Overview of Storage Issues and Projects on the Island of Hawai‘i

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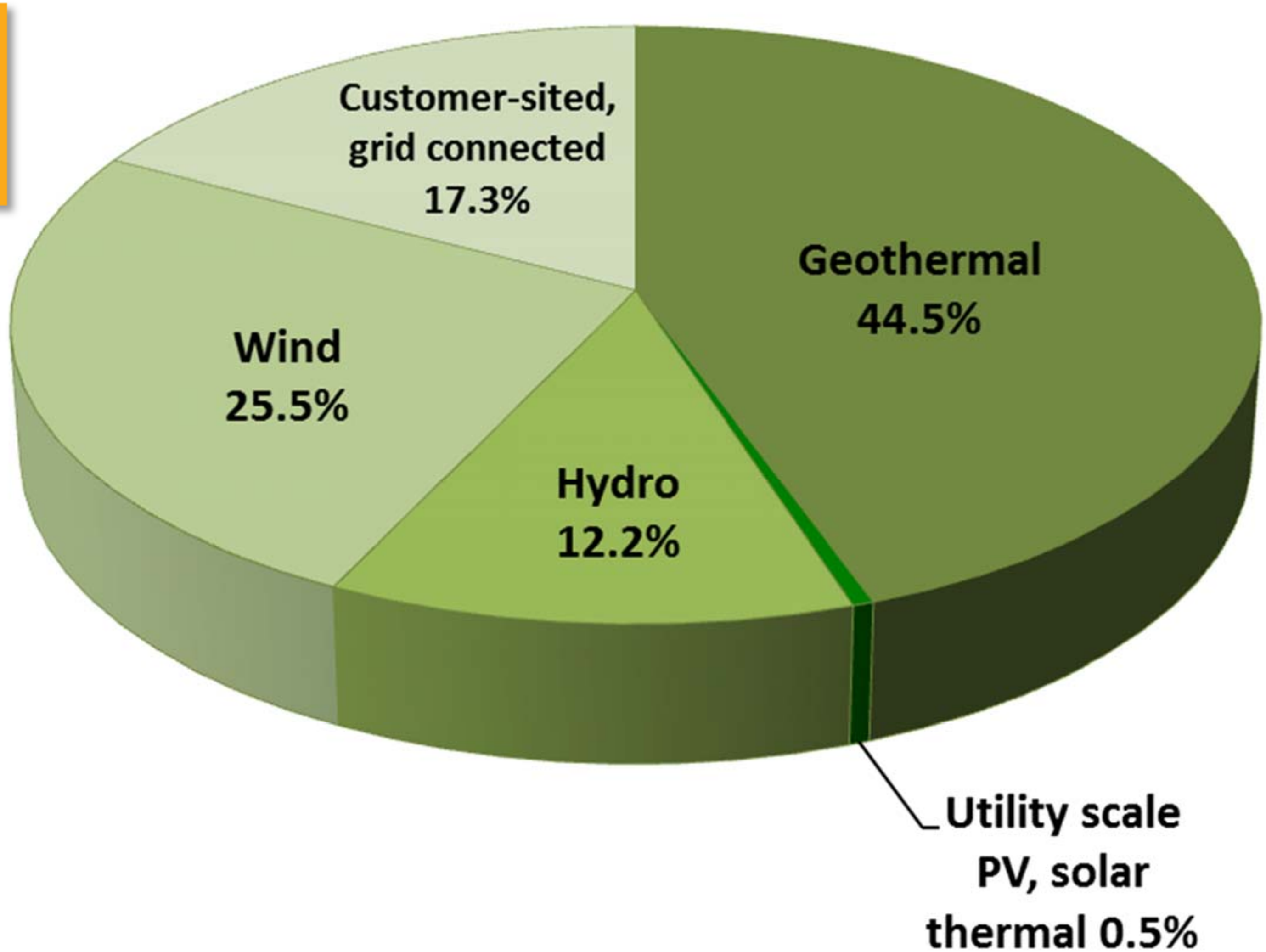
Hawai‘i Island Exceeds RPS Goal

48.7% in 2015



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SOURCE: 2015 Sustainability Report

* Includes amount of electricity generated by Hawai‘i Electric Light, purchased from independent power producers, and produced by rooftop solar systems

Challenges of High Renewable Penetration

- System Hosting Capacity - Excess Energy
  - Storage
  - Unit Turn down
  - Demand Response
  - Curtailment
- Storage provides a resource unlike any other in the energy market
  - Generation no longer always needs to follow the load
- Contingency Storage
- Power Quality

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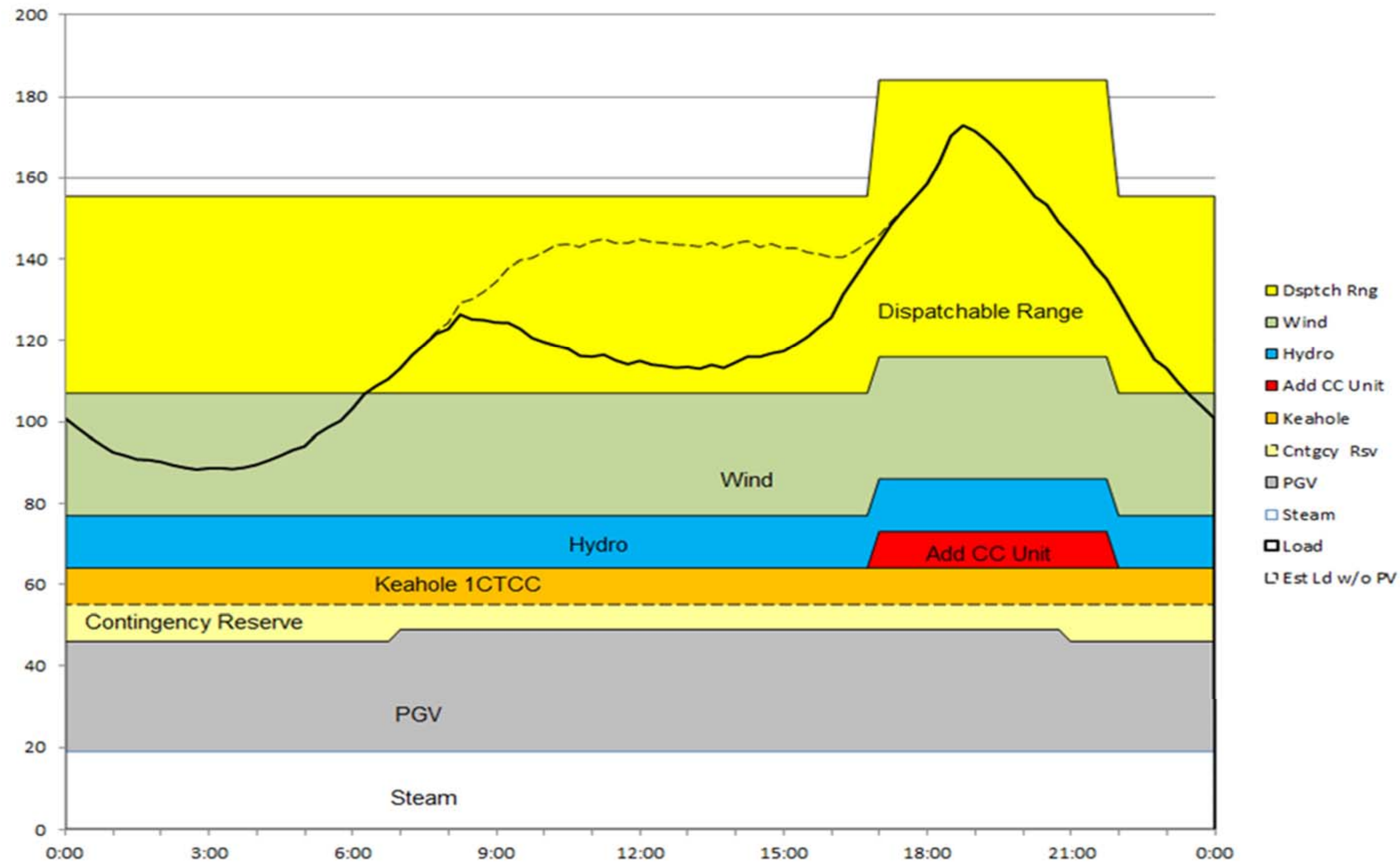
Current Daily Dispatch



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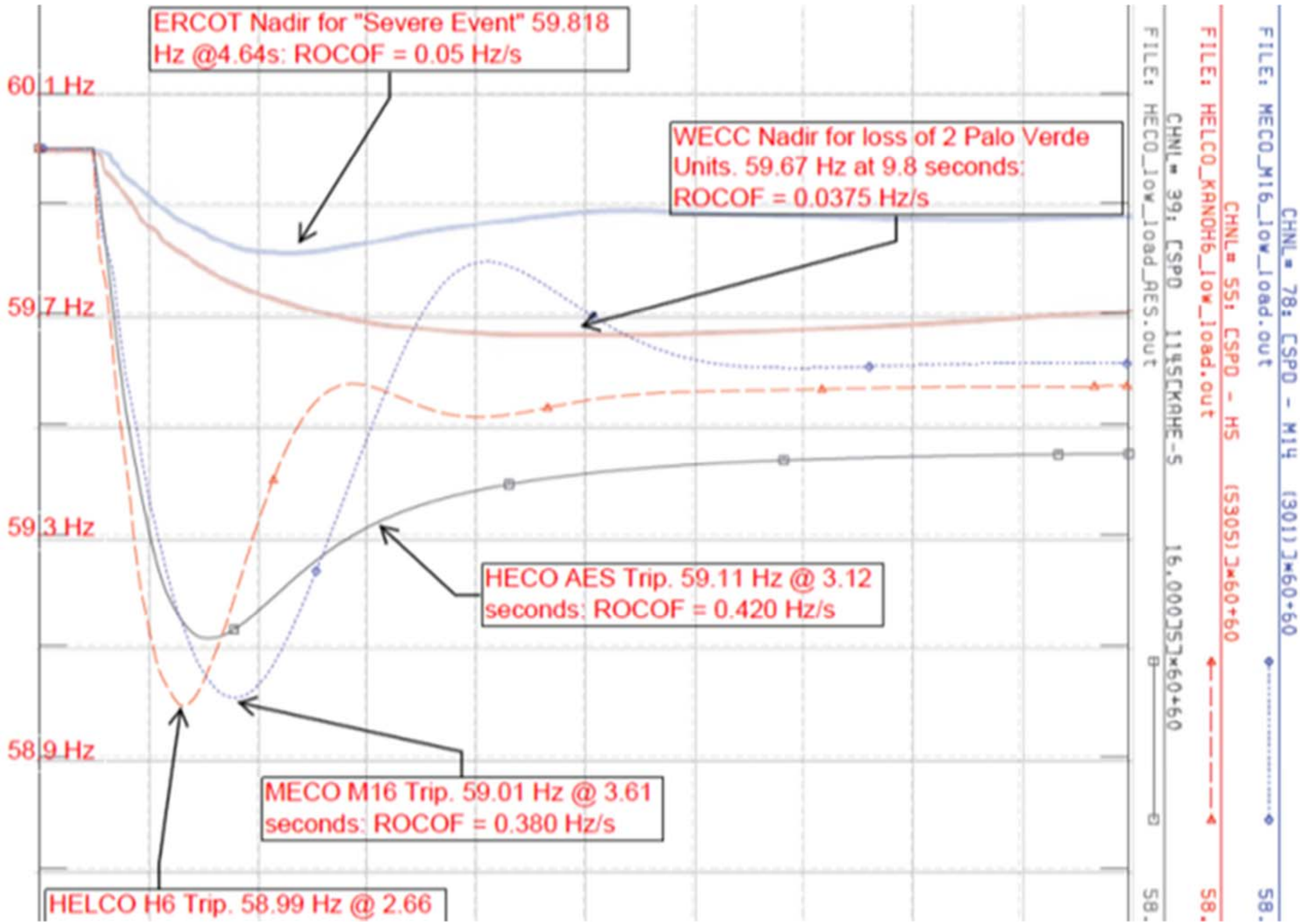
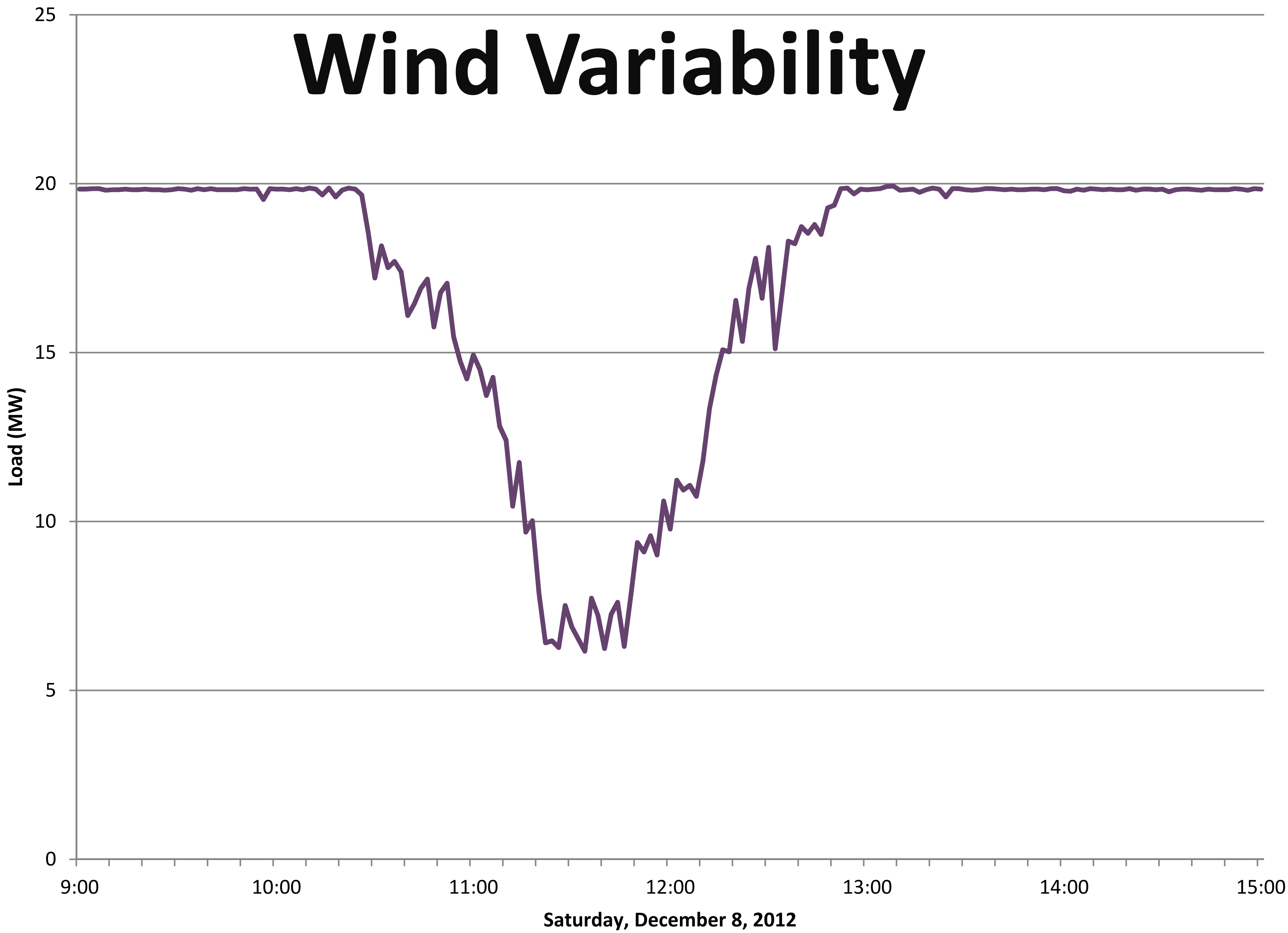
System Stability



Wind Variability



The Swiss Army knife of the Utility industry – Where and When Does Energy Storage Make Sense?

Behind the Meter
Frequency Response

Peaker Replacement

Renewables Integration

Energy time shift

Regulation Energy Management

Solar Backup

T&D Deferrals

EV Charging

Demand Charge Management

Microgrids

Real time Energy

Generation-sited

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Energy storage can provide 13 fundamental use cases (I/II)

Stakeholder	Use case	Description
Utility	Load Shifting	The purchase of wholesale electricity while the marginal price of energy is low (typically during nighttime hours) and sale of electricity back to the wholesale market when prices are highest.
	Regulating reserves	Regulating reserves is the immediate and automatic response of power to a change in locally sensed system frequency, either from a system or from elements of the system. Regulation is required to ensure that system-wide generation is perfectly matched with system-level load on a moment-by moment basis to avoid system-level frequency spikes or dips, which create grid instability.
	Fast frequency reserves (FFR)	FFR is the generation capacity that is online and able to serve load immediately in response to an unexpected contingency event, such as an unplanned generation outage.
	Voltage Support	Reliable and continuous electricity flow across the power grid (T&D) within an acceptable range
	Black start	Restoring operation to larger power stations in an event of grid outage to bring the regional grid back online.
	Replacement reserves	Instead of investing in new generation assets to meet generation requirements during peak electricity-consumption hours, grid operators and utilities can pay for other assets, including energy storage, to incrementally defer or reduce the need for new generation capacity and minimize the risk of overinvestment in that area.

Source: RMI , EPRI

Energy storage can provide 13 fundamental use cases(II/II)

Stakeholder	Use case	Description
Utility	Distribution deferral	Delaying, reducing the size of, or entirely avoiding utility investments in distribution system upgrades necessary to meet projected load growth on specific regions of the grid.
	Transmission Congestion Relief	Assets including energy storage can be deployed downstream of congested transmission corridors to discharge during congested periods and minimize congestion in the transmission system.
	Transmission deferral	Delaying, reducing the size of, or entirely avoiding utility investments in transmission system upgrades necessary to meet projected load growth on specific regions of the grid.
Customer	Energy Arbitrage (pricing)	By minimizing electricity purchases during peak electricity-consumption hours when time-of-use (TOU) rates are highest and shifting these purchase to periods of lower rates, behind-the-meter customers can use energy storage systems to reduce their bill.
	Increased PV self-consumption	Minimizing export of electricity generated by behind-the-meter photovoltaic (PV) systems to maximize the financial benefit of solar PV in areas with utility rate structures that are unfavorable to distributed PV (e.g., non-export tariffs).
	Demand Charge Reduction	In the event of grid failure, energy storage paired with a local generator can provide backup power at multiple scales, ranging from second-to-second power quality maintenance for industrial operations to daily backup for residential customers.
	Backup Power	In the event of grid failure, energy storage paired with a local generator can provide backup power at multiple scales, ranging from second-to-second power quality maintenance for industrial operations to daily backup for residential customers.

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Source: RMI , EPRI

BTM location offers the most flexibility in services offered

Stakeholder	Use case	Transmission	Distribution	BTM
Utility	Load shifting	✓	✓	✓
	Regulating reserves	✓	✓	✓
	Fast frequency response	✓	✓	✓
	Voltage Support	✓	✓	✓
	Black start	✓	✓	✓
	Replacement reserves	✓	✓	✓
	Distribution deferral		✓	✓
	Transmission Congestion Relief	✓	✓	✓
	Transmission deferral	✓	✓	✓
Customer	Energy arbitrage (pricing)			✓
	Increased PV self-consumption			✓
	Demand Charge Reduction			✓
	Backup Power			✓

✓ Use case can be provided

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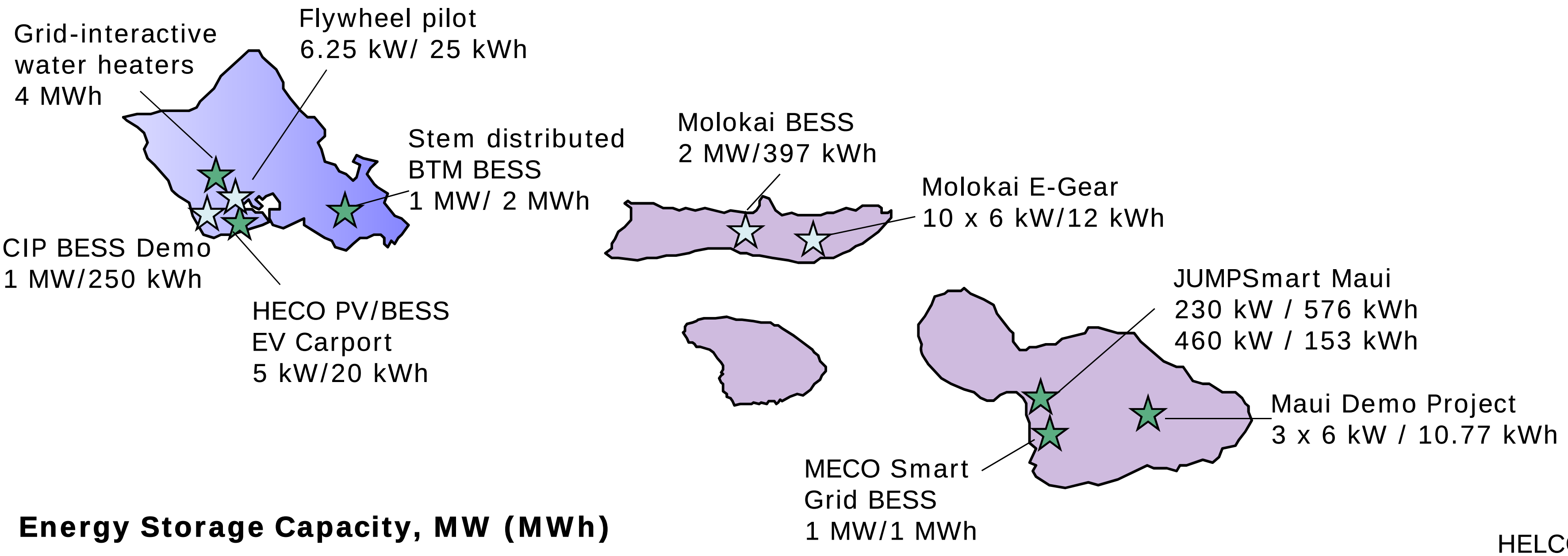
Source: RMI – The Economics of Battery Energy Storage, Oct 2015; EPRI – Cost-effectiveness of Energy Storage in California, Jun 2013

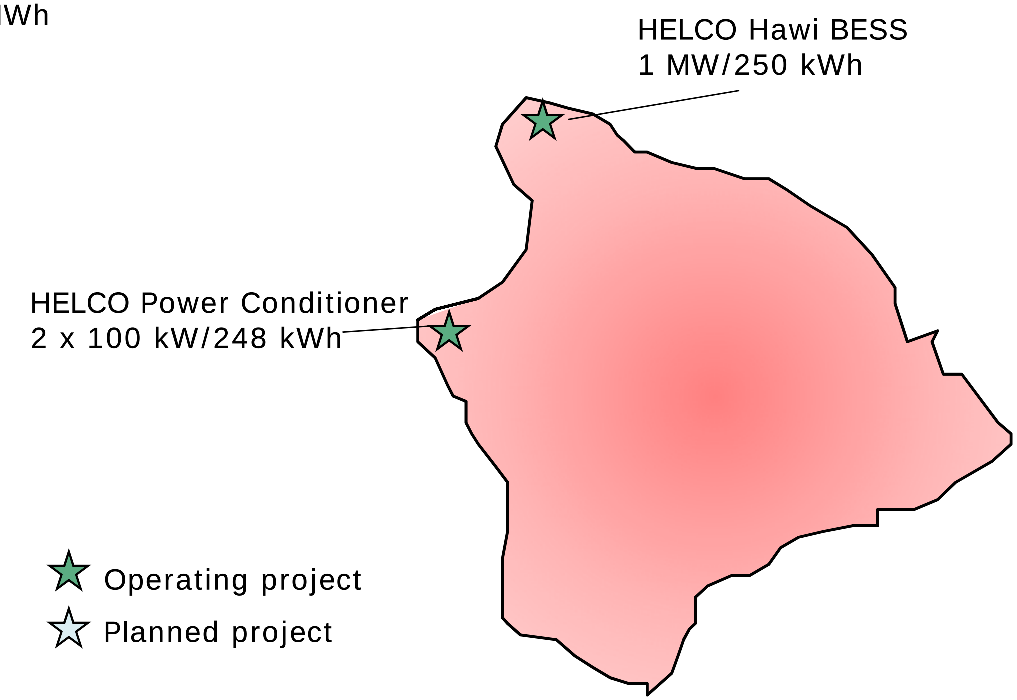
12 ongoing energy storage pilots across three companies

~7 MW / ~9.3 MWh total capacity



Energy Storage Capacity, MW (MWh)

	Operating	Planned	Total
Oahu	~1.01 MW (6.02MWh)	~1 MW (0.275 MWh)	~2.01 MW (~6.3 MWh)
Maui County	~1.7 MW (~1.74MWh)	2.06 MW (0.517 MWh)	~3.76 MW (2.26 MWh)
Big Island	1.2 MW (0.746 MWh)	0	1.2 MW (0.746 MWh)
Total	**~3.91 MW (~8.51 MWh)**	**3.06 MW (~0.79 MWh)**	**~7 MW (~9.3 MWh)**



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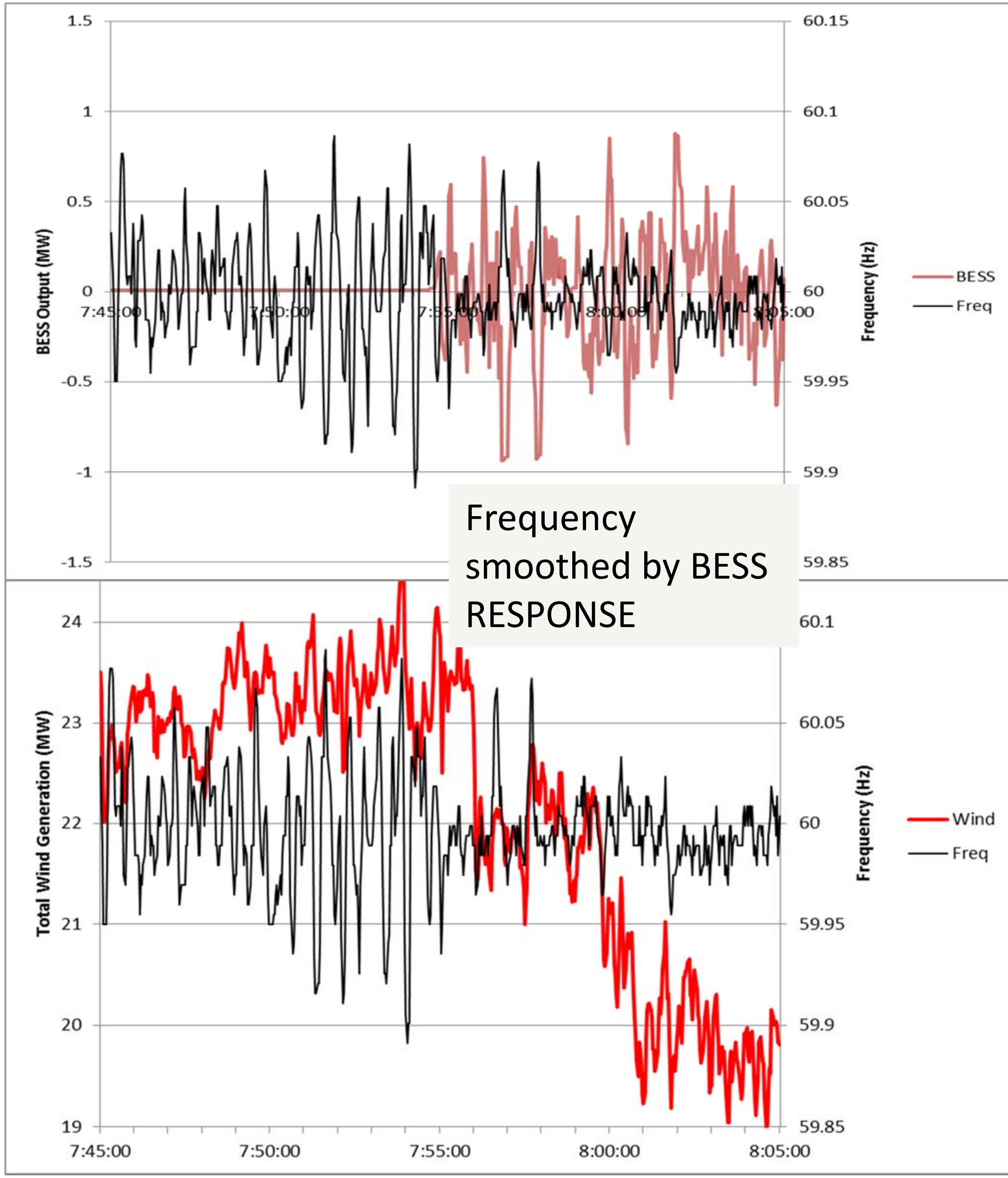
Source: HECO energy storage database as of May 2016

Storage (BESS)

Storage can reduce frequency variability due to wind output



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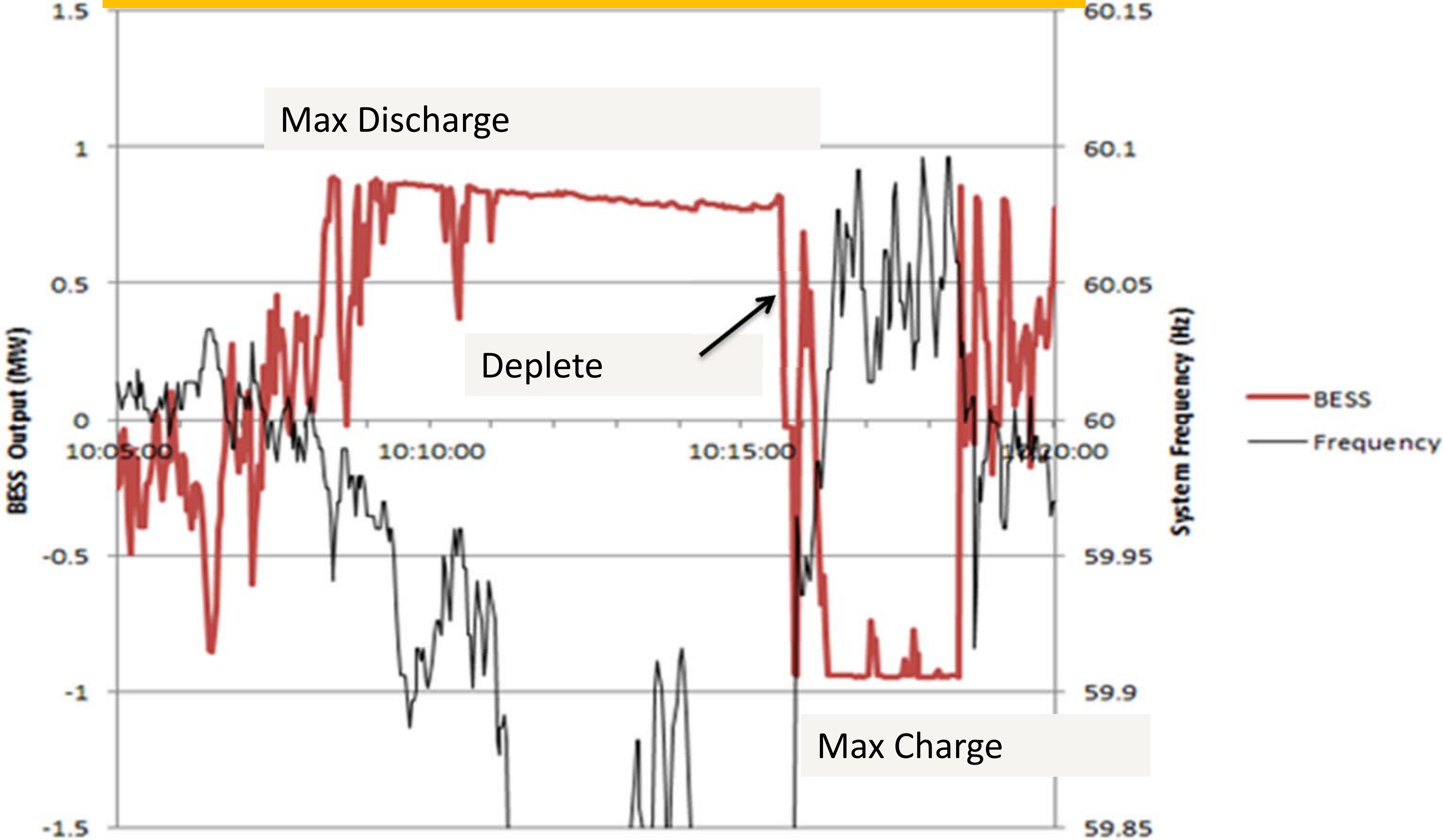
BESS Performance – During Event

Battery charges/discharges to help offset frequency changes



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Hawai‘i Island’s Lessons Learned

- Contingency functions can work well
- Power Converters & Controls key component
- Stability and Support of Manufacturer is critical
- Simultaneous Functions complex to implement

Going Forward

- Customer Self Supply
- 16 MW Contingency Storage
- Long Term Storage on distribution
- Pumped Storage
- Egear
- Second Use EV batteries
- Disposal of batteries

Mahalo!

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