Demand Response for Electric Vehicle Charging

Noel Crisostomo
Fuels & Transportation Division, California Energy Commission
March 23, 2021 OpenADR Summit

Overview & Takeaways

Opportunity: Efficiently and cleanly electrifying transportation

- CEC's *AB 2127 Electric Vehicle Charging Infrastructure Assessment* illustrates how off-peak pricing and automated control could shift ~1,000 MW of residential light duty vehicle charging from the peak to after midnight in 2030. EPIC research has shown that up to 90% load reduction is possible in demand response (DR) events.
- New transportation electrification applications warrant load profiling, but in the interim a simplified and extensible method for calculating flexibility is useful.

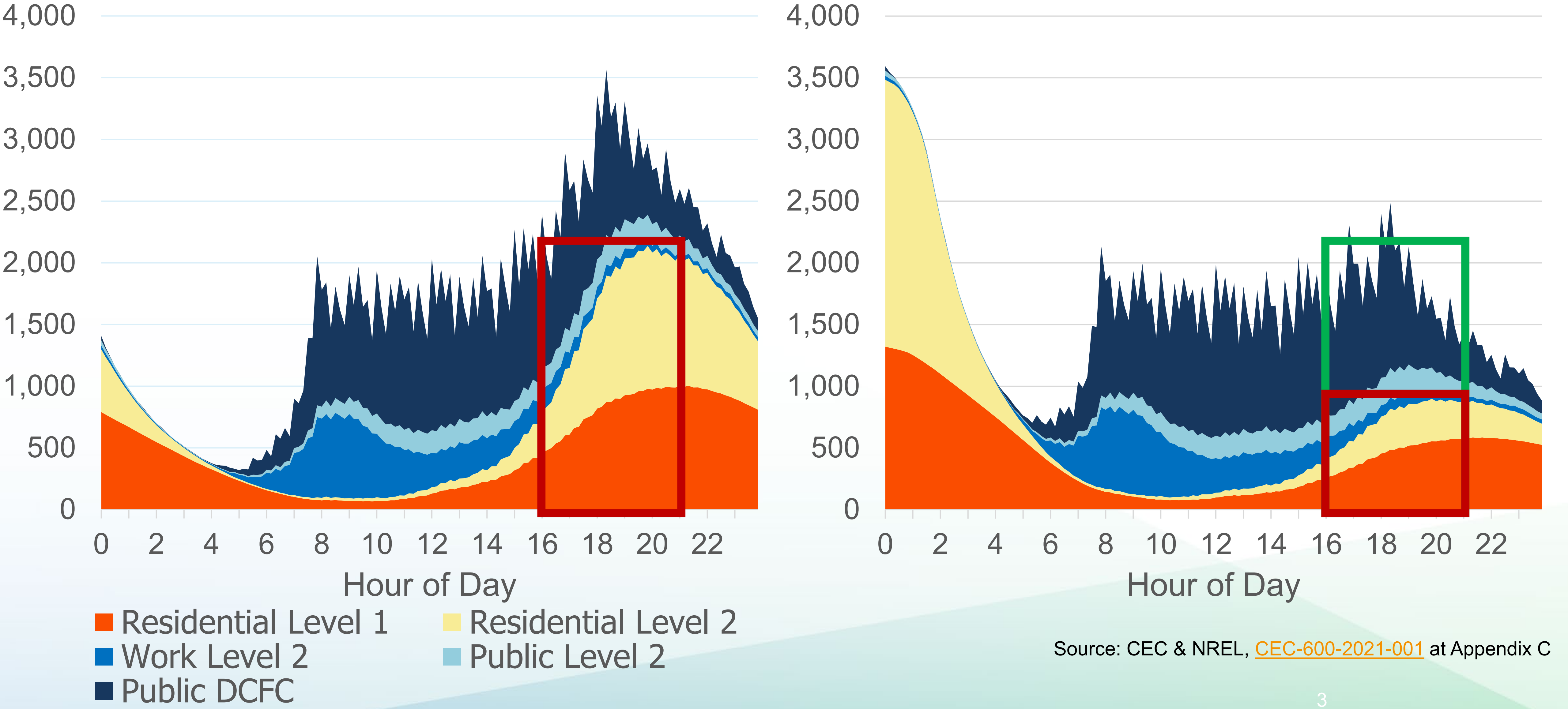
Barriers and Solutions

- Drivers are poorly engaged with DR and load management, and do not accurately provide the parameters needed to maximize shedding. Charging with standards-based distributed intelligence will help preserve drivers' range confidence while maximizing DR potential.

Outlook on Hardware & Software to integrate vehicles & chargers with the grid

5M LDEV Charging Load (MW) in 2030

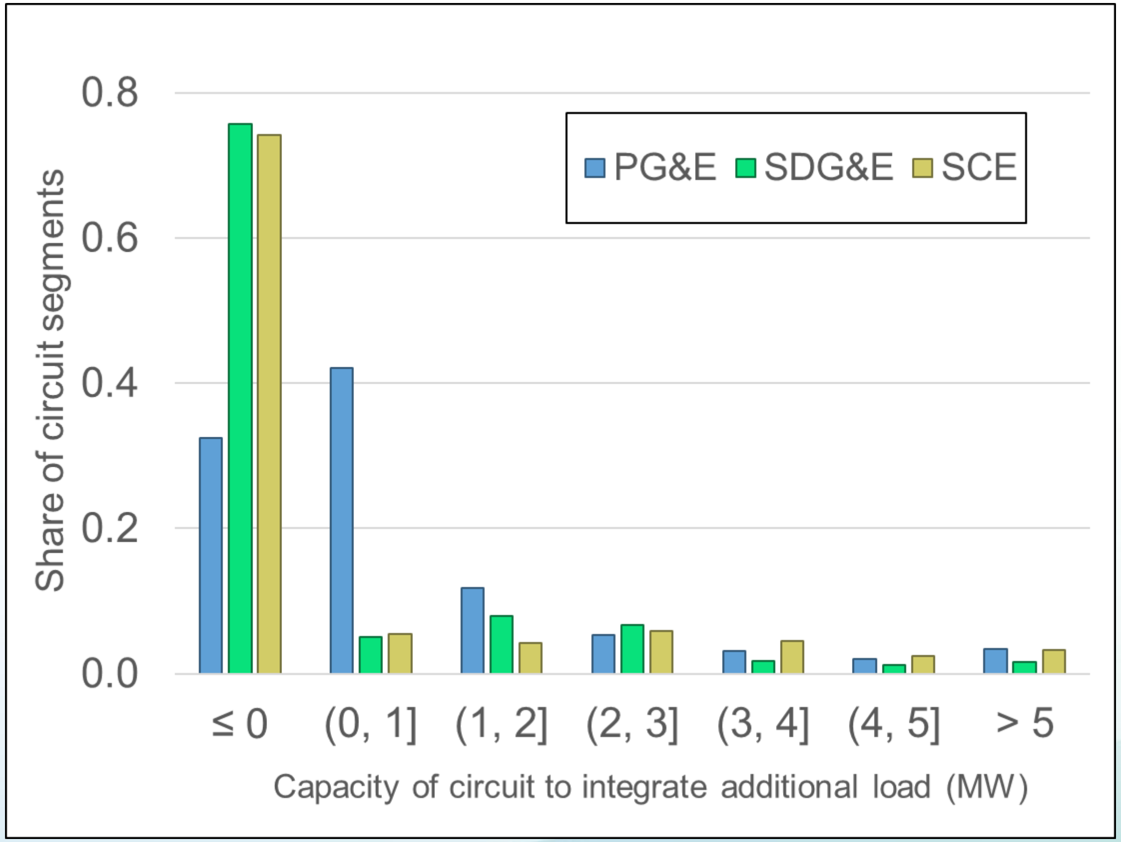
Unconstrained / Time-Of-Use

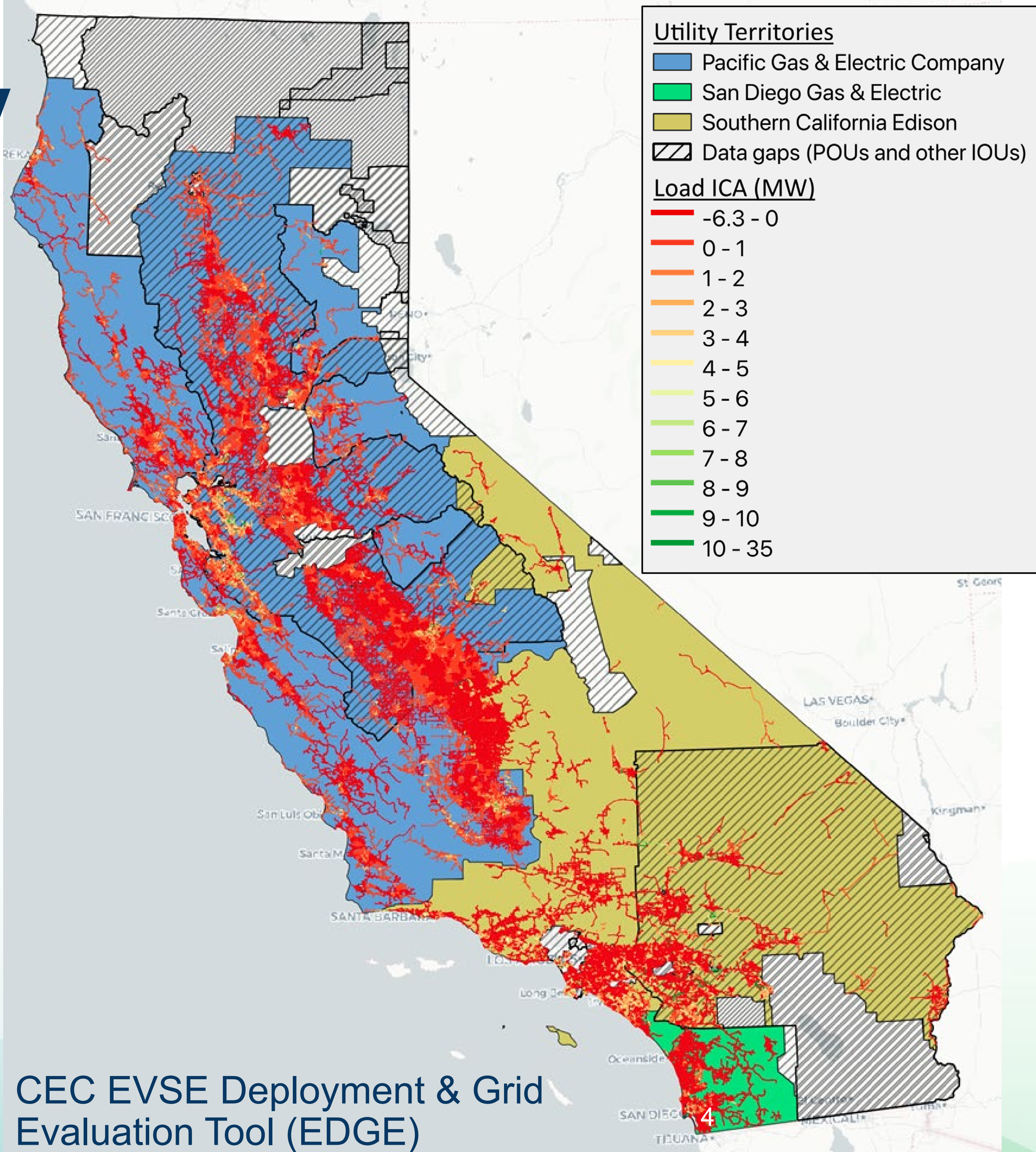


Source: CEC & NREL, CEC-600-2021-001 at Appendix C

The time is now

Potential Impacts per NREL, 2020
- Clustering
- Under voltage
- Line overloading
- Transformer heating & aging





CEC EVSE Deployment & Grid Evaluation Tool (EDGE)

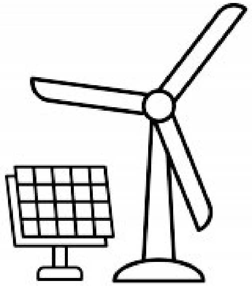
SB 100 clean energy requirements identify a need for sustained additions of 6 GW annually to 2045

California
Clean Electricity Resources

	Existing Resources 2019*	Projected New Resources 2030**	Projected New Resources 2045**
Solar (Utility-Scale)	12.5 GW	16.9 GW	69.4 GW
Solar (Customer)	8.0 GW	12.5 GW	28.2 GW
Storage (Battery)	0.2 GW	9.5 GW	48.8 GW
Storage (Long Duration)	3.7 GW	0.9 GW	4.0 GW
Wind (Onshore)	6.0 GW	8.2 GW	12.6 GW
Wind (Offshore)	0 GW	0 GW	10.0 GW
Geothermal	2.7 GW	0 GW	0.1 GW
Biomass	1.3 GW	0 GW	0 GW
Hydrogen Fuel Cells	0 GW	0 GW	0 GW
Hydro (Large)	12.3 GW	N/A†	N/A†
Hydro (Small)	1.8 GW	N/A†	N/A†
Nuclear	2.4 GW	N/A†	N/A†

**Includes in-state | **Includes in-state and out of state capacity | †New hydro and nuclear resources were not candidate technologies for this round of modeling and could not be selected*

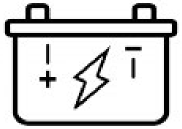
To Achieve Clean Energy
Development Needs To Rapidly Accelerate



Solar & Wind

3X

Solar and wind build rates need to nearly triple*



Battery

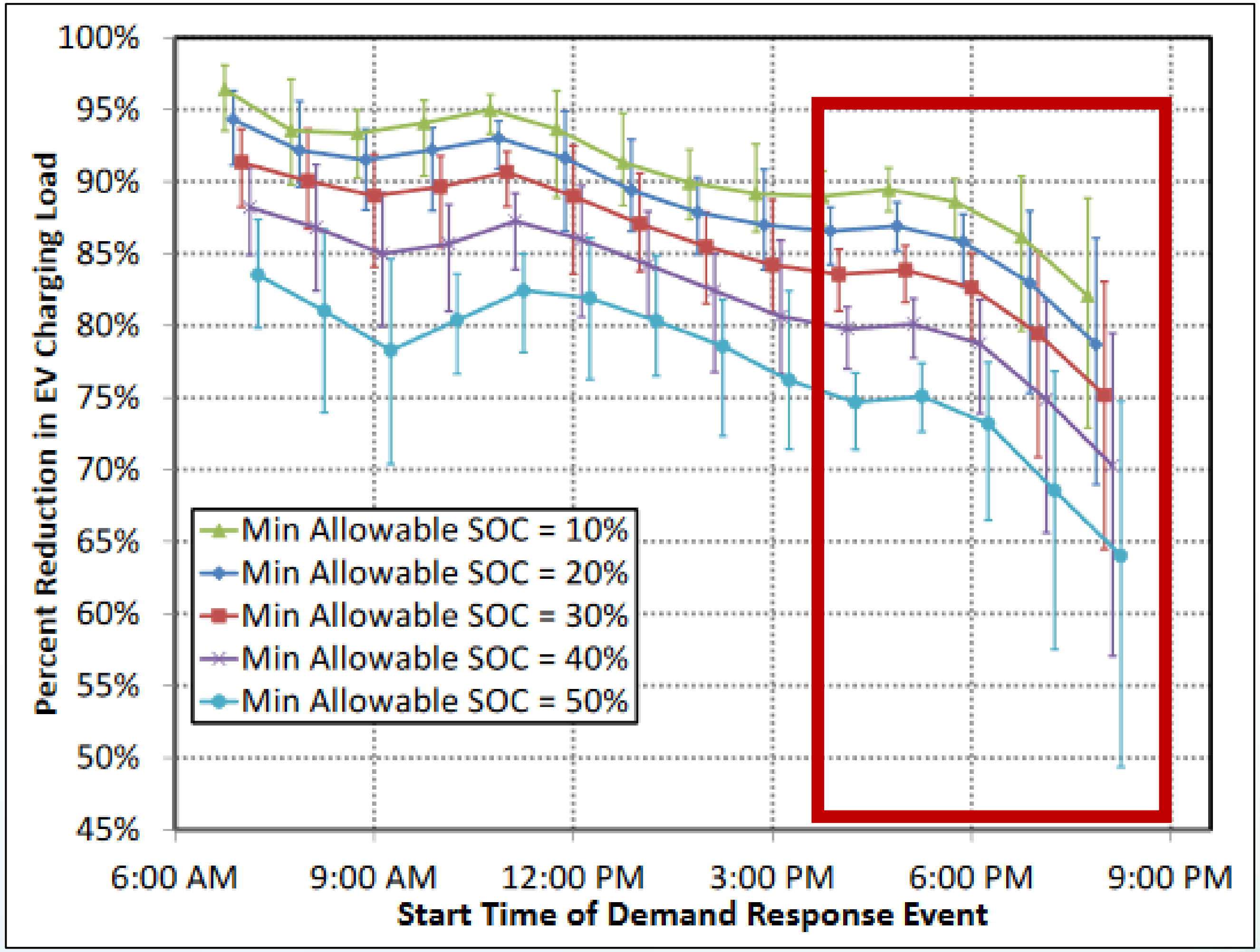
8X

Battery storage build rates need to increase by nearly eightfold**

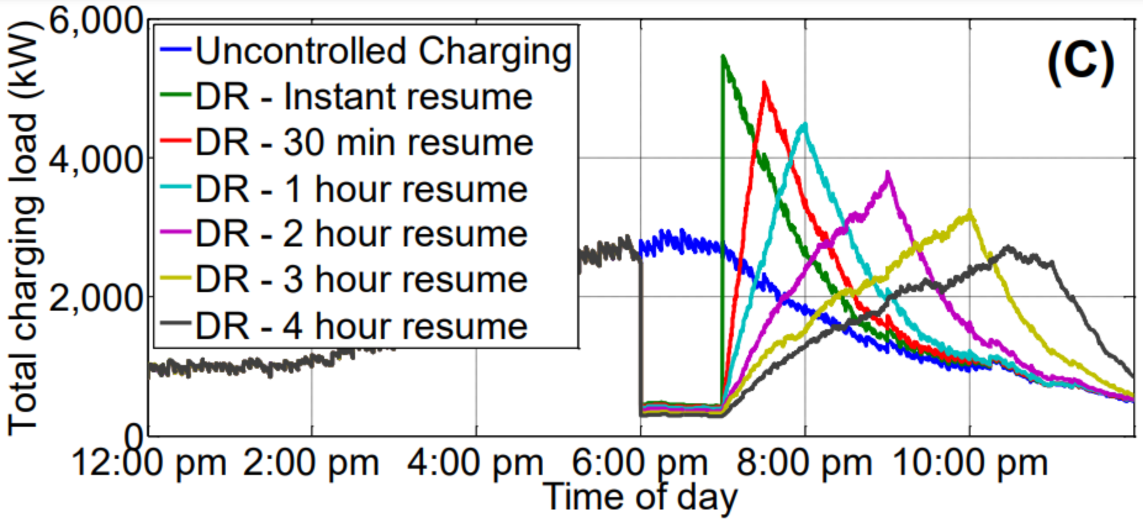
**Based on 10-year average | **Based on 2020*

Joint Agency SB 100 Report Summary, 2021

65-90% load shed is possible if less battery is reserved for trips

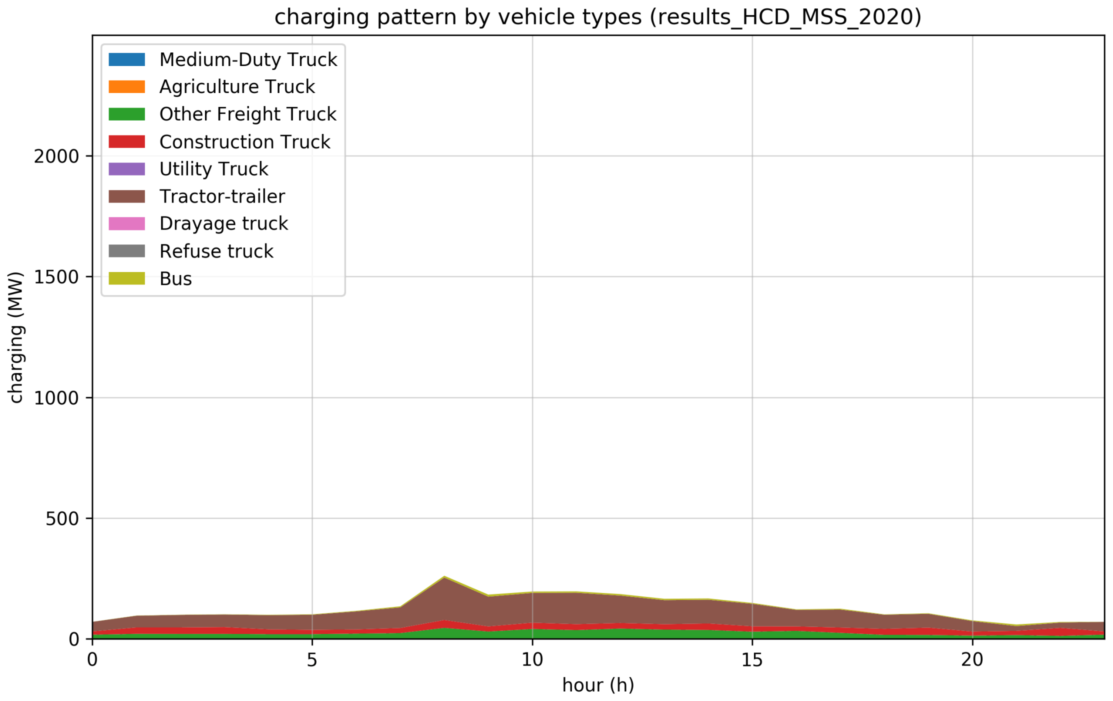


After the conclusion of the DR event, resuming charge over a longer duration moderates the impacts from the recovery period (e.g. a new system peak or local voltage issues from "timer spikes").



Source: ChargePoint and LBNL, CEC-500-2019-009 at 30

Load profiling is ongoing, but flexibility is easily calculated.



The number of times a charging session that fulfills the driver's energy need can be completed within their dwell time:

$$Flexibility = \frac{kW_{EVSE}}{\frac{kWh_{Needed}}{h_{Depart} - h_{Plugin}}}$$

If Flexibility < 1, driver's mobility need is violated.

If Flexibility = 1 minimum charging can be completed.

If Flexibility ≥ 2, multiple sessions and DR are feasible.

$\boldsymbol{kWh_{Needed}}$ and $\boldsymbol{h_{Depart}}$ are critical parameters.

Source:
CEC & LBNL, HEVI-LOAD AB 2127 Workshop February 5, 2021
Formula derived with Jason Harper, EV Smart Grid Interoperability Center, Argonne National Laboratory

Level 2 Lessons

Focus group of ***factory workers were disinterested in providing manual inputs*** to help manage charge load

Honda, CEC-600-2019-033 at 60

7 drivers participated in ***48% of DR events***; ***91%*** of user inputs exceeded kWh_{Needed}

LBNL, CEC-500-2019-036 at 40

104 drivers participating in load management; ***74%*** of user inputs exceeded kWh_{Needed}

NREL, DOI: 10.1109/ITEC.2018.8450227

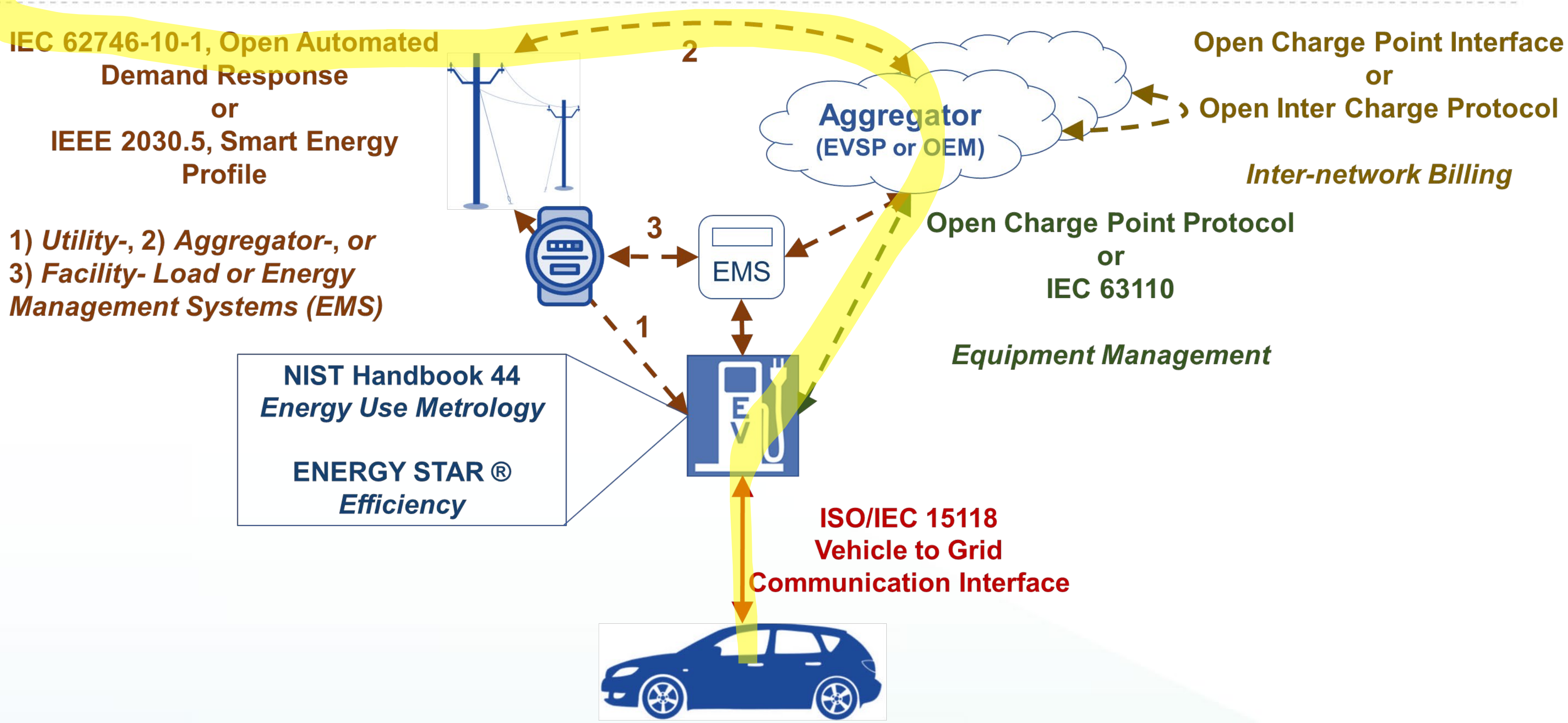
On average over 32k+ sessions, user inputs exceeded kWh_{Needed} by ***~10 kWh***; overstayed and h_{Depart} by ***>1 hour***.

Dr. Scott Moura, UC Berkeley, May 2020

30 drivers in a smart home study : "Distributed ***intelligence will be needed*** to automate grid-friendly charging. Consumers will benefit from a plug-and-play experience that ***ensures that their vehicle's primary purpose, transportation, isn't negatively impacted***."

AESC, et al, CEC-500-2020-057 at 86

“Recommended Communication Protocols to Enable VGI High Level Communication for Level 2 AC Conductive EVSE”



Credit: California Energy Commission

1) SCE Smart Charging Pilot, May 2016, page 10: “No OEM…has actually included nor indicated their desire to implement [onboard vehicle communications using SEP 2.0 and Powerline Communications] on a vehicle, thus EVSE communications for vehicle load management will be the most prevalent for direct architecture implementations.”
2) VGI Communication Protocol Working Group, CPUC Energy Division Staff Report, February 2018, page 25, Table 5. Communication involving “a combination of the following” PFE-EVSE protocols, listed 1, 2, and 3; and “one of the following” EVSE-EV protocols, listed 1.
3) CPUC Energy Division Draft Transportation Electrification Framework, February 2020, page 82, footnote 201 with reference to *see next*
4) CEC Fuels and Transportation Division CALeVIP Future Equipment Technology Workshop, November 2019, pages 47-54 and revised in *see next*
5) CEC, CEC-600-2021-001. The above figure is adapted from Figure 21 of the Assessment.

Network Providers with OpenADR

Amply ▫	EverCharge ▫	Mobility House, LLC
AmpUp ▫	EvGateway ▫	Noodoe ▫
Blink ▫	EVSE LLC	OpConnect ▫
Chargie LLC ▫	FleetCarma ▫	PowerFlex Systems ▫
ChargeLab	Flo ▫	PowerTree Services
ChargePoint, Inc ▫	Green Charge ▫	SemaConnect ▫
Driivz Ltd. ▫	Greenlots / Shell ▫	Siemens
Electriphi ▫	Gridscape ▫	Tellus Power, Inc ▫
Enel X ▫	Innogy SE ▫	ZEF Energy Inc. ▫
EV Charging Solutions Inc	KiGT Inc ▫	Zero Impact Electrical
EV Connect ▫	KnGrid/Oxygen Initiative ▫	Zevtron, LLC ▫

▫ = OpenADR Alliance Member
Source: CALeVIP Connects, OpenADR Certified Product Database

Chargers planned or capable of HLC

Manufacturer	Available	Next Generation
ABB	Terra HP (DC)	
BTC Power	Level 2 EVSE (AC)	
Coritech Services	VGI-30 (DC)	
Delta	AC Max (AC)	
Efacec	HV350 G2 (DC)	
Elitegroup Computer Systems	LIVA (AC)	
Electrify Home	HomeStation (AC) *Announced*	
EverCharge	Level 2 EVSE Hardware (AC)	
Innogy SE ▫	EVP, eStation, and eBox (AC)	
Nuvve	Heavy Duty Charging Station (DC)	
Siemens	Versicharge (AC)	
Signet	DP350K-CC (DC)	
Tritium	RT175-S (DC)	
Blink ▫		TBA
Enel X ▫		TBA
EVBox		TBA
ChargePoint ▫		TBA
EVConnect ▫		TBA
Blink ▫		TBA
Flo ▫		TBA
Freewire		TBA
Noodoe ▫		TBA
Volta		TBA
Webasto		TBA

▫ = OpenADR Alliance Member
Source: CALeVIP Connects, OpenADR Certified Product Database, CEC analysis of press releases and public filings

EVs planned or capable of HLC*

Manufacturer	DC Conductive	AC Conductive	AC Wireless
Audi ▫	X	X	X
BMW	X	X	X
Daimler ▫	X	X	X
FCA aka Stellantis	X		X
Ford ▫	X	X	X
GM	X		
Honda	X	X	
Hyundai-Kia ▫	X	X	X
Lucid ▫	X	X	
Porsche ▫	X	X	X
Rivian ▫	X	X	
Volvo	X	X	
Volkswagen ▫	X	X	X

* = Most OEMs plan to leverage AC charging with high-level communications based on ISO 15118 in tandem and ***as a complement to*** their vehicle telemetry systems

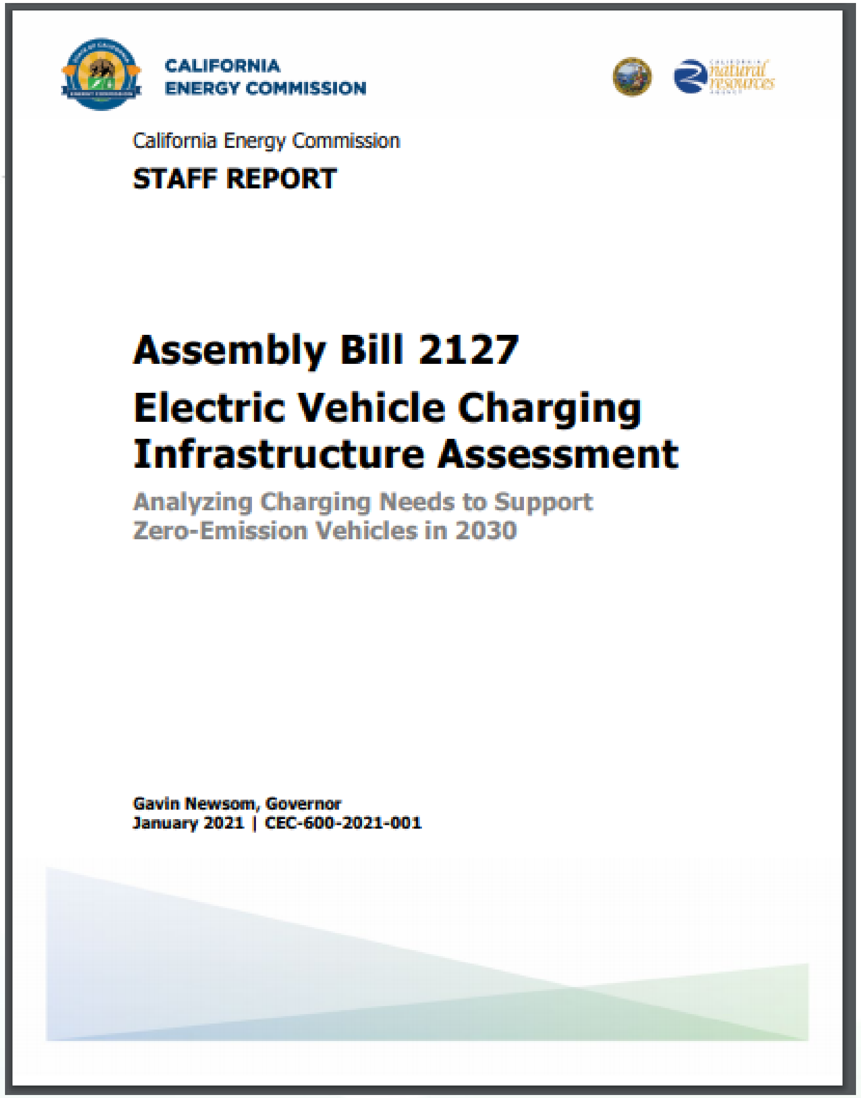
▫ = Specific vehicle model(s) identified for U.S. release, example at right

Source: CEC analysis of press releases and public filings


MIDAS
ENERGY COMMISSION
STATE OF CALIFORNIA
Market Informed Demand Automation Server
Hourly & Locational Rates
Load Serving Entities
Rates
& GHG
openADR
ALLIANCE
Network
Providers'
VENs
OCPP or
IEC 63110
ISO/IEC 15118

Thank You!

Noel Crisostomo
Air Pollution Specialist
Fuels and Transportation Division
California Energy Commission
noel.crisostomo@energy.ca.gov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STAFF REPORT

Assembly Bill 2127

Electric Vehicle Charging Infrastructure Assessment

Analyzing Charging Needs to Support Zero-Emission Vehicles in 2030

Gavin Newsom, Governor
January 2021 | CEC-600-2021-001

https://www.energy.ca.gov/programs-and-topics/programs/electric-vehicle-charging-infrastructure-assessment-ab-2127

Select EPIC VGI Projects

- Demonstrating Plug-in Electric Vehicles Smart Charging and Storage Supporting the Grid
  - (EPC-14-056)
- Smart Charging of Plug-in Electric Vehicles with Driver Engagement for Demand Management and Participation in Electricity Markets
  - (EPC-14-057)
- Next-Generation Grid Communication for Residential Plug-in Electric Vehicles
  - (EPC-14-078)
- Distribution System Aware Vehicle to Grid Services for Improved Grid Stability and Reliability
  - (EPC-14-086)
- Open Source Platform for Plug-in Electric Vehicle Smart Charging in California
  - (EPC-15-013)
- Grid Communication Interface for Smart Electric Vehicle Services Research and Development
  - (EPC-15-015)
- Total Charge Management: Advanced Charge Management for Renewable Integration*
  - (EPC-15-084)
- Open Vehicle-to-Building/Microgrid Integration Enabling Zero Net Energy and Improved Distribution Grid Services*
  - (EPC-16-054)
- Improving Commercial Viability of Fast Charging by Providing Renewable Integration and Grid Services with Integrated Multiple DC Fast Chargers*
  - (EPC-16-055)
- Advanced Transit Bus VGI Project
  - (EPC-16-058)
- Advanced VGI Control to Maximize Battery Life and Use of Second-Life Batteries to Increase Grid Services and Renewable Power Penetration*
  - (EPC-16-059)
- Intelligent Electric Vehicle Integration (INVENT)*
  - (EPC-16-061)
- California E-Bus-to-Grid Integration Project
  - (EPC-16-065)