Electric Vehicles and Energy Storage: Impacts on Distribution Grid Operations

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Trade Secret

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Topics

- Current Trends – Electric Vehicles (EVs) and Energy Storage
- Impacts on Electric Power Industry Operations and Bottom Line
- Smart Inverters
- Provision of Grid Services
- Case Studies
- Questions

Industry in Transition

- Focus on the Environment
- Federal Energy Regulatory Commission (FERC) Order 841
- De-carbonization of Power and Transportation Sectors
  - *Example: U.K. de-carbonization plan*
    - Objective: cut residential, industrial, transportation, and power sector greenhouse gas emissions
    - $210 million in Research and Development, $4.7 billion to upgrade around 1 million homes, and $5.9 billion to support low carbon heat technologies in homes and businesses between 2016 and 2021
    - Higher taxes on diesel engines, 25% subsidy on the cost of new plug-in vehicles, 12,000 charging points (2017)

Industry in Transition (Continued)

- *Example: Volvo will sell only Plug-in Hybrid Electric Vehicles (PHEVs), introducing electric trucks*
- *Example: The California Public Utilities Commission (PUC) approved $750 million for proposals from the state's investor-owned utilities to expand EV infrastructure and rebate programs*

Battery Storage Systems and EVs

- Lithium-Ion Batteries
  - *Increasing demand*
  - *Lowering of prices - $70/kWh by 2030*
- EVs
  - *Government incentive programs*
  - *Tightening fuel economy standards*
  - *Commitments from auto makers: Volkswagen, Volvo, Daimler, and Nissan*
  - *Growing commitment to invest in charging infrastructure*

55% EV Share
of new car sales in 2040

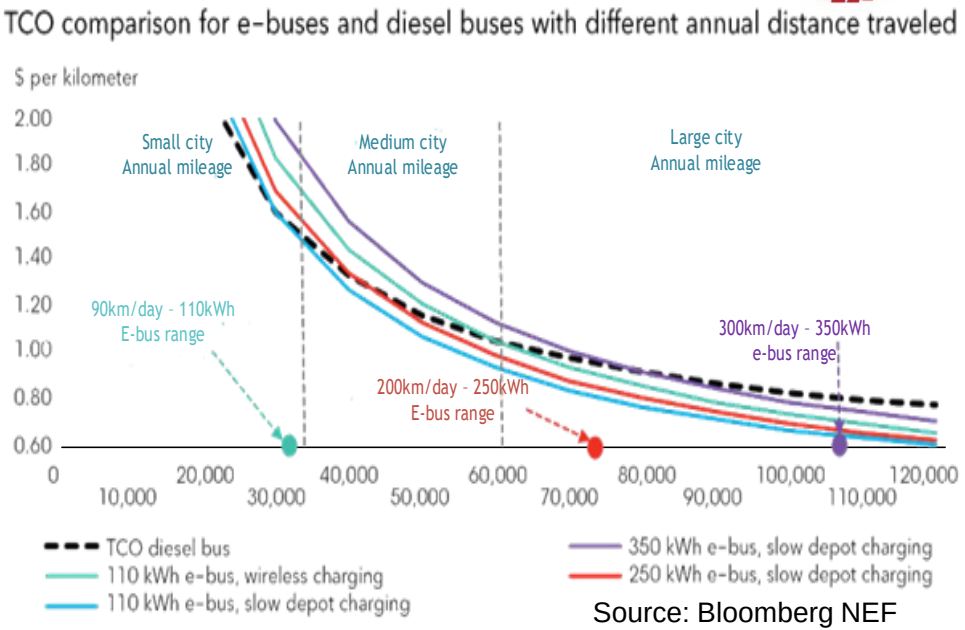
$70/kWh
battery pack
prices in 2030

Sources: Bloomberg New Energy Finance
Nicholas School of Business of the Environment/Duke University

EVs - O&M/TCO

	EV	ICE
Oil Change	$0	$10,000
Transmission Fluid	$0	$50
Fuel	$3,500	$12,500
Spark Plugs/Wires	$0	$200
Muffler	$0	$150
100 K Maintenance	$0	$1,100
Battery Life 15 Years	$5,500	N/A
Total O&M Costs	$9,000	$24,000

Source: eMotorWerks

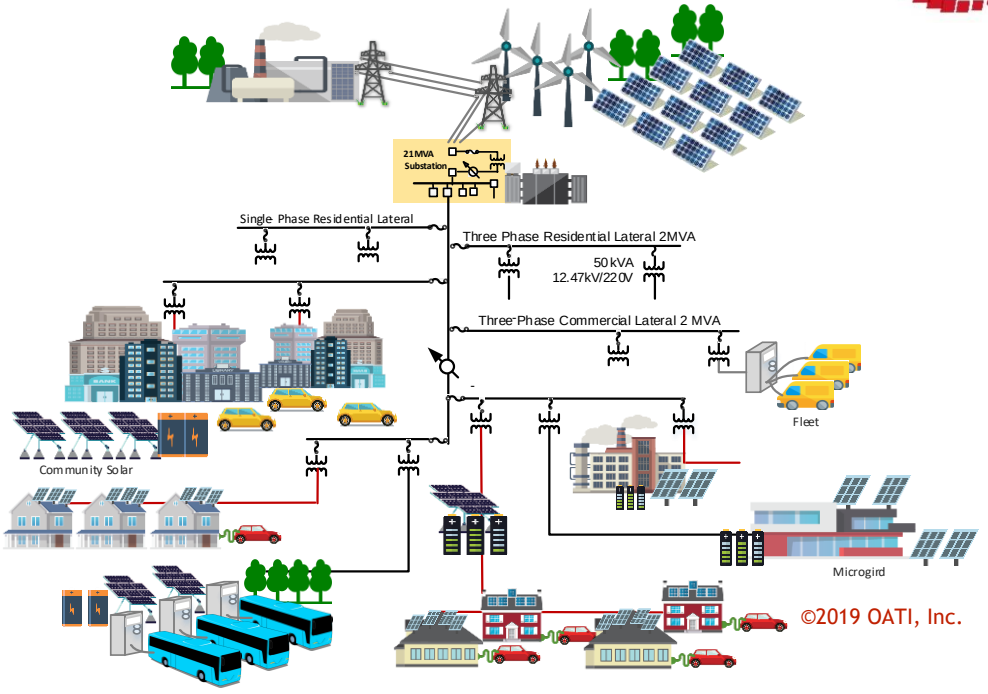


Source: Bloomberg NEF

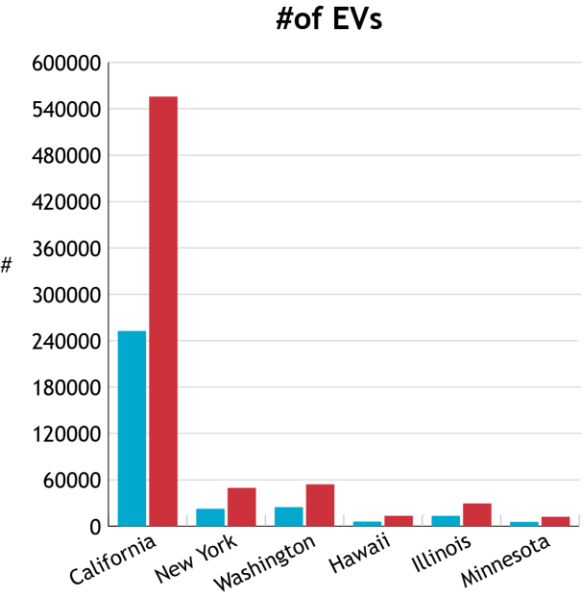
Note: Diesel price at $2.5/gallon, electricity price at $0.10/kWh

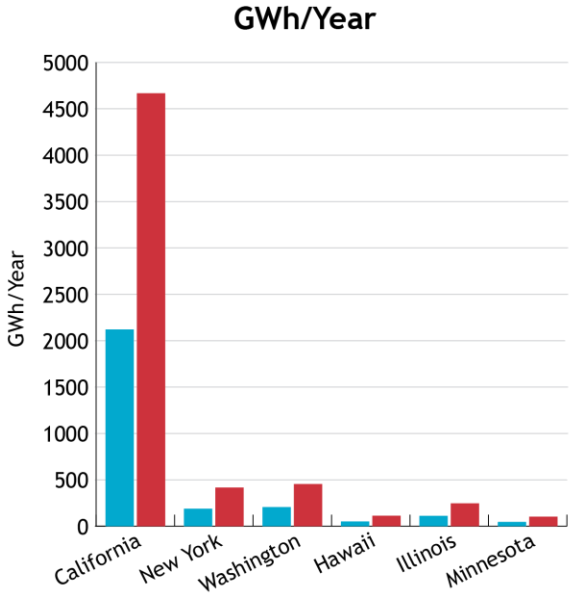
Impact on Distribution System

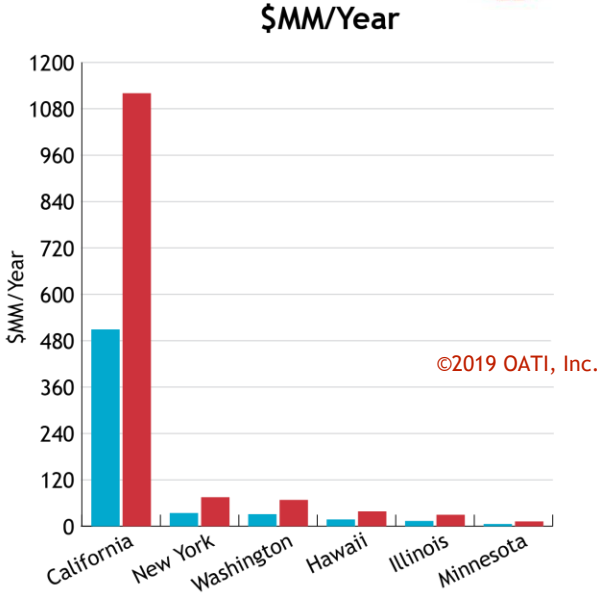
- Reverse Power Flows
- Voltage Fluctuations
- Phase Imbalances
- Frequency Fluctuations



Impact on the Utility Business







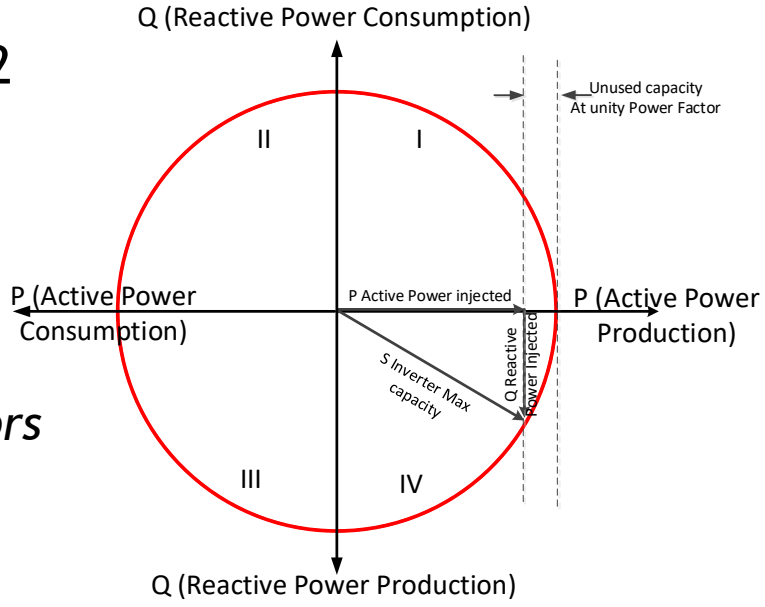
Source: Bloomberg New Energy Finance

Utility's Role

- Develop EV Rate Options
- Enhance Charging Infrastructure
- Manage Charging Stations
- Enable Delivery of Grid Services

Delivering Services - Smart Inverters

- CA Rule 21, IEEE 1547.a, IEEE 2003.5, IEC 61850, UL 1741, UL 1998, and SEP 2 and DNP 3.0
- New Regulations and Requirements for Smart Inverters
  - *Real and reactive power control*
  - *Operating regions with differing behaviors*
  - *Low/high voltage and frequency ride through*



Modes of Operations – Autonomous

- Measure Local/Terminal Variables (Voltage, Frequency, Active Power, and Reactive Power)
- Local Control Decisions based on Pre-set Thresholds and Parameters
- Addresses Local Issues
- Fast Response (Cycles-Sub Second)
- No Requirements for Sophisticated Communications and Remote Control

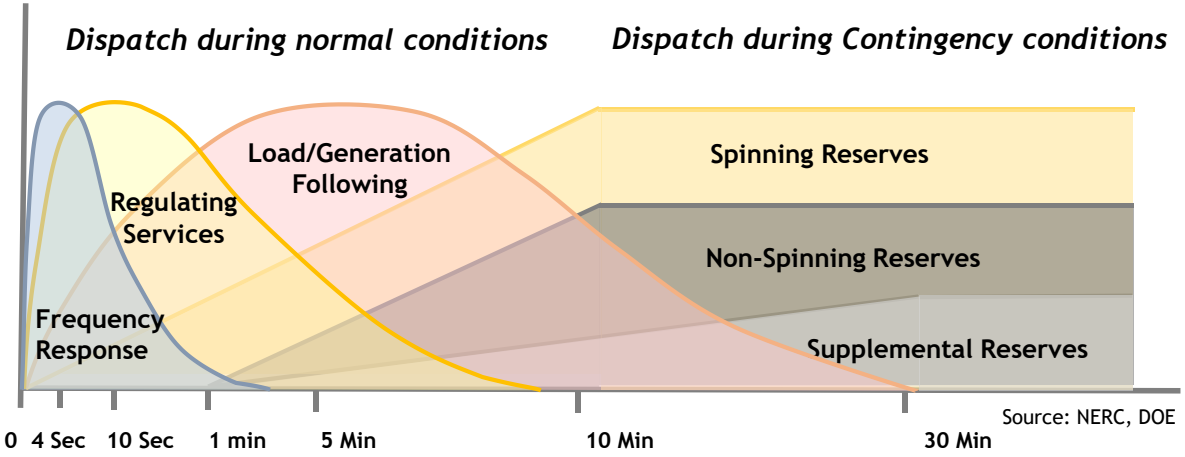
Modes of Operations – Remote Control/ On Demand

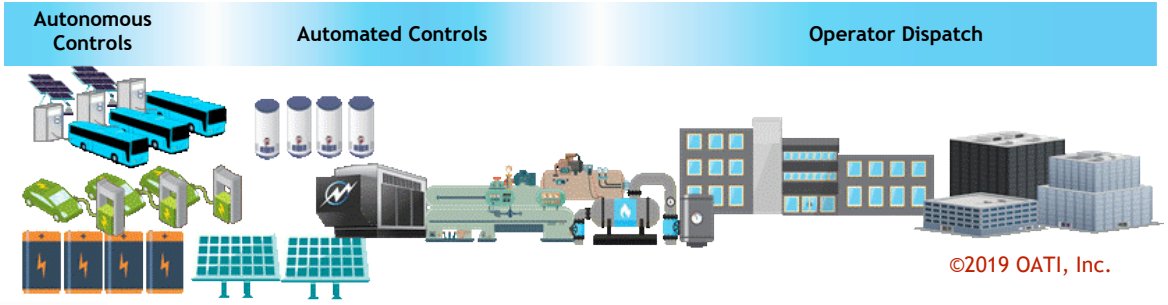
- Measures and Communicates Local/Terminal Variables (Voltage, Frequency, Active Power, Reactive Power)
- Control Instructions from the Distributed Energy Resource Management System (DERMS)
- Addresses System-wide Issues in Concert with Other Resources
- Response in Near Real-Time (RT) (seconds/minutes)
- Requires Communications and Control Infrastructure

Delivering Services

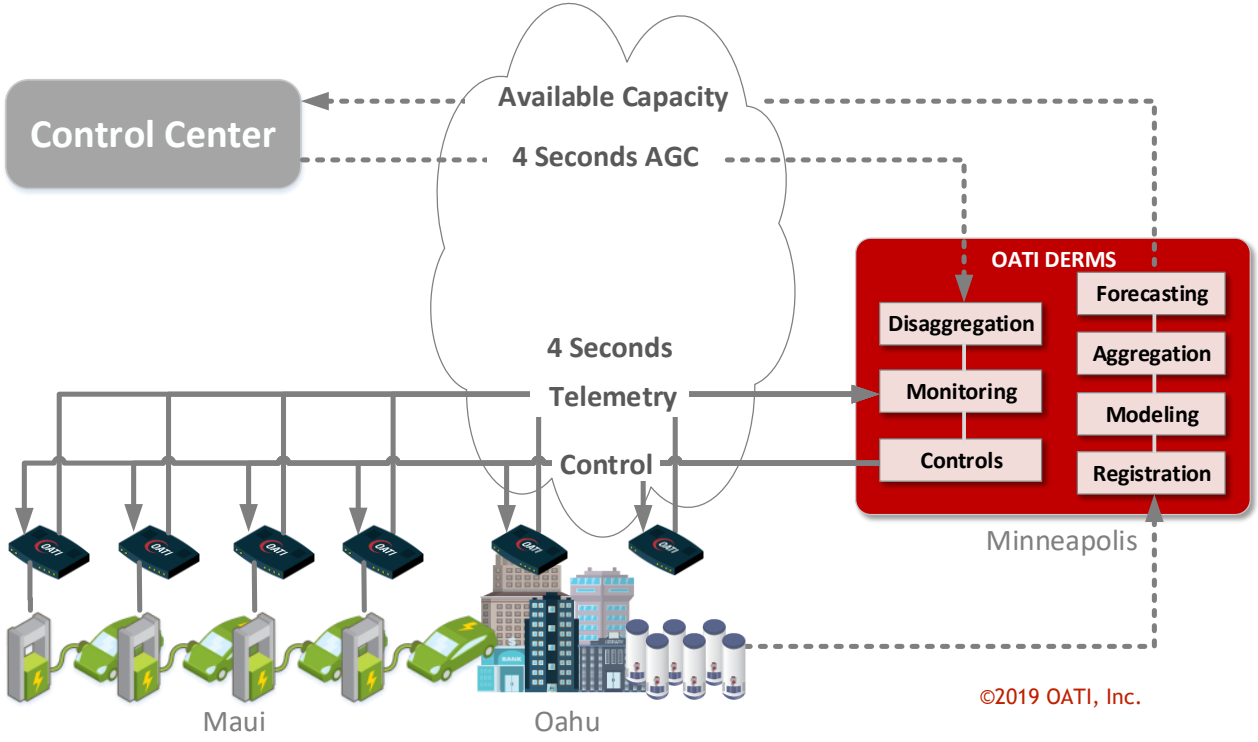
- Vehicle to Building (V2B)/Vehicle to Home (V2H)
  - *Improved economics*
  - *Improved resiliency*
- Vehicle to Grid (V2G)
  - *Improved resiliency*
  - *Provision of grid services (capacity, energy, frequency response, regulation, reserves, and voltage support)*
  - *Non-wires alternatives, deferment of capital expenditures*

Focus on Grid Services

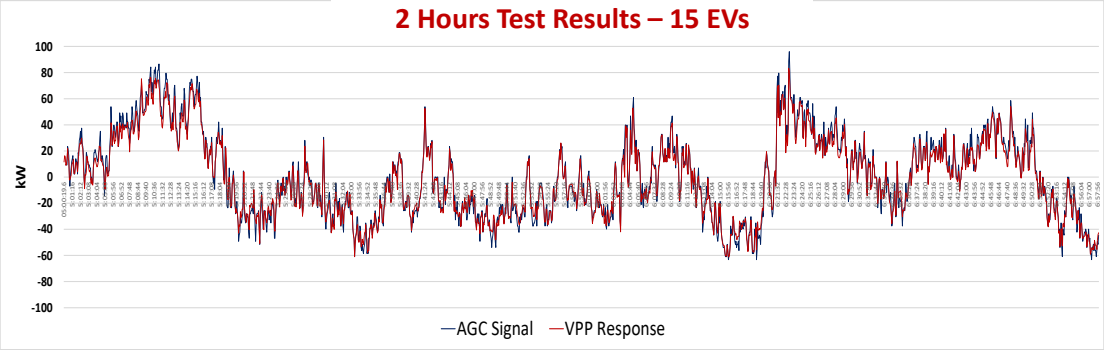


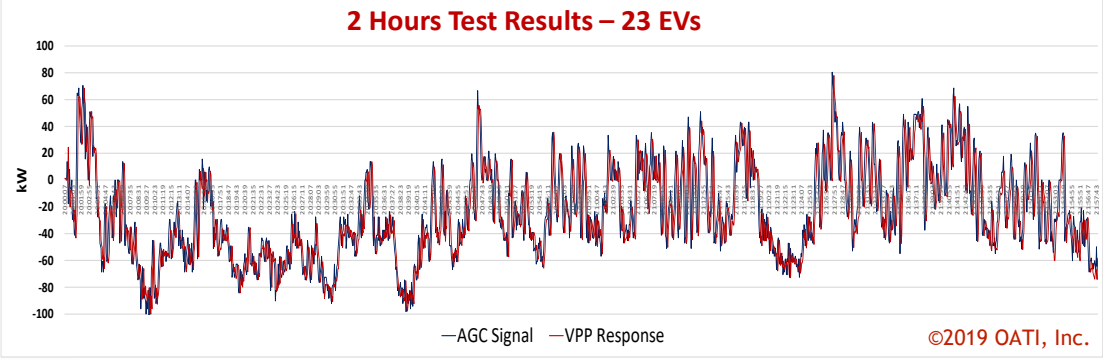


Case Study - HECO



Case Study - HECO (Continued)

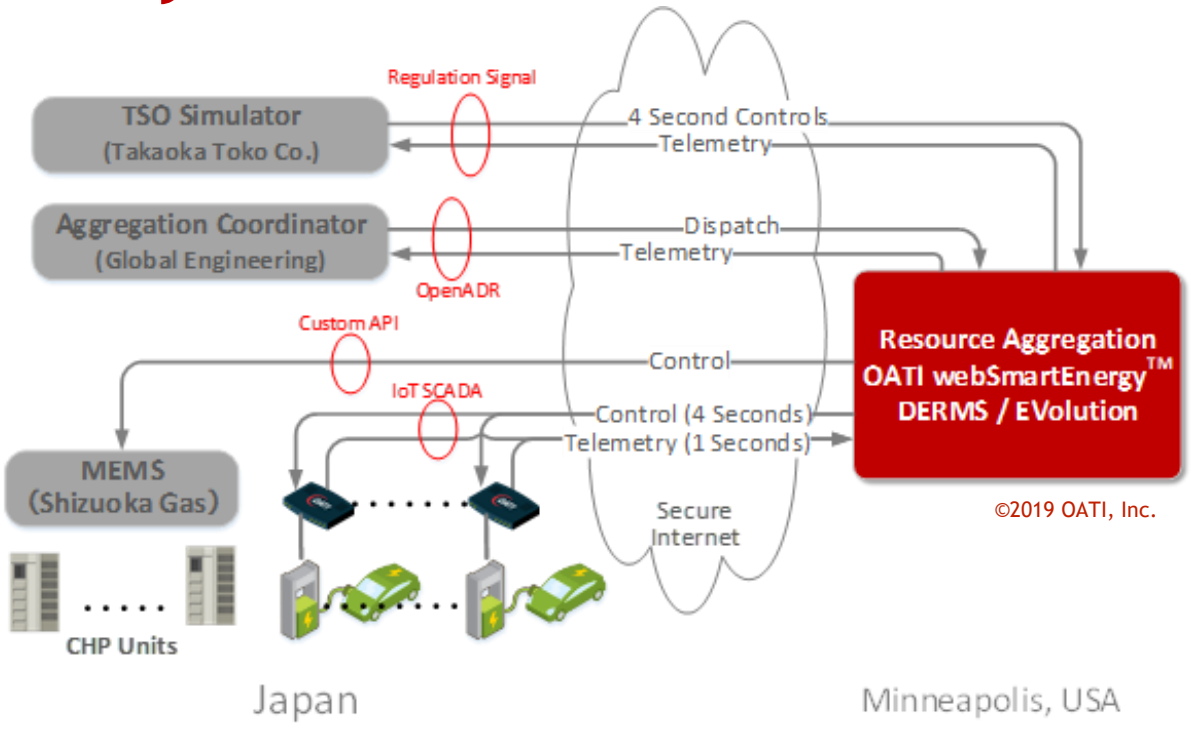




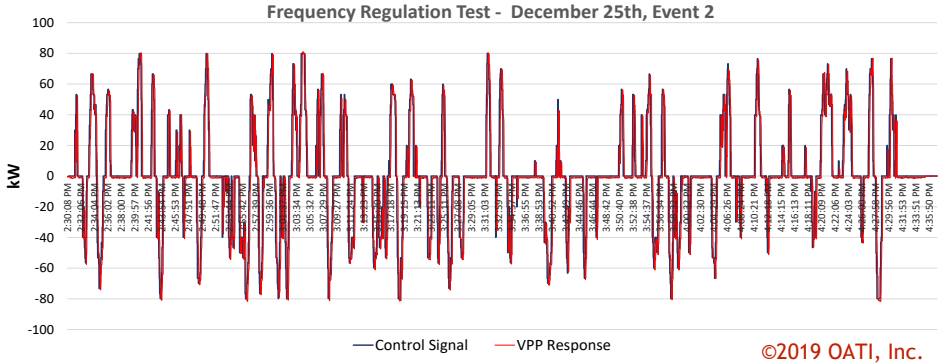
Case Study - HECO (Continued)

	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**

Case Study - METI

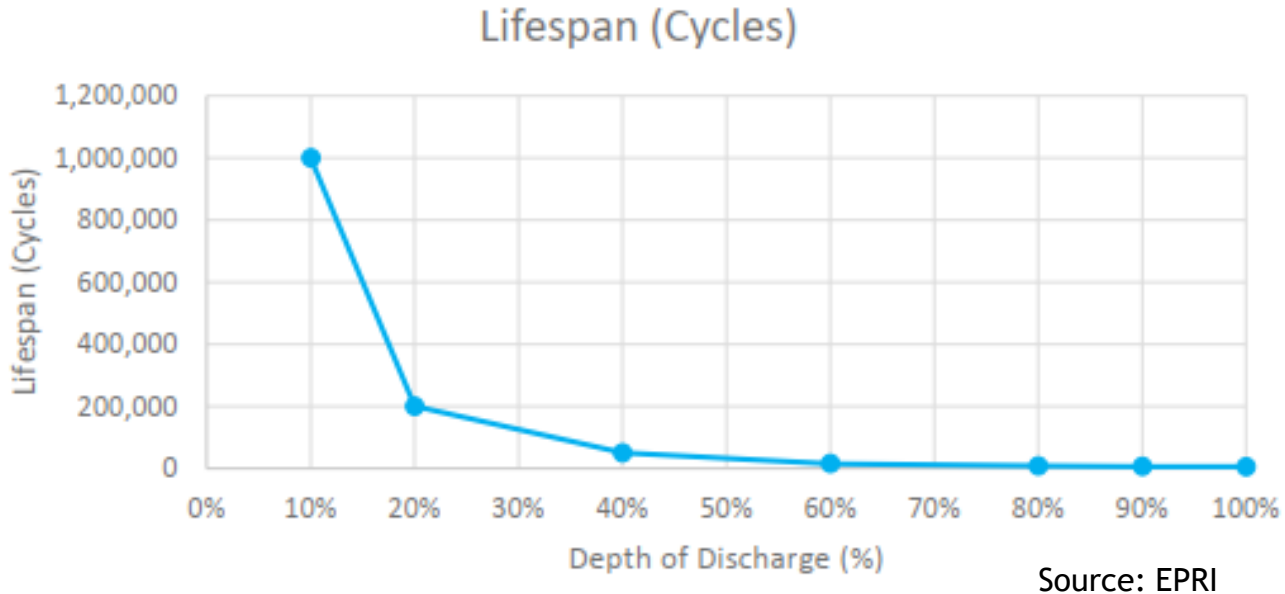


Case Study - METI (Continued)



PJM Scores	Jan 19 - Event 3-Hour 1	Jan 19 - Event 3-Hour 2	Jan 19 - Event 4-Hour 1	Jan 9 - Event 4-Hour 2
Accuracy Score	0.9888	0.9840	0.9656	0.9838
Delay Score	1.0000	1.0000	1.0000	1.0000
Precisioon Score	0.8595	0.8652	0.8100	0.8254
Composite Score	**0.9494**	**0.9497**	**0.9252**	**0.9364**

Impacts on Battery Life



Source: EPRI

Questions

Thank You!

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