Hawai'i DER Experience
Updates from Hawaii on DER Integration Issues
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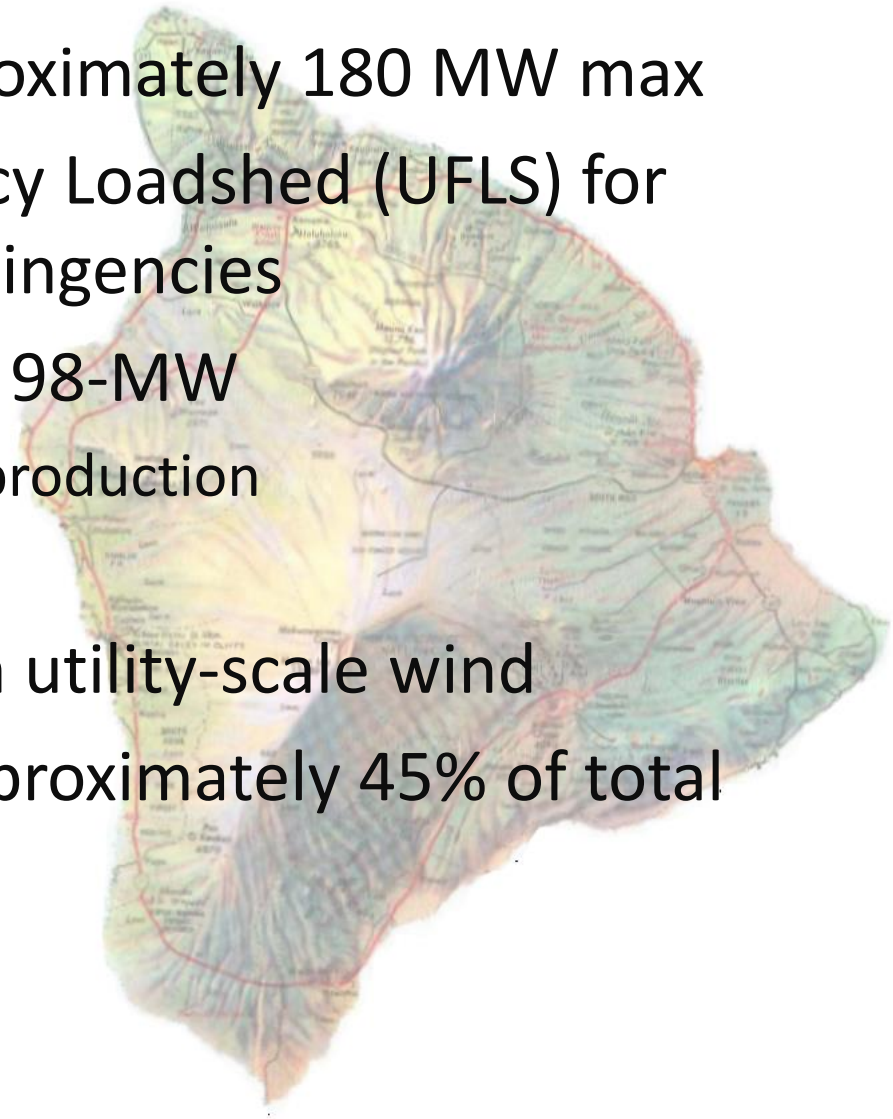
Hawai'i Electric Light System Review

- No interconnections
- Daytime demand approximately 180 MW max
- Rely on Underfrequency Loadshed (UFLS) for loss of generation contingencies
- Distributed PV approx. 98-MW
  - Not visible, estimated production
  - Not controllable
- High contribution from utility-scale wind
- DER can contribute approximately 45% of total energy



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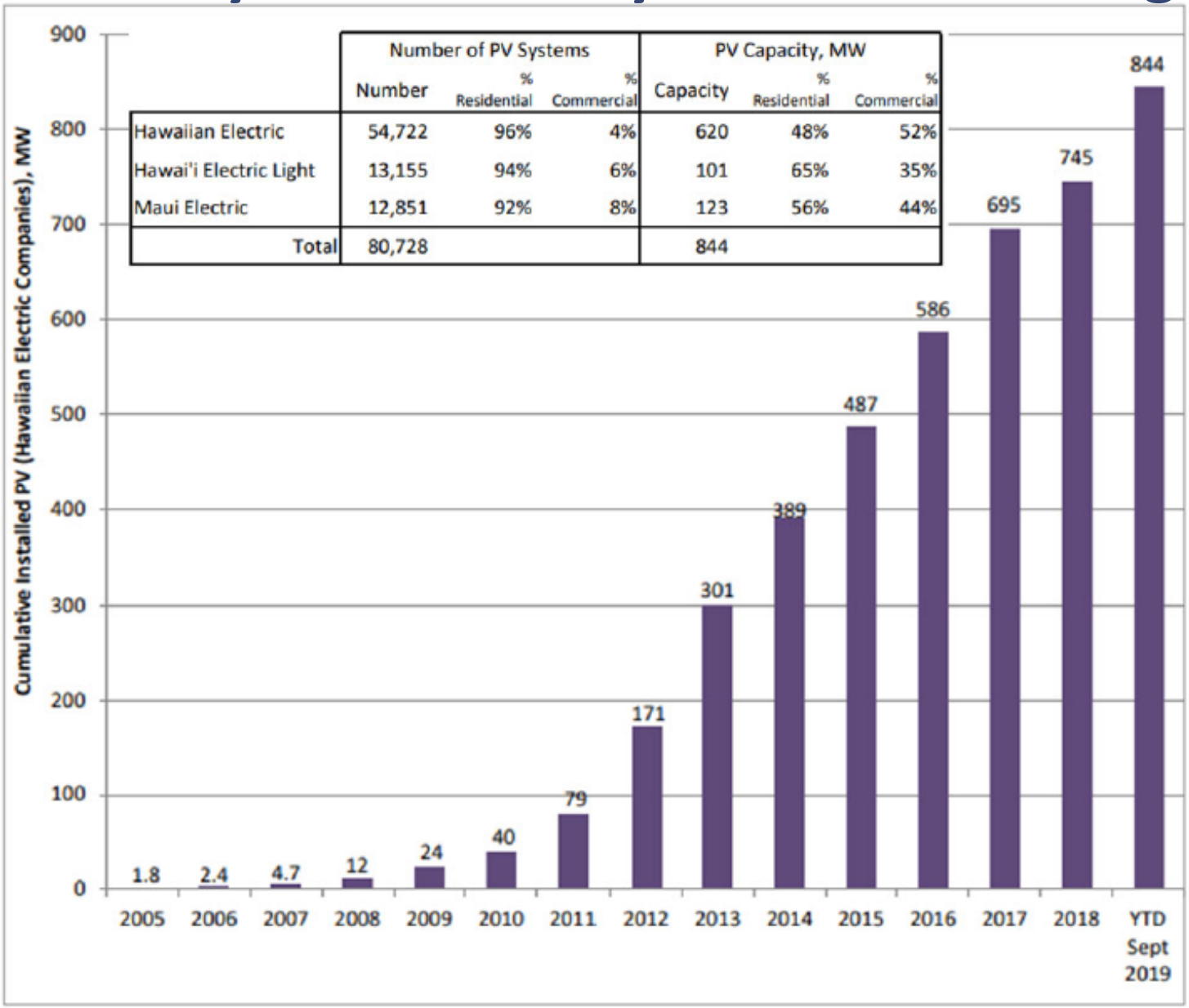
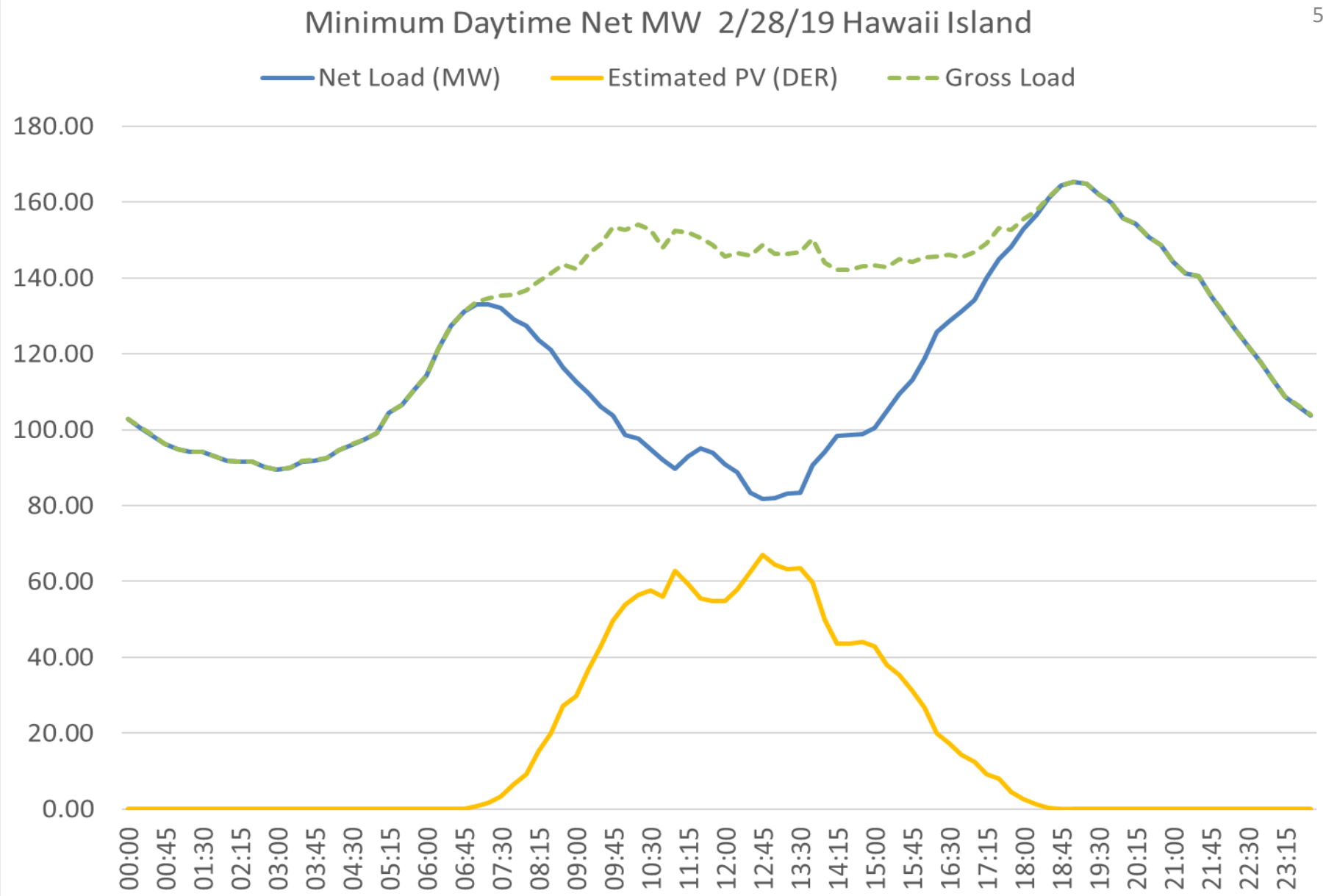
Update on DER Growth

- The following slides are an update of the DER increase on Hawaii Electric Light (Hawaii), Maui Electric (Maui, Lanai and Molokai) , and Hawaiian Electric systems
- Also some illustrative days of impacts

DER Continued Increase (three companies)
Many of the new systems have storage

	Number of PV Systems			PV Capacity, MW		
	Number	% Residential	% Commercial	Capacity	% Residential	% Commercial
Hawaiian Electric	54,722	96%	4%	620	48%	52%
Hawai'i Electric Light	13,155	94%	6%	101	65%	35%
Maui Electric	12,851	92%	8%	123	56%	44%
Total	80,728			844		





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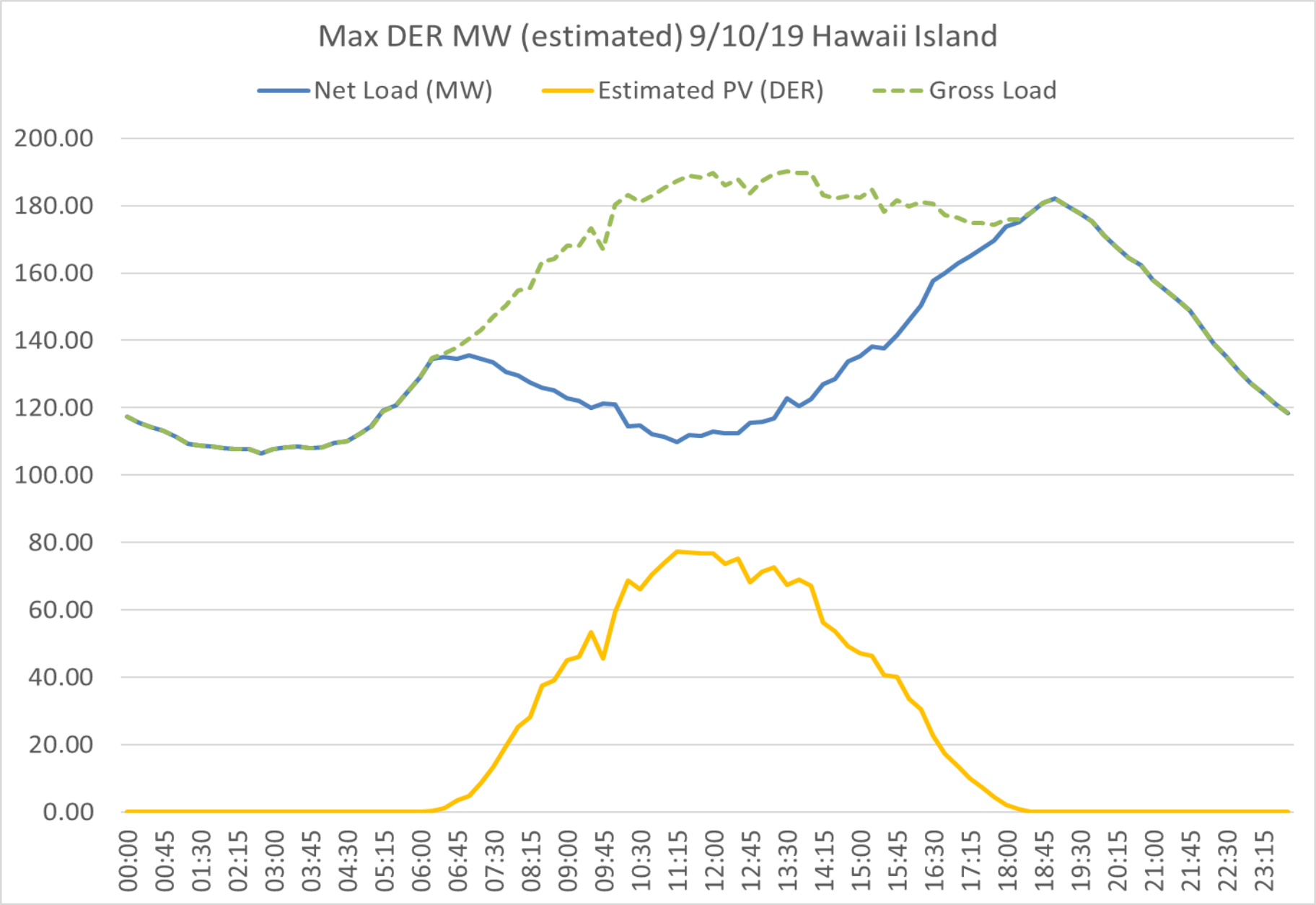

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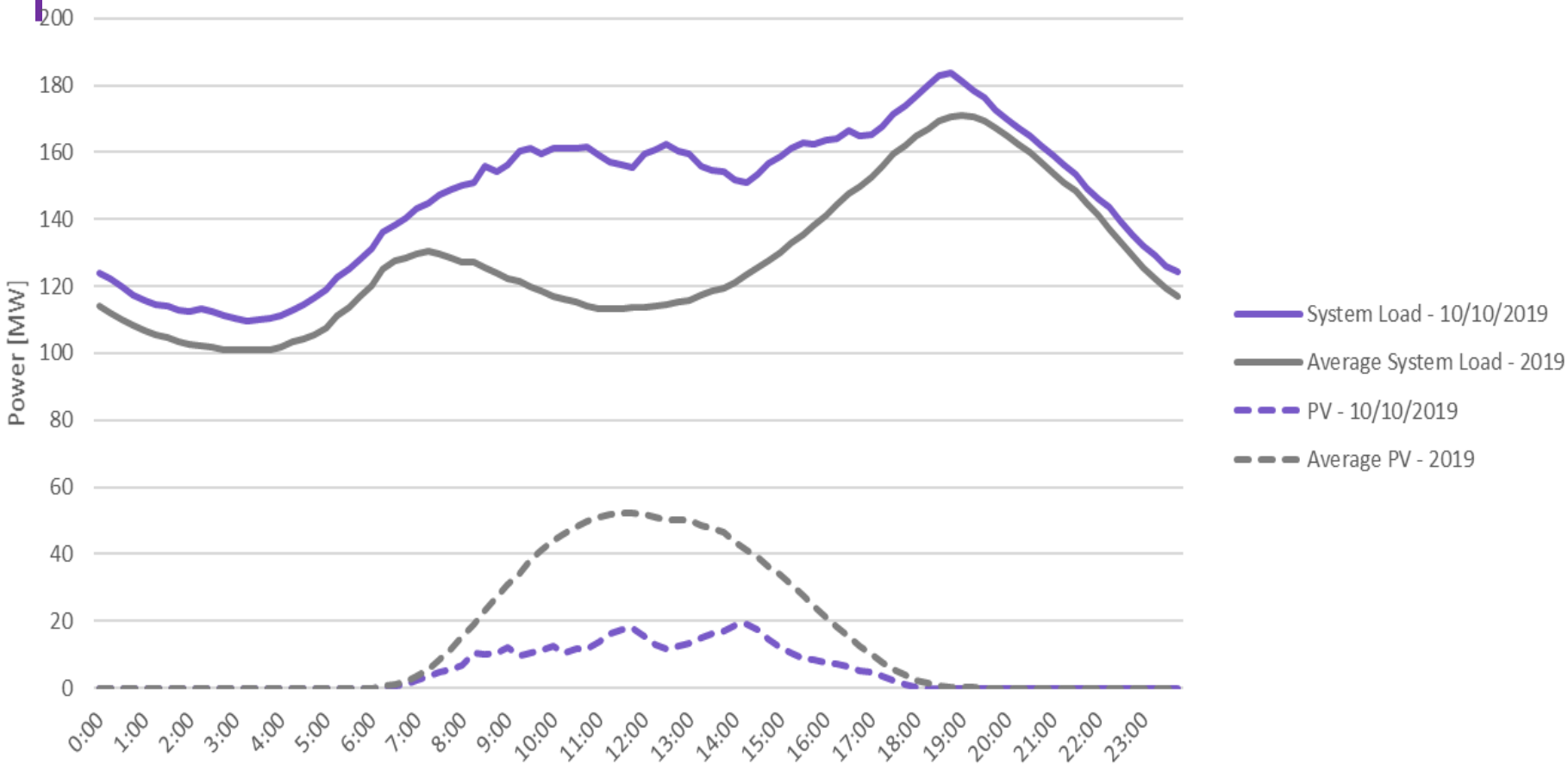
Minimum DER (Estimated) 10/10/19 Hawaii Island



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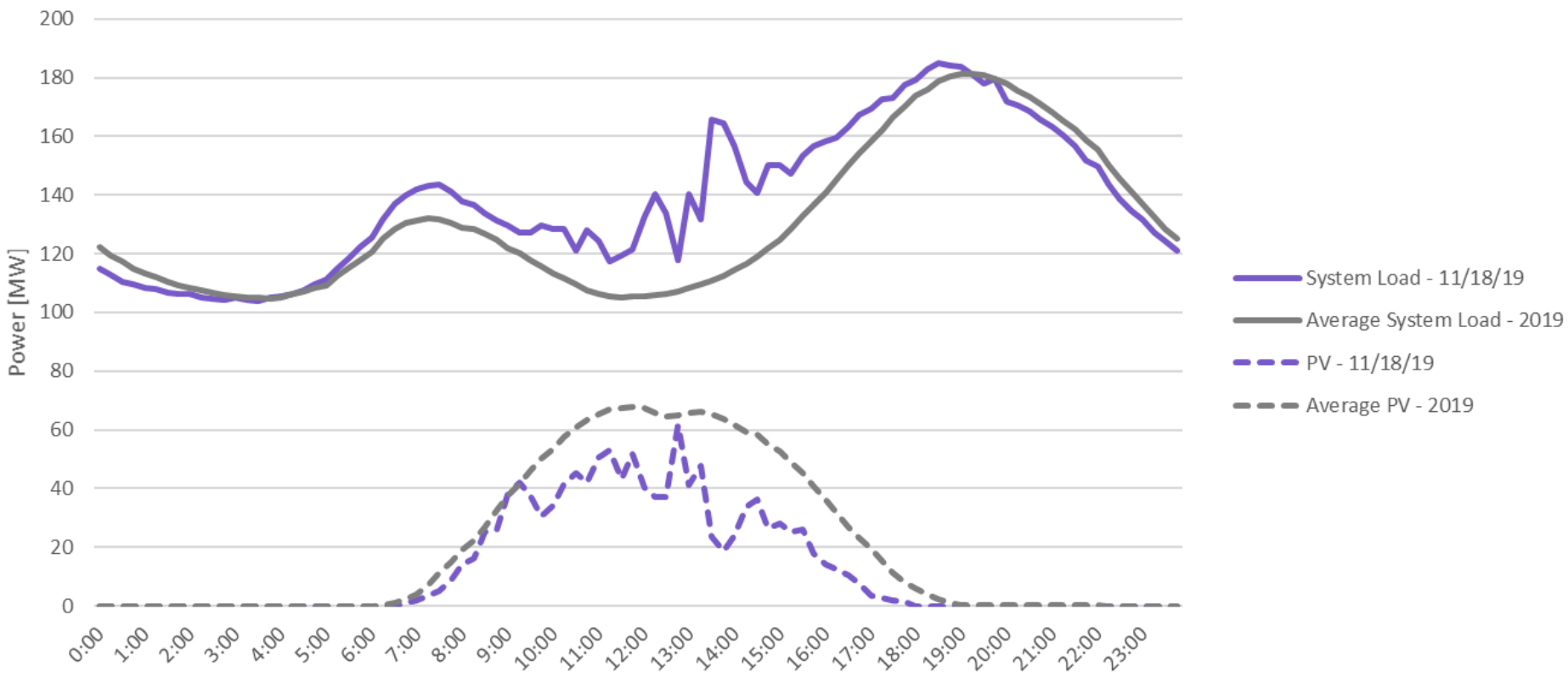
Volatile DER (Estimated) 11/18/19 Maui Island



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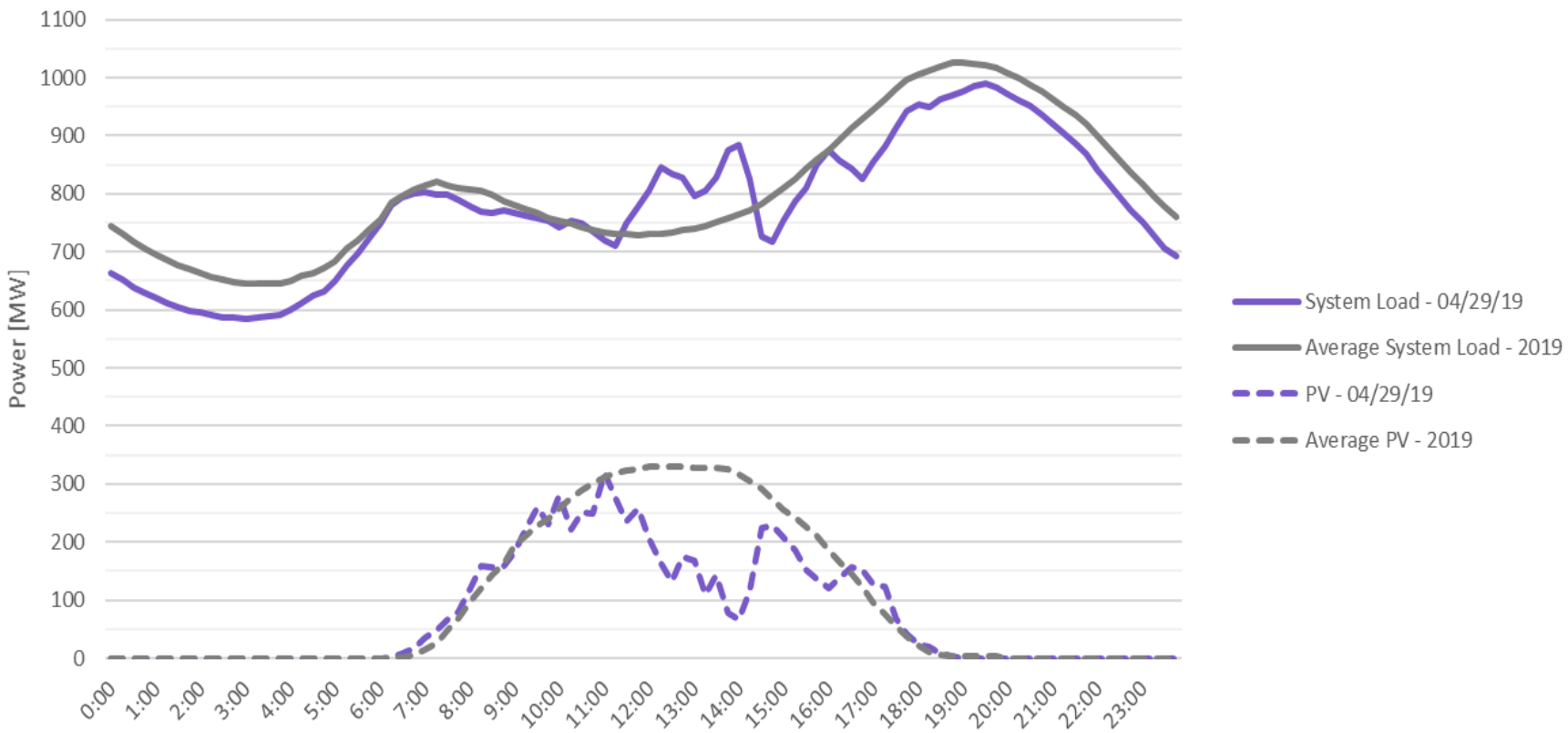
Volatile DER (Estimated) 4/29/19 Oahu



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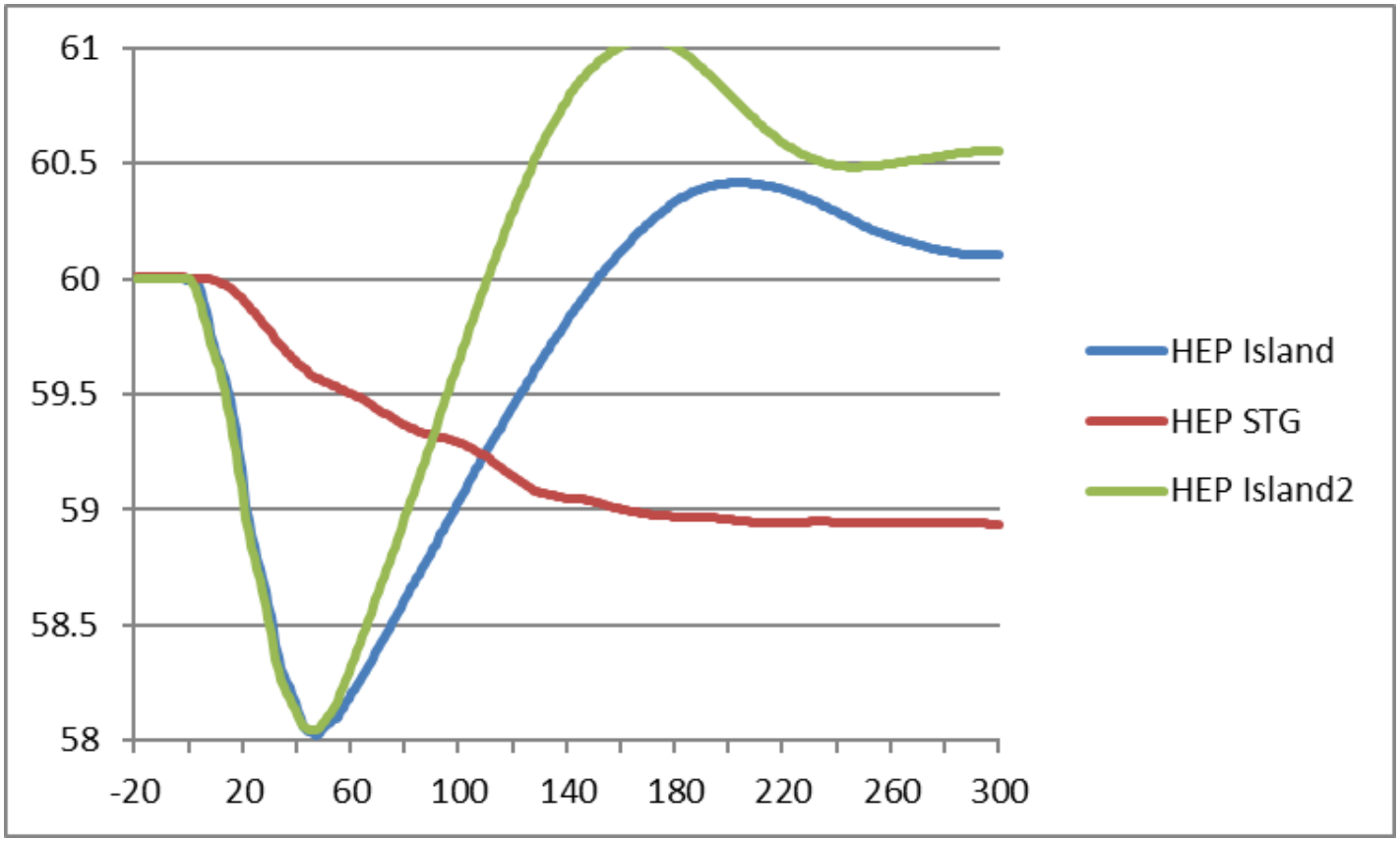
Updates on System Reliability Activities

- DER interconnection requirements
- DER in planning models
- Adaptive under-frequency load-shed updates and performance
- Fast responding contingency reserve to mitigate legacy DER (mostly PV) trip

DER Interconnection – Hawaii Rule 14H – Microgrids - in Progress

- IEEE 1547-2018 includes useful requirements not in 14H
  - Ride through for phase angle jump, ROCOF ride through, consecutive disturbances
  - Collected data from grid-events to demonstrate need
  - Most settings in 1547-2018 provide parameter configurability to suit island grid requirements
  - Different approaches under consideration to avoid regulatory process for updates
- Microgrids
  - Desire to accommodate microgrids
  - Rule 14H modifications to consider microgrid implications
  - Possible impacts on planning

Some example grid events used for setting ROCOF requirements



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DER Data and Performance Tracking

- Tracking DER quantities for system planning models (i.e.; different amounts of various trip settings) essential
  - Policies do not allow for upgrades with replacement to meet present standards
  - Over time we are seeing legacy numbers decline due to remote updates for some suppliers of which we are informed. But we can't be sure how many replacements have newer settings.
- Some inverters appear not to have correct behavior –
  - How to track this? PMU data is useful to detect aggregate impact
  - Unclear what action can be taken if find them to be incorrect (no process)
- Impact of DER with storage and microgrids needs to be included in future studies and operational forecasts

System DER Control

- Despite clear operational need, currently most systems aren't controllable but new tariffs provide for control requirements
- Potential for excess energy. Certain islands reaching problem levels
- Various means for control and communication will be required for near-term
  - cellular, power line carrier, future mesh network; inverter or meter
  - Aggregators often use internet based communication
- DER auto-reconnections impact system restoration

Adaptive UFLS Application Review

- EMS application monitors system load, and circuit loads, limited hold-offs, and number of UFLS operations.
- Calculates target MW for each stage based on scheme – percentage for each state
- Can accommodate ROCOF and frequency triggers
  - ROCOF not enabled in 2019
- Assigns circuits to UFLS stages to achieve MW targets

Hawaii Island System Disturbance 7/8/19 (Geothermal offline)

- Loss of two facilities – 40 MW total
  - sequential transmission line trips during storm
  - Larger than "single contingency" – n-1-1
- East side of the island was overcast (low PV)
- West side of the island saw measurable, significant loss solar generation
  - For example, net load increased from 7.5MW to 9MW at one West Hawaii distribution station
- Significant customer impact and over frequency

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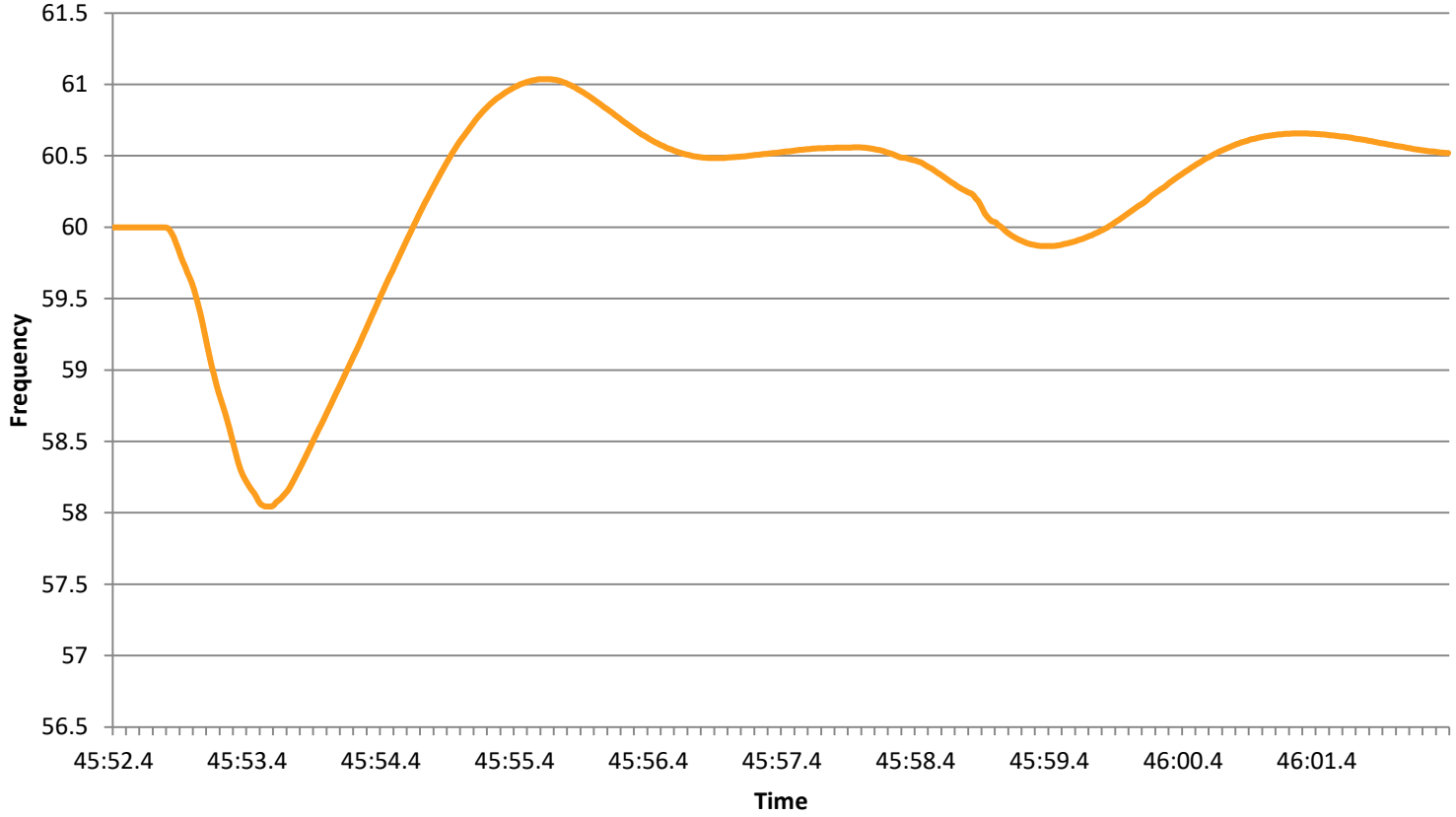
July 8, 2019 UFLS Event



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Dynamic Underfrequency Loadshed (DUFLS) – Update Study

- Setting review study conducted by EPS (consulting engineers) using benchmarking against recent events
- Examined schemes for a range of contingencies and base cases with following goals:
  - Avoid over shedding to over frequency trip point for legacy DER (large potential DER loss)
  - Minimize amount of customer load shed
  - Minimize magnitude of frequency dips or rises

Updated Scheme

Table 7: Comparison of Original UFLS Setting to New Recommended Settings

Stage	Original Frequency Trip Points	New Frequency Trip Points	Original Load Allocation	New Load Allocation	Original DFDT	New DFDT
1	59.1	59.2	5%	10%	N/A	-2 Hz/s
2	58.8	59	10%	10%	N/A	-2 Hz/s
3	58.5	58.6	10%	10%	N/A	N/A
4	58.2	58.4	15%	10%	N/A	N/A
5	57.9	57.9	10%	10%	N/A	N/A
6	57.6	57.6	20%	20%	N/A	N/A

- Updated scheme was proposed to improve performance
- Settings are chosen to perform over a wide range of conditions – high/medium/low DER PV, various base case conditions, evening peak.
- Recommended activating rate of change of frequency trigger at a setting which would avoid false trips

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Benchmarking Case Comparisons

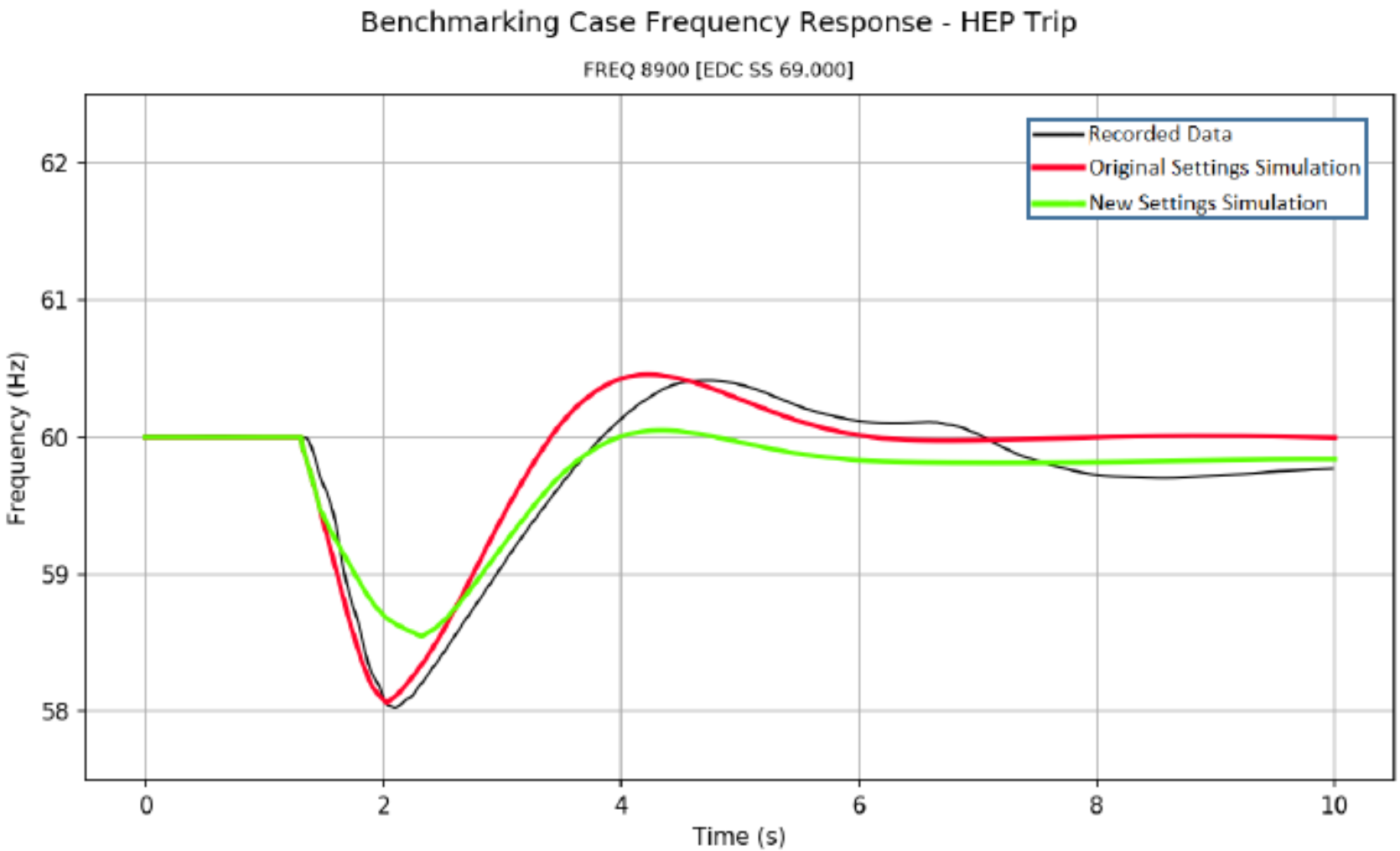

Figure 8: HEP Trip Frequency Response - Benchmarking Case

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Avoiding DF/DT False Positives

Stage	Frequency Trip Point	% of Net Load	DFDT (-2 Hz/s)
1	59.2	10	yes
2	59	10	yes
3	58.6	10	no
4	58.4	10	no

NOTE: Both the underfrequency trip settings and DFDT trip settings use a 3-cycle timer.

- Simulations of line faults were performed to test DFDT would not cause load shed during transients for non-generation events
- Highest DFDT setting recommended that still resulted in activation during the benchmark case for margin of safety against fault cases

KEY Recommendations

- New settings for first four stages of UFLS
- Accuracy and timeliness of assigning circuits to UFLS stages is critical – system very sensitive (may investigate additional triggers for evaluation on the EMS application)
- DFDT tripping should not be limited by frequency setting (independent)
- Legacy DER trips during system events pose a risk to the system, continue to update legacy DER to present ride-through requirements.
  - Especially critical for low-inertia cases.
- HELCO may need different schemes dependent upon online generation mix

Dynamic Underfrequency Loadshed (DUFLS) - Update

- HELCO plans implement recommendations by end of February
- Most of these changes straightforward through configurable application parameters .
  - Key recommendation is to design flexibility into future protection schemes (we're glad we did)!
- DFDT can be disabled from EMS if needed
- Plan is to implement relay group settings that can be adjusted quickly dependent on a specific resource state (online or not)
- Considering updates based on system load change instead of 15 minute timer given sensitivity of the scheme to changes and system dynamics

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Time Delay Blocks (Kicker) Unchanged

Stage	Frequency Trip Setting (Hz)	Relay Delay (Cycles)
Kicker Block 1a	59.3	600
Kicker Block 1b	59.5	1800
Kicker Block 2	59.5	1200

- Time-delay blocks have been performing well
- Review of events shows they are performing to restore frequency near target for sustained low-frequency events

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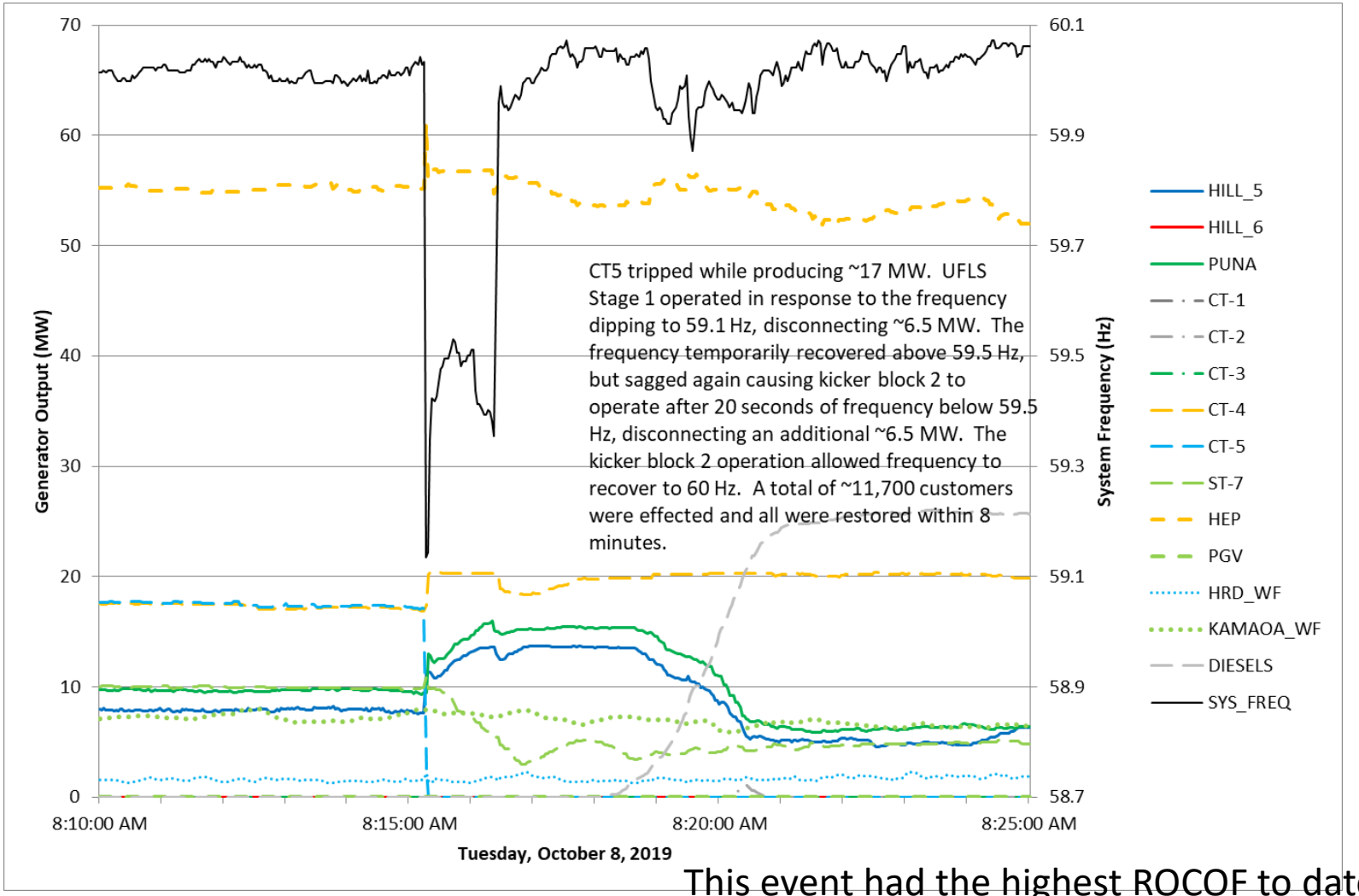
Event with Fastest ROCOF to Date and Kicker Block Activation



This event had the highest ROCOF to date, at -2.45 Hz/Sec overall, and an instantaneous rate over -4.5 Hz/Sec.

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Fast Frequency Contingency Storage (BESS) Procurement in Progress

- Size to meet planning criteria for reliability impact
  - Analysis based on resource plans, and legacy DER amounts
- 30 minute duration to bring standby generation online
  - Increased duration to allow more flexibility to respond to over-frequency (1 hour)
- Competitive bid procurement
  - Flexible requirements to allow use as energy resource during non-PV hours, grid forming, black start
  - Bids were received and are under evaluation
- Allow participation by distributed resources - but not if on UFLS circuit

FFR Storage System Procurement (Cont.)

- Fast frequency response contingency reserve
  - Configurable parameters (droop, deadband, etc.)
  - Proportional response outside of deadband
  - Respond to over and under frequency
  - Maintain established state of charge within deadband

https://www.hawaiielectriclight.com/documents/clean_energy_hawaii/selling_power_to_the_utility/competitive_bidding/20190822_final_stage_2_hawaii_variable_rfp.pdf (document)

www.hawaiielectriclight.com/competitivebidding

(procurement page)

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Other work in progress/completed

- Reduce potential for conditions that trigger loss of DER
  - Breaker Failure
  - Replacing 5 cycle oil breakers
  - Reducing secondary clearing time
  - Dual communication for POTT schemes
  - Improving communications to reduce clearing times

MAHALO! Questions?

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