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Los Angeles Air Force Base Vehicle-to-Grid for Ancillary Services Demonstration

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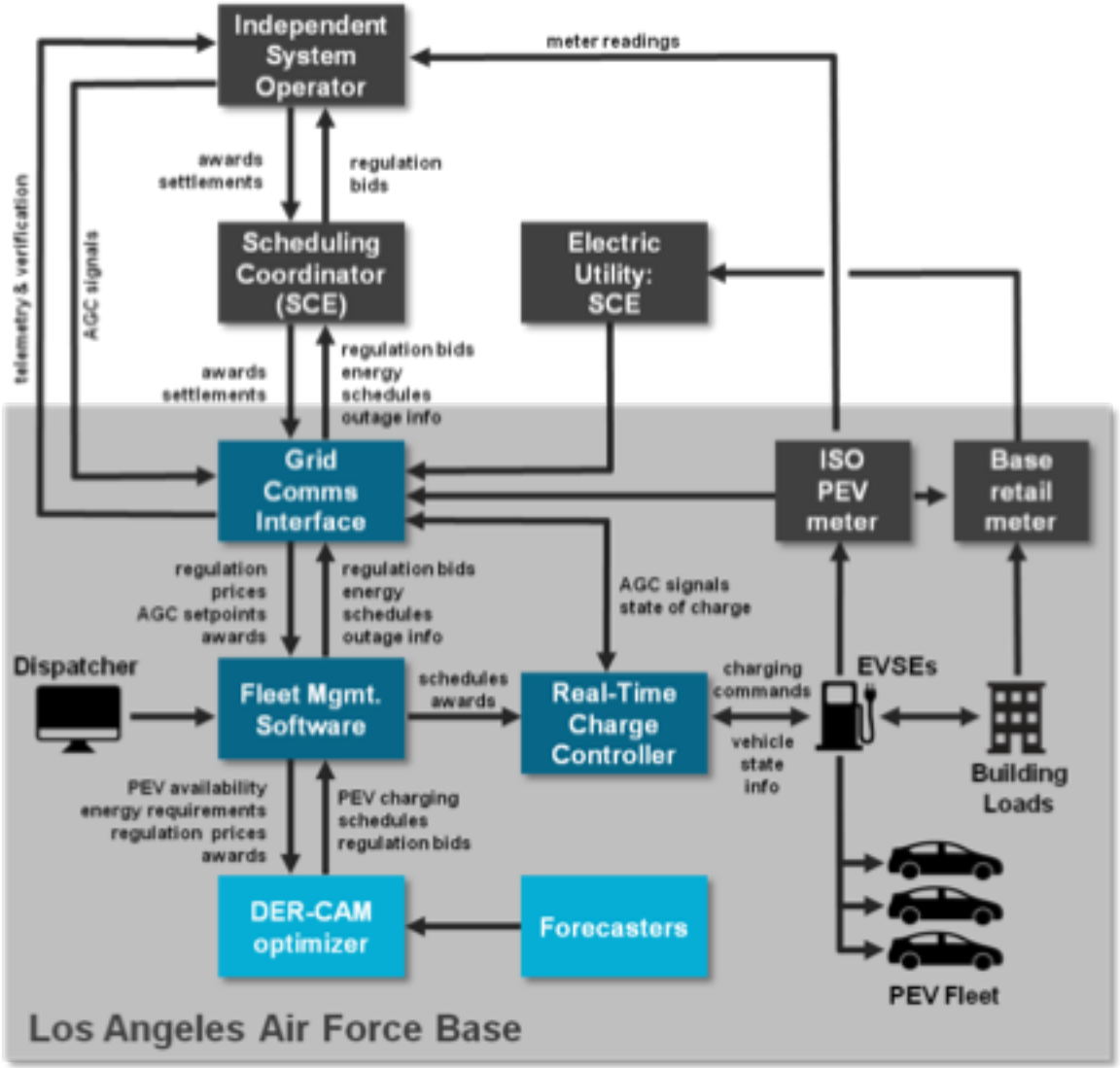
June 20, 2018

LA AFB Project Objectives

- Manage dispatch and charging of 29 vehicle PEV fleet
- Ensure sufficient charge to meet mobility needs
- Charge PEVs under cost-minimizing schedules
- Optimize participation in grid service markets to generate revenue
- Determine extent to which PEV fleet cost gap can be narrowed

LA AFB System Architecture



Submitting Bids and Receiving Awards

- From resource perspective process of determining bids, submitting bids, receiving awards, implementing charge plans, and following AGC dispatch has been a fully automated process since 7/12/17
- Have to monitor for unexpected changes, e.g. SCE changed award file format (xls to pdf), which our automated file processing could not handle

Hour Ending	Energy (Generation)	Energy (Load)	RegUp	RegDown	Initial SOC
100	0.0	0.0	0.0	0.0	0.11
200	0.0	0.0	0.0	0.0	
300	0.0	0.0	0.0	0.0	
400	0.0	0.0	0.0	0.0	
500	0.0	0.0	0.0	0.0	
600	0.0	0.0	0.0	0.0	
700	0.0	0.0	0.0	0.0	
800	0.0	0.0	0.0	0.0	
900	0.0	0.0	0.0	0.0	
1000	0.0	0.0	0.0	0.0	
1100	0.0	0.0	0.0	0.0	
1200	0.0	0.0	0.0	0.0	
1300	0.0	0.0	0.0	0.0	
1400	0.0	0.0	0.0	0.0	
1500	0.0	0.0	0.0	0.0	
1600	0.0	0.0	0.0	0.0	
1700	0.0	0.0	0.0	0.0	
1800	0.0	0.01	0.1	0.1	
1900	0.0	0.01	0.1	0.1	
2000	0.0	0.01	0.1	0.1	
2100	0.0	0.01	0.1	0.1	
2200	0.0	0.01	0.1	0.1	
2300	0.0	0.0	0.0	0.0	
2400	0.0	0.0	0.0	0.0	
Total 1-24	0.00	0.05	0.5	0.5	

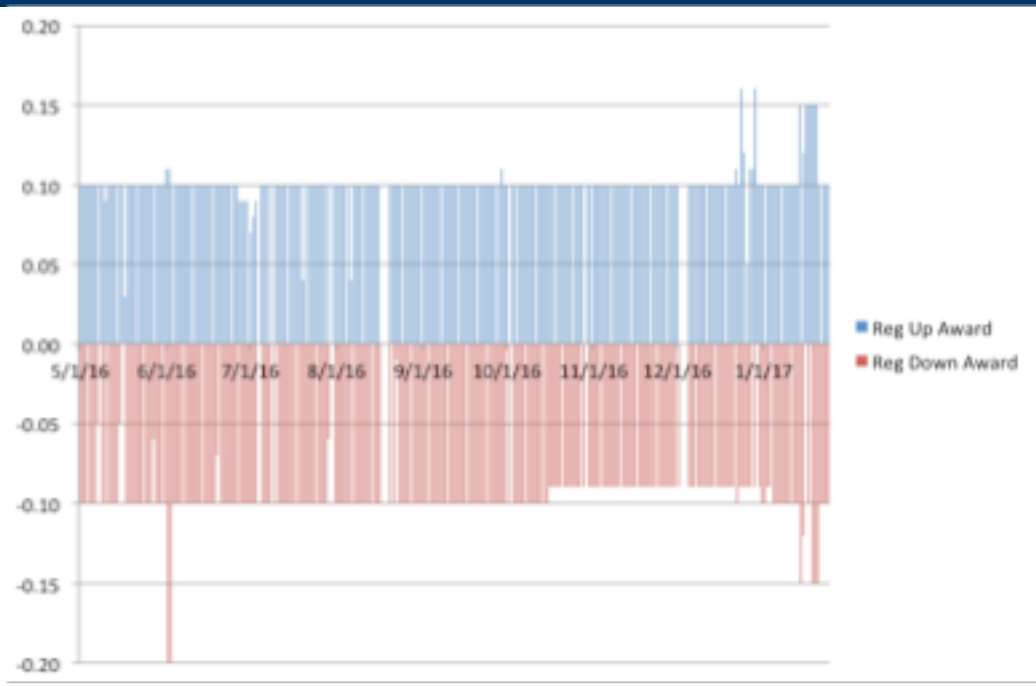
Bid File

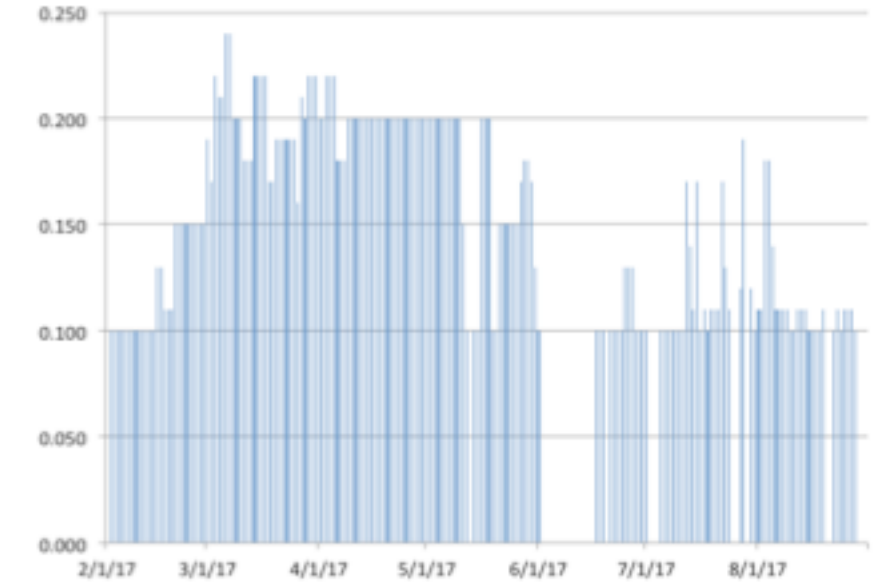
Hour Ending	Energy Award	RegUp Award	RegDown Award
100	0.000	0.000	0.000
200	0.000	0.000	0.000
300	0.000	0.000	0.000
400	0.000	0.000	0.000
500	0.000	0.000	0.000
600	0.000	0.000	0.000
700	0.000	0.000	0.000
800	0.000	0.000	0.000
900	0.000	0.000	0.000
1000	0.000	0.000	0.000
1100	0.000	0.000	0.000
1200	0.000	0.000	0.000
1300	0.000	0.000	0.000
1400	0.000	0.000	0.000
1500	0.000	0.000	0.000
1600	0.000	0.000	0.000
1700	0.000	0.000	0.000
1800	-0.010	0.100	0.100
1900	-0.010	0.100	0.100
2000	-0.010	0.100	0.100
2100	-0.010	0.100	0.100
2200	-0.010	0.100	0.100
2300	0.000	0.000	0.000
2400	0.000	0.000	0.000
Total 1-24	0		

Award File

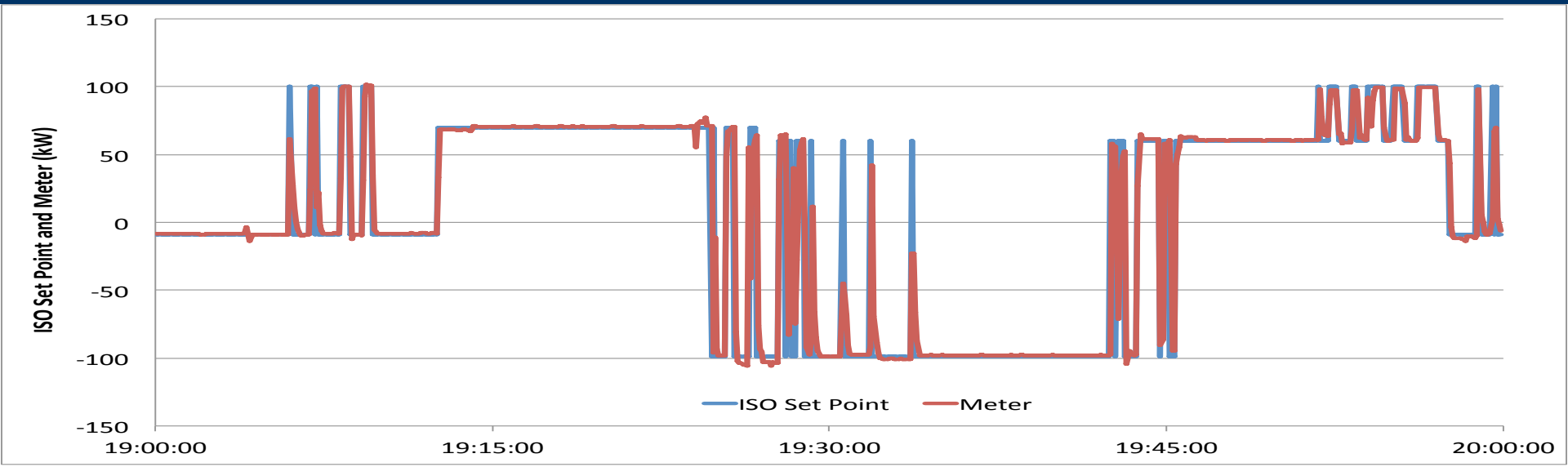
Bids and Awards

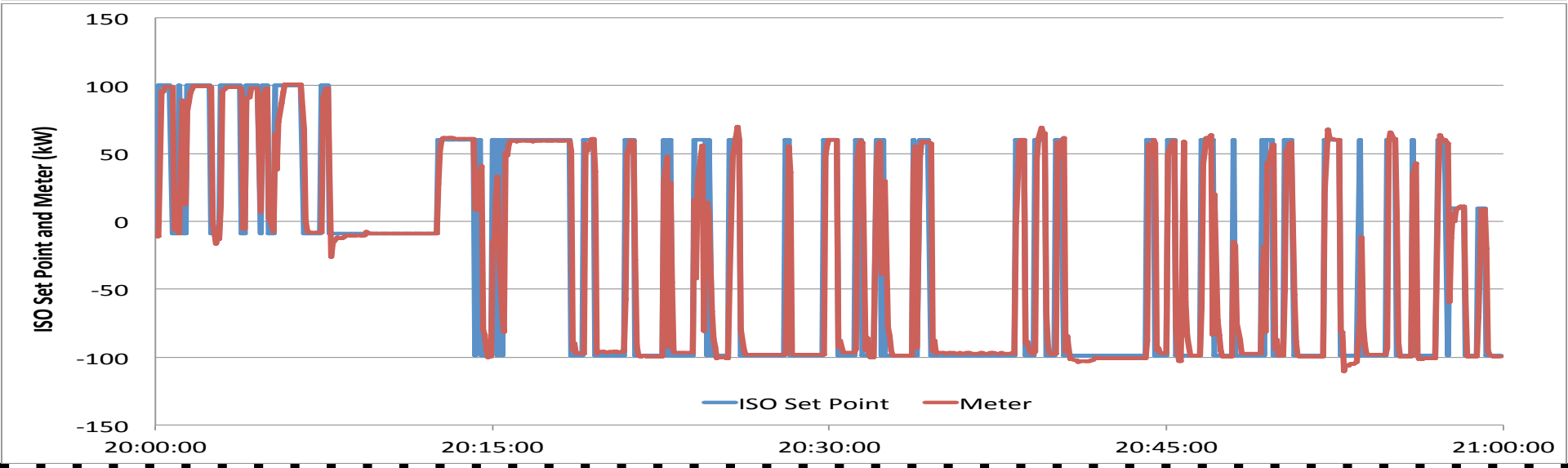
- **230 MWh** of Regulation Up
- **102 MWh** of Regulation Down
- 5/1/16 to 8/27/17





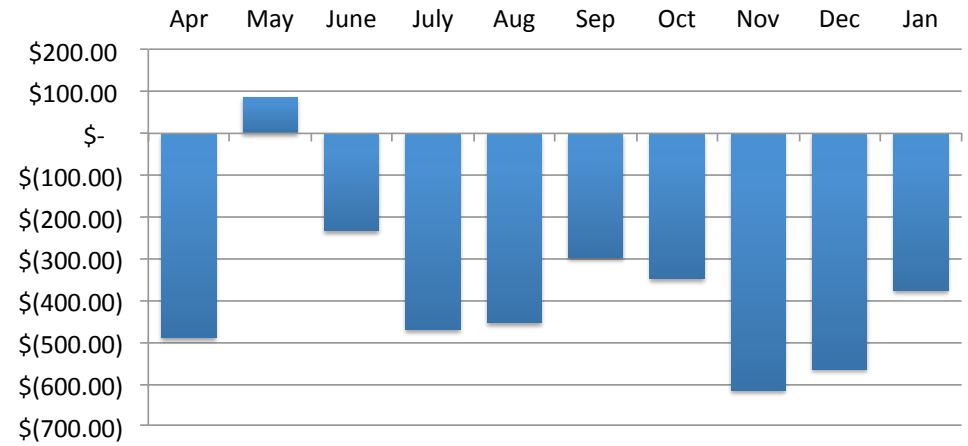
Example Performance by Hour



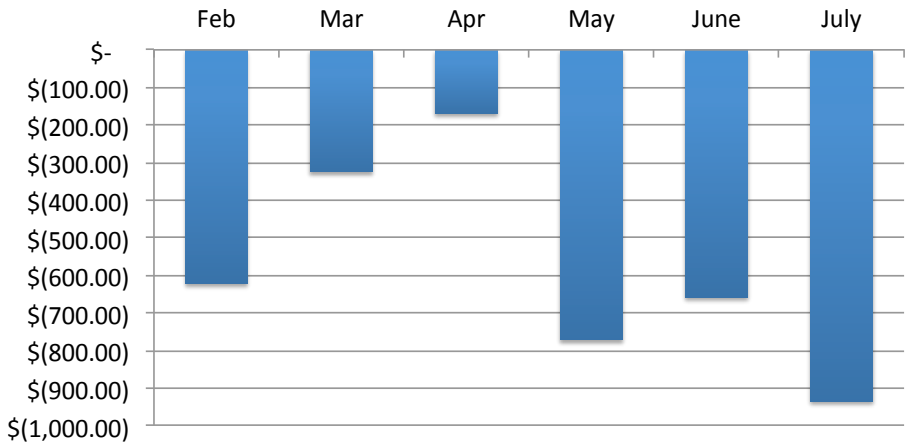


Actual Settlements

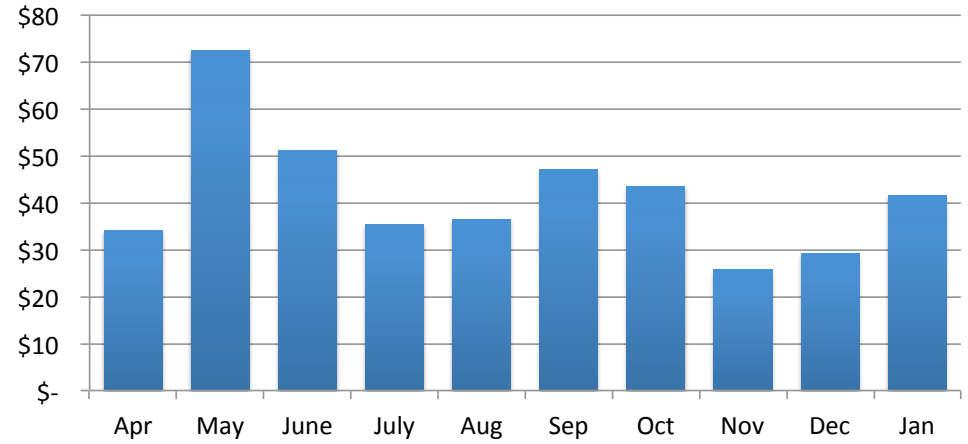
2016 CAISO Settlement with Both Reg Up and Reg Down



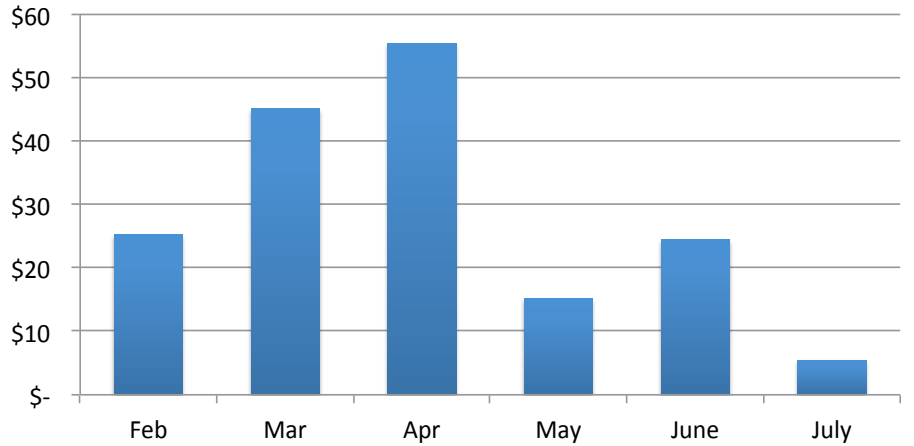
2017 CAISO Settlement with Reg Up Only



2016 $ Per PEV (without fees) with Reg Up and Reg Down



2017 $ per PEV (without fees) with Reg Up Only



Costs of Frequency Regulation Participation

- Fixed Costs*:
  - Capital: bi-directional charging stations, electrical service upgrades, metering and telemetry infrastructure
  - Interconnection: Distribution interconnection studies, certified meter installation and certification
- Monthly Transaction Costs:
  - CAISO Resource ID Fee: $1000/month
  - CAISO miscellaneous Fees (Bid-segments, Flexible Capacity obligation, etc.): <$40/month
  - Scheduling Coordinator Fees:
    - "Manual Billing": $118.46/month
    - "Meter Data Feed": $216.50/month
  - Network access fee (CAISO's private Energy Communication Network): ~$100/month through AT&T's ANIRA VPN router
- Transaction costs account for nearly 50% of Day Ahead revenue potential for V2G resource aggregations of a comparable size

* Costs discussed are additions to the cost of deployment of a PEV fleet.

Market Participation Challenges:

Fundamentally Dynamic Resource Parameters

- An aggregation of EV resources changes size in all resource parameters (Power Capacity, Energy Storage, Ramp Rate) throughout a day as individual EVs unplug and leave on trips.
- EVs are Limited Energy Storage Resources (LESR), but advantageous Regulation Energy Management (REM) is incompatible with EV aggregations.
- For LESR, CAISO's day ahead market algorithm attempts to calculate the LESR's SOC to determine the viability of an award, **but:**
  - An aggregation of EV resources changes in size throughout a day as individual EVs arrive and depart.
  - EVs consume energy while driving that does not register on the ISO meter
  - The ISO algorithm does not account for energy charged or discharged while providing regulation
  - ISO now allows a resource to provide its initial SOC at 12AM with a Day-Ahead bid. While helpful, still inaccurate (no EV departures/arrivals or EV driving energy)

Market Participation Challenges:

Telemetry and Scheduling Coordination Automation

- Telemetry: If physical resource capacity is reported greater than award, AGC will dispatch resource past award.
  - Can ruin optimization outcomes or jeopardize future EV mobility
  - LA AFB solution: Report the lesser of physical capacity and capacity bid as power limit in telemetry
  - Creates risk of no-pay if calculation of capacity bid-based limit is off.
- As a non-REM resource, hour-ahead bidding is essential to allow the resource to manage its SOC and continuously provide services
- Results: the lack of automated bidding and machine-machine APIs prevented the resource from continuous provision of regulation services.

Second-life Battery Project Objectives

- Develop V2G and V2B control methods for maximizing EV and second-life battery lifetimes that are based on customer needs and grid conditions.
- Conduct a controlled study of the impact of providing V2G/V2B services on EV batteries by using new batteries in 12 Nissan LEAFs and dedicating a number of them as control batteries that provide mobility only.
- Develop a scalable second-life battery storage solution for fleet applications and demonstrate the integration and application of second-life battery storage into V2G/V2B service applications.
- Develop and demonstrate the use of EV and second-life battery storage for load shifting, demand management, and improving power quality and reliability for customers with PV generation.

Location of 2nd-Life Battery Enclosures

Summary

- This project demonstrated technical accomplishments in bringing together PEVs and EVSEs with varying performance characteristics from multiple vendors, most of which were first generation, to successfully provide AS Reg Up and Reg Down following 4-second AGC
- Along with the technical accomplishments in controls development, there were market operation lessons learned and improvements implemented by CAISO
- The airplane was being built as it was flying in that hardware and software were being tested and developed while in actual market participation.
  - The current EPIC project will only use the EVs and EVSEs that performed most reliably and not be subject to constraints of market participation
- Future work will explore benefits of second-life batteries and conduct more controlled studies of impacts of grid services on battery health

Extra Slides

- Extra Slides

LA AFB Project Partners and Participants