ZEV School Buses They're Here and Possibly Free

Clinton Global Initiative V2G EV School Bus Working Group

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April 22, 2016

Session Outline

- Introduction (Kevin Matthews)
- “Here and possibly free” (Steve Crolius)
- EV school bus technology (Joshua Goldman)
- Charging infrastructure (Niki De Leon)
- Funding opportunities (Kevin Matthews)
- Q & A (Kevin Matthews)

Introduction

“Here and Possibly Free”

EV School Bus Are Here (1)

OEM: ADOMANI

- Propulsion system supplier: ADOMANI
- Type A, C, and D buses
- Repowered and new-build buses
- Repowered buses available now; new-builds available in Q3/Q4 ’16 via partnership with GreenPower Motor Co.
- Roots:
  - ADOMANI is based in Los Altos, CA
  - GreenPower Motor Co. is based in Vancouver, BC
- Dealer/distributor: ADOMANI (Orange, CA; other sites are planned)
- Other notes: Gilroy USD has operated an ADOMANI type D demonstration bus since 2015

EV School Bus Are Here (2)

OEM: Complete Coach Works

- Propulsion system supplier: Complete Coach Works
- Bus type(s): To be determined
- Repowered buses
- Arrival in the market will depend on when development funds are secured (Q3 ‘16 at the earliest)
- Roots: Complete Coach Works is based in Riverside, CA
- Dealer/distributor: Complete Coach Works
- Other notes: CCW plans to adapt its EV transit bus Zero-Emission Propulsion System (ZEPS) for use in school buses

EV School Bus Are Here (3)

OEM: Lion Bus

- Propulsion system supplier: Lion Bus
- Type C buses
- New-build buses
- Available now
- Roots: Lion is a Canadian based in Quebec
- Dealer/distributor: First Priority Bus Sales (Reedley, CA)

EV School Bus Are Here (4)

OEM: Trans Tech

- Propulsion system supplier: Motiv Power Systems
- Type A buses
- New-build buses
- Have been available since 2014
- Roots:
  - Trans Tech is based in Warwick, NY
  - Motiv is based in Foster City, CA
- Dealer/distributor: First Priority Bus Sales (Reedley, CA)
- Other notes: 4 Trans Tech/Motiv buses are in service at the Kings Canyon USD

EV School Bus Are Here (5)

OEM: TransPower

- Propulsion system supplier: TransPower
- Type C and D buses
- Repowered buses
- Available now
- Dealer/distributor: TransPower (Poway, CA)
- Other notes: TransPower produces the world's first vehicle-to-grid (V2G) school bus

CGI V2G EV School Bus Phase 1 Project

- Objective: Move EV school buses toward full, unsubsidized commercial availability by demonstrating vehicle-to-grid as the “missing link” of economic competitiveness
- Scope: Build and deploy six V2G-enabled type C school buses
  - Two each for Torrance Unified School District, Napa Valley Unified School District, and Edison School District (Bakersfield)
- Project elements:
  - Buses equipped with bidirectional inverters
  - Charging infrastructure
  - Utility interconnection
  - Charge/discharge control system
- Lead funding from California Energy Commission, South Coast Air Quality Management District, and NRG/EVGo

V2G School Bus Economic Modeling

	Diesel	EV	Key Assumptions
Initial Vehicle Price	$110,000	$230,000	Type C bus; includes cost of charging infrastructure for EV bus
Annual Expense for			
Fuel	$5,000	$3,024	12K miles/year; diesel at $2.50/gal; electricity at $0.18/kWh
Propulsion System Maintenance	$5,743	$1,306	Oil change, brake replenishment major drivers of cost
Accrual for Battery Replacement	--	$3,061	$500/kWh to start; 2% annual rate of cost decrease
Annual V2G Revenues	--	$6,100	Based on actual electric market parameters
Years to Breakeven	**13**		

Source: Financial model developed by PJM Interconnection and CGI V2G EV School Bus Working Group

TUSD: V2G Economic Modeling

- Two-step modeling
  - Step 1: Model school district electric bill based on
    - Increase in total electricity consumption
    - Shift from one rate (the “TOU-B”) rate to another (the “TOU-A” rate)
  - Step 2: Using the TOU-B rate and projected consumption, model electric bill based on use of the bus batteries for
    - Rate arbitrage (substituting low-price off-peak electricity for high-price on-peak electricity)
    - Demand peak-shaving

TUSD: V2G Economic Impact

- Step 1 results in a higher electricity bill but elimination of petroleum fuel costs
  - Calculation:

    Incremental cost of electricity: $900

    Elimination of fuel cost: ($9,000)

    Net impact: ($8,100)

V2G functionality helps ensure that the monthly demand peak does not go up with increase in kWh

- Step 2 results in further savings of $4,100
  - Demand charge reduction year-round: ($2,800)
  - Energy charge reduction during the summer: ($1,100)
  - Energy charge reduction in other periods: ($200)

V2G functionality enables the execution of arbitrage and peak-shaving techniques

Category	Annual Savings	Per Bus
Step 1	$8,100	$4,050
Step 2	$4,100	$2,050
Total	**$12,200**	**$6,100**

Questions?

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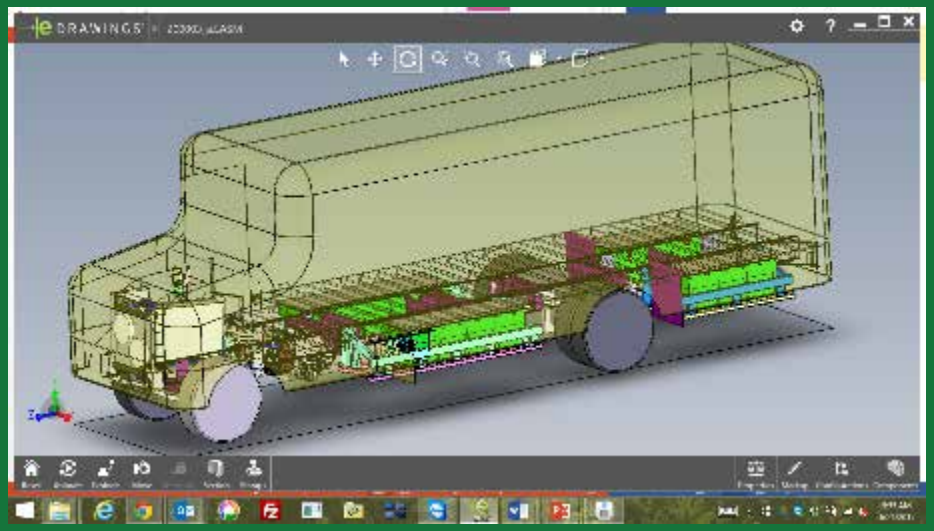
EV School Bus Technology

Overview

- 6 V2G Capable School Buses for Clinton Global Initiative Team Funded by Ca Energy Commission SCAQMD/EPA
- Torrance, Bakersfield, Napa field demonstrations
- Grant funded 1996 MD DT466 chassis conversions
- SDUSD international/bluebird buses used for conversion
- Project Leverages TransPower's MD and HD drive system developments from Drayage and Yard Tractor systems.

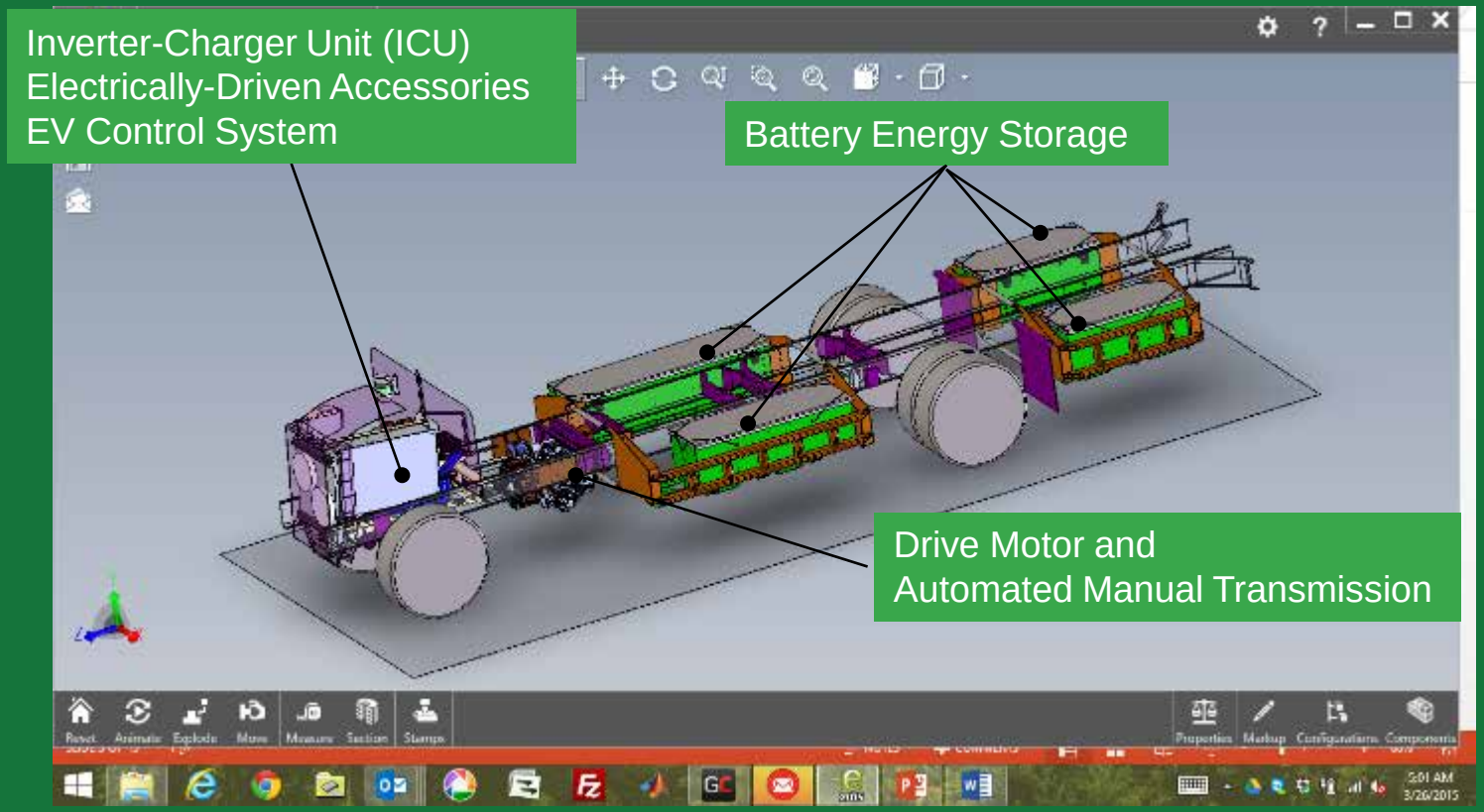


Progress To Date

- *1st Bus Complete with 250 miles of testing.*
- *2nd Bus complete, awaiting batteries. Targeting 4/25/16 delivery to NREL for V2G J3068 testing.*
- *Buses 3-6 targeted for July Deliveries. Battery supply major issue causing delay.*
- *PE review of CHP in updated. Expect confirmation from CHP in Sacramento in April 2016.*
- *Continuing UDEL/TransPower EVSE development in preparation of the NREL and Torrance testing in April 2016*
- *TransPower's similar systems in test in 8 drayage trucks and 5 yard tractors has improved overall V2GSB system controls thanks to over 45k miles of real world testing.*

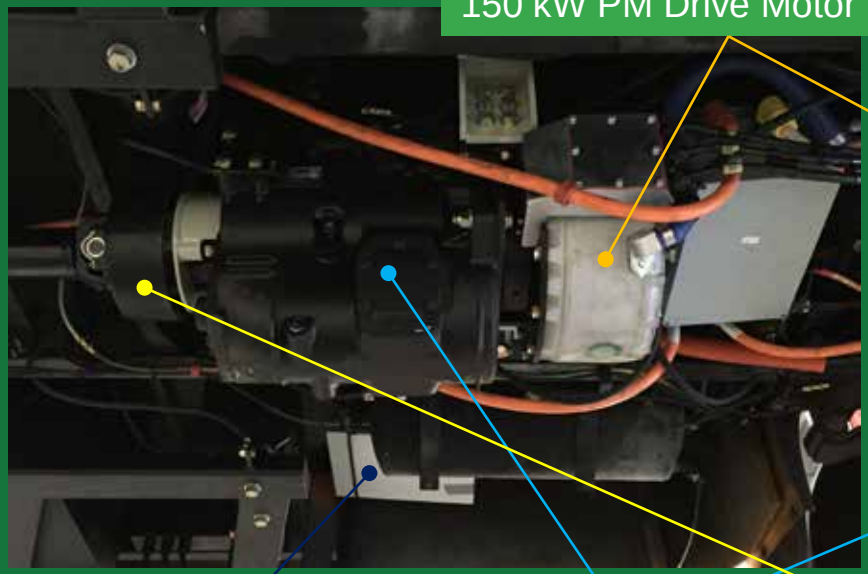
V2GSB Vehicle Specifications

Specification	Units	Stock Diesel	TransPower
Model	Name	Type – C	V2GSB 1.0
Engine / Motor	Model	D466	TP – 150 -6
Transmission	Type	5-spd Auto	6-spd Auto shift Manual (5 speeds used)
Motor	Type	Diesel	Permanent Magnet 3 Phase Electric 150kW Peak, 110 kW Cont.
Power	HP	200	201
Torque	ft-lb	400 @1440	530 @ 50 RPM
Curb / Gross Vehicle Weight	lbs	13920/25500	17000/25500
Rated Propulsion (Engine vs Motor/Battery) "Useful Life"	Years	10 years	10 years
Fuel Tank Capacity to 20%	kWh	2432 (80 gal * 38 kWh/gal * 0.80)	115.2 Total (92.1 usable)
Range	Miles	400	70 (+/- 30)
Refueling Time	Minutes	10	90 (with TransPower EVSE) 300 (with Udel EVSE)
Alternator	Amps @ Volts	200 amps @ 14 VDC	150amps @ 12VDC
HVAC	Type	Engine Supplied BTU TBD	2x4000W High Voltage Heater
Power Steering	Type	Engine Driven	Electric : 2.7 GPM @ 2100 psi
Hydraulic Brake Booster	Type	Engine Driven full time	Electric on Demand TBD

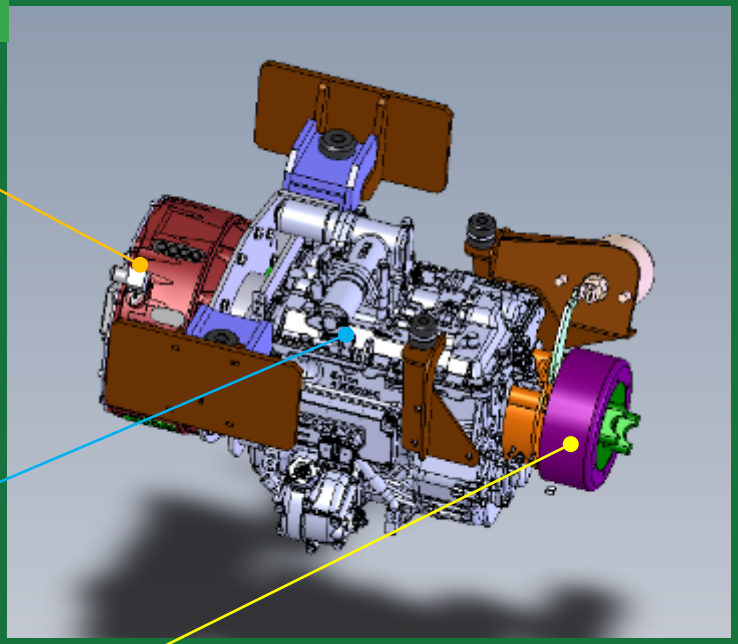


- ***Overall vehicle component layout***

- ***Motive Drive System***



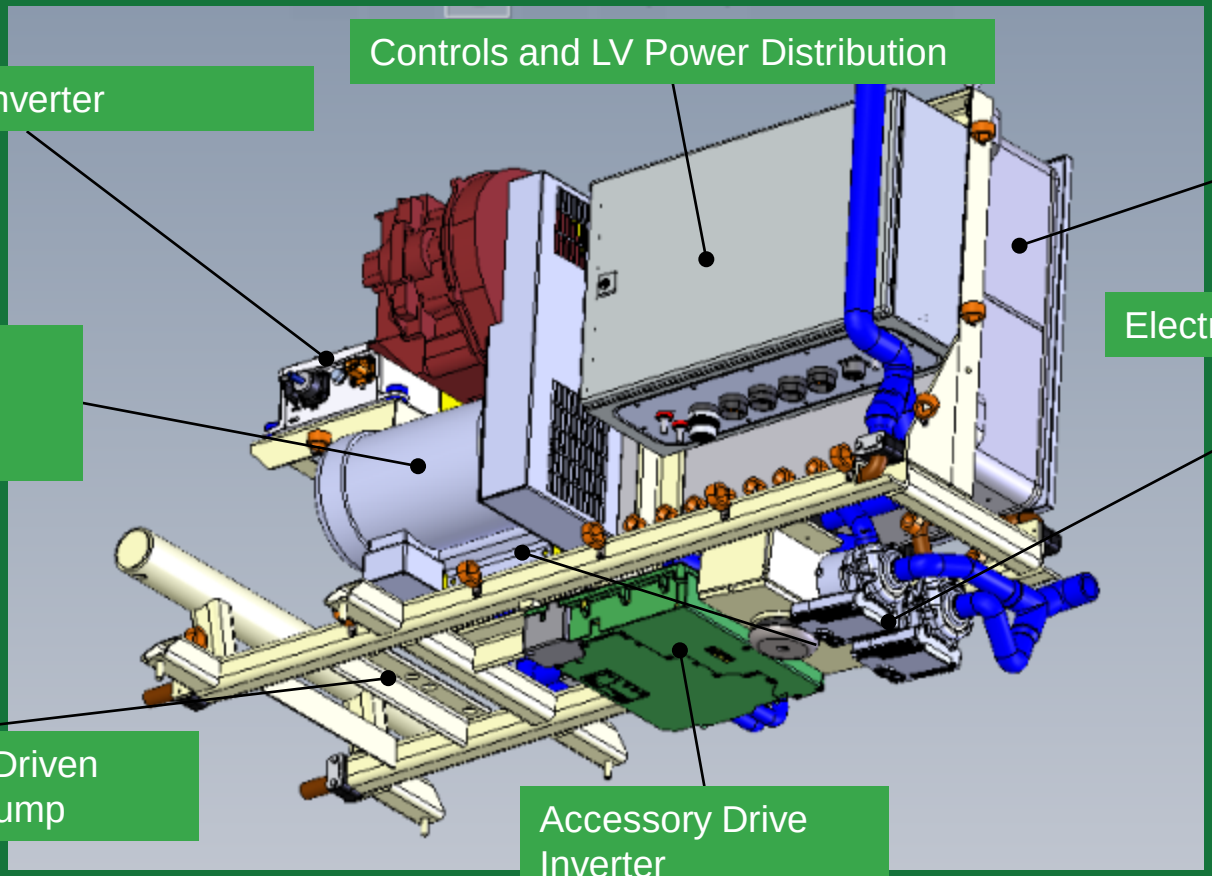
150 kW PM Drive Motor



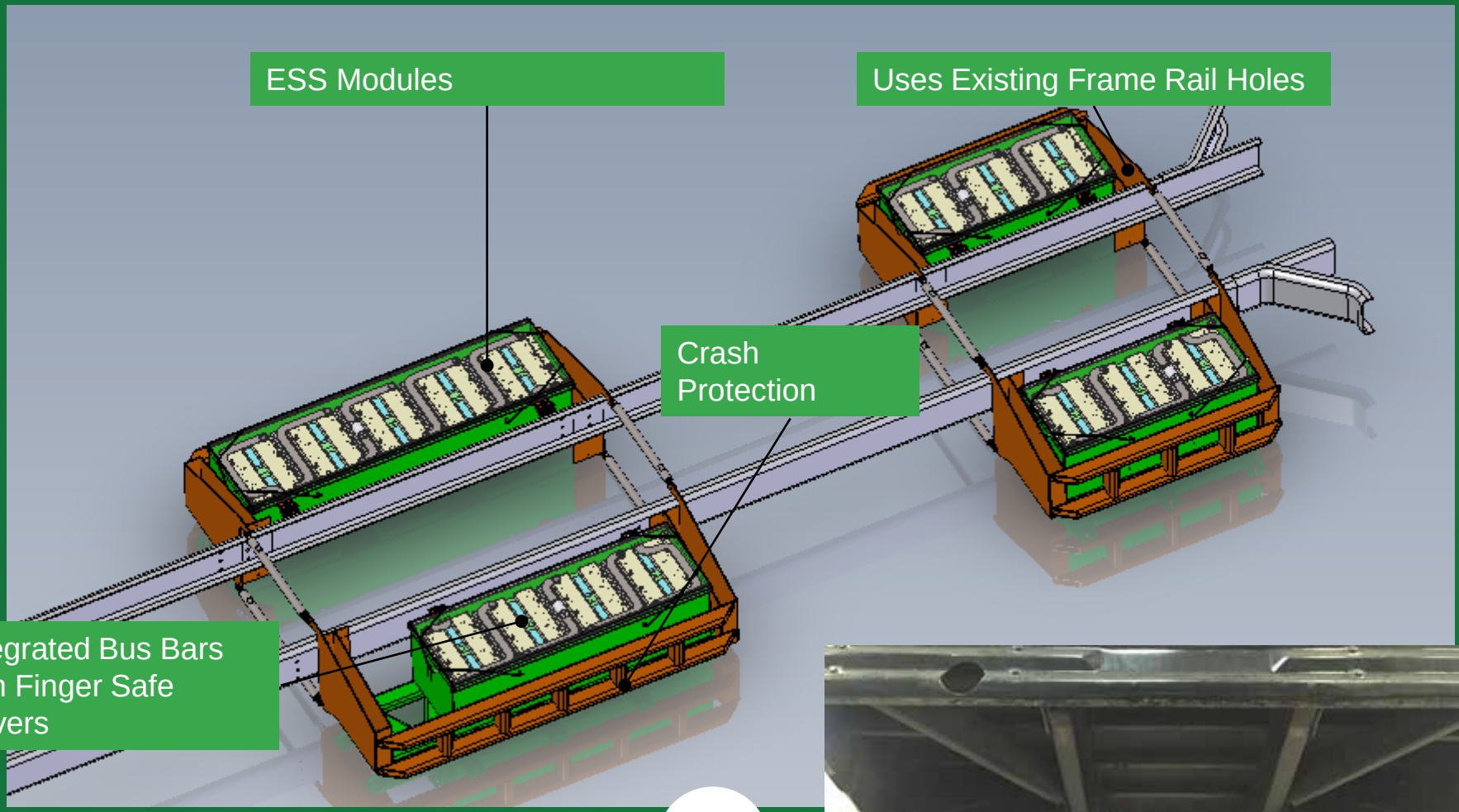
Powertrain Control Module (PCM)

Automated Manual Transmission

Parking Brake



- ***Powertrain Controls and Accessory Subsystem (PCAS)***



- ***Energy Storage System (ESS)***

Future Look

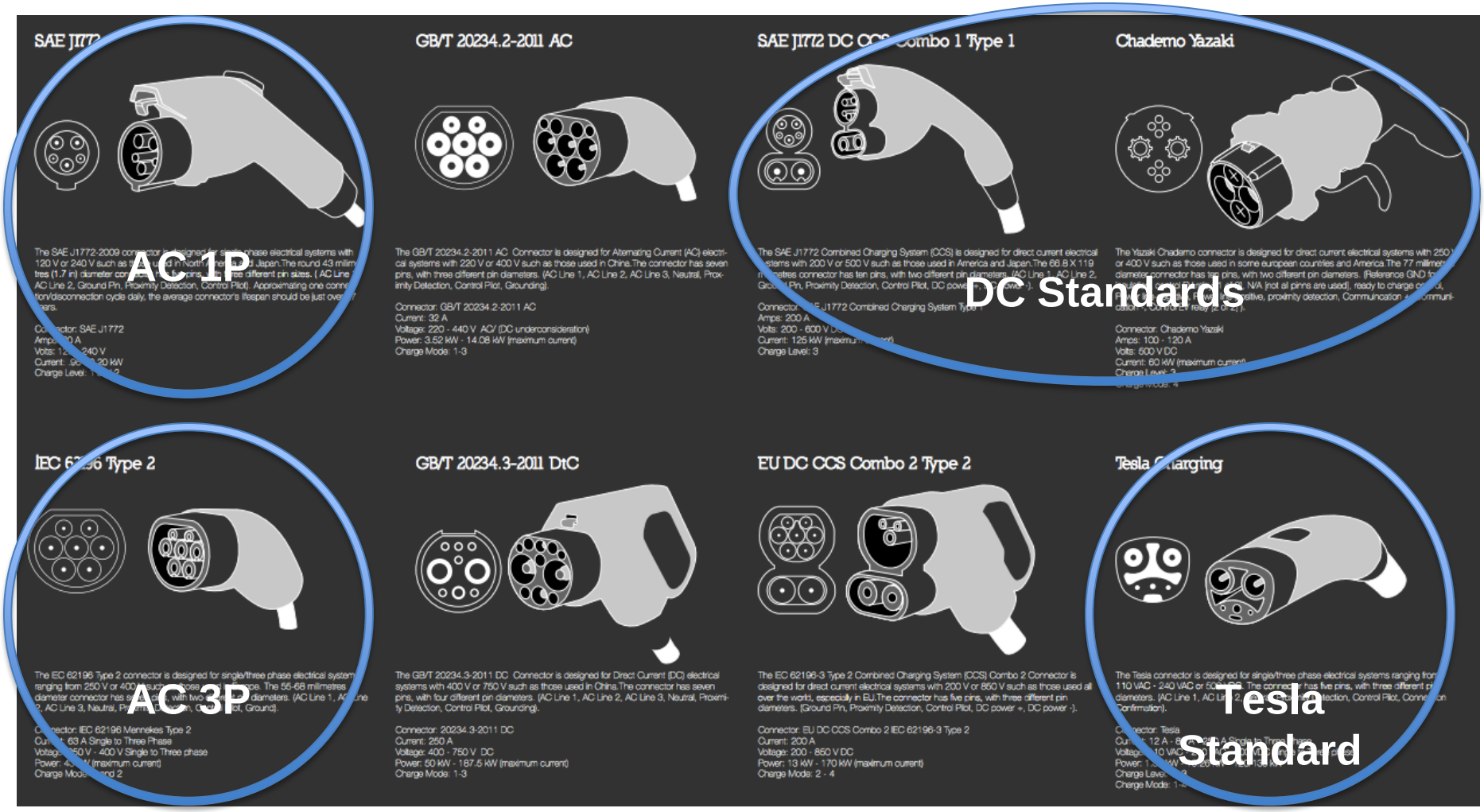
- *Adapt Design for Type D Front Engine Bus*
- *Reduce Final Assembly of Glider Bus to 2 days*
- *Test Next Generation Batteries with 60% greater energy density in Drayage Truck*
  - *Would allow for 150 kWh ESS (100+ mile range) to fit between Frame Rails*
- *Major Components used inside V2GSB's to complete UL like Certification Testing in Q1 2016*
- *Ramp up for 100 unit production capability in 2017 and 500 unit capability in 2019*

Charging Infrastructure

EV Charging Infrastructure Key Questions to Ask:

1. For what purpose(s) will this vehicle serve? (transportation only, V2B / emergency power / demand mitigation, etc.)
2. Do I have space to park my vehicle near a source of electricity?
3. Does the building I want to park at have power available?
4. What plug standard does my vehicle come with? What power rating is the bus?
5. Who will install the conduit and equipment at the site? (3rd party or in-house)
6. Who inspects the work at my site? (city or self certify on campus)
7. What is the maintenance plan for my charging equipment?
8. If I want to backfeed power, what are the rules for utility interconnection?
9. Does my installation require internet connection?

Consider your site and where the power is located. If the building you are trying to locate your vehicles near is limited in power availability, you may need to go back to the utility service drop for the site, or consider bringing in a new utility service to your building.



Source: http://ev-institute.com/images/media/Plug_World_map_v5.pdf

Lots of plug standards for charging electric vehicles exist. Consult with your EV provider to understand which standards they offer. Determine what the maximum voltage and amperage rating for the 1) Plug, 2) Vehicle, 3) Electric Vehicle Service Equipment (EVSE or Charging Station). Like a series of funnels, the power can only flow as strong as the smallest funnel.

Most Important!

If your facilities are considering any structural work now or in advance of your project timeline, work with them to preemptively build for EV infrastructure. This will save time and money for your future projects!

Examples:

- If there is trenching or repaying being done in the parking lot, add additional conduits for future charging station. Add 1 ½ “ conduits for power, 1” conduits for internet, consider adding a conduit for low power 120V outlet near the charging equipment.

- If there is a power upgrade happening in your building, ask how much excess power will be available after the work, consider adding additional power concurrent with the power requirements for your EVs

Questions?

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Funding Opportunities

Show Me The Money!

- The State of California is leading in developing funding sources for EV School Buses
- The Carl Moyer Program
- Up to $400,000 per bus
- Up to $20,000 for Charging Infrastructure
- Grants
- CARB's recent Truck and Bus Grant Program
- Future use of Cap and Trade funds
- Air Quality Districts