Hawai'i Powered

Hawaiian Electric's Plans for Meeting Clean Energy Targets and Role of Grid Forming Inverters

ESIG Webinar

Hawaiian Electric

July 27, 2022

Agenda

Hawaiian Electric Overview

Near-Term Renewable Plan

System Stability Findings

- Methodology
- Findings
- Recommendations and Action Items


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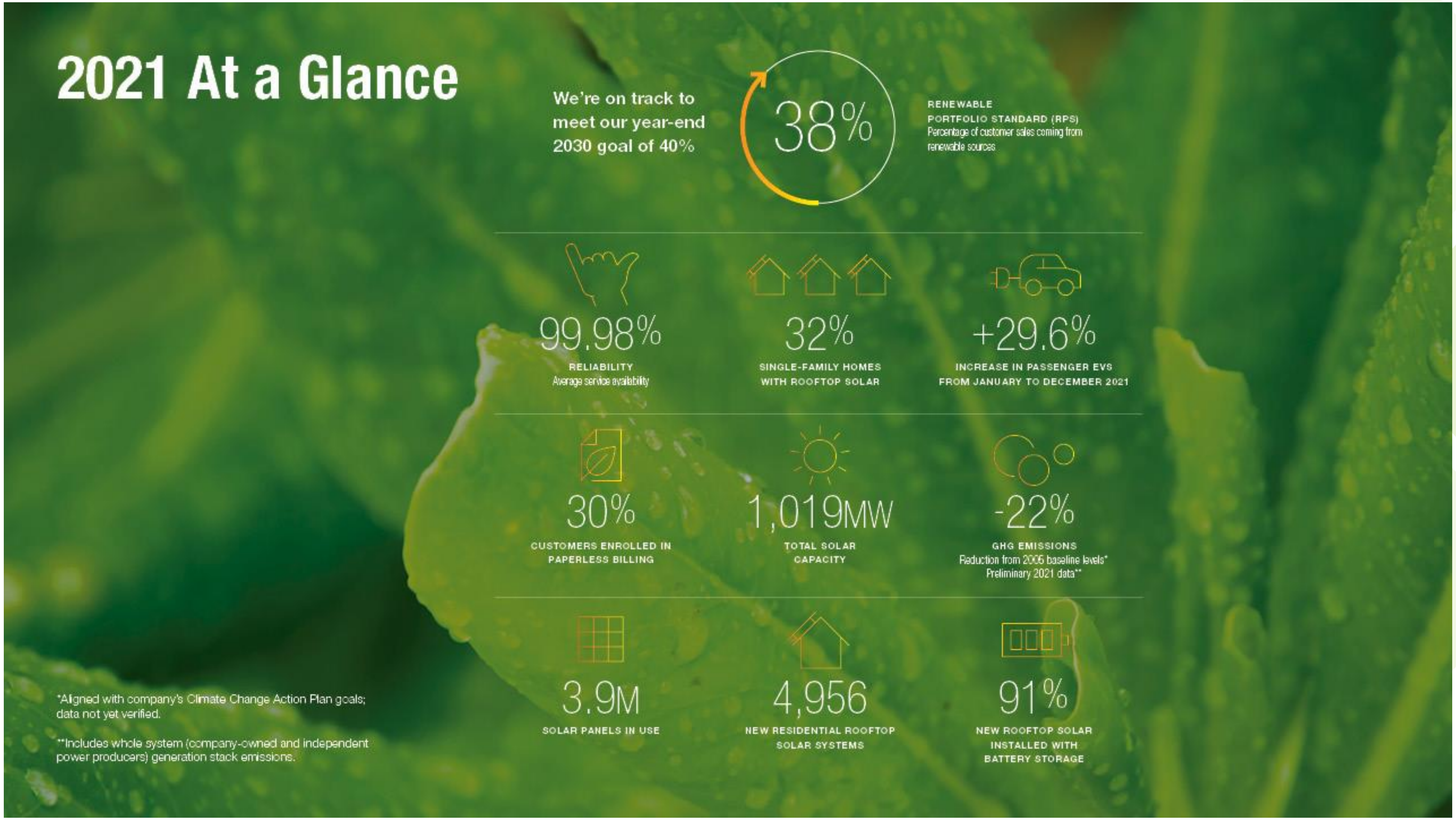
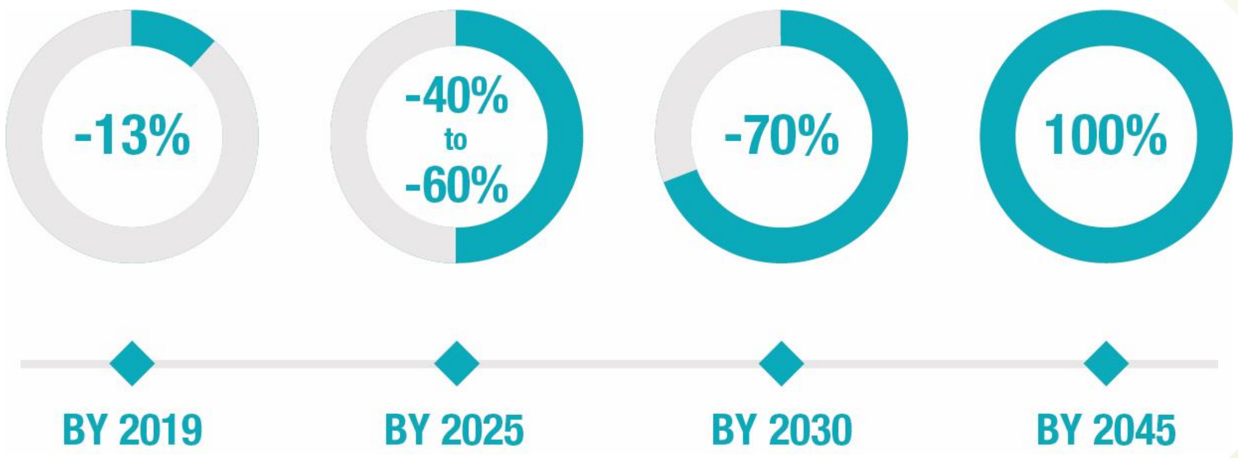
Hawaiian Electric



2045 Goal: Net Zero Carbon Emissions



Hawai‘i has the most ambitious clean energy goals in the nation.

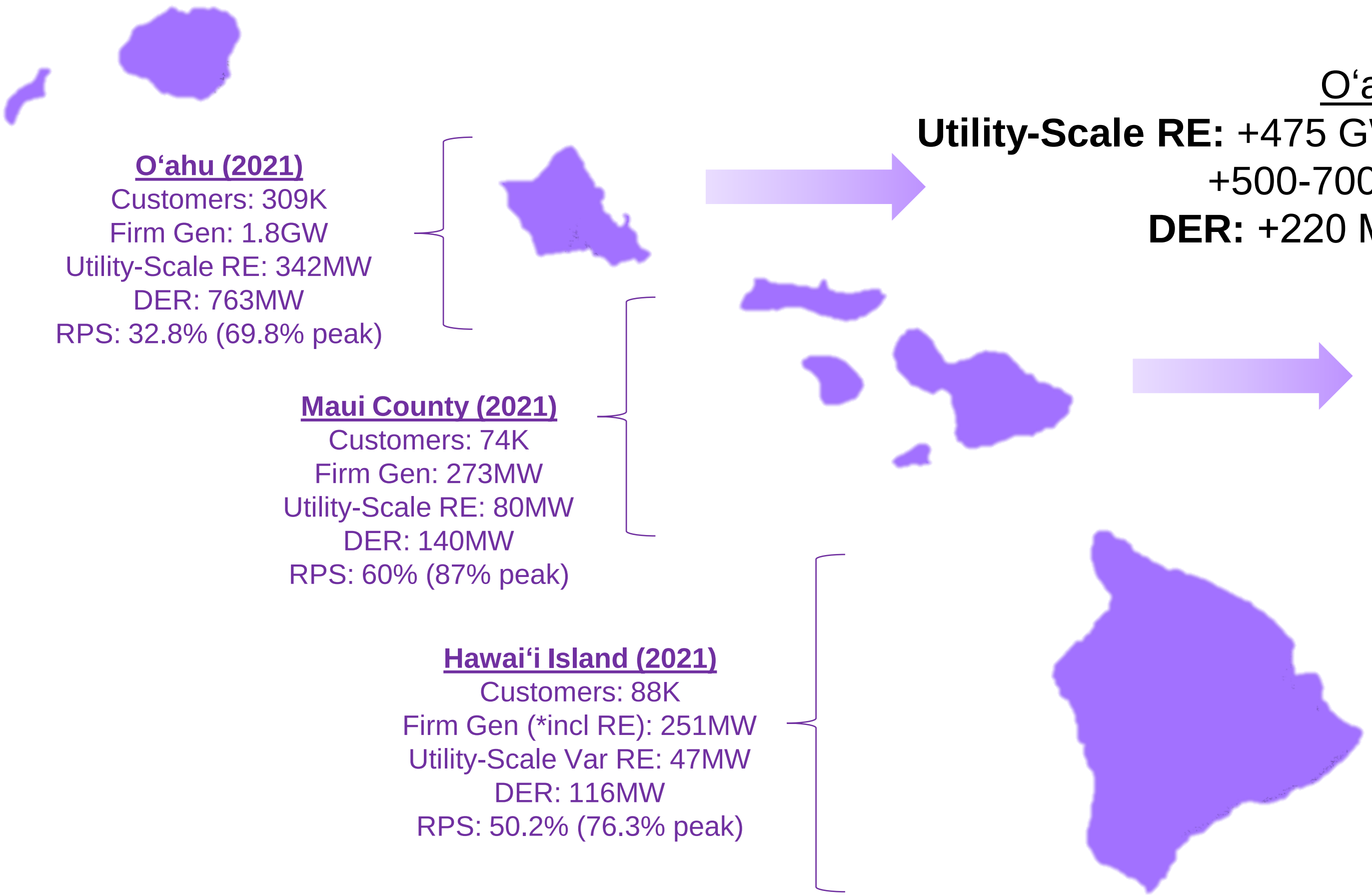
Hawaiian Electric is committed to 100% reduction of carbon emissions by 2045.

Climate Change Action Plan

Our path to cut carbon emissions 70% by 2030*

- **Shutting down** the state's last coal plant in September 2022
- **Retiring** at least 6 fossil-fueled generating units and significantly reducing the use of others as new renewable resources come online
- **Using more** grid-scale and customer-owned energy storage
- **Promoting** energy efficiency
- **Adding** nearly 50,000 rooftop solar systems to the 92,500 now online
- **Adding** renewable energy projects capable of generating a total of at least 1 gigawatt, including shared solar (community-based renewable energy)
- **Expanding** geothermal
- **Creating** innovative programs that provide customers incentives for using clean, lower-cost energy at certain times of the day and using less fossil-fueled energy at night

Near-Term Renewable Plan: 2027-2033 (aka Stage 3)



O‘ahu (2021)
Customers: 309K
Firm Gen: 1.8GW
Utility-Scale RE: 342MW
DER: 763MW
RPS: 32.8% (69.8% peak)

Maui County (2021)
Customers: 74K
Firm Gen: 273MW
Utility-Scale RE: 80MW
DER: 140MW
RPS: 60% (87% peak)

Hawai‘i Island (2021)
Customers: 88K
Firm Gen (*incl RE): 251MW
Utility-Scale Var RE: 47MW
DER: 116MW
RPS: 50.2% (76.3% peak)

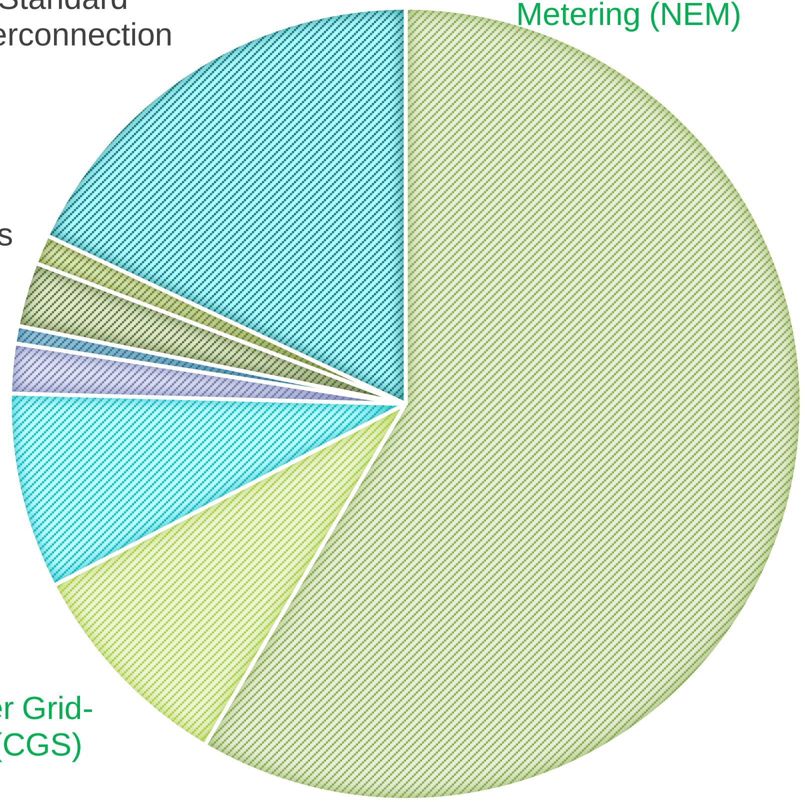
O‘ahu
Utility-Scale RE: +475 GWh (Annual Var)
+500-700 MW (Firm)
DER: +220 MW (↑ 28%)

Maui
Utility-Scale RE: +180 GWh (Annual Var)
+40 MW (Firm)
DER: +55MW (↑ 39%)

Hawai‘i Island
Utility-Scale RE: +325 GWh (Annual Var)
+65 MW (Firm/Var)
DER: +50MW (↑ 43%)

Currently >1GW of DER

Types of Programs (majority exporting)



DER Type	Description
Net Energy Metering (NEM)	• Export allowed
Customer Grid-Supply (CGS)	• Export allowed
CGS Plus	• Export allowed • Controllable under grid emergency
Smart Export	• Export allowed 4 p.m.- 9 a.m.
Battery Bonus	• Must use/export during 6 p.m.-8 p.m.
Customer Self-Supply	• Non-Export System
NEM Plus	• NEM Customer, plus additional non-export system
Standard Interconnection	• No compensation for export; mix of non-export and exporting systems

2021 System Stability Study

Acknowledgement

IGP Technical Advisory Panel Transmission Subcommittee

- Andy Hoke (NREL)
- Debbie Lew (ESIG)
- Matt Richwine (Telos Energy)
- Dana Cabbell, Vishal Patel (Southern California Edison)
- Deepak Ramasubramanian (EPRI)

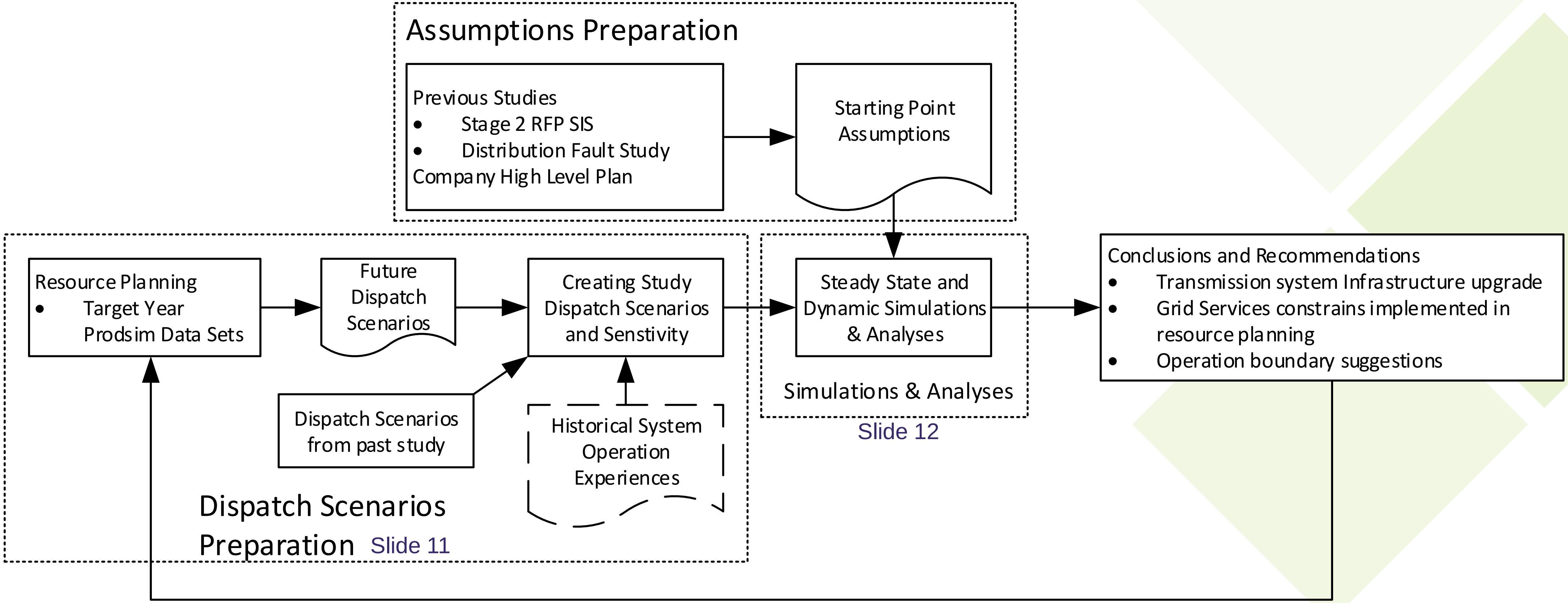
IGP TAP team feedbacks are available from:

https://www.hawaiianelectric.com/clean-energy-hawaii/integrated-grid-planning

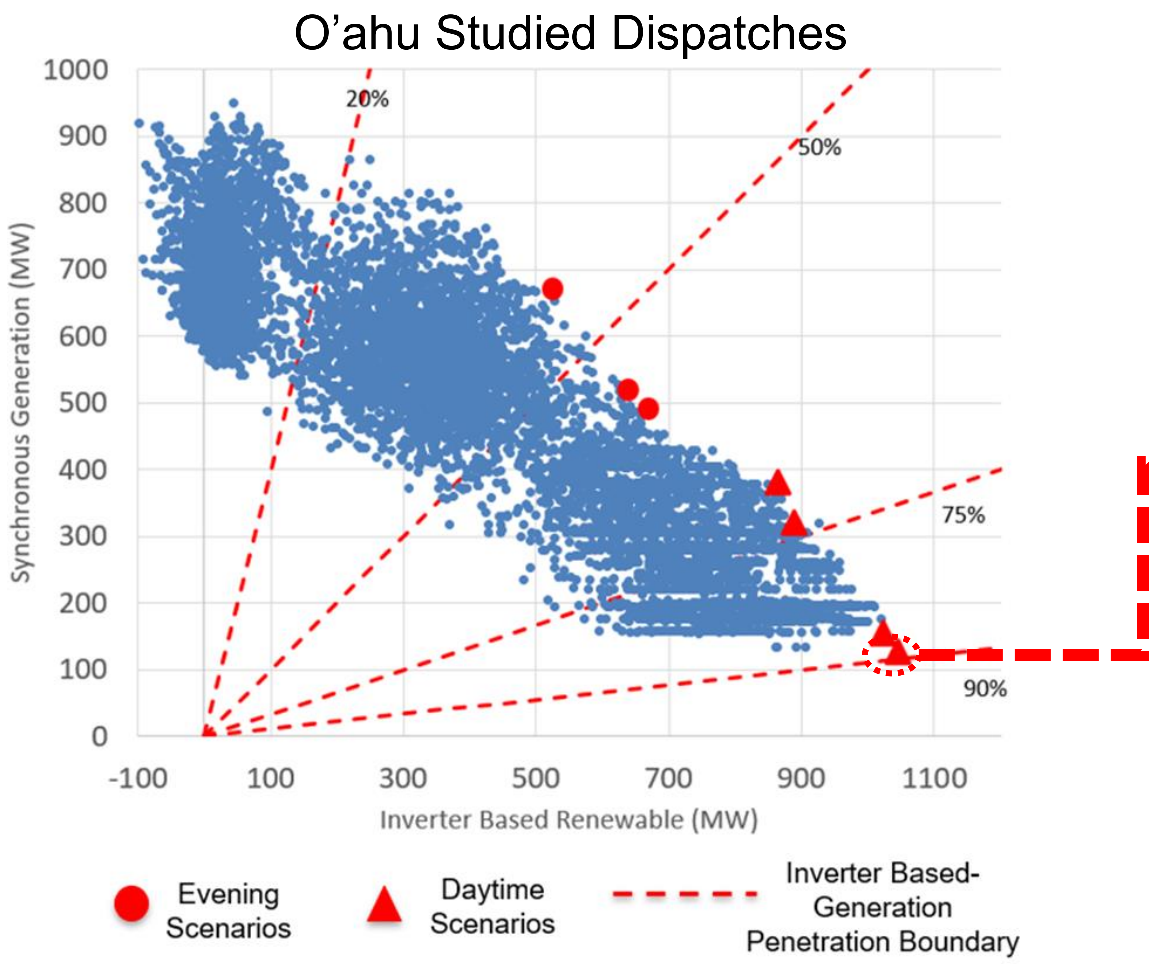
Electranix team for study support

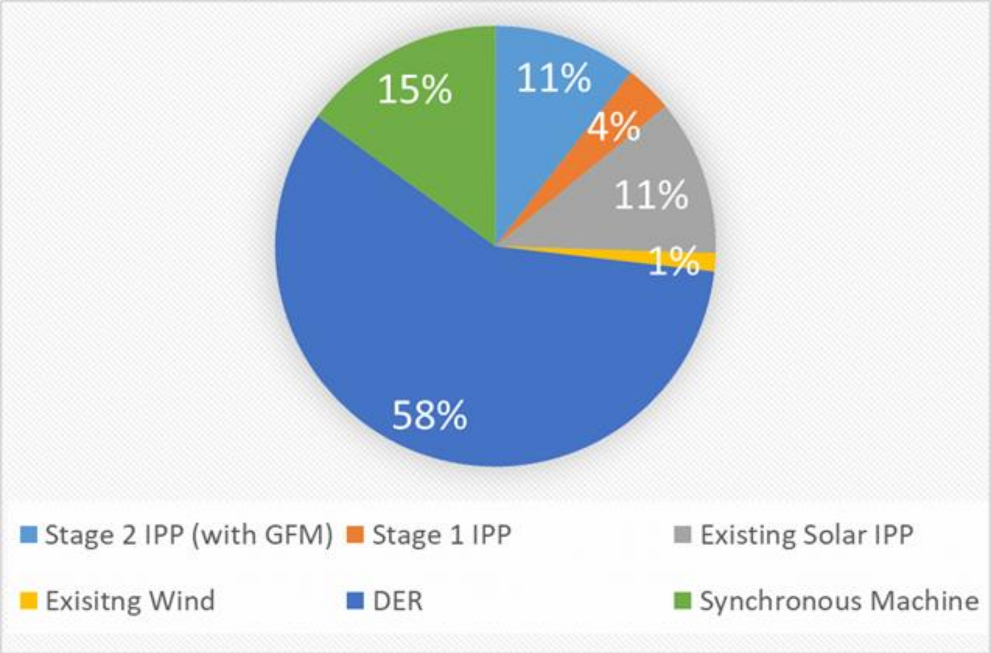
TESLA and SMA for GFM IBR EMT model support

2021 System Stability Study Methodology

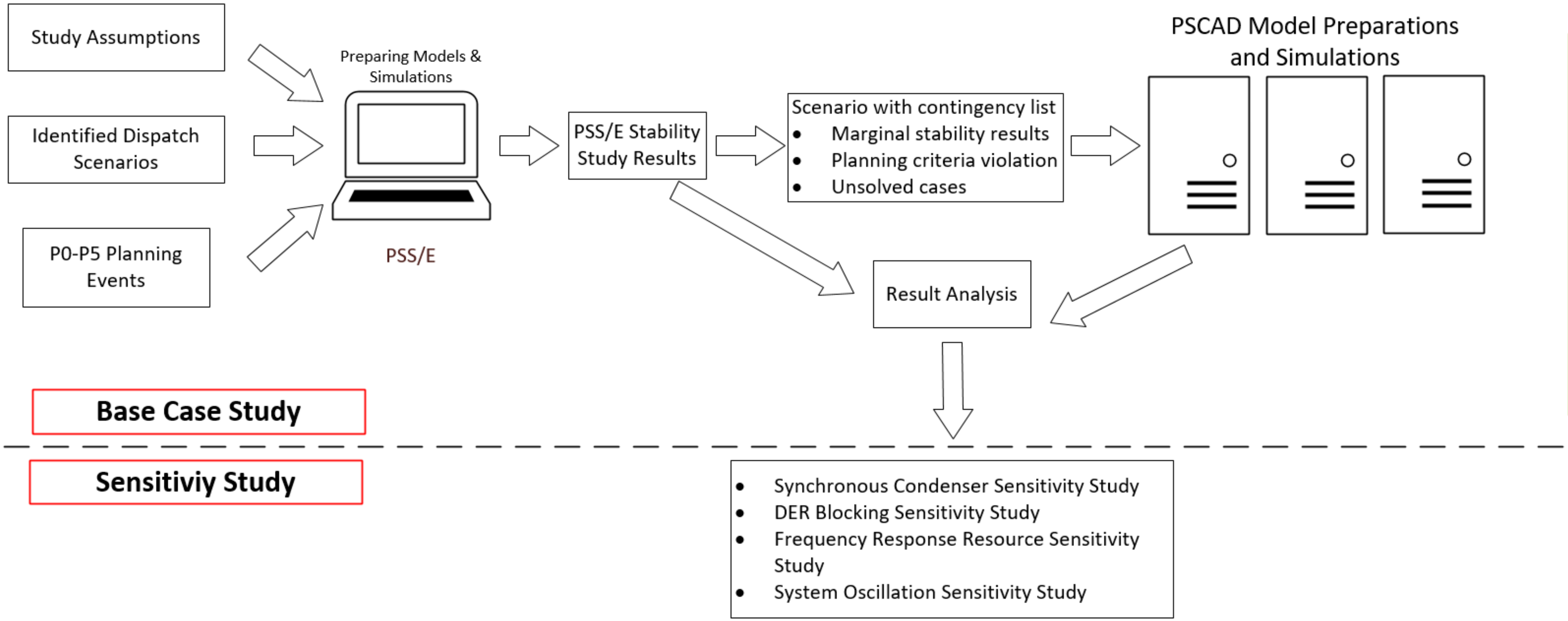


Studied Generation Dispatches





2021 System Stability Study Methodology
Hybrid Simulation Process



System Stability Study Findings
Systemwide DER Momentary Cessation

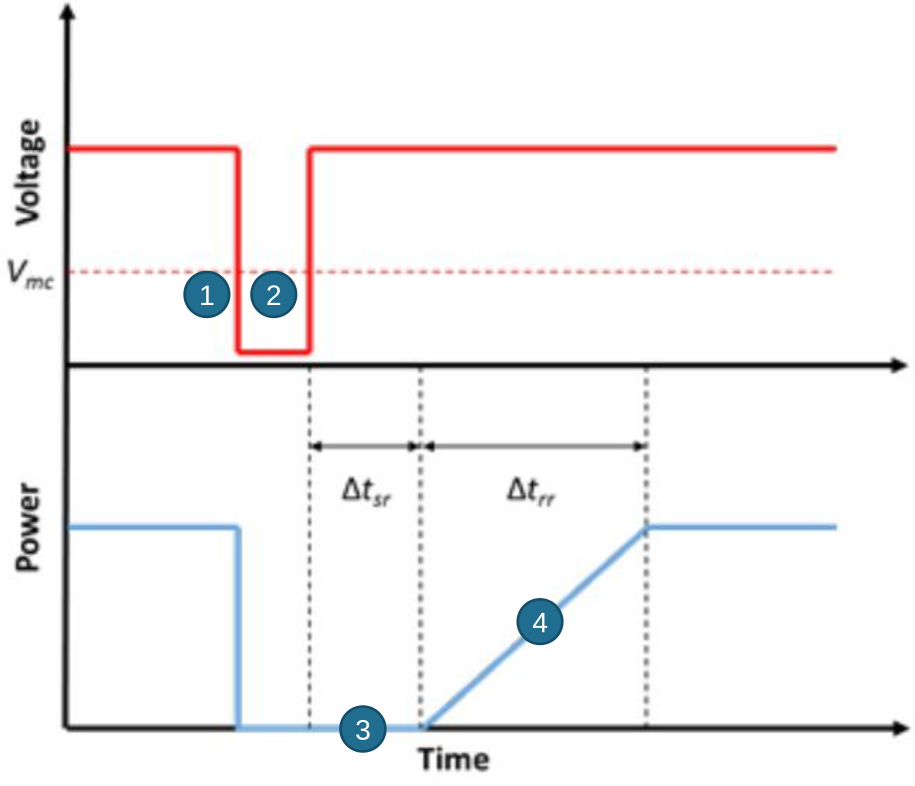


Figure 1: Illustration of Momentary Cessation

Credit: NERC

DER Type	① UV Block Limit (Vmc, PU)	② UV Unblock Limit (Vmc, PU)	③ Recovery Delay* (∆tsr, s)	④ Recovery Ramp Rate (during ∆trr, pu/s)
P1	0.45	0.45	0.033	2.2
P2	0.45	0.45	0.033	2.2
P3	0.5	0.5	0.033	2.2

Table 16—Voltage ride-through requirements for DER of abnormal operating performance Category III (see Figure H.9)

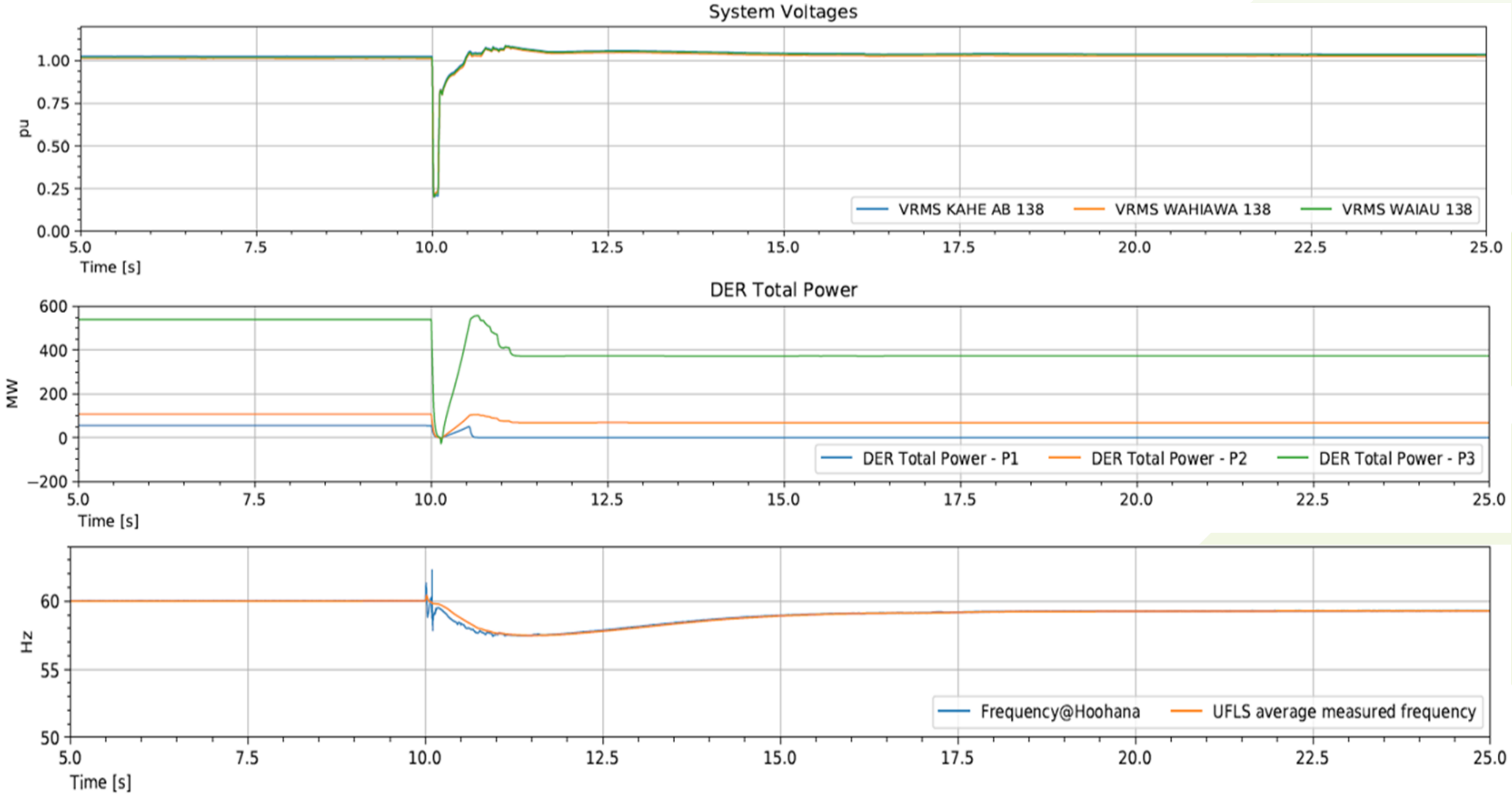
Voltage range (p.u.)	Operating mode/response	Minimum ride-through time (s) (design criteria)	Maximum response time (s) (design criteria)
$V > 1.20$	Cease to Energize[a]	N/A	0.16
$1.10 < V \leq 1.20$	Momentary Cessation[b]	12	0.083
$0.88 \leq V \leq 1.10$	Continuous Operation	Infinite	N/A
$0.70 \leq V < 0.88$	Mandatory Operation	20	N/A
0.50[c] $\leq V < 0.70$	Mandatory Operation	10	N/A
$V <$ 0.50[c]	Momentary Cessation[b]	1	0.083

[a]Cessation of current exchange of DER with Area EPS in not more than the maximum specified time and with no intentional delay. This does not necessarily imply disconnection, isolation, or a trip of the DER. This may include momentary cessation or trip.

[b]Temporarily cease to energize an EPS, while connected to the Area EPS, in response to a disturbance of the applicable voltages or the system frequency, with the capability of immediate restore output of operation when the applicable voltages and the system frequency return to within defined ranges.

[c]The voltage threshold between mandatory operation and momentary operation may be changed by mutual agreement between the Area EPS operator and DER operator, for example to allow the DER to provide Dynamic Voltage Support below 0.5 p.u.

System Stability Study Findings
Systemwide DER Momentary Cessation



System Stability Study Findings
Systemwide DER Tripping

- Undervoltage Tripping

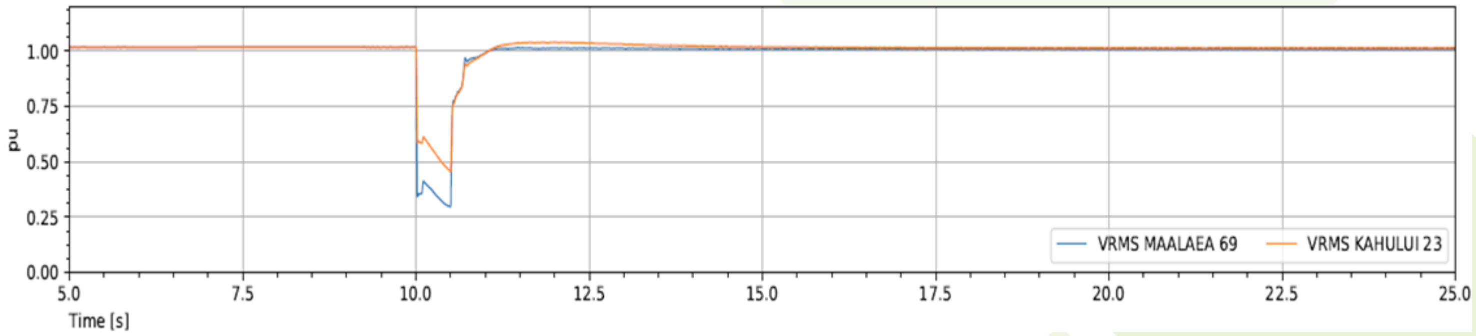
Current Rule 14h SRD Requirements

Operating Region	Voltage at Point of Interconnection (% of Nominal Voltage)	Operating Mode	Ride-Through Until (s)	Default Maximum Trip Time (s)	Range of Adjustability Voltage Trip Magnitude (% of Nominal Voltage)	Range of Adjustability Clearing Time (s)
OV2	V > 120	Cease to Energize	N/A	0.16 [(1)]	N/A	N/A
OV1	120 ≥ V > 110	Mandatory Operation	0.92	1	110 – 120	1 – 13
CO	110 ≥ V > 100	Continuous Operation (Volt-Watt)	N/A	N/A	N/A	N/A
CO	100 > V ≥ 88	Continuous Operation	N/A	N/A	N/A	N/A
UV1	88 > V ≥ 70	Mandatory Operation	20	21	50-88	21-50
UV2	70 > V ≥ 50	Mandatory Operation	10-20	11-21[(2)]	50-88	11-50
UV3	50 > V	Momentary Cessation	N/A	2	N/A	0.5-21

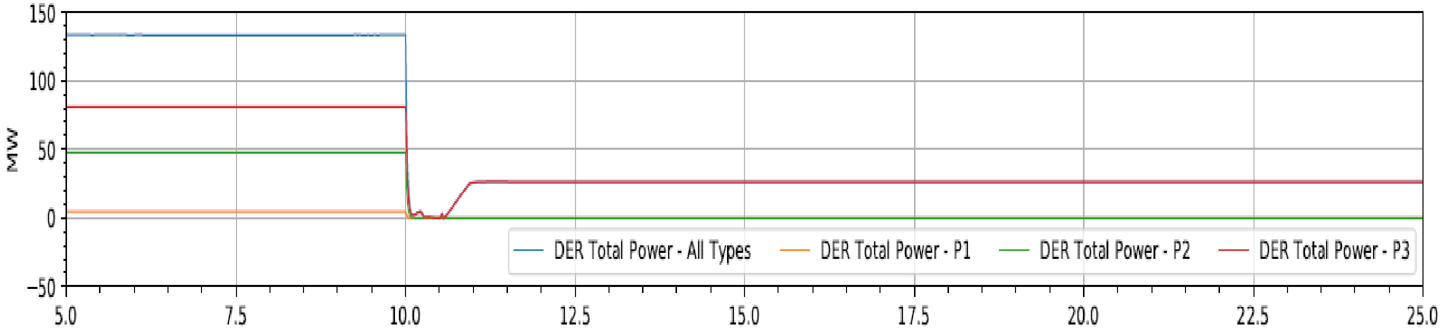
Table 4: Voltage Ride-Through (L/HVRT) ranges of adjustability and default settings

[(1)] Must trip time under steady state condition. Inverters will also be required to meet the Company's Transient Overvoltage criterion (TrOV-2). Ride-Through shall not inhibit TrOV-2 requirements. (See Rule 14H)
[(2)] May be adjusted within these ranges at manufacturer's discretion.

System Voltage



System DER Generation



- ROCOF tripping

System Stability Study Findings
DER Impacts on UFLS

UFLS is an important tool for system frequency stabilization

- Hawaiʻi Island system currently uses dynamic UFLS
- Maui system is adopting dynamic UFLS
- Oʻahu system currently uses static UFLS

DER, both secondary and primary interconnected reduce effectiveness of UFLS

- With higher DER penetration, circuit-based UFLS will shed more customers to reach same load shedding target.

Currently, performing long term UFLS roadmap study, and plan to convert Oʻahu static UFLS to dynamic UFLS.

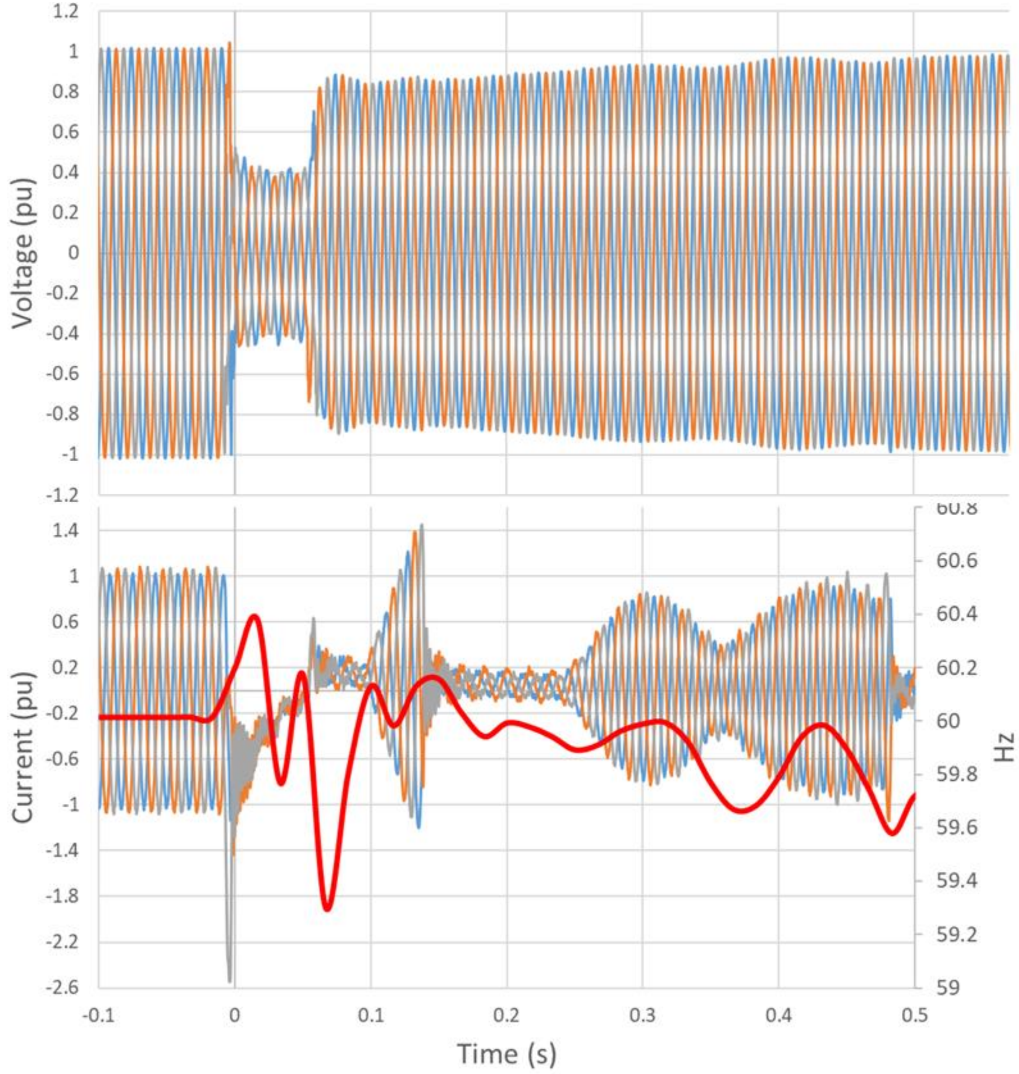
System Stability Study Findings
Existing Grid-Scale Solar IBR Plants

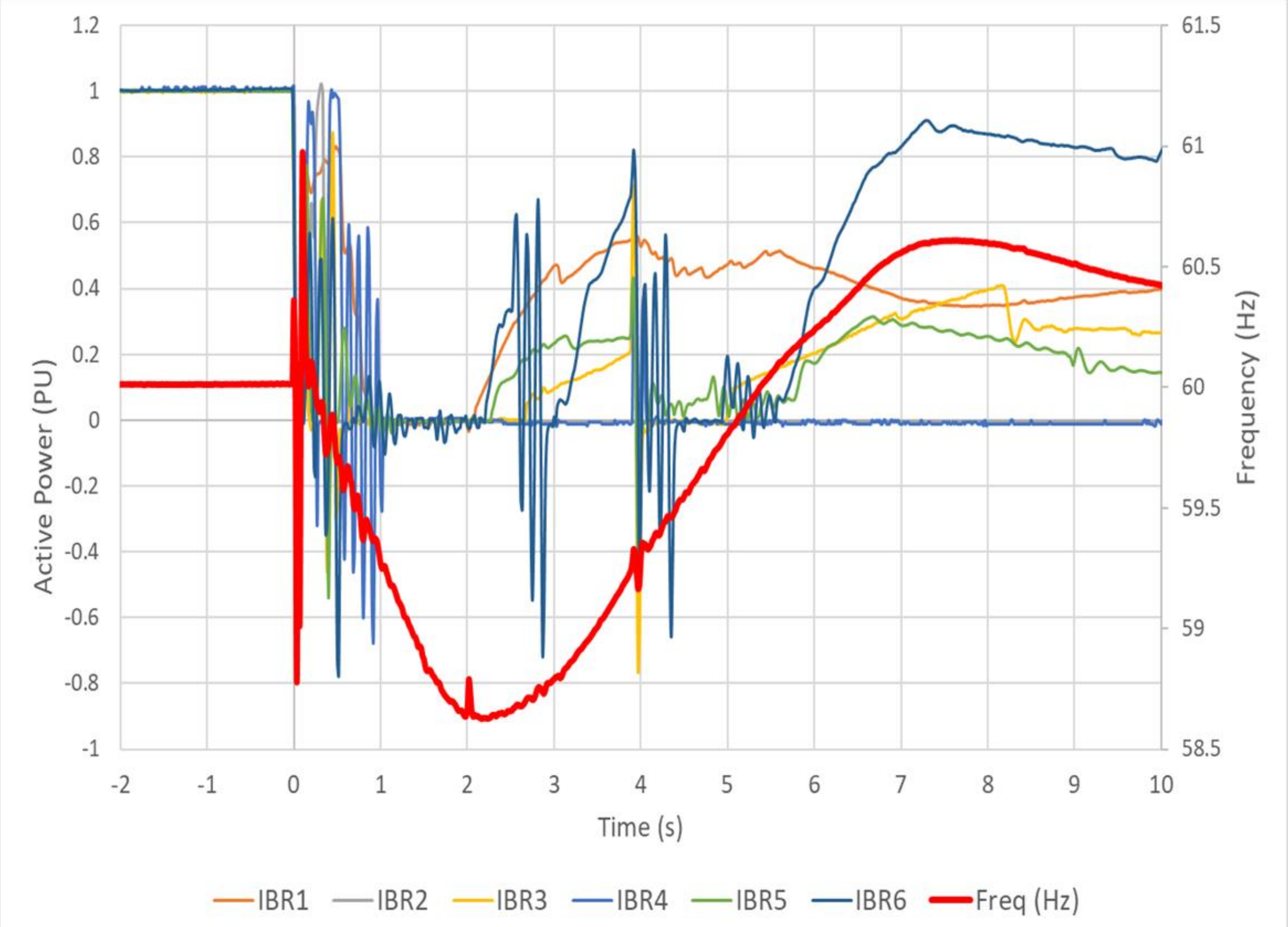
All GFL control, almost no grid stability support

Instantaneous tripping (only from planning study)

"False Positive" simulation results from vender specific planning models

System Stability Study Findings
Existing Grid-Scale Standalone Solar IBR Plants

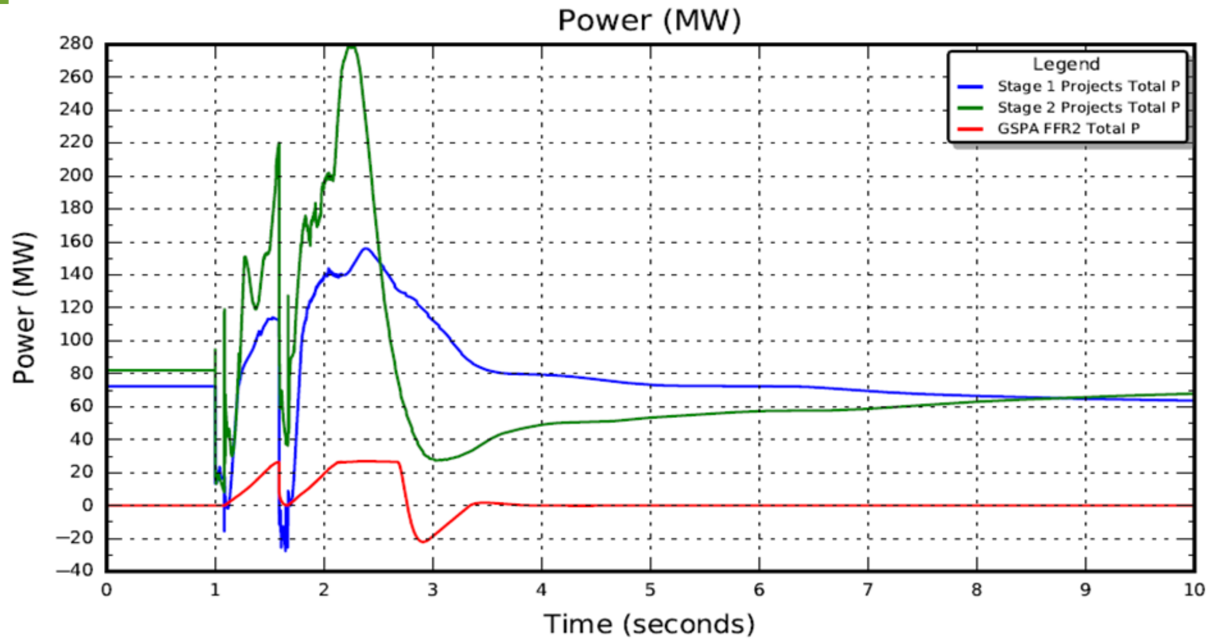


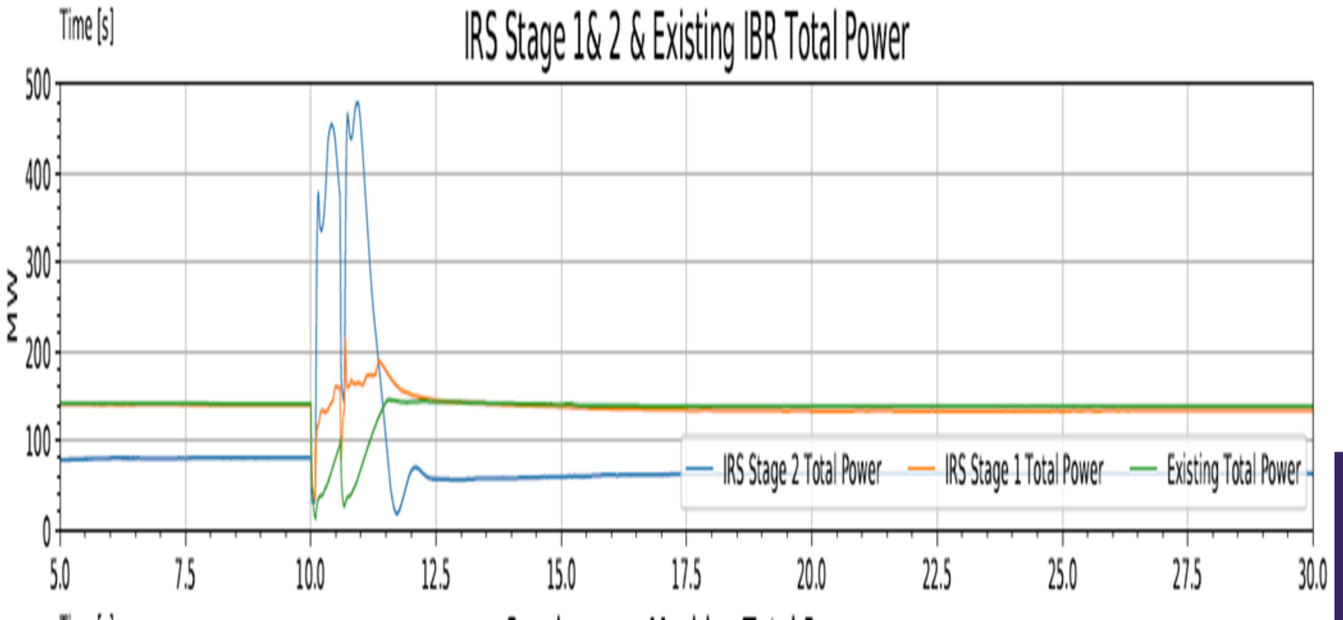


System Stability Study Findings
Grid-Forming IBR is Critical

Storage GFM function requirement in our PPA contract

- Using internal voltage reference for control instead of relying on POI measurements
- Immediate response to system event to support system stability
- Work on very weak grid condition and no grid condition
- Self-energization/black start

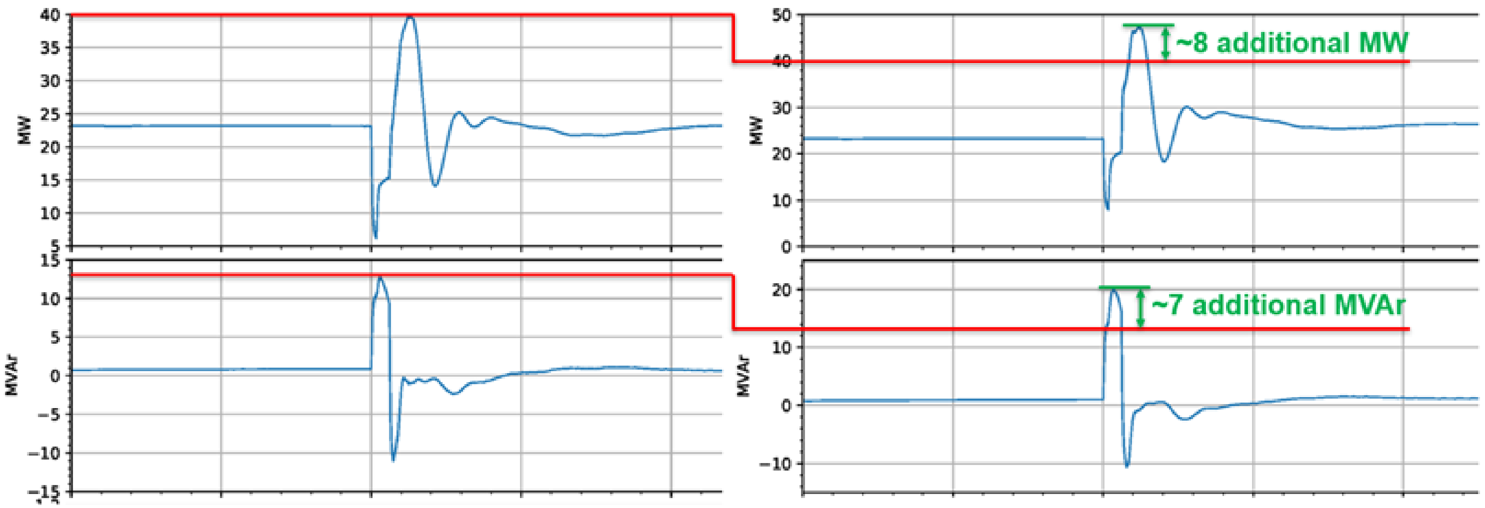




System Stability Study Findings
Grid-Forming IBR is Critical

- Both GFM control and short-term overcurrent capability are important.

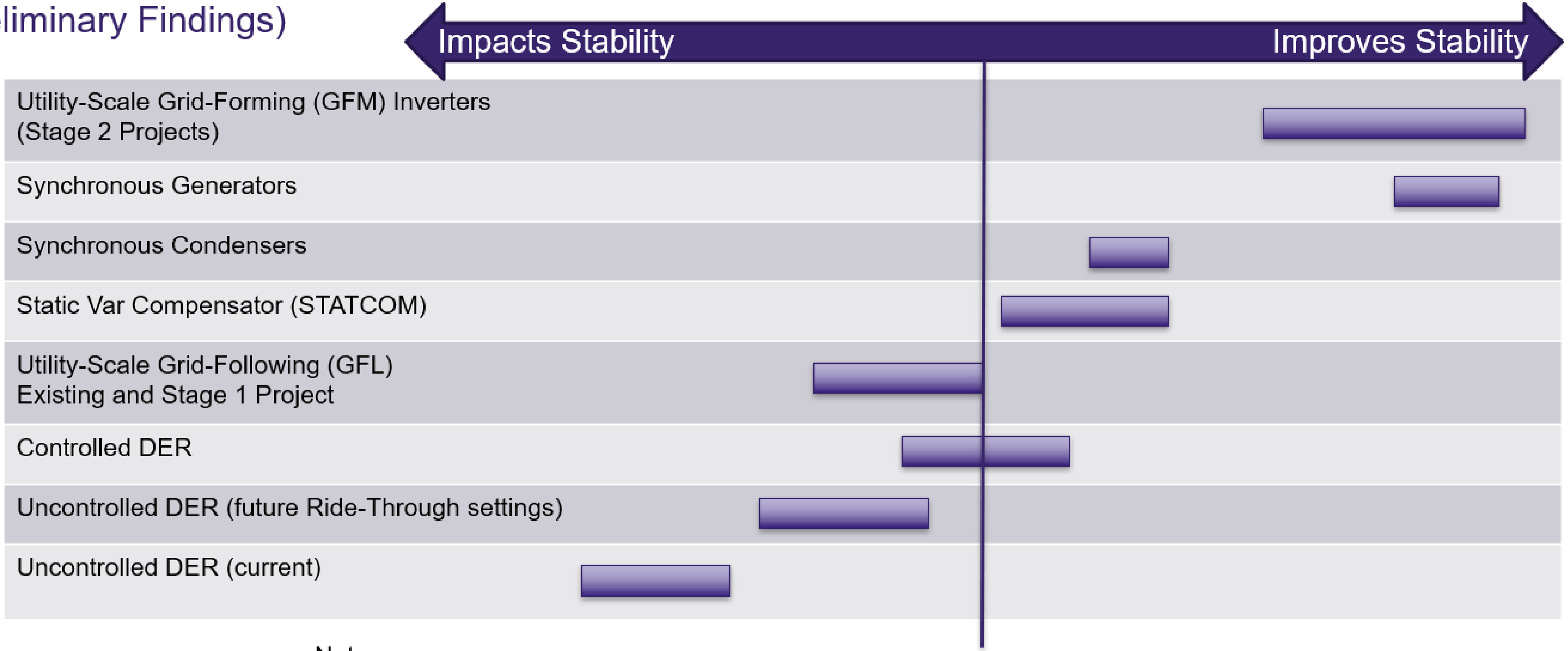
$$\text{Facility Short-Term Overcurrent Capability} = \text{Per Unit BESS Inverter Overcurrent Capability} \cdot \frac{\text{Total of BESS Inverters MVA}}{\text{Facility Contract Capacity (MW)}} \geq 1.6 \text{ for at least 5 seconds}$$



System Stability Study Findings

Relative Range of Stability Support by Resource Type

(Preliminary Findings)



Notes

- Applicable to Hawaiian Electric system only (under low-Synchronous Generator cases)
- Qualitatively based on results from system security study

Recommendations and Action Items

Continue to procure GFM IBR

- For all future battery inverters, only accept GFM control with short-term overcurrent capability requirement.

DER-related

- Doing more inverter testing to understand momentary cessation and ROCOF ride-through.
- Sending out survey to DER inverter OEM
- Possibly revising Rule 14h SRD

UFLS

- Migrating to Dynamic UFLS
- Understanding EV load dynamic characters and evaluate its impact on system.

Recommendations and Action Items

Validating GFM IBR performance post-commission

- Utilizing Digital Fault Recorder (DFR) to capture GFM IBR performance during system event
- Comparing GFM IBR field performance with model simulation results and PPA requirements

Planning study

- Observed lots of limitations on positive sequence simulation software
  - GFM IBR model for dynamic stability study is not available – Controls are OEM-specific
  - Large amount of dynamic simulation are not solvable
- Must perform EMT simulation-based planning study
  - Requires lots of training, building new EMT-based planning platform, and high-end workstations
  - Simulation runtime is much longer

Conclusions

Our Grids continue to evolve… quickly!

What we do know:

- GFM IBR is critical for a 100% renewable plan, and GFL alone will not get us there!
- Need to address risks/impacts due to IBRs (utility-scale and DER) currently on the system AND those being added in the near-term.

We may be scratching the surface of future risks.

Collaboration with stakeholders is critical to getting to a renewable, decarbonized future.

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Mahalo for your time

Questions?

Learn More

hawaiianelectric.com/clean-energy-Hawaii/integrated-grid-planning

ken.aramaki@hawaiianelectric.com

li.yu@hawaiianelectric.com

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