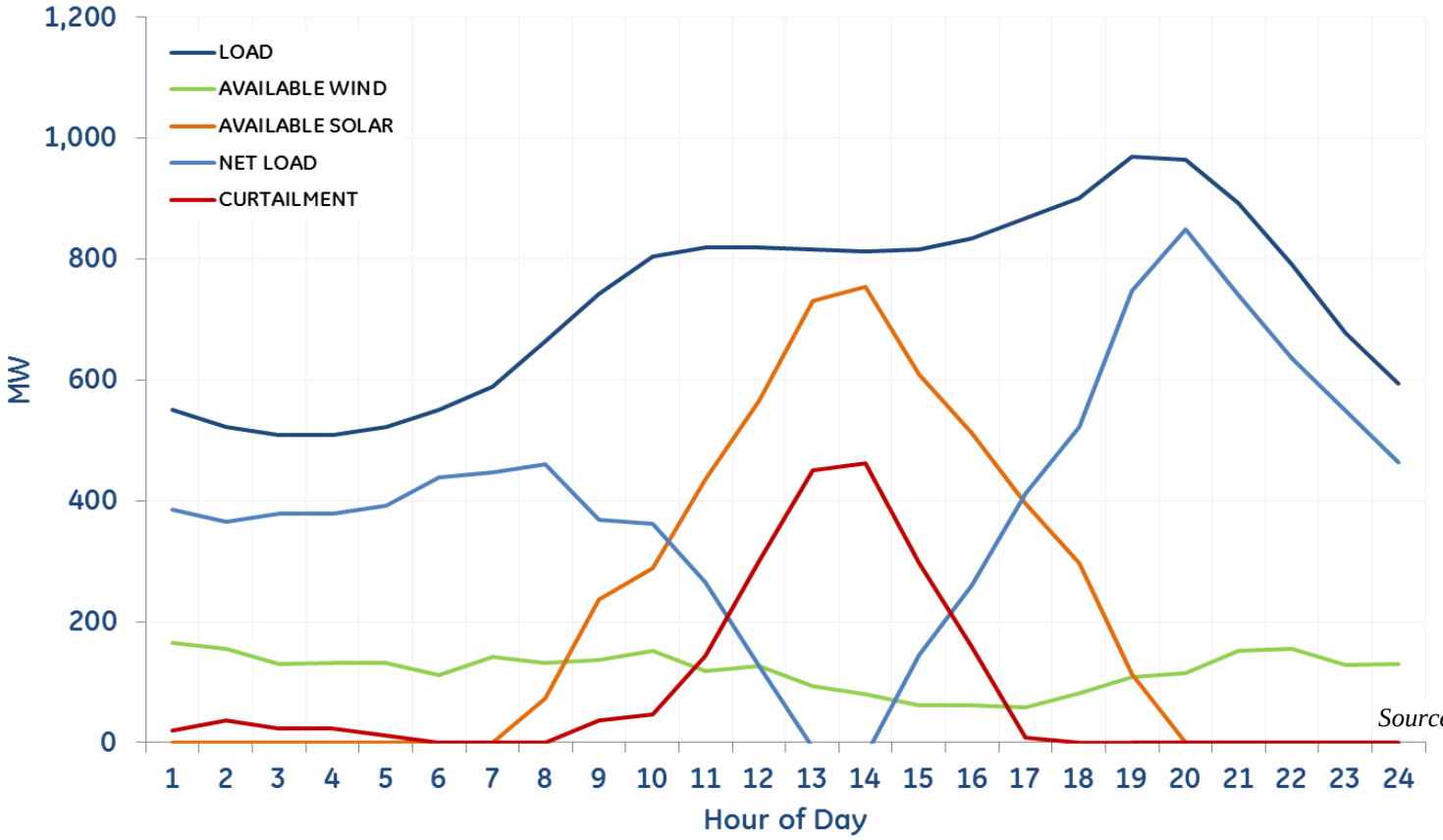
Power Systems Modeling for Grid Planning

- Established and experienced team
  - HNEI: Technical lead, overall coordination
  - GE: Validated system models, Hawaii experience
  - Advisory committee includes HPUC, DBEDT, USDOE, HECO, MECO, HELCO, energy developers
- Models and procedures **accepted by broad range of stakeholders**
- Six studies completed www.hnei.Hawaii.edu including different resource mixes, island interconnections, grid modifications, dynamic stability
- Potential pathways to higher renewable penetration identified
- **New techniques developed to identify stability risk over wide range of generation technologies**
- **Ongoing studies focus on stability, reliability, power quality, and mitigation (including transportation, DR, storage**)

Oahu: Average March day with 26% available wind and solar



Oahu: “High Renewable” March day with 26% available wind and solar

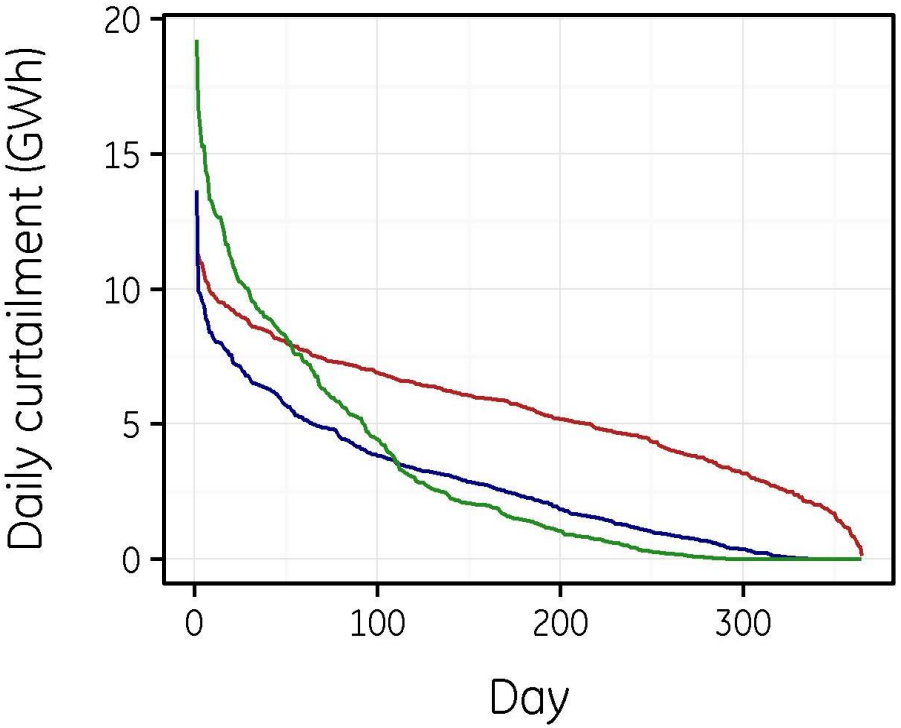


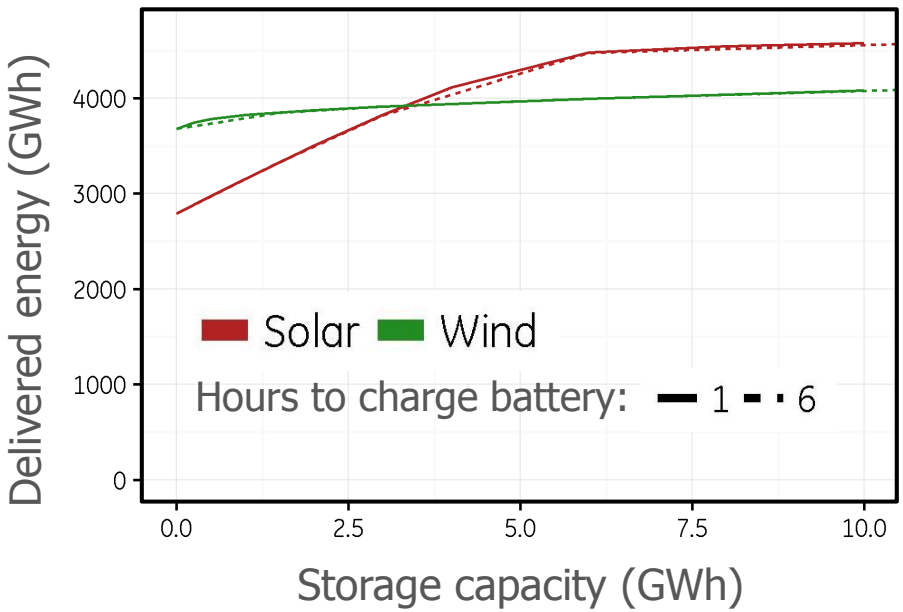
Source: Hawaii RPS Study

Stability and operations at risk even at ‘moderate’ penetration

Storage Effectiveness

Advanced grid, 60% W&S penetration



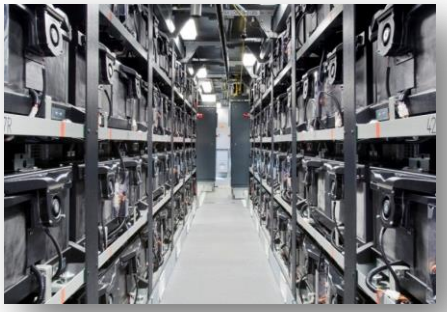


- **Storage more effective for solar than wind - at least in Hawaii**
- **Clustering of high and low wind curtailment days significantly lowers effectiveness of storage**
- **Use (and cost) of storage must consider specific resource/grid behavior**

Grid Scale BESS Projects (HNEI)

Demonstrate optimized BESS operating strategies for high value grid applications

photos courtesy of Altairnano



Upolu Point, Hawaii Island (1MW, 250kWh)

- Modeling showing benefit completed in 2007
- Frequency regulation and wind smoothing
- 3.3 GWh over 3yrs, > 6000 full cycles

Molokai Secure Renewable Microgrid (2MW)

- Operating reserves (fault management), frequency regulation,
- Fast response decision and control (<50ms response)

Campbell Park industrial feeder with high penetration (1MW)

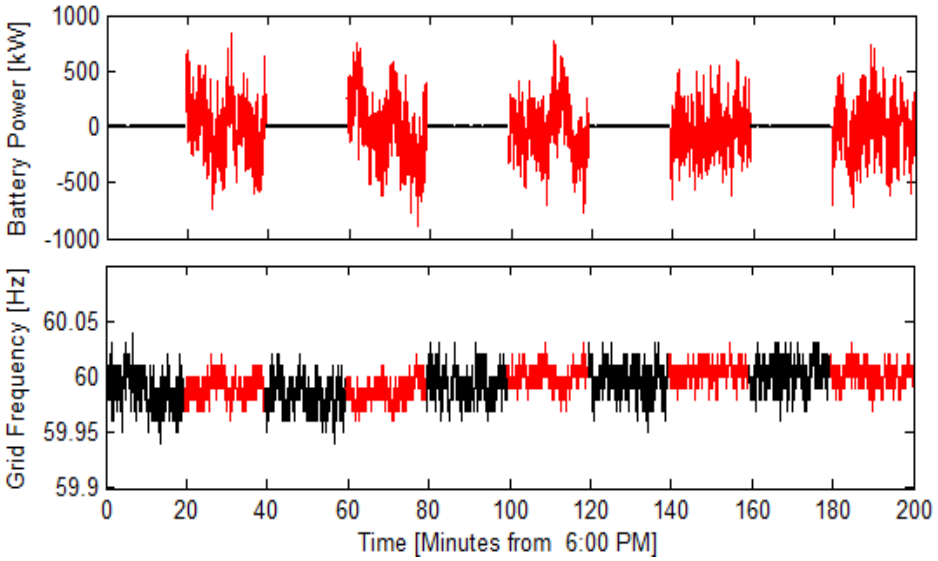
- Power smoothing, voltage and VAr support, and frequency regulation

Laboratory testing of single cells

- Novel technique to characterize state-of-health
- Performance models to predict lifetime of grid scale BESS

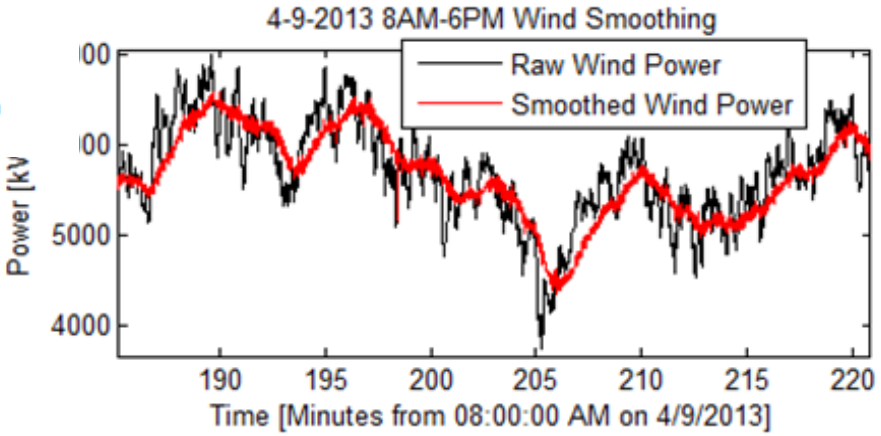
Grid Scale BESS Projects (HNEI)

Select Results



1MW BESS reduces Big Island frequency variability up to 40%

Wind smoothing: Significant reduction 1 min ramp rates



- Reduce battery cycling while maintaining grid benefit
- Integrate with other technologies for longer events
- More analysis of utility value

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Hawaiian Electric
Maui Electric
Hawai'i Electric Light

NEWS RELEASE

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FOR IMMEDIATE RELEASE

Utility-scale battery system goes into service at Campbell Industrial Park

Two-year demo to determine how storage can smooth journey to 100% renewables

September 23, 2016: 3rd HNEI BESS on-line

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The Path Forward

- Renewable integration challenges are non-linear, low hanging fruit is exhausted, need creative and novel solutions
  - Can no longer rely on conventional generators to provide “ancillary” services and grid stability…
  - Curtailment will become a reality… learn to manage it and use it for productive purposes
  - Optimize mix of solutions
- Distributed PV will play a prominent role in the future grid, but need policies that promote a mix of renewable technologies
- Policy needs to offer freedom of solutions - technology needs to be tailored for specific power systems

- Storage will be very important, but not the only tool
- Reliability of storage is becoming more critical – small changes in outage rates can have big impact on “Loss of Load Expectations”. How do we build storage outages into models?

Thanks to:
Tom Gorak (HPUC)
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GE (Derek Stenclik)

MAHALO

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