Advanced Clean Local Trucks

Second Workgroup Meeting

August 30, 2017

Sacramento, California

Mobile Source Control Division

California Environmental Protection Agency

Air Resources Board

Agenda

- Program status update
- Early heavy-duty zero-emission vehicle (HD ZEV) market
- Future HD ZEV market potential and data needs
- Cost saving opportunities
- Key vehicle weight class differences
- Next steps

Program Status Update

- Action items from last workgroup meeting
  - Update electricity charging cost calculator
  - Update energy efficiency ratio (EER) paper
  - Comments on draft fleet operations survey
- Recent meetings with manufacturers
  - Truck and Engine Manufacturer's Association (EMA), Alliance of Automobile Manufacturers (AAM), Ford, Navistar, PACCAR, Volvo, Cummins, Tesla, Motiv, BYD, TransPower, Phoenix Motorcars
- Proposed chassis manufacturer sales of zero-emission vehicles
  - 2.5% for 2023 model year increasing to 15% for 2030 model year
  - Performance based greenhouse gas (GHG) reduction strategy post 2030
- Scheduled for Board consideration in November 2018

Key Issues

- Where is best potential for self-sustaining market
- How to match HD ZEV sales and fleet demand
- How to foster innovation
- Role of class 8 trucks
- How to foster robust maintenance network and supply chain
- What information gaps need to be filled
- How to leverage other information and experience
  - Zero-emission buses, zero-emission cars, other technology developments
  - Fueling/charging standards and infrastructure
  - Markets outside California
- Overlap with Phase 2 GHG and future low NOx engine standards

Early Heavy-Duty Zero-Emission Vehicle Market

HD ZEV Market Status

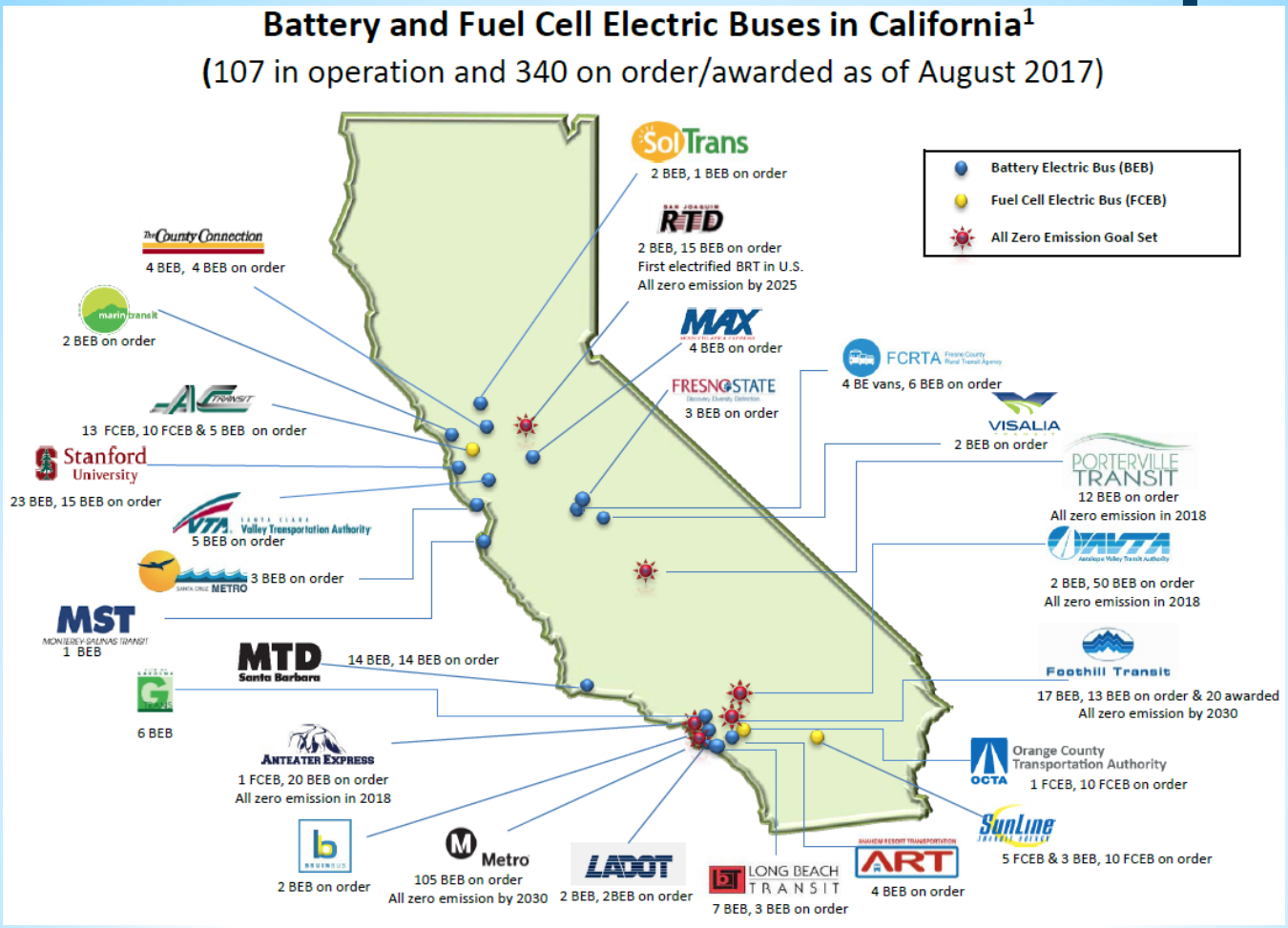
- Transit buses market growing rapidly
  - More zero-emission bus manufacturers than conventional buses
  - Battery electric and fuel cell electric drivetrains
- Battery electric trucks commercial sales in small numbers (all electric and range-extended)
  - Short haul, vans, yard trucks
  - Chassis and complete vehicles
- Pre-commercial demonstrations
  - Fuel cell, battery electric, plug-in hybrid configurations
  - Tractor, vocational, delivery, and other
- SAE medium and heavy-duty vehicle charging standards progress
  - Plug-in standard finalized and approval likely in October 2017
  - Overhead bus charging standard likely in 2018
  - Wireless heavy duty charging likely 2019

Robust Zero-Emission Bus Market

- Fuel cell electric
  - Offered by three manufacturers on existing platforms
  - Fueling and range similar to conventional buses
  - Costs declining with volume and technology improvements
- Battery electric
  - Eleven manufacturers
  - Total cost of ownership comparable to conventional where suitable
  - Extended range from 100-350 miles on single charge
    - ➢ Depot charging typically 40-120 kW
  - On-route charging up to 500 kW
- Performance and operating cost data available

Additional information at https://www.arb.ca.gov/msprog/ict/ict.htm

Zero-Emission Bus Market Update



1. Buses in transit fleets and universities
2. Six transit agencies to have more than 3,000 zero emission buses by 2030

Commercial Zero-Emission Truck Manufacturers

- BYD – California
  - Box trucks, drayage tractor, yard truck, refuse trucks, and transit buses
- Motiv - California
  - Offers all-electric powertrain for school bus, cutaway shuttle, stepvan, and refuse trucks currently
- Orange EV - Missouri
  - T-Series electric yard truck
- Phoenix Motorcars - California
  - Shuttle bus, flatbed and utility truck
- TransPower – California
  - School buses, drayage trucks, yard tractors, and refuse trucks
- Workhorse Group - Ohio
  - Range-extended (electric/gasoline) and full electric step van
  - Range-extended (electric/gasoline) pickup truck – coming 2018
- Zenith Motors – Kentucky
  - Cargo and passenger vans

Other Manufacturers Entering Zero-Emission Market

- Ford has recently created its electric qualified vehicle modifier (eQVM) program with three approved eQVMs
  - Allows customers to purchase electric powertrain from dealership
  - Sets standards that vehicle modifiers must meet to become an eQVM
- Mitsubishi Fuso announces electric eCanter
  - Electric box truck on existing platform to start production 2017
  - Full commercialization 2019
- Chanje to produce battery-electric delivery van (ground up design) in California starting this year

Other HD ZEV Announcements

- Toyota demonstrating a fuel-cell drayage truck
  - Based on light-duty Mirai fuel-cell technology
- Cummins announced an electric powertrain option
  - Class 7 truck demonstration
  - Transit bus powertrain in 2018
  - Extended-range heavy duty electric powertrain in 2020
- Siemens, Hydrogenics, and US Hybrid deploying heavy-duty fuel-cell systems
- Tesla to reveal electric semi this September

Recent HD ZEV Demonstrations

California Incentives

- Greenhouse Gas Reduction Fund (GGRF)
  - Funds demonstrations, pilots, and incentives for low-carbon transportation
  - Cap-and-trade authorization extended to 2030 gives more certainty to funding
    - $945 million generated in August auction
  - The Hybrid and Zero-Emission Truck and Bus Voucher Incentive Program (HVIP) – Funded by GGRF
    - Offsets incremental cost of advanced technology engines, equipment and drivetrains - 37 zero-emission vehicles now eligible
    - Vouchers up from $20,000 to $110,000 for zero-emission trucks and buses
- Are there other valuable fleet incentives?
  - Green fleet recognition, other

Zero-Emission Drayage Truck Demonstration

Manufacturers:
25 BYD – battery electric vehicle (BEV)
12 Peterbilt / TransPower - BEV
4 Kenworth / BAE – plug-in hybrid electric vehicle (PHEV)
2 Volvo - PHEV
43 Total

BEV: 70-150 mi
PHEV: 10-30 mi/150-300 mi

Locations:
South Coast, Bay Area, San Joaquin Valley, Sacramento, and San Diego





San Bernardino Multisource Facility Demonstration

Manufacturer

BYD

23 BEV yard tractors

4 BEV medium-duty service trucks

27 Total

Deployments

7 at DayLight Transportation in Fontana

10 at BNSF in San Bernardino

10 at BNSF in Los Angeles

California Zero-Emission Bus Pilot Projects

San Joaquin Valley Cities
15 Proterra battery electric transit buses

Orange County and East Bay
New Flyer fuel cell buses
10 for Orange County Transit Authority
10 for Alameda-Contra Costa Transit

City of Porterville
10 GreenPower battery electric transit buses

Coachella Valley
5 New Flyer fuel cell transit buses for Sunline Transit

California Battery-Electric Truck Pilot Projects

UPS
21 BYD delivery vans
LA County

USPS
15 Motiv/EVI step vans
Central Valley

School Districts
13 TransTech/Motiv
16 First Priority GreenFleet
Sacramento School Districts

AmeriPride
20 Motiv linen delivery vans
San Joaquin Valley

Goodwill
10 BYD class 6 delivery trucks
1 BYD class 8 tractor
Bay Area

Other Heavy Duty Fuel Cell Electric Demonstrations

TransPower / US Hybrid
4 fuel cell electric plug-in hybrid drayage trucks

UPS
17 delivery trucks w/ fuel cell range-extended design

FedEx
20 delivery trucks w/ fuel cell range-extended design

Notable Zero-Emission Vehicle Policies

Zero-Emission Vehicle Demand

- California ZEV Action Plan calls for state fleets to procure zero-emission light-duty and heavy-duty vehicles
- Proposed California fleet rules
  - Zero-emission Airport Shuttle Bus
  - Amendments for Innovative Clean Transit
- Mayor's National Climate Action Agenda
  - Began with four largest cities aim to electrify their fleets
  - Requested information to understand zero-emission vehicle capability, cost, availability, and other factors (ended March 2017)
  - Participating cities own 115,000 vehicles from over 30 cities

https://www.labavn.org/index.cfm?fuseaction=contract.opportunity_view&recordid=29142

Port of Los Angeles/Long Beach Clean Air Action Plan

- Strategies to reduce pollution from every source
- Next step in truck strategy begins 2023
  - All trucks registered in Ports' truck registry must pay a truck entry fee except if near-zero or zero-emissions trucks
  - New trucks registered in Ports' truck registry must meet the near-zero standard or be zero-emission
- In 2035, only trucks that meet zero-emissions or the equivalent will be exempt from the rate
- All cargo-handling equipment zero-emission by 2030

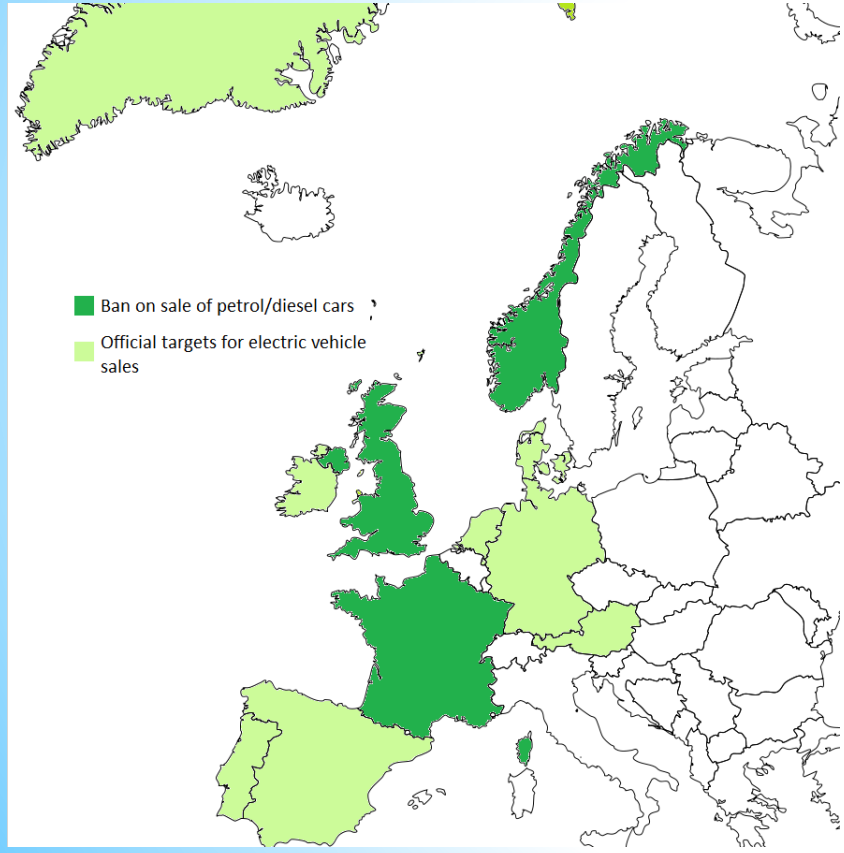
http://www.cleanairactionplan.org/

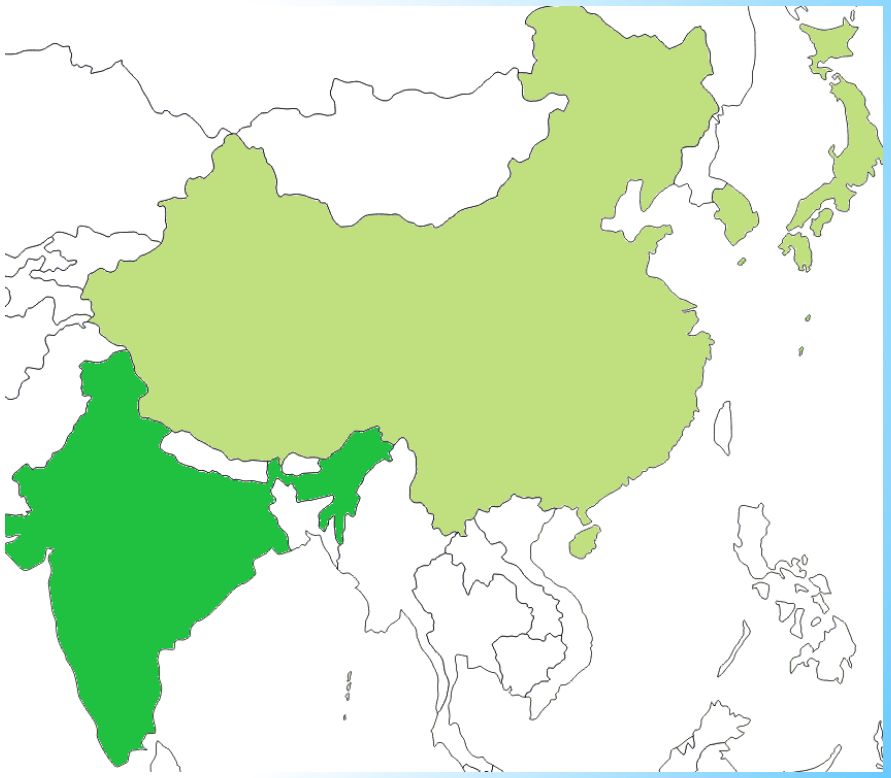
Foreign Markets

- StreetScooter WORK XL and Ford building 2,500 electric delivery vans for DHL
- Mercedes to deliver 1,500 electric Sprinter vans for Hermes
- European cities banning diesel vehicles in city centers

Foreign Markets (Continued)

- 4 world governments plan to phase out petroleum cars
- 10 other countries have official targets for electrification





Low Carbon Fuel Standard

- Lowers California transportation fuel carbon intensity
- Producers or users of low carbon fuels to generate credits which can be sold on open market
  - Fuels include electricity, hydrogen, fossil and renewable natural gas
  - Credits go to fuel producer for hydrogen, renewable fuels (diesel, natural gas) and reflected in net price
- Battery-electric truck owner can generate credits
  - Can be sold to offset substantial cost of electricity
- Program updates expected early 2018

Low Carbon Fuel Standard Program https://www.arb.ca.gov/fuels/lcfs/lcfs.htm

SB 350 - Clean Energy and Pollution Reduction Act of 2015

- Increases Renewable Portfolio Standard to 50% by 2030, improves energy efficiency, and supports transportation electrification
- California Public Utilities Commission (CPUC) decisions
  - Coordination with Air Resources Board and California Energy Commission
- PG&E, SCE, and SDG&E have proposed to invest over $1 billion over the next 5 years in transportation electrification
  - $779 million for medium-duty, heavy-duty, and off-road
  - New rate schedules to help incentivize electric vehicle usage
  - Priority review projects approval — October 2017
  - Evidentiary hearings on testimony — September 25 to October 13, 2017
  - Standard review projects approval — April 2018
- Publically-owned utilities proposals submitted

California Public Utilities Commission Transportation Electrification http://www.cpuc.ca.gov/sb350te/

Overlapping Clean Vehicle Policies

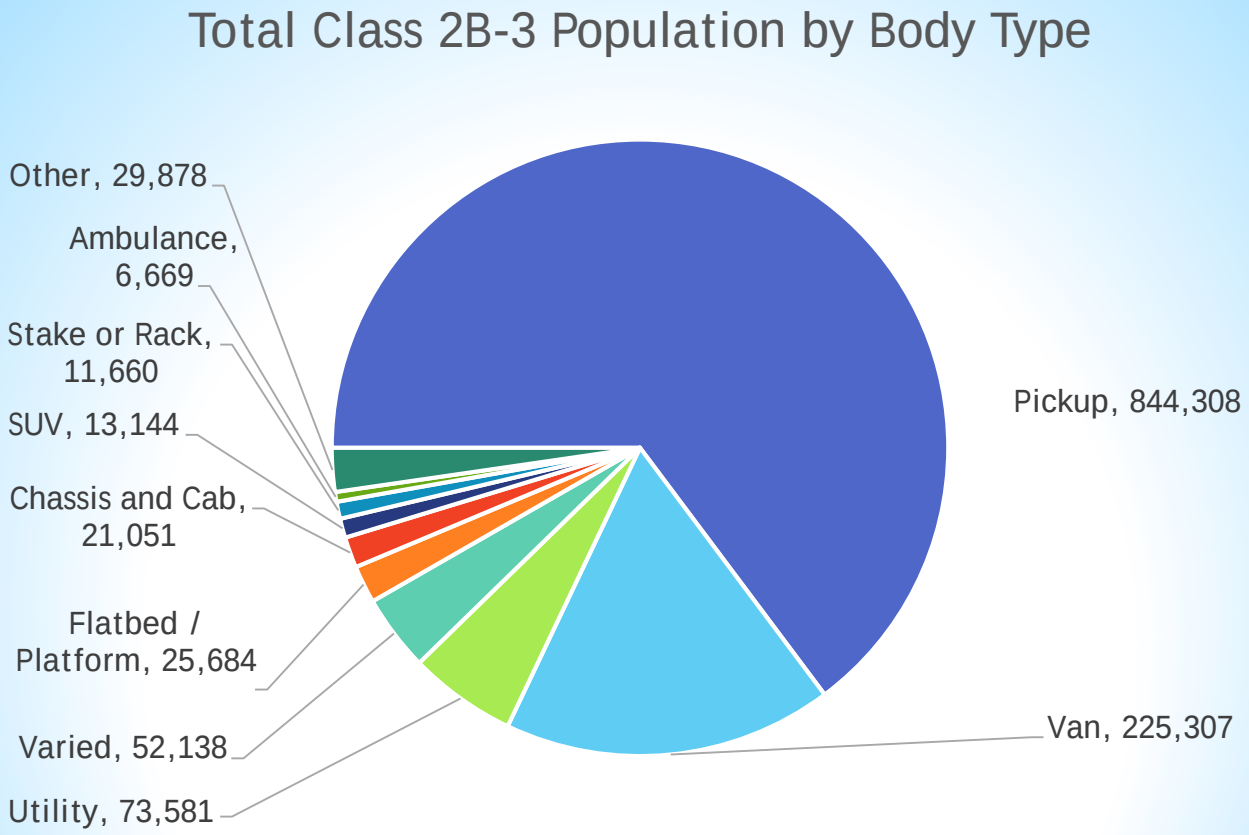
- Truck and Bus Regulation
  - All trucks upgrade to 2010 engine or newer by 2023
- Local community strategies to reduce health impacts of freight transportation
  - https://www.arb.ca.gov/lispub/rss/displaypost.php?pno=10528
- Sustainable Freight Initiative
- Local air district policies
  - Funding and rules

Market Potential for HD ZEVs

Fleet Information

- Need additional information to determine early market opportunities for HD ZEV technology
- Current data sources
  - DMV registration
  - California government fleet
  - Some municipal fleet data
- Need data to determine potential HD ZEV suitability
  - Fleet vehicle daily use and needs
  - Site specific information for needed infrastructure

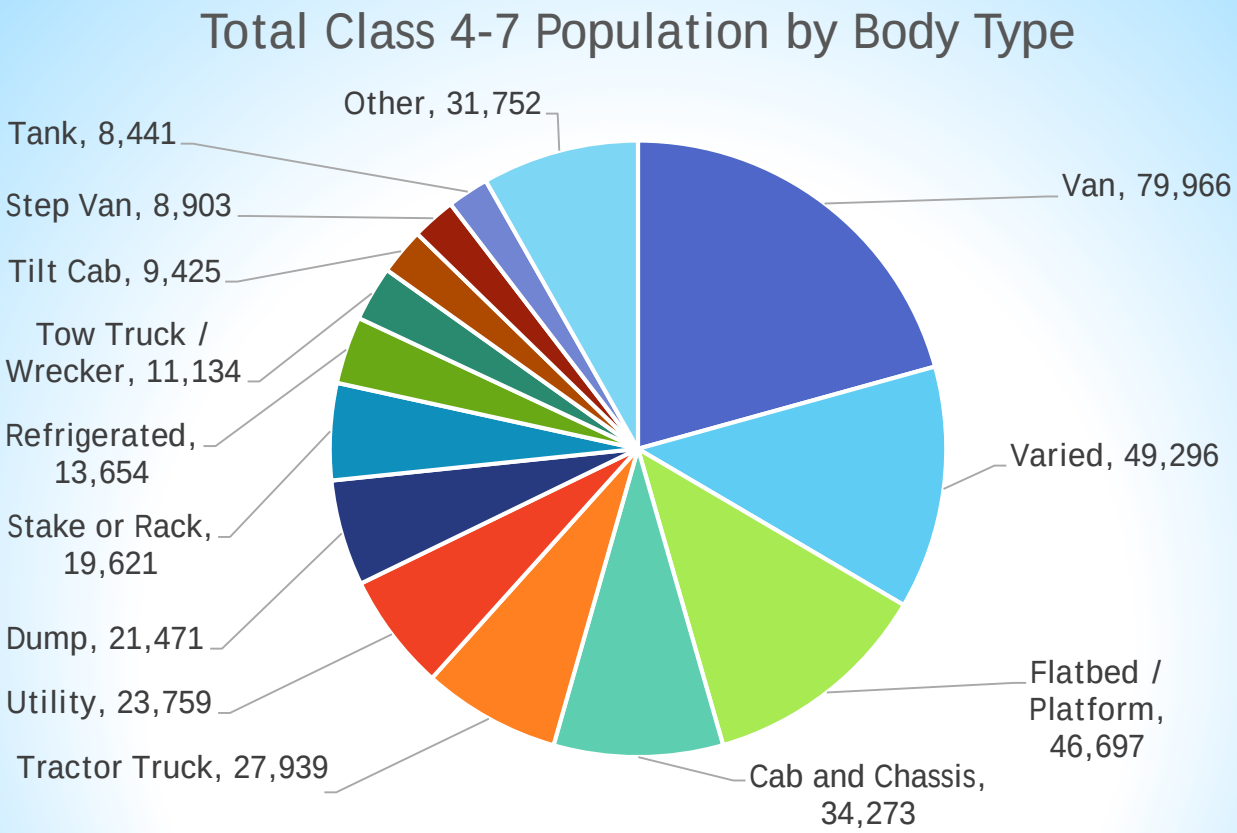
California Vehicle Registration Department of Motor Vehicles – Class 2B-3



Total: 1,303,420

Source: 2016 CA Department of Motor Vehicles

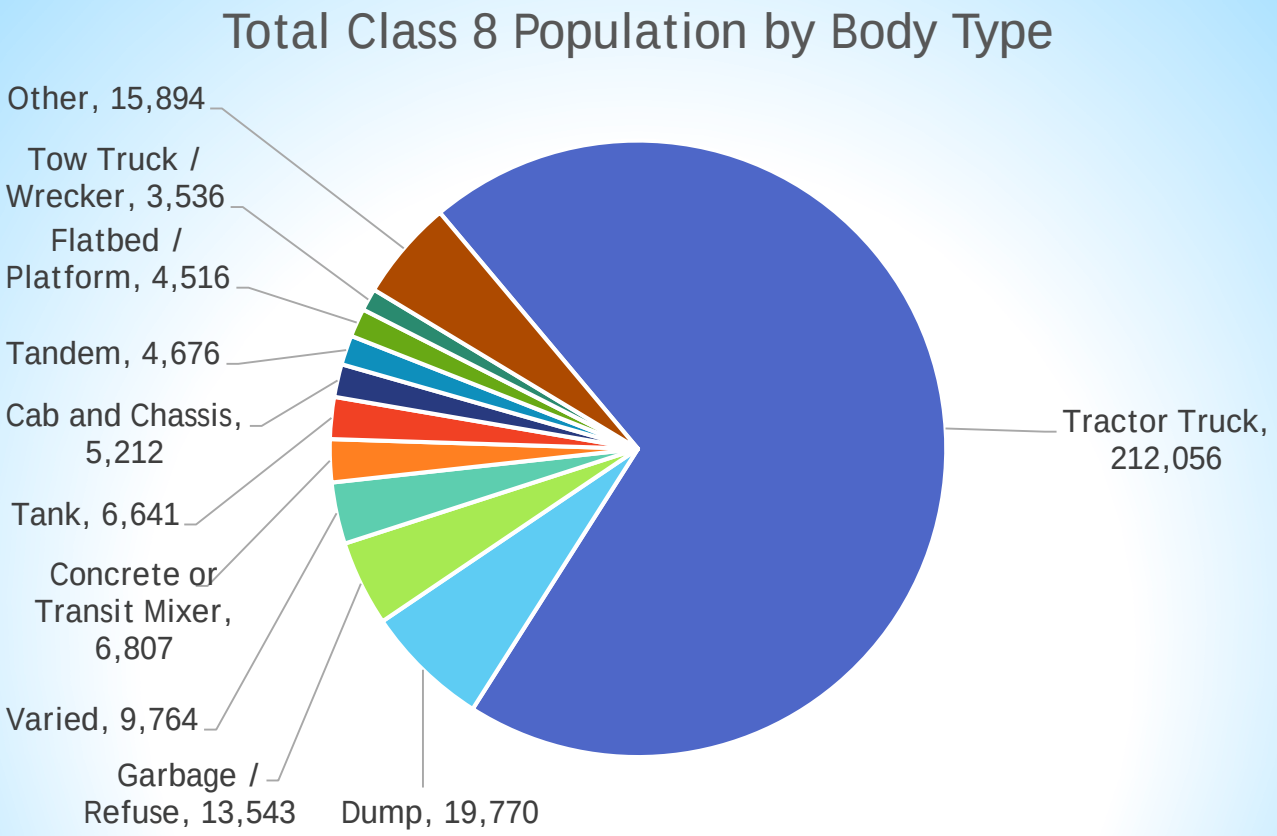
California Vehicle Registration Department of Motor Vehicles Data – Class 4-7



Total: 386,327

Source: 2016 CA Department of Motor Vehicles

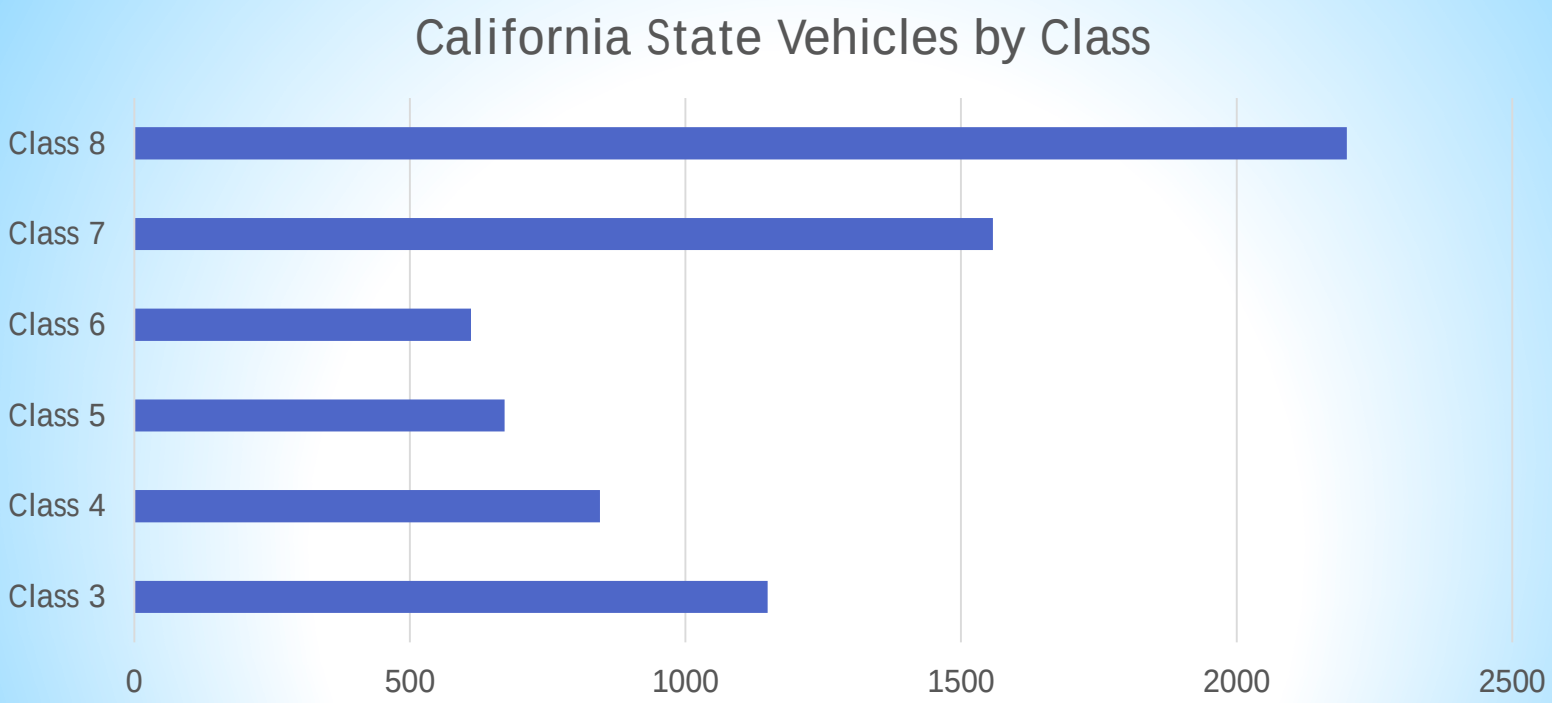
California Vehicle Registration Department of Motor Vehicles Data – Class 8



Total: 302,407

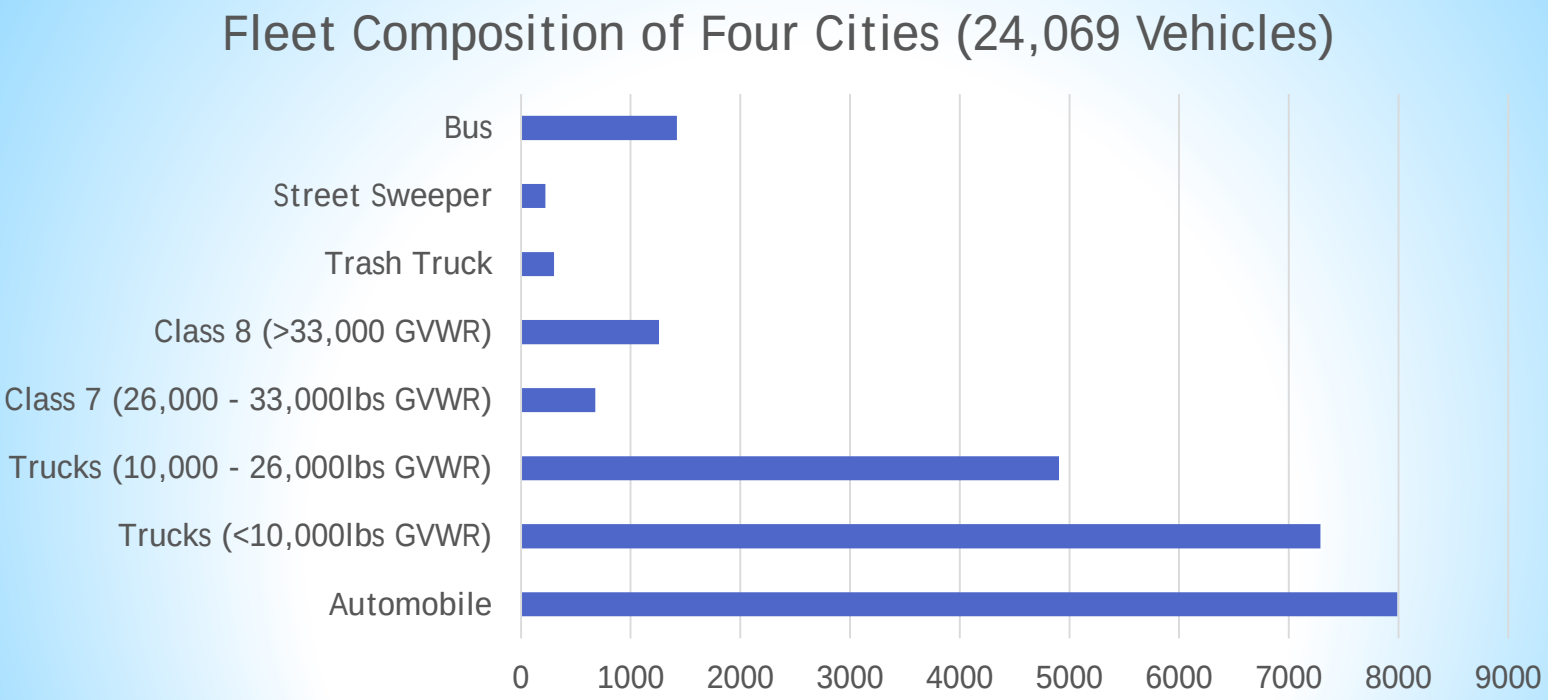
Source: 2016 CA Department of Motor Vehicles

California Government Fleet



Class 3-8 Total: 7,077

Fleet Composition of Los Angeles, San Francisco, Portland, and Seattle



Data Gathering Efforts

- California Vehicle In-Use Survey (CAVIUS)
  - Collect operational data on vehicles in California
  - Expected completion - March 2018
- Freight hub data collection
  - Series of surveys truck stops, railyards, seaports, airports, border crossings and warehouses/freight hubs
  - Last survey - Warehouse/Freight Hub Timeline – March 2018
- UC Davis STEPS survey
  - Better understand fleet purchasing decision factors

Advanced Clean Local Truck Fleet Survey

- Purpose is to assess market potential for HD ZEV technology
  - Focus on centrally operated fleets with predictable usage
- Draft for comment April 2017
  - Fleets concerned about confidential/business practice information
  - Survey too lengthy and would not be completed by fleets
  - Manufacturers interested in more information to help find best use cases for zero-emission vehicles
- Revisions needed to address competing interests

Fleet Survey Questions
Company and Yard Characteristics

- Company information
  - Name, location, primary business purpose, NAICS codes, typical vehicle replacement cycle
- Characteristics of the yard or depot
  - Electric utility provider
  - Daily fueling (on-site, off site)
  - Parking (dedicated parking, park front-to-back, park off-site)
  - Where is routine maintenance performed (on-site or local dealership)
  - Barriers with additional onsite fueling/charging infrastructure

Fleet Survey Questions
Operational and Vehicle Characteristics

- Return to base nightly, park away from yard, peak operation, weight/volume limited
- Vehicle features - towing, power take off, other

Class/ Type	Fuel	Typical MPG	Average Annual Miles	Average Speed	Bin Vehicles by Daily Miles Traveled (miles/day)						
					< 50	50-75	75-100	100-150	150-200	200+	Total

Manufacturer Information Needed

- Costs of producing HD ZEVs
  - Impacts on new vehicle production
  - Impacts for new drive train options on existing platforms
- Past California sales by vehicle type
  - General customer profiles
  - Vehicle features and options
  - Other
- Value of aggregated data
- How to avoid issues with business confidential information

Cost Saving Opportunities

General Goals for Evaluating Costs

- Evaluate total cost of ownership where zero-emission vehicles can meet existing fleet needs
  - Guide to evaluate potential market opportunities
  - Educational tool for fleet owners
- Electricity costs depend on utility and charging strategy
  - Savings common with overnight charging
  - Electricity charging calculator to assist fleets
- Potential for lower operational costs
- Future vehicle costs expected to decline
  - Decreasing battery costs
  - Vehicle sales volumes
- Additional cost data needed

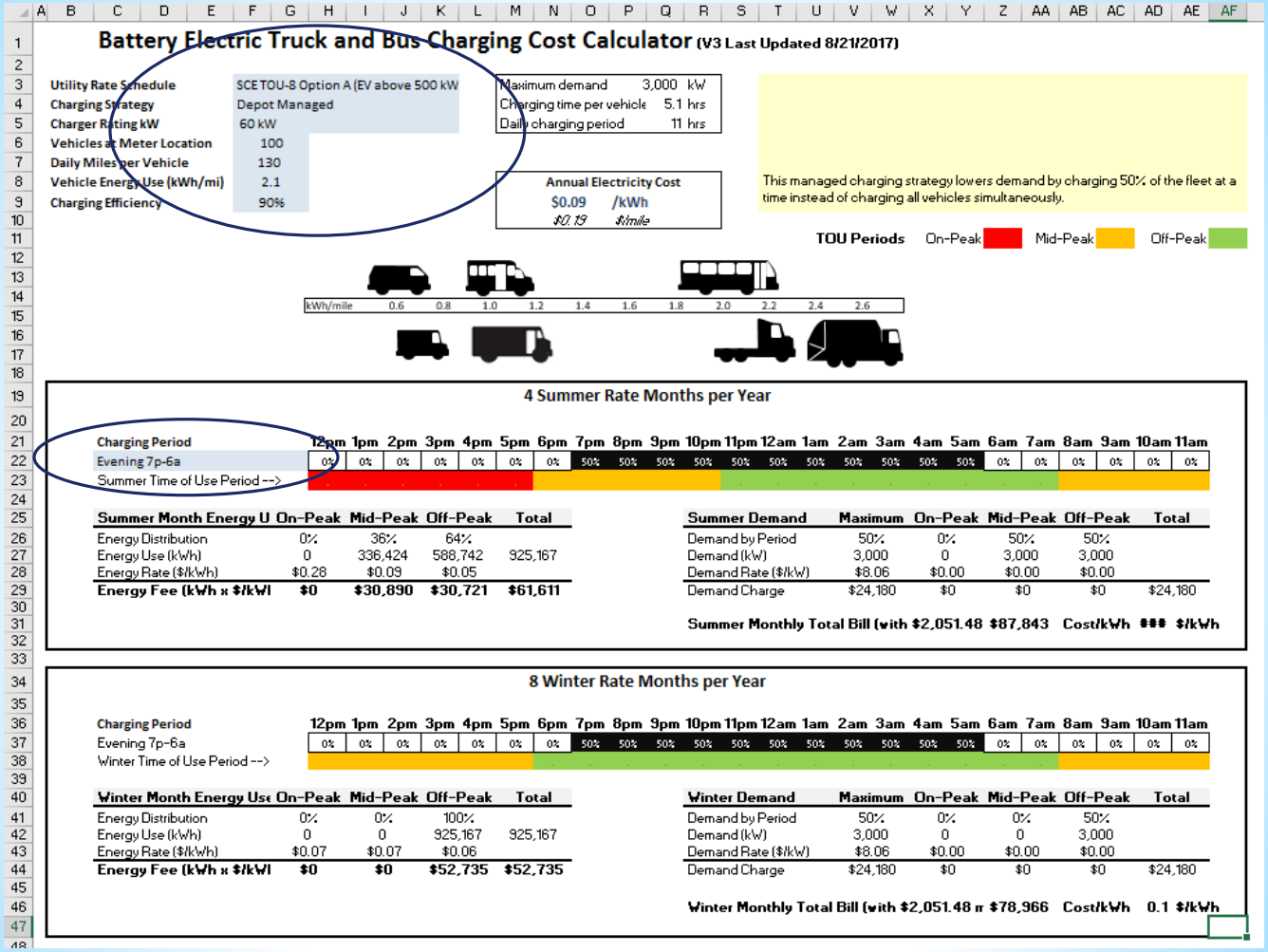
Electricity Rates

- Most commercial electricity rates based on time of use
  - Demand charges, usage charges and meter fees
  - Varies by utility and customer usage
- Vehicle charging costs depend on utility rate, charging strategy, number of vehicles charging
  - Off-peak charging with large groups of vehicles generally lower cost than charging during day
  - Staggered charging reduces demand and may result in lower total costs
    - ➢Can be controlled by software or timers

Charging Cost Calculator

- Battery-Electric Truck and Bus Charging Calculator
  - Assist fleets in calculating electricity costs of different charging strategies
  - Select from several California utility rate schedules, charging periods, charger sizes
  - Input daily mileage, vehicle energy usage, daily charging time, monthly mileage variations
- Users can add new rates, chargers, and charging periods if not already included
- Updated with feedback from truck and bus fleets

Battery Electric Truck and Bus Charging Cost Calculator



Battery Electric Truck and Bus Charging Cost Calculator (V3 Last Updated 8/21/2017)

Utility Rate Schedule	SCE TOU-8 Option A (EV above 500 kW
Charging Strategy	Depot Managed
Charger Rating kW	60 kW
Vehicles at Meter Location	100
Daily Miles per Vehicle	130
Vehicle Energy Use (kWh/mi)	2.1
Charging Efficiency	90%

Maximum demand	3,000	kW
Charging time per vehicle	5.1	hrs
Daily charging period	11	hrs

Annual Electricity Cost
$0.09 /kWh
$0.19 $/mile

This managed charging strategy lowers demand by charging 50% of the fleet at a time instead of charging all vehicles simultaneously.

TOU Periods On-Peak Mid-Peak Off-Peak

kWh/mile 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6

4 Summer Rate Months per Year

Charging Period	12pm	1pm	2pm	3pm	4pm	5pm	6pm	7pm	8pm	9pm	10pm	11pm	12am	1am	2am	3am	4am	5am	6am	7am	8am	9am	10am	11am
Evening 7p-6a	0%	0%	0%	0%	0%	0%	0%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	0%	0%	0%	0%	0%	0%
Summer Time of Use Period -->																								

Summer Month Energy U	On-Peak	Mid-Peak	Off-Peak	Total
Energy Distribution	0%	36%	64%	
Energy Use (kWh)	0	336,424	588,742	925,167
Energy Rate ($/kWh)	$0.28	$0.09	$0.05	
Energy Fee (kWh x $/kWh	**$0**	**$30,890**	**$30,721**	**$61,611**

Summer Demand	Maximum	On-Peak	Mid-Peak	Off-Peak	Total
Demand by Period	50%	0%	50%	50%	
Demand (kW)	3,000	0	3,000	3,000	
Demand Rate ($/kW)	$8.06	$0.00	$0.00	$0.00	
Demand Charge	$24,180	$0	$0	$0	$24,180

Summer Monthly Total Bill (with $2,051.48 **$87,843** Cost/kWh ### $/kWh

8 Winter Rate Months per Year

Charging Period	12pm	1pm	2pm	3pm	4pm	5pm	6pm	7pm	8pm	9pm	10pm	11pm	12am	1am	2am	3am	4am	5am	6am	7am	8am	9am	10am	11am
Evening 7p-6a	0%	0%	0%	0%	0%	0%	0%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	0%	0%	0%	0%	0%	0%
Winter Time of Use Period -->																								

Winter Month Energy Use	On-Peak	Mid-Peak	Off-Peak	Total
Energy Distribution	0%	0%	100%	
Energy Use (kWh)	0	0	925,167	925,167
Energy Rate ($/kWh)	$0.07	$0.07	$0.06	
Energy Fee (kWh x $/kWh	**$0**	**$0**	**$52,735**	**$52,735**

Winter Demand	Maximum	On-Peak	Mid-Peak	Off-Peak	Total
Demand by Period	50%	0%	0%	50%	
Demand (kW)	3,000	0	0	3,000	
Demand Rate ($/kW)	$8.06	$0.00	$0.00	$0.00	
Demand Charge	$24,180	$0	$0	$0	$24,180

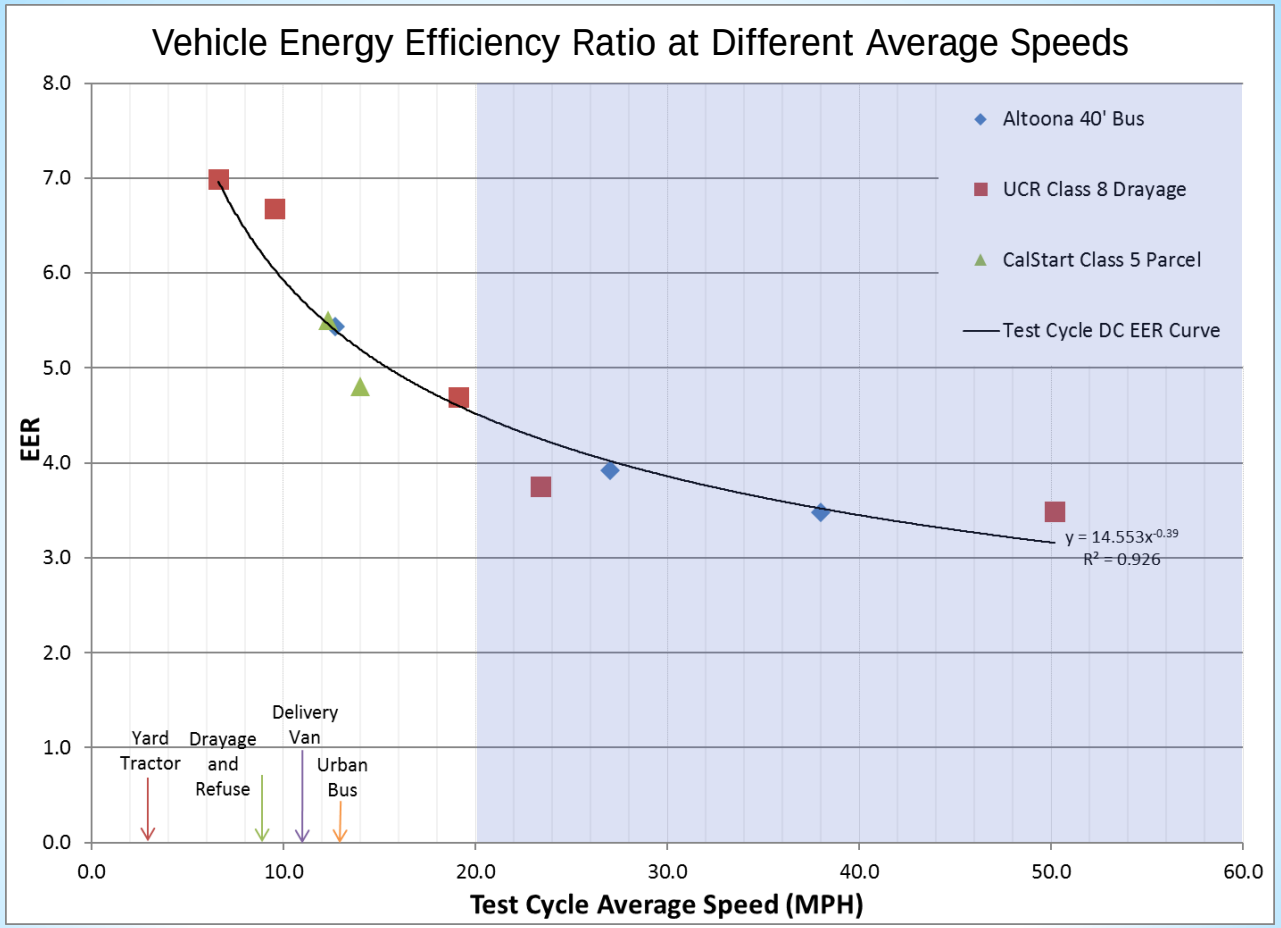
Winter Monthly Total Bill (with $2,051.48 **$78,966** Cost/kWh 0.1 $/kWh

Charging Cost Calculator: https://arb.ca.gov/msprog/actruck/chargecalc.xlsm

Battery Electric Truck and Bus Energy Efficiency Ratio

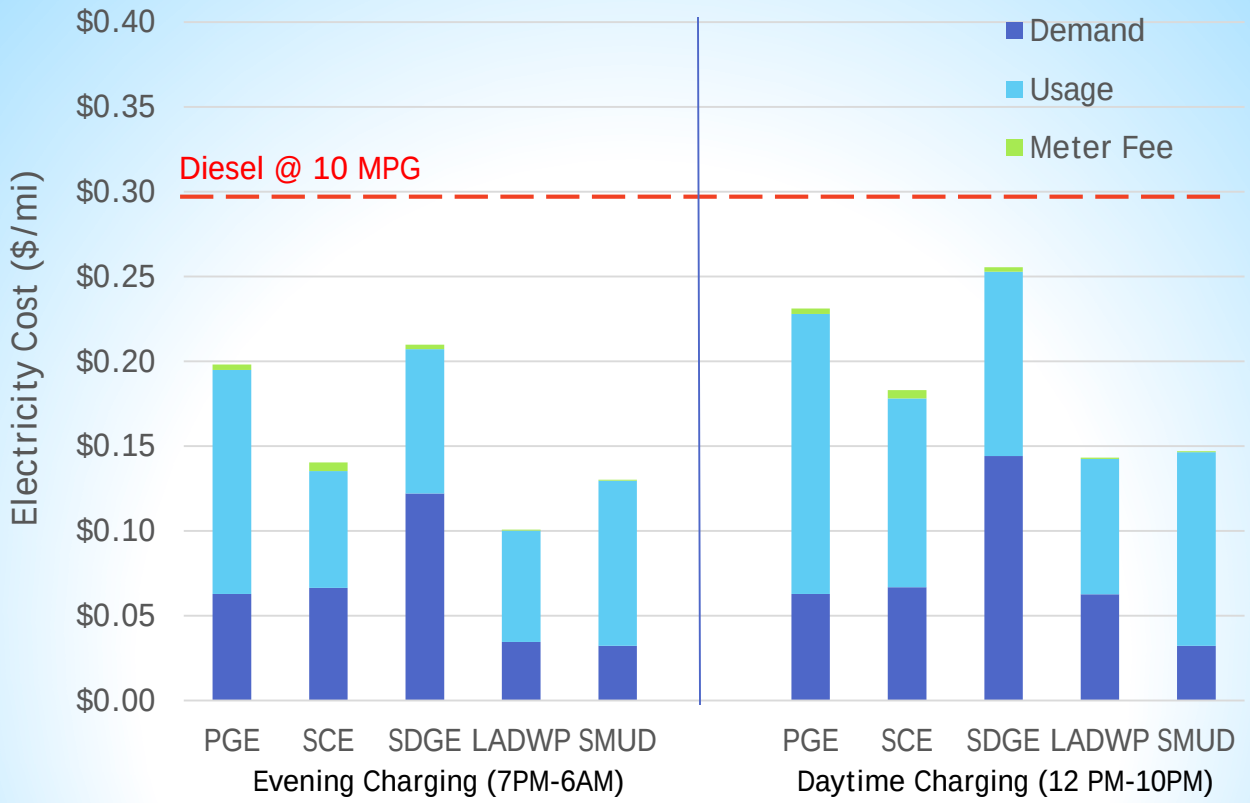
- New data used to evaluate EER for battery electric trucks and buses
  - Transit buses, drayage trucks, parcel delivery test cycles
  - Supports higher EER for battery-electric trucks and buses
  - Could increase number of credits/kWh in LCFS program
- Most vehicles operate less than 20 mph
  - Regional and short-haul EER ranges from 4.5 to 7.0
- Revenue would be near $0.14/kWh at a price of $100 per credit if EER increased to 5.0
- Update with additional bus data from Foothill Transit Study
  - EER of 8.4 when compared to CNG buses on same route (about 7 mph)
- Still need data for fuel cell electric vehicles

Energy Efficiency Ratio (Cont'd)



April draft for comment https://www.arb.ca.gov/msprog/actruck/mtg/170425eerdraftdocument.pdf

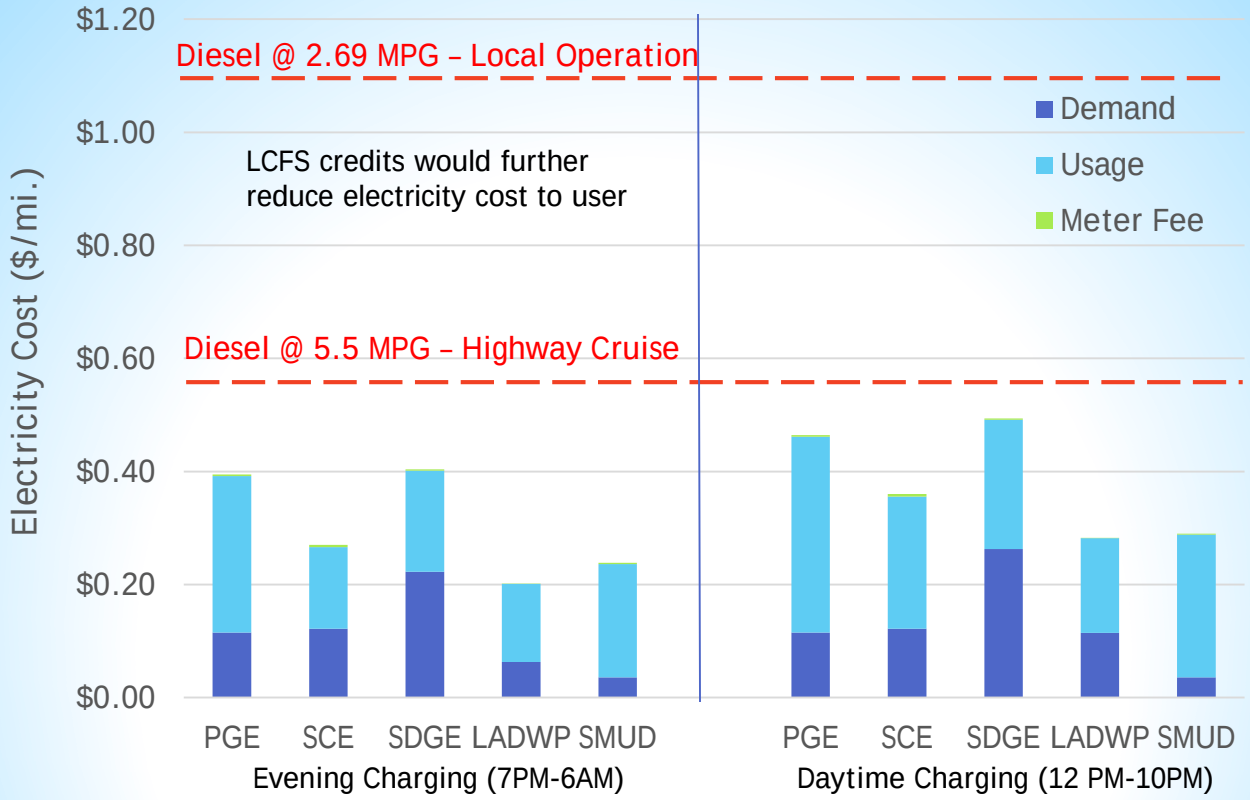
Fuel Cost Comparison
Delivery Van Example



LCFS credits could reduce net costs by additional $0.14/mile to user at $100/credit at 5.0 EER

Assumptions: 65 mi./day, 20 vehicles at location, 1.0 kWh/mi., 90% charging efficiency, 19.2 kW charger, managed charging strategy, $2.95/gal diesel (EIA Weekly)
Rate schedules: PGE A-10, SCE EV-4, SDGE AL-TOU, LADWP A-2(B) TOU, SMUD GS GSS_T

Fuel Cost Comparison
Drayage Truck Example

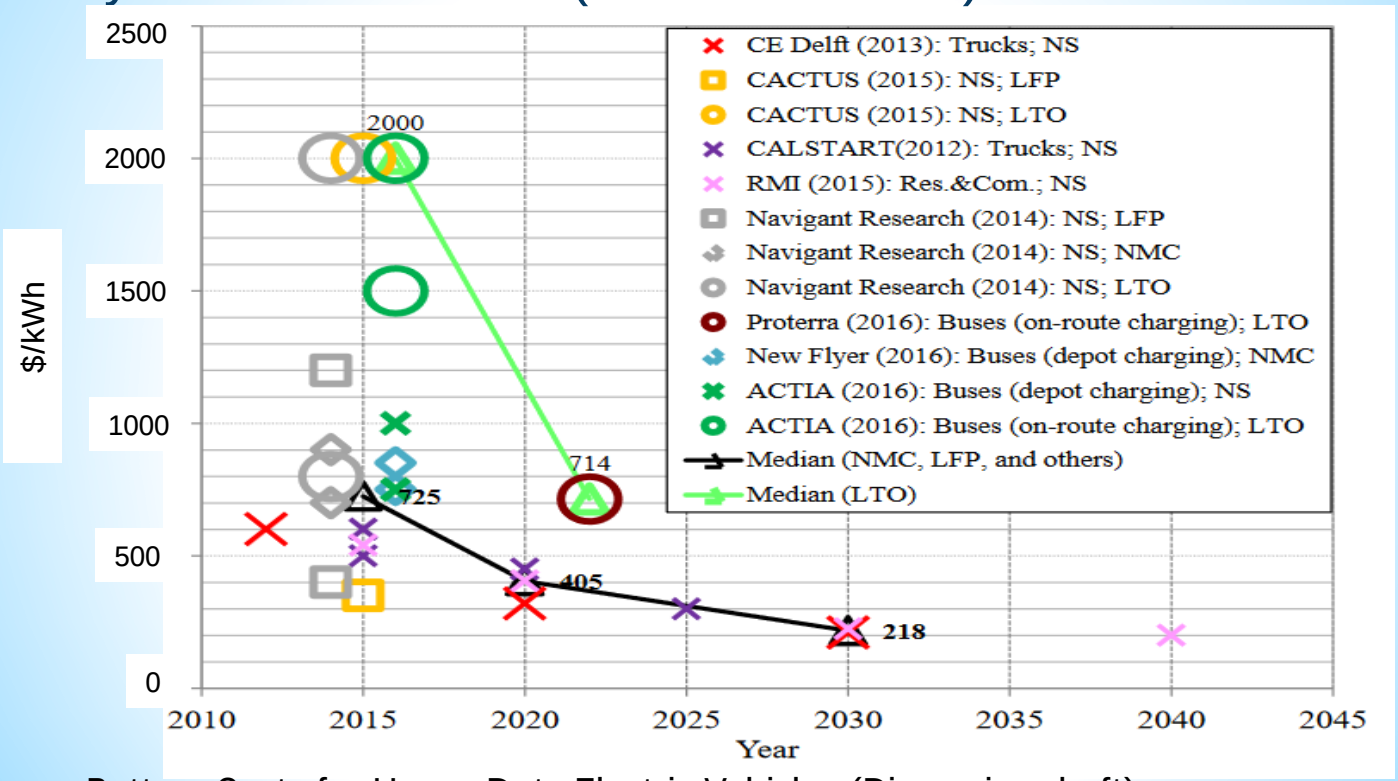


LCFS credits could reduce net costs by additional $0.29/mile to user at $100/credit at 5.0 EER

Assumptions: 75 mi./day, 20 vehicles at location, 2.1 kWh/mi., 90% charging efficiency, 40 kW charger, managed charging strategy, $2.95/gal diesel (EIA Weekly)
Rate Schedules used: PGE A-10, SCE EV-4, SDGE AL-TOU, LADWP A-2(B) TOU, SMUD GS GSS_T

Heavy-Duty Battery Costs Declining

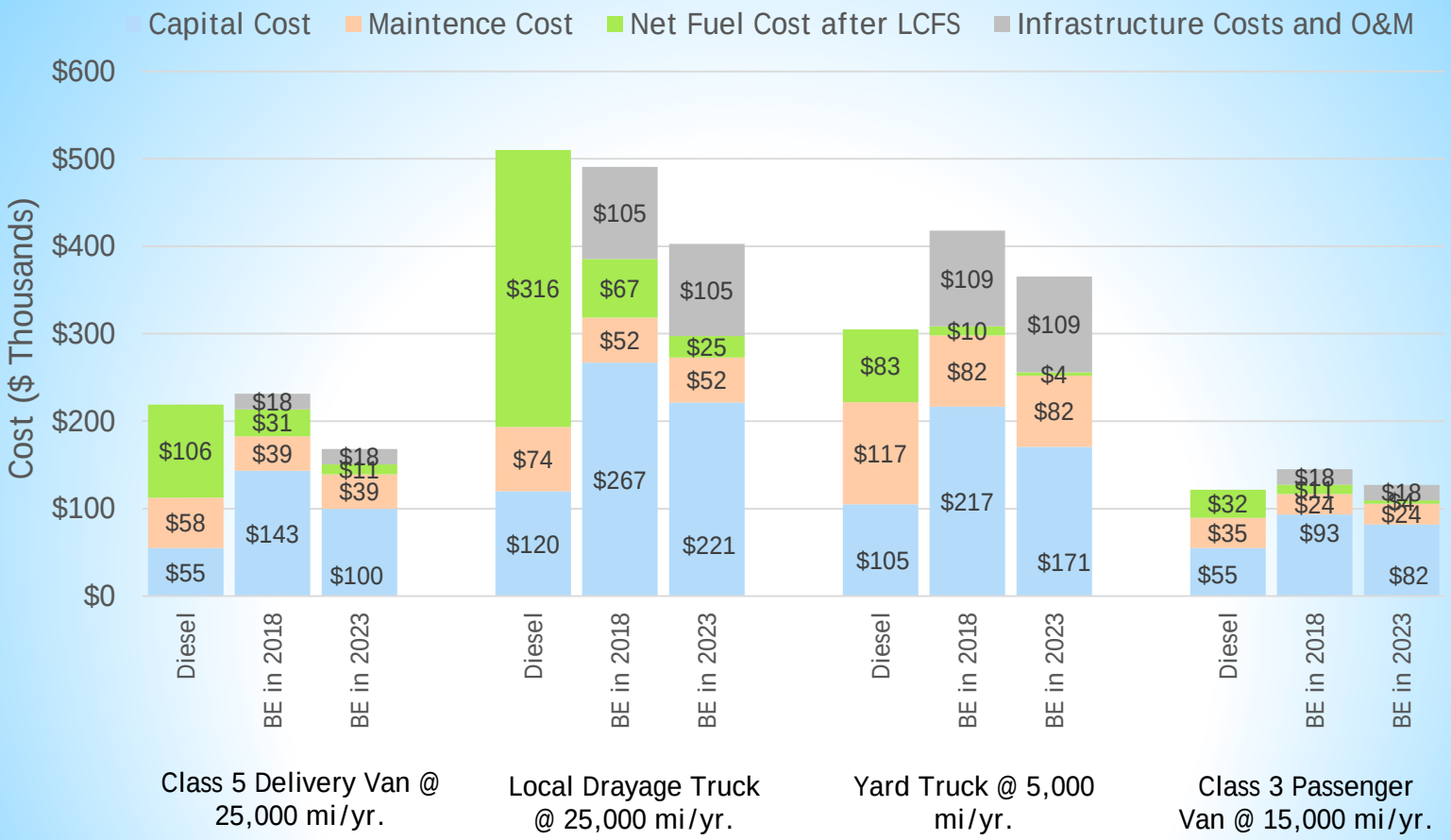
- Battery costs projected to continue declining
  - Battery Costs for HD ZEV (Discussion draft)



Battery Costs for Heavy Duty Electric Vehicles (Discussion draft): https://www.arb.ca.gov/msprog/bus/battery_cost.pdf

Lifecycle Truck Cost Examples

Low Volume Sales



Assumptions: Battery cost of $565/kWh in 2018, $348/kWh in 2023. Electricity Cost: $0.15/kWh adjusted using EIA annual outlook, diesel from EIA annual outlook. LCFS value of 2.7 in 2018, 5.0 in 2023, LCFS credit value of $100. Maintenance costs for electric vehicles are assumed 30% lower than a comparable diesel vehicle. Insufficient data to calculate midlife costs. Maintenance is performed offsite so no maintenance facility upgrades. Infrastructure upgrades include charger ($2,500 for passenger van and delivery van, $50,000 for drayage truck and yard truck) and electrical infrastructure upgrades ($10,000 for passenger van and delivery van, $50,000 for drayage truck and yard truck)

Key Weight Class Differences

Class 2B-3 and Class 4-7

Manufacturers have identified differences between the smaller 2B-3 and larger 4-7 classes

- **Usage**
  - 2B-3: High payload/towing needs for some categories (primarily pickups)
  - 4-7: High payload capacity for some categories, towing needs less common
- **Customer Base**
  - 2B-3: Primarily commercial, but large % personal use customers
  - 4-7: Almost exclusively commercial customers
- **Assembly**
  - 2B-3: Built and assembled as whole vehicle; limited space may require separate vehicle assembly line, not many fully custom
  - 4-7: Chassis, engine, body typically manufactured separately and assembled at body builder, many are fully custom orders
- **Certification**
  - 2B-3: Nearly always certified as whole vehicle. Class 3 have some engine certification
  - 4-7: Engine certified and uses GEM

Comparing Weight Classes

Weight Class	Class 2B-3	Class 4-7	Class 8
Consists of:	Pickups, Vans, some Vocational Vehicles	Vocational Trucks, Tractors, and Vans	Tractor Trailers and Vocational Trucks
Vertical integration	Yes	No	Some for tractors, no for vocational
Production	Assembly line	Custom Order	Custom Order
Personal use	Some	No	No
Emissions certification	Vehicle (Class 3-some engine certified)	Engine and GEM	Engine and GEM

- Are differences enough to warrant a separate sub-group?

Need for Heavy-Duty Zero-Emission Certification Procedures

- Standardized evaluation criteria to validate zero-emission technology performance in order to:
  - Support Advanced Clean Local Trucks, and other potential technology-advancing CARB regulations and incentive programs
  - Help ensure product reliability and increase consumer confidence
- Possible evaluation criteria
  - Durability, efficiency, performance, range, etc.
- Tentative Board date – late 2018 / early 2019
- Workshops on HD ZEV certification procedures to be scheduled
- Staff Lead: Matt Diener, Air Pollution Specialist, matthew.diener@arb.ca.gov or tel. (626)575-6684

Next Steps

- Publish updated EER paper
- Update fleet survey and send for last round of comments
- Work with manufacturers on sales and production cost data
- California Phase 2 GHG Workshop tomorrow
  - Overlap with zero-emission sales proposal
- Other