



Grid Integration for Electric Buses & Trucks

Opportunities, Challenges & Recommendations

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CALSTART, Inc.



CALSTART's 150+ Member Companies and Organizations (Partial Listing)





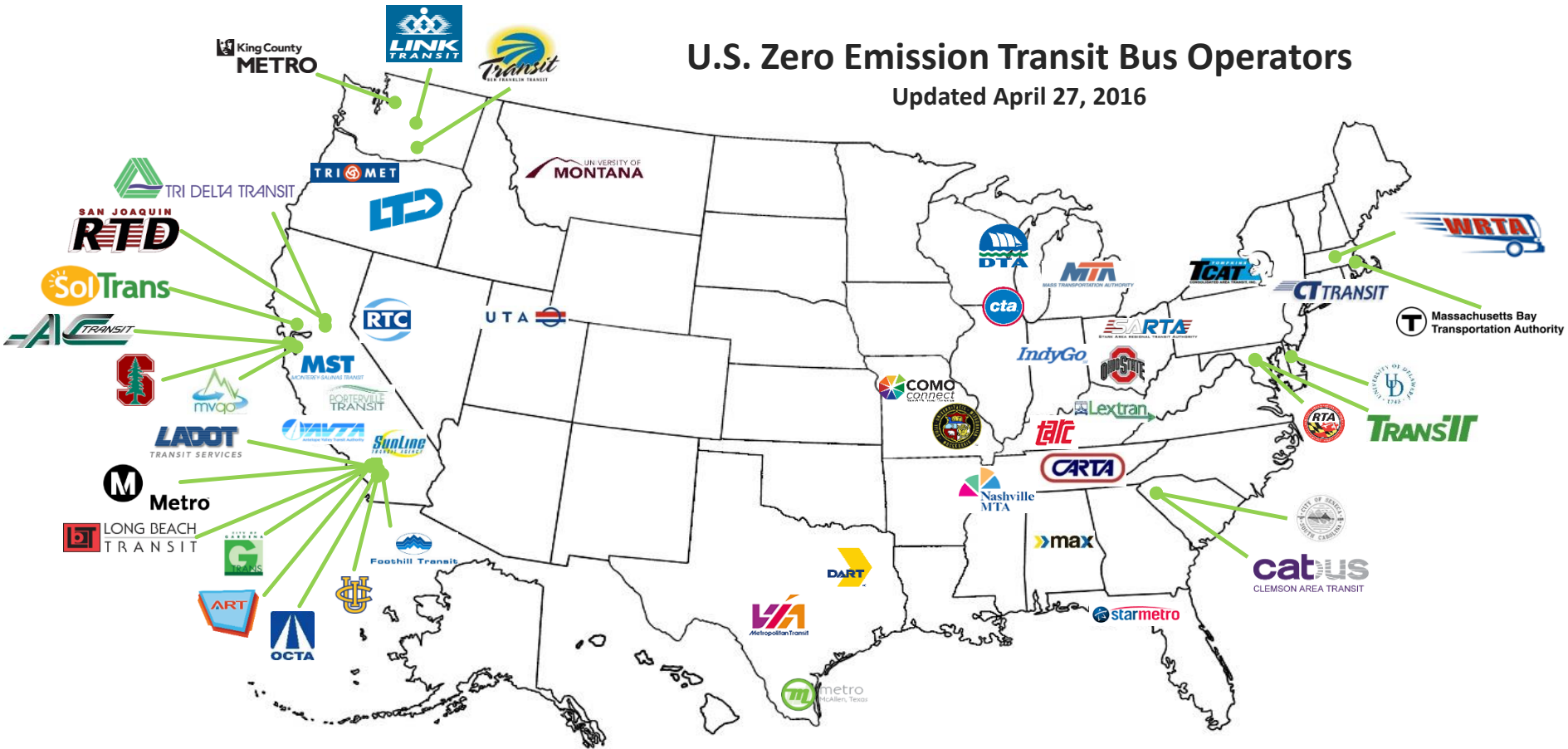
Almost Twenty ZEB Products Across
Nine Bus Makers and Up-fitters



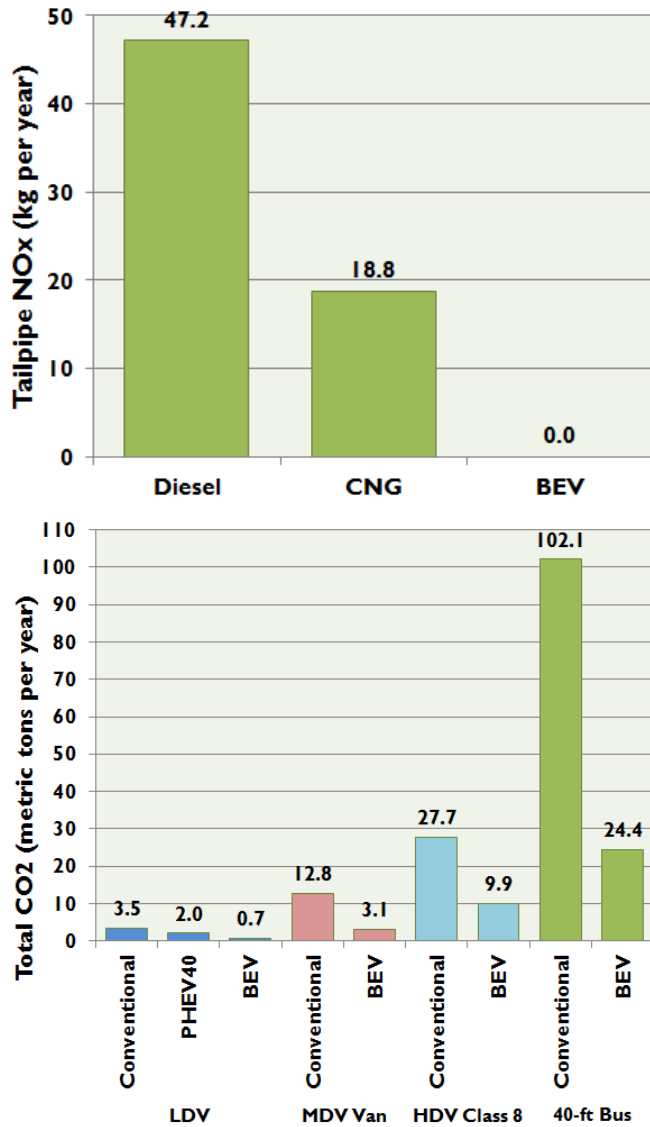
300 E-buses

U.S. Zero Emission Transit Bus Operators

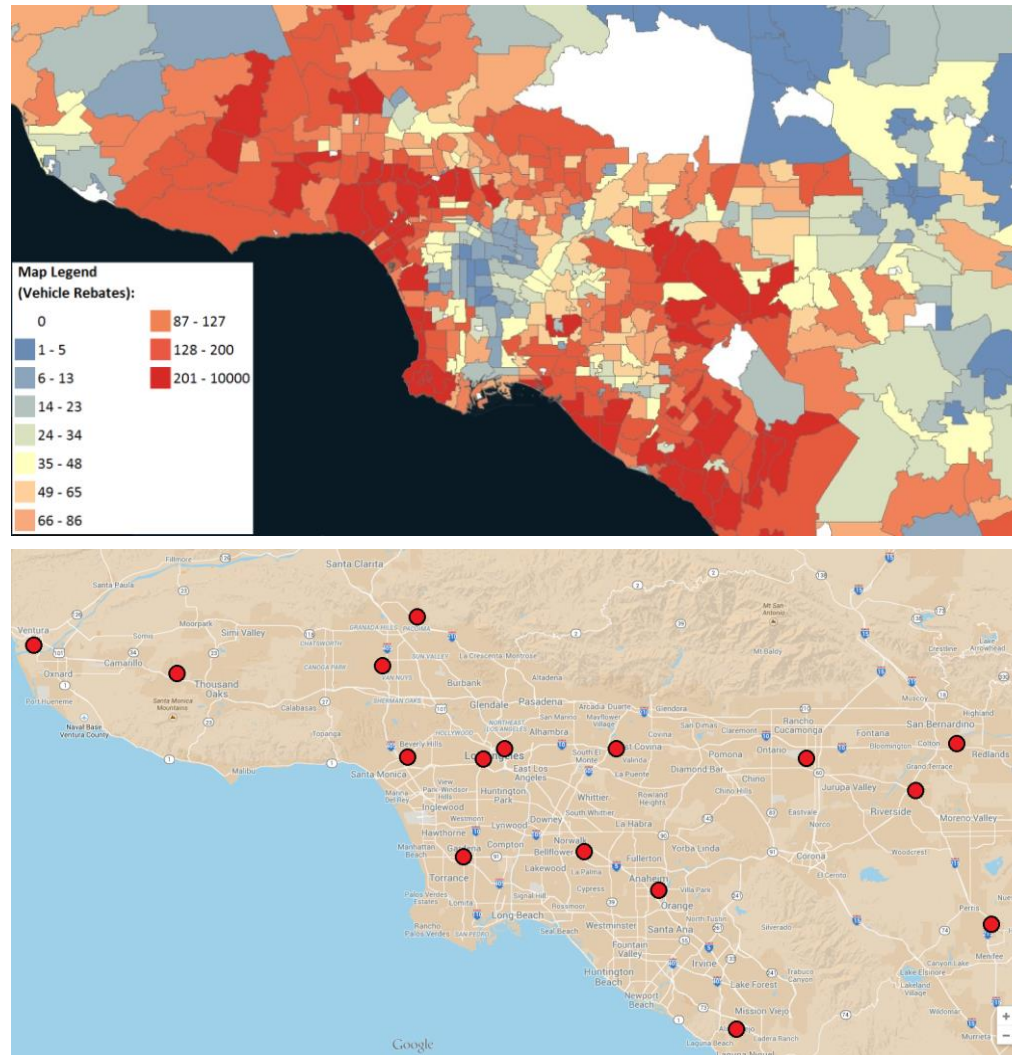
Updated April 27, 2016



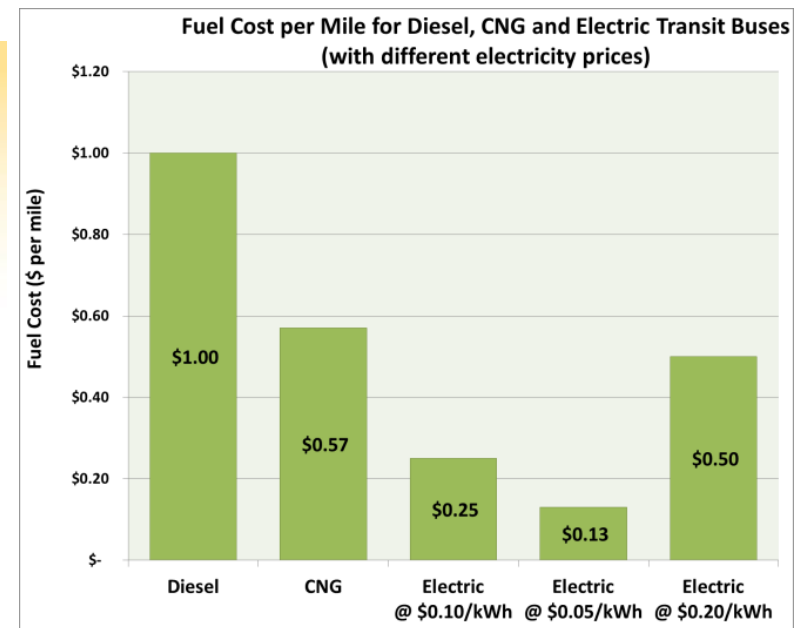
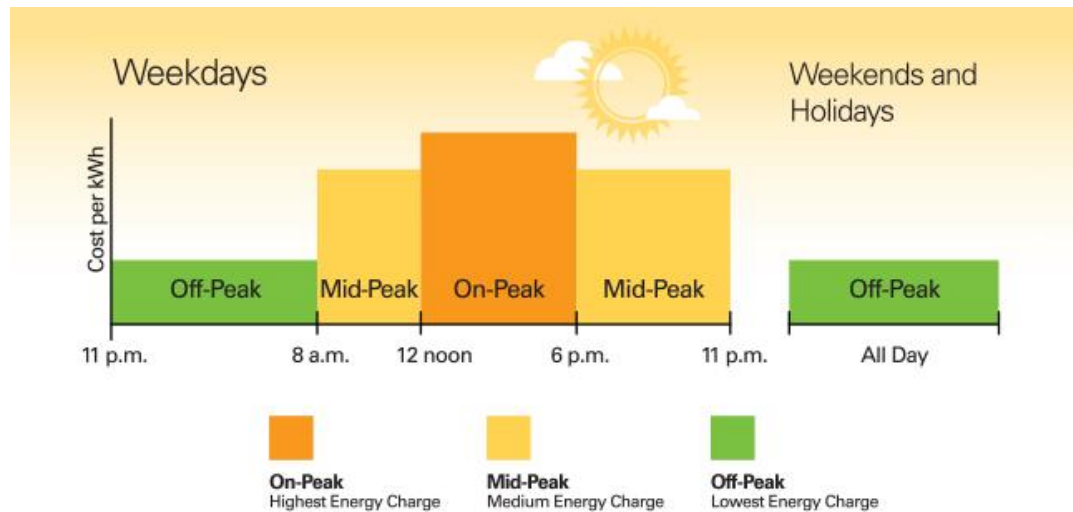
One E-Truck or E-Bus provides substantial environmental benefits compared to one light-duty EV



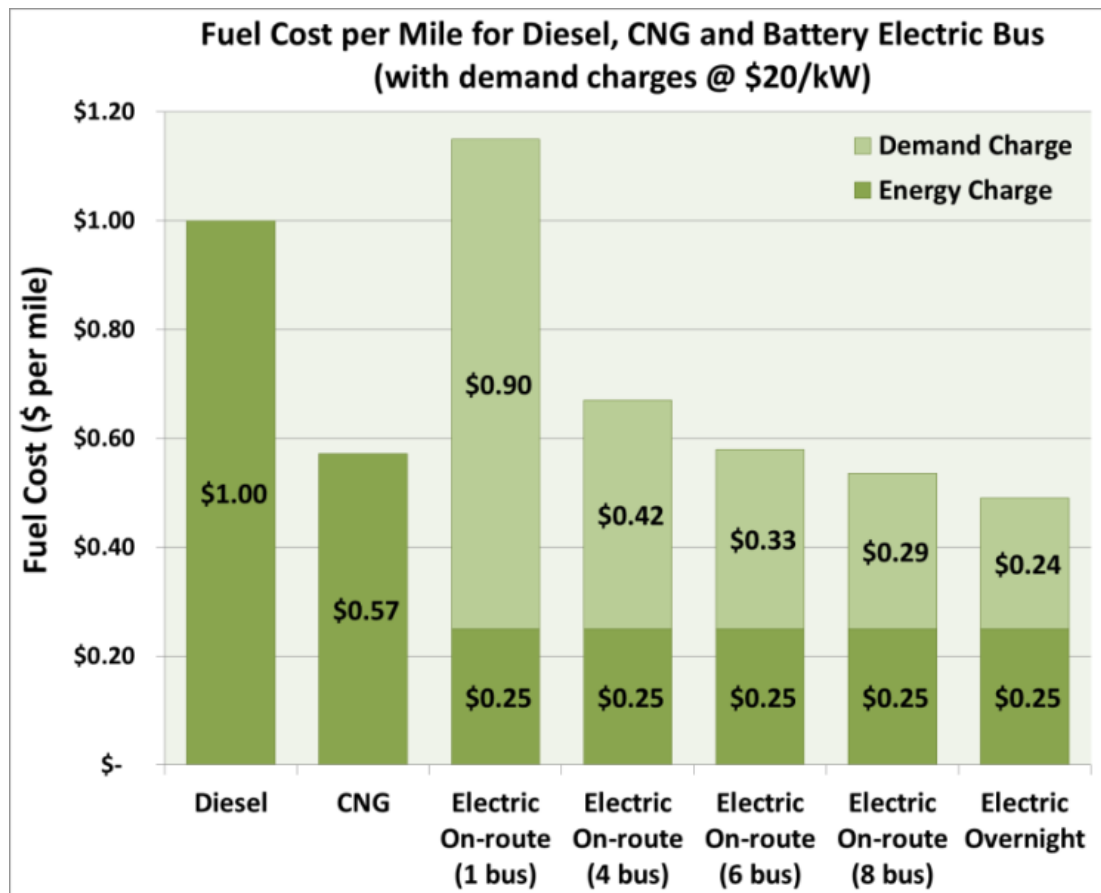
Utility load planning will be easier for E-Trucks & Buses as they will be concentrated in fewer areas



Charging has to support vehicle operation and unlike light-duty EVs cannot easily be shifted



Demand charges can be prohibitively costly for early E-Bus & Truck deployments



Assumptions:

Each bus drives 40,000 miles per year. The diesel bus has a fuel economy of 4 MPG and diesel is priced at \$4.00 per gallon. The CNG bus has a fuel economy of 3.5 MPDGE and CNG is priced at \$2.00 per DGE. The electric transit buses have an efficiency of 2.5 AC kWh/mile and electricity is priced at \$0.10/kWh. One electric bus charging on-route draws 150 kW from the grid, 4 draw 280 kW, 6 draw 330 kW and 8 draw 380 kW. The electric bus charging overnight draws 40 kW from the grid.

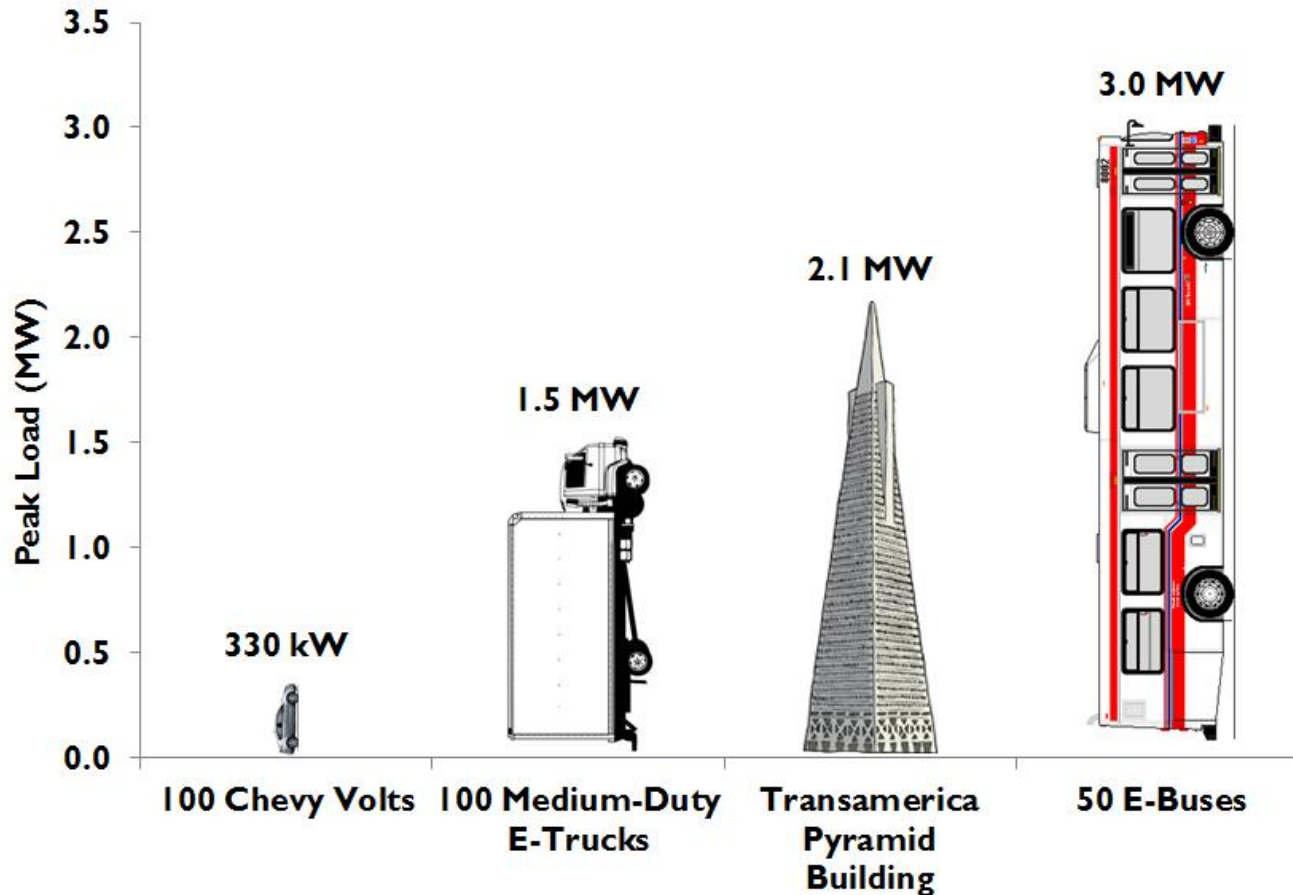
E-Truck & Bus charging infrastructure is a limiting factor for further vehicle adoption



*Fleet cost estimates
per one charger installation*

	EVSE	EVSE Installation	
		Low	High
16.5kW (220V / 75A)	\$1,000 - \$3,000	\$17,000	\$32,000
70kW (208VAC 3Ø / 200A)	\$5,000 - \$10,000	\$20,000	\$75,000
450kW (480VAC 3Ø / 640A)	\$350,000	\$150,000	\$200,000

E-Truck & Bus charging, if unmanaged, can have significant impacts on the grid



Assumptions: the Chevy Volt charging rate is 3.3 kW, the medium-duty E-Truck charging rate is 15 kW and the E-Bus charging rate is 60 kW. The peak load for the Transamerica Pyramid building is from [26].

Storage – Distributed Generation – Intelligent Management

- Energy Storage System
- Battery Swapping
- Distributed Generator
- Load Management System

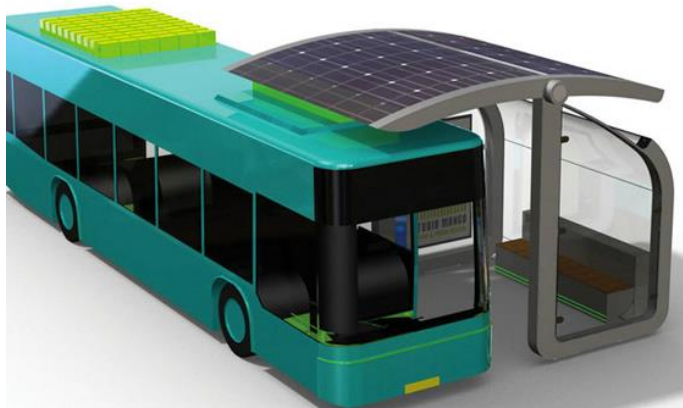
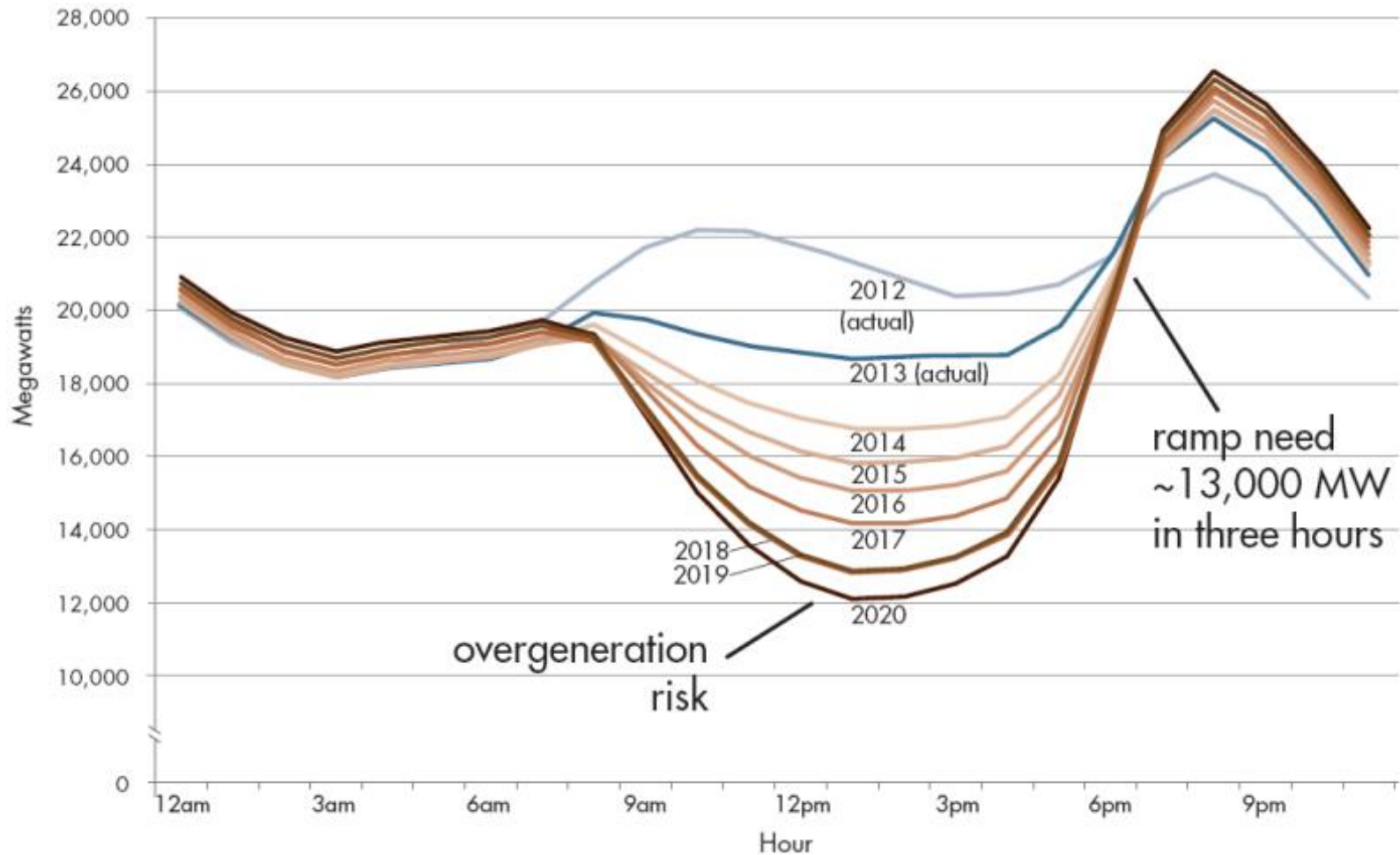


ABB TOSA bus charging system with ultracapacitors



	Grid to Charger	Charger to Bus
Maximum charging power	40 kW	400 kW
Charging duration	2.5 minutes	15 seconds
Energy transferred	1.7 kWh	1.7 kWh

E-Trucks & Buses could provide additional benefits to the electric grid



Electrifying the truck & bus market requires innovative utility rates



Utility	SCE		
Rate Schedule	TOU-EV-3	TOU-EV-4	TOU-EV-6*
Maximum Demand	<20kW	>20kW <500kW	>500kW
EV Submetering	Required		
Energy Charge	Max. \$0.36/kWh Min. \$0.06/kWh	Max. \$0.29/kWh Min. \$0.06/kWh	Max. \$0.39/kWh Min. \$0.07/kWh
Demand Charge	A - \$0.00/kW B - \$7.23/kW	\$13.20/kW	\$10.93/kW
Notes	No EV demand charges if EV account demand does not exceed General Service account demand of associated facility.		

Commercial Electric Vehicle Working Group

Shared understanding of common issues, costs, impacts, and opportunities

- **Utility**
- **Transit Agency**
- **Truck Fleet**
- **Vehicle OEM**
- **Tech Provider**



Overview of Participating Fleets

Summary of Stated Challenges

Infrastructure

- Infrastructure costs (in-depot and on-route)
- Power upgrades for 50+ vehicles
- Need for off-street property to accommodate on-route chargers
- Delays from utility during construction
- Inter-city coordination

Rates

- Electricity rates
- Demand charges / peak pricing

Other (Cross-Cutting)

- Regulatory uncertainty
- Inadequate funding levels

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