



Grid Reliability and Resilience Augmentation with Storage and DERs

Farrokh Rahimi, Ph.D.
Senior Vice President,
Market Design & Consulting



Trade Secret

This document and attachments contain confidential and proprietary information of Open Access Technology International, Inc. This information is not to be used, disseminated, distributed, or otherwise transferred without the expressed written permission of Open Access Technology International, Inc.

Proprietary Notice

All OATI products and services listed are trademarks and service marks of Open Access Technology International, Inc. All rights reserved.

Topics

- Resilience versus Reliability
- Role of Storage/Distributed Energy Resources (DERs) in Reliability Augmentation
 - *Bulk Power Ancillary Services (AS)*
 - *Distribution Reliability Services*
 - *Valuation and Monetization*
 - *Field Experiments*
- Role of Storage/DER in Improving Resilience
- Representative Use Cases
- Gaps and Topics for Further Research
 - *Resilience Metrics*
 - *Resilience Valuation and Monetization Standards*

Resilience versus Reliability

Resilience

- According to the National Infrastructure Advisory Council (2009, 8):
 - *Critical infrastructure resilience is defined as the ability to reduce the magnitude and/or duration of disruptive events*
 - *The effectiveness of a resilient infrastructure or enterprise depends upon its ability to **anticipate, absorb, adapt to, and/or rapidly recover** from a potentially disruptive event*
- There are **no standard metrics** today to quantify resilience
- Qualitative measures can be used for comparison

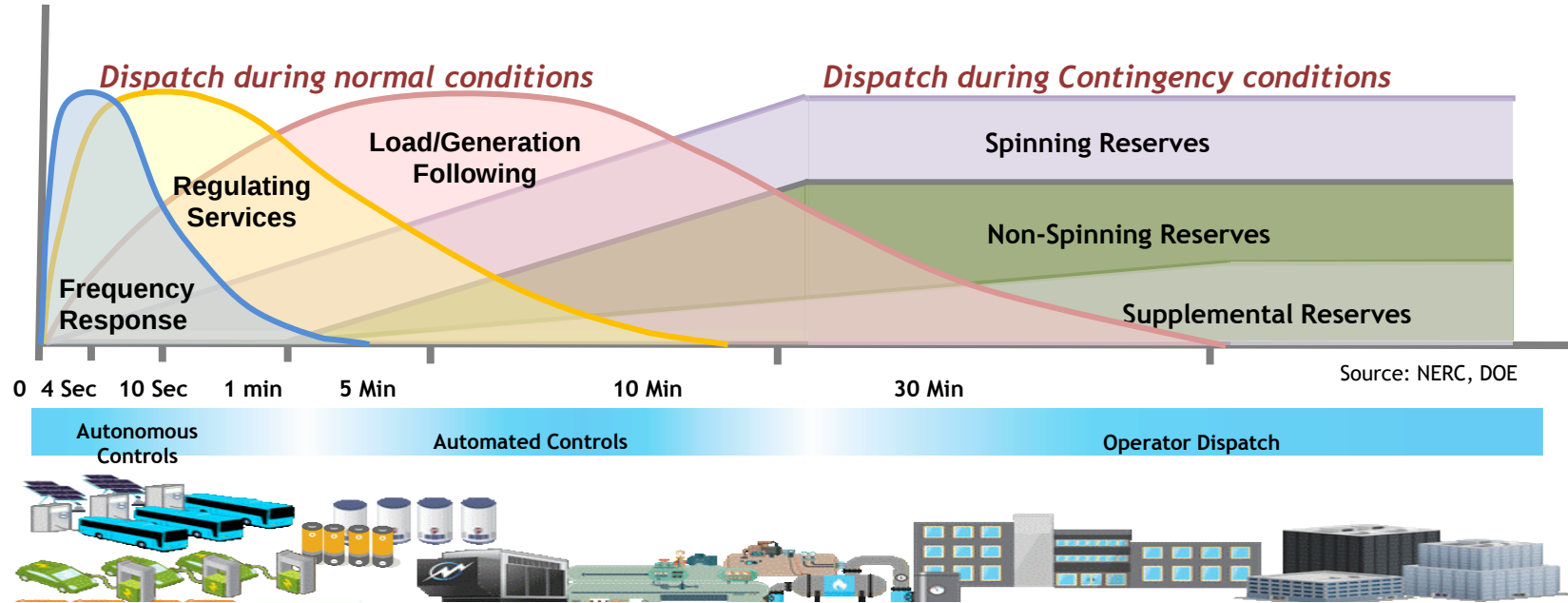
Reliability

- Reliability is defined as the ability of the power system to **deliver electricity in the quantity and with the quality needed to satisfy demand**
- Reliability is generally measured by interruption indices such as:
 - **SAIDI** (System Average Interruption Duration Index)
 - **SAIFI** (System Average Interruption Frequency Index)
 - **CAIDI** (Customer Average Interruption Duration Index)

Role of Storage/DERs in Reliability Augmentation

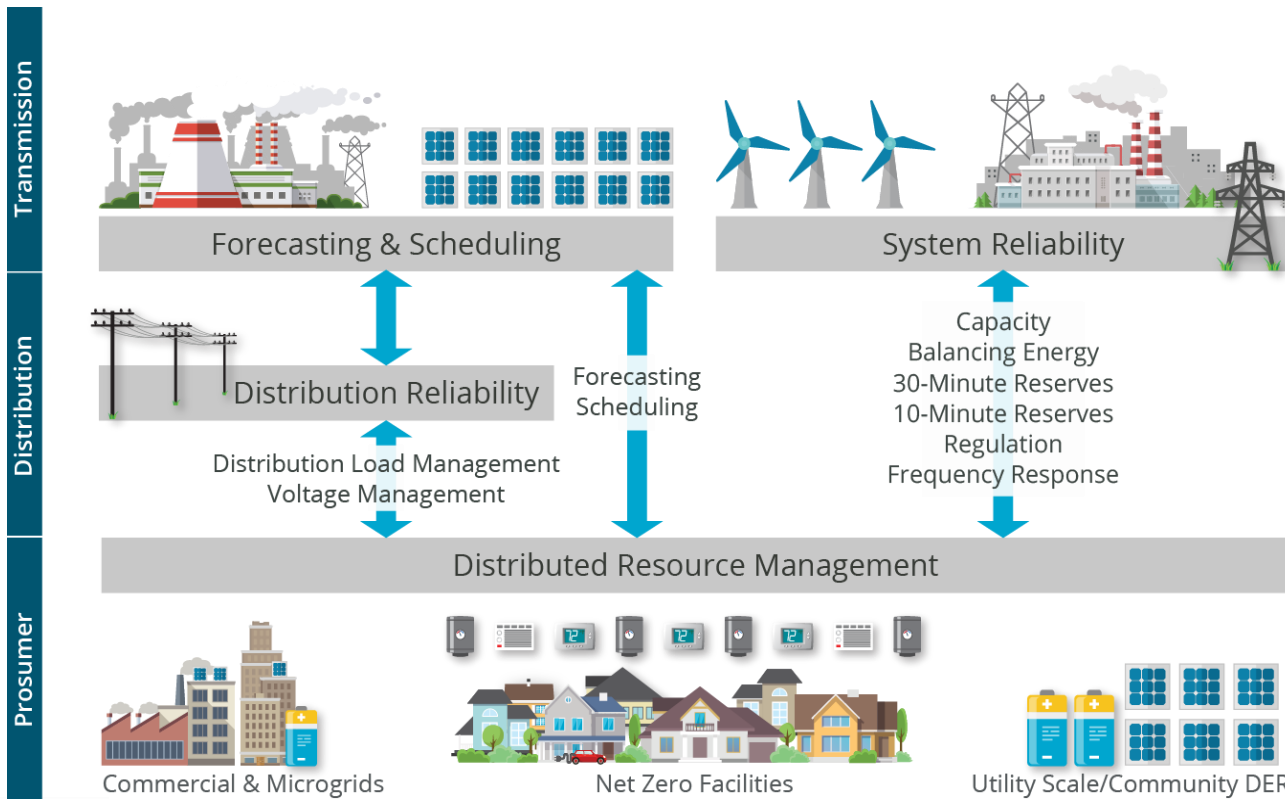
- Bulk Power AS
- Distribution Reliability Services
- Valuation and Monetization
- Field Experiments

Supply of Grid Services

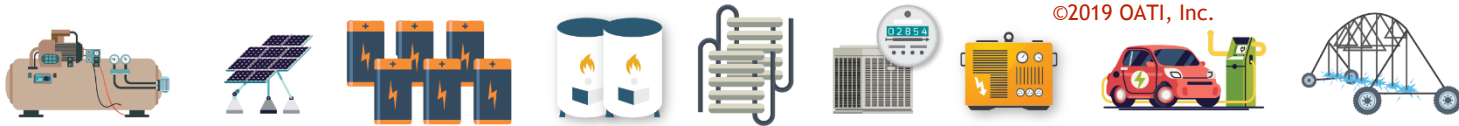
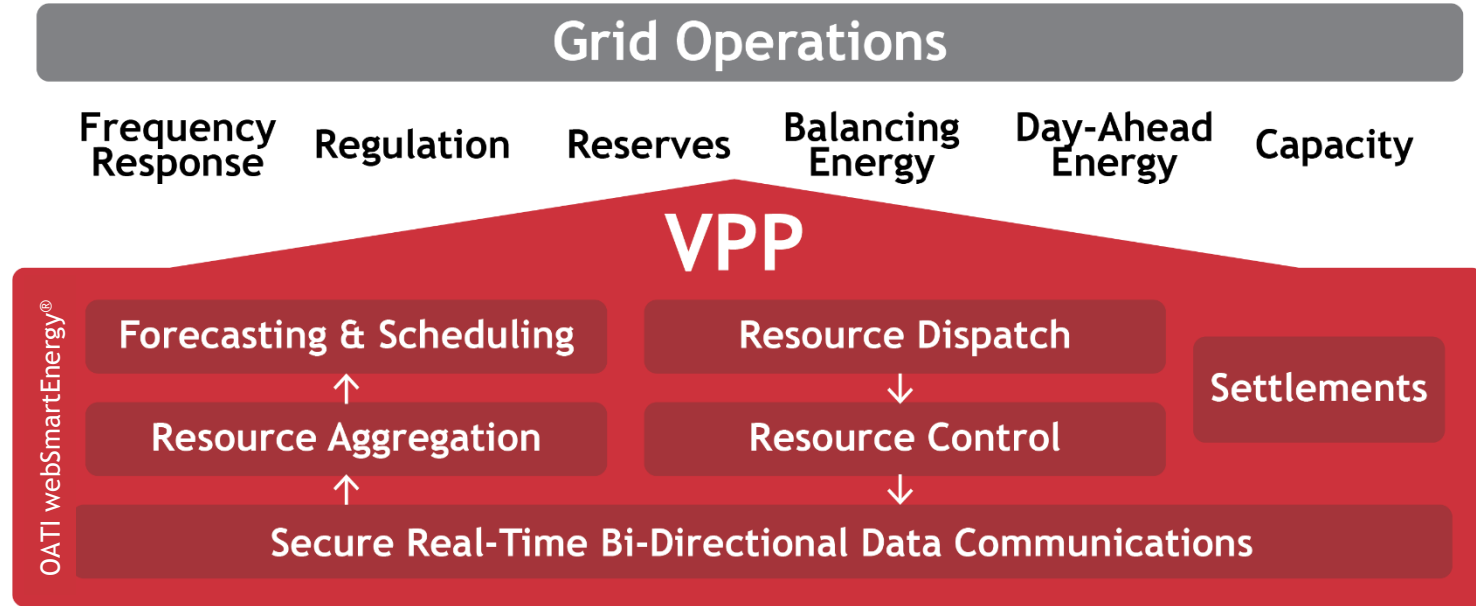


©2019 OATI, Inc.

Supply Grid Services From Demand-Side Resources

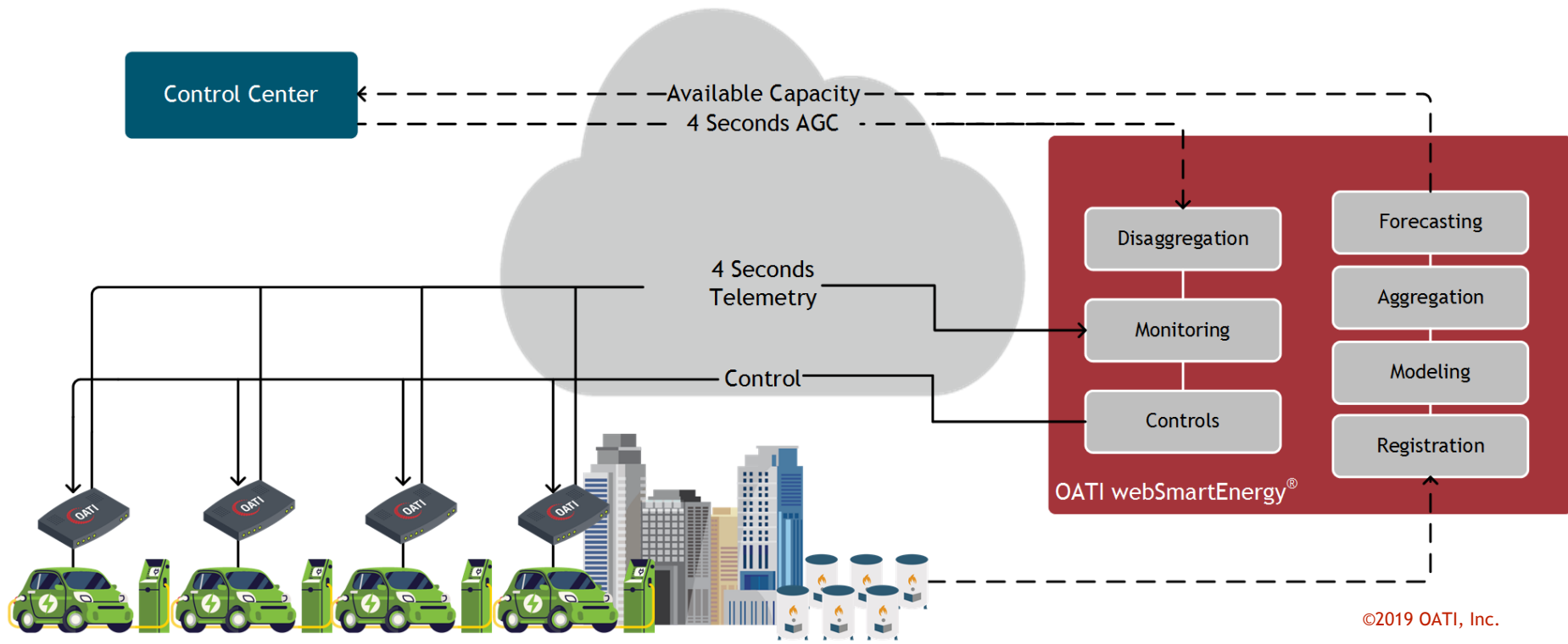


Virtual Power Plant (VPP) Concept



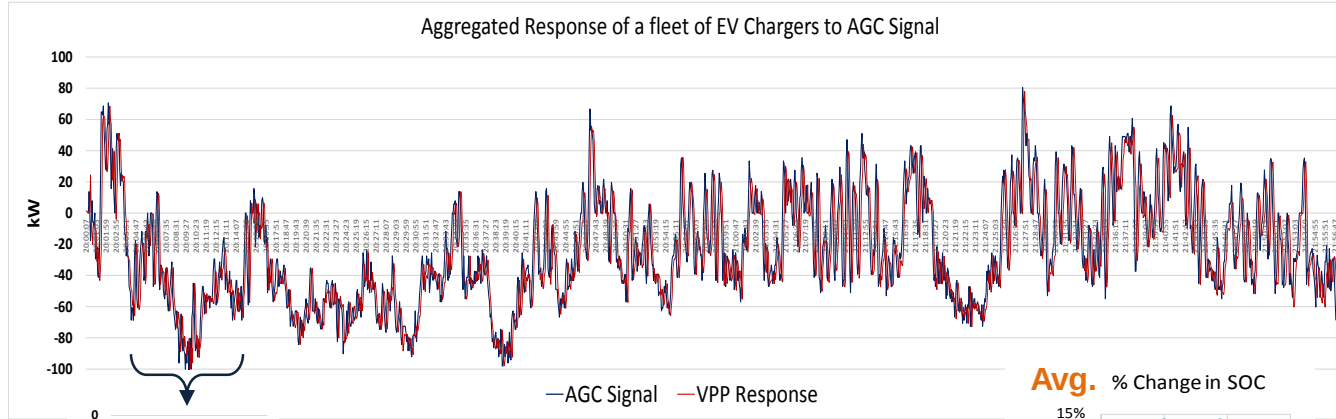
©2019 OATI, Inc.

Response of DER Portfolio to AGC/Regulation Signal



©2019 OATI, Inc.

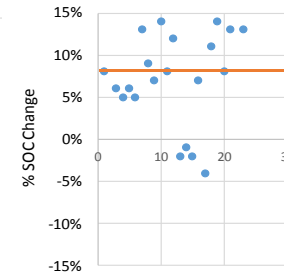
Response of a VPP (23 EVs) to AGC Signal



PJM Score

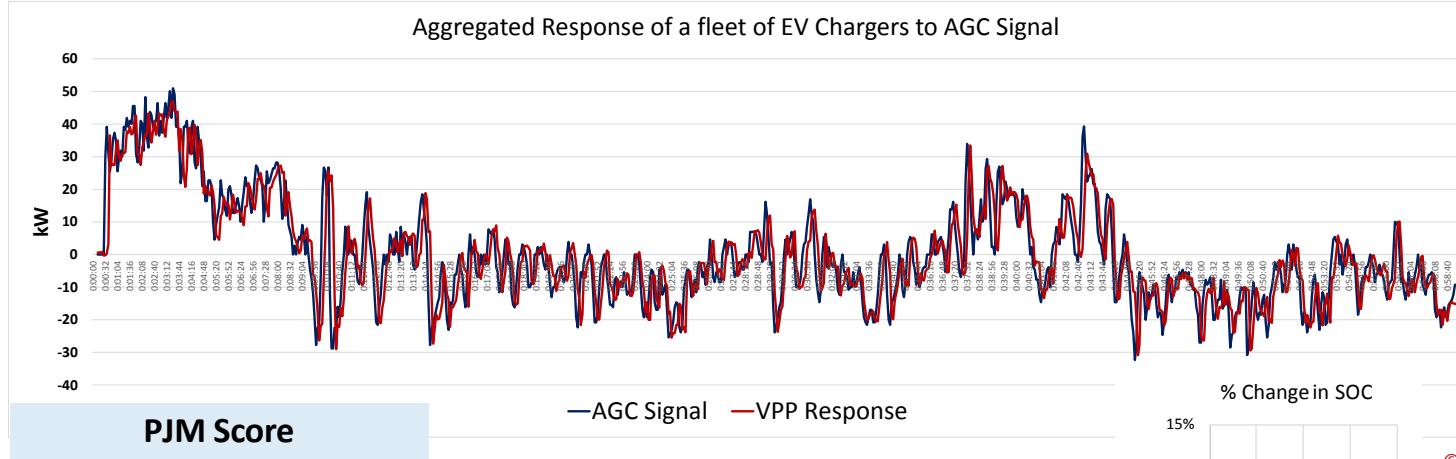
Accuracy Score	97.0
Delay Score	100.0
Precision Score	90.0
Composite Score	95.7

Avg. % Change in SOC



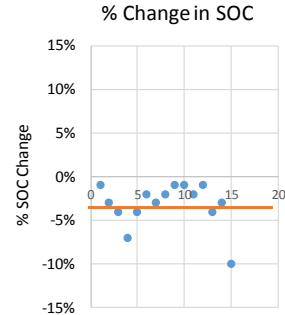
©2019 OATI, Inc.

Response of a VPP (15 EVs) to AGC Signal



PJM Score

Accuracy Score	96.6
Delay Score	100.0
Precision Score	96.6
Composite Score	97.7

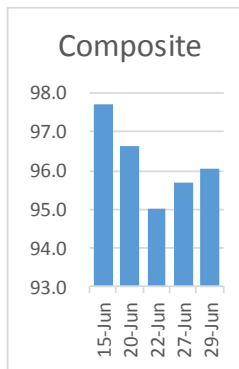
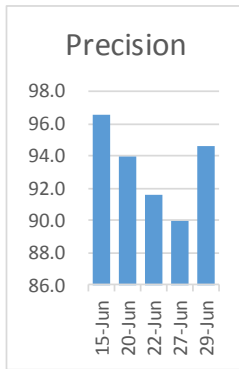
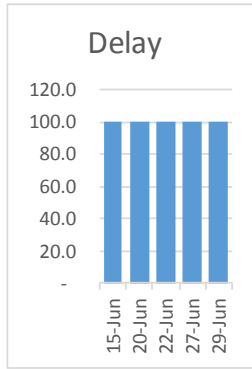
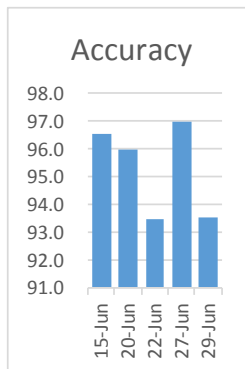


©2019 OATI, Inc.

Summary & Comparison with the PJM Benchmark

EV Fleet Performance

	15-Jun	20-Jun	22-Jun	27-Jun	29-Jun	Average
Number of EVs	15	16	15	23	18	17.4
Accuracy	96.6	96.0	93.4	97.0	93.5	95.3
Delay	100.0	100.0	100.0	100.0	100.0	100.0
Precision	96.6	93.9	91.6	90.0	94.6	93.3
Composite	97.7	96.6	95.0	95.7	96.0	96.2



PJM Composite Benchmark



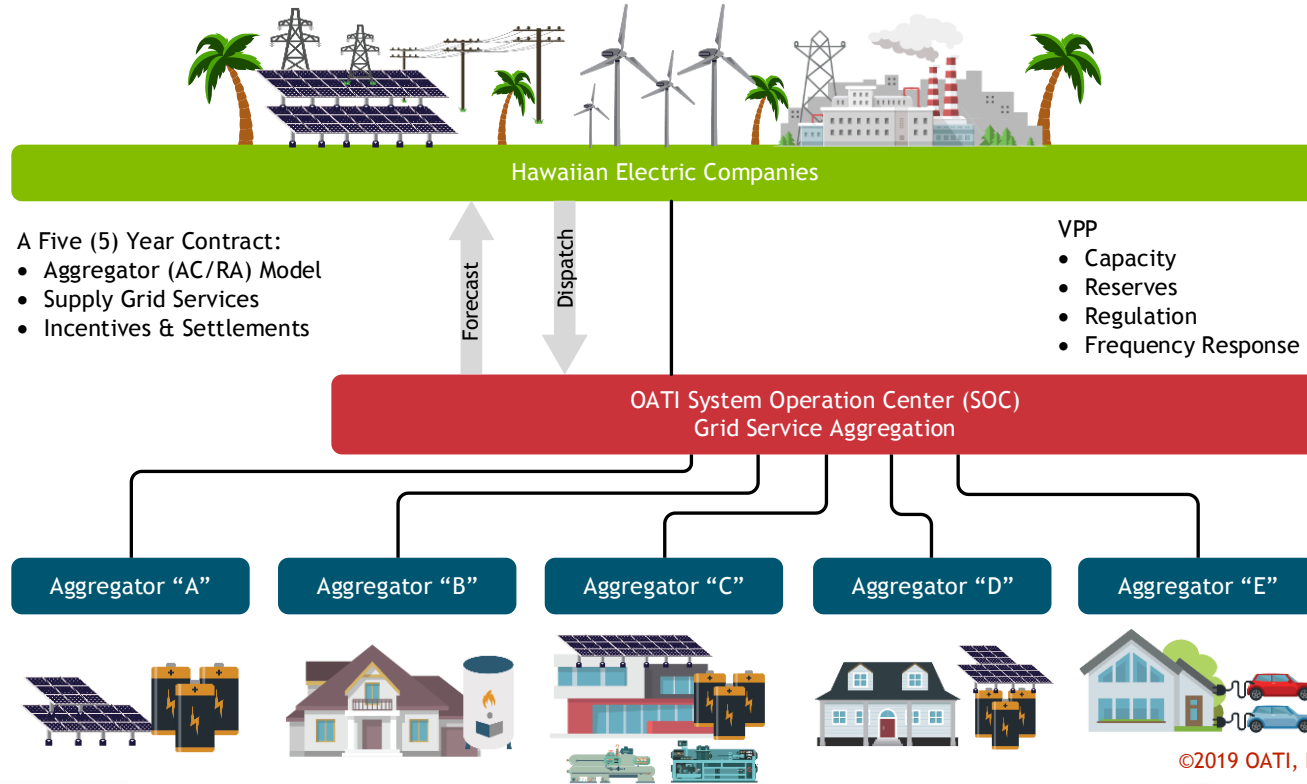
Average Performance Scores by Class, Nov 2015

Resource Type	Resource Sub Type	REGA Performance	REGD Performance
GEN	Battery		94.0
GEN	CT	84.4	90.0
GEN	Hydro	79.6	75.7
GEN	Steam	73.6	
DSR	DSR	78.8	84.2

DSR: Demand-Side Resource

©2019 OATI, Inc.

Hawaiian Electric Company (HECO) Grid Services



©2019 OATI, Inc.

Role of Storage/DER in Improving Resilience

- Representative Use Cases
- Gaps and Topics for Further Research
 - *Resilience Metrics*
 - *Resilience Valuation and Monetization Standards*

Resilience Criteria

- Criteria
 - *Ability to withstand extreme events and cyber attacks: Hardening the grid infrastructure*
 - *Capability to limit the impact of extreme events and attacks: Vigilance and Early Detection*
 - *Agility to recover from failure in the face of extreme events: Speedy restoration/Self-healing*

Resilience Measures

- Resilience **Enhancement** Measures:
 - *Grid Hardening: Investment in grid infrastructure*
 - Conventional: Generation, Transmission, and Distribution upgrade investments
 - Additional new measures: Microgrids; Leveraging Demand Response (DR)/DER (Non-wires Alternatives [NWA])
 - *Vigilance and Early Detection*
 - Conventional: Fault Location and Isolation; Remedial Action Schemes (RAS)
 - Additional new measures: A number of emerging standards for both grid and grid edge system operations, including ride through standards (IEEE 1547), Microgrid interconnection standards, etc.
 - *Speedy Restoration*
 - Conventional: Manual system restoration
 - Additional new measures: Automatic self-healing capabilities

Proposed Metrics to Measure Resilience

- Metrics based on early detection and self-healing capabilities (comparison of resilience measure compared to status quo):
 - *Reduction of the geographical scope of the impact of probable extreme events*
 - *Reduction of the effective impact intensity of the extreme events*
 - *Reduction of the duration of impact of the extreme events*
 - *Reduction of the impacts of probable extreme events on loss of human life*
 - *Reduction of the impacts of probable extreme events on economic losses*
- Metrics based on system hardening:
 - *Number of malicious cyber attacks averted*
 - *Number of natural disasters averted*

Questions

Thank You

Farrokh Rahimi
sales@oati.net
763.201.2081