Advanced Clean Fleets
Cost Analysis Workgroup

December 9, 2020

Today's Outline

- Overview and background
- 2019 Advanced Clean Trucks (ACT) regulation cost analysis
- Cost elements and assumptions
- Next steps

Advanced Clean Fleets Overview

- Maximize use of ZEVs where feasible and meet Board direction
- Goal to achieve a zero-emission fleet by 2045 where feasible
  - Implementation from 2023 through 2045
  - 2035 and 2040 ZE goals for certain segments
- Focus on areas to accelerate ZEV market and protect public health
  - All vehicles with a GVWR greater than 8,500 lbs.
  - Initial focus on well-suited vehicles and fleets
  - Gradual phase-in to include all trucks and buses

Purpose of Cost Workgroup

- Update analysis to inform and support fleet regulation strategies
  - Will not be discussing regulatory strategies today
- Update sources and assumptions
- Start with costs on a per-vehicle basis
- Develop/update models to assess cost
  - Vehicle comparisons
  - Individual fleet costs
  - Statewide analysis for rulemaking

Regulatory Cost Methodology

- Compare costs with regulation to baseline scenario
- Does not include rebates or grants
- Analysis will be in constant dollars without discount rates
- Evaluate statewide costs associated with regulatory proposal
  - Total costs to California fleets
  - Apportion costs to different fleet categories
- Additional analysis of individual fleet examples or case studies
- Build on 2019 analysis for the Advanced Clean Trucks Regulation

Advanced Clean Trucks Background

- Approved August 2020
- Percent of manufacturer sales in California must be ZEV
  - Partial credit for plug-in hybrids
- Flexibility to shift sales among categories
  - Requires tractor sales
  - Banking and trading
- Large entity one-time reporting requirement

Model Year (MY)	Class 2b-3	Class 4-8	Class 7-8 Tractors
2024	5%	9%	5%
2025	7%	11%	7%
2026	10%	13%	10%
2027	15%	20%	15%
2028	20%	30%	20%
2029	25%	40%	25%
2030	30%	50%	30%
2031	35%	55%	35%
2032	40%	60%	40%
2033	45%	65%	40%
2034	50%	70%	40%
2035+	55%	75%	40%

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2019 Advanced Clean Trucks Cost Analysis

- Costs of deploying ZEVs in California including costs to fleets
- Included:
  - Vehicle costs
  - Fuel costs
  - Sales tax, Federal excise tax
  - Phase 2 GHG costs
  - Zero-emission Powertrain (ZEP) certification
  - ZEV Infrastructure – Charging, station, site upgrades, maintenance
  - Maintenance costs
  - Maintenance bay upgrades
  - Low Carbon Fuel Standard (LCFS) revenue
  - Workforce development
  - Midlife costs (battery replacements, engine rebuilds)
  - Registration fees

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Potential Cost Elements to Add

- Low-NOx Omnibus costs (approved August 2020)
- Diesel exhaust maintenance and fluid costs
- Depreciation
- Insurance costs
- Weight/payload effects
- Cost information for CNG vehicles
  - Refuse trucks, buses, tractors
- Other

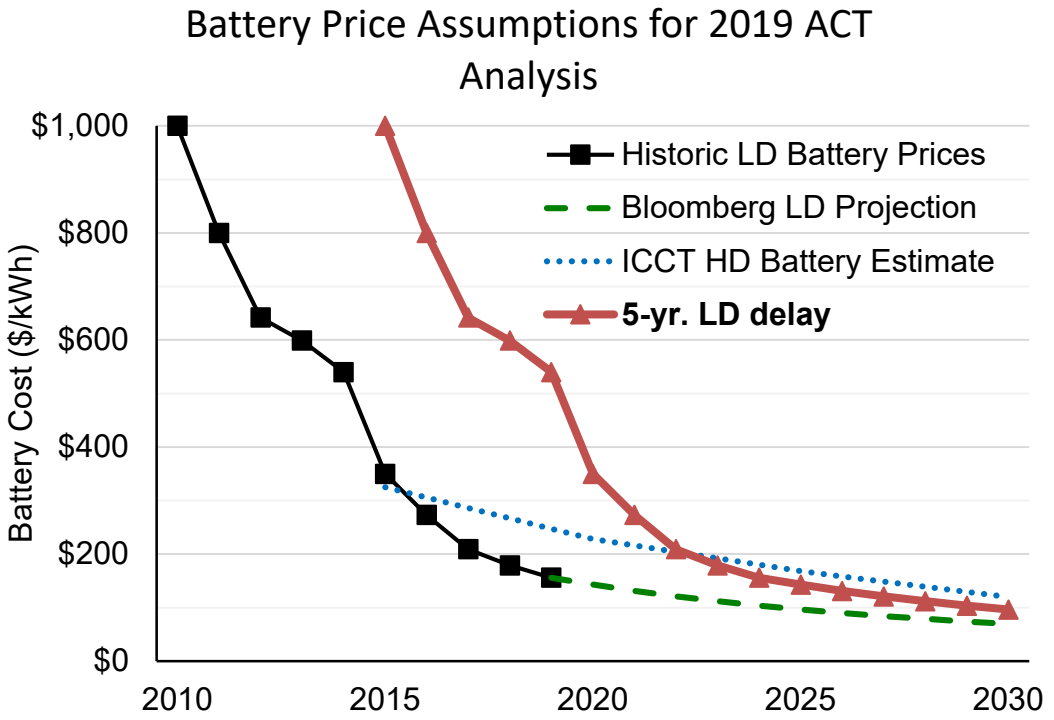
Cost Elements and Assumptions

Vehicle Costs

- Gasoline, diesel, and natural gas vehicle cost based on manufacturer websites and truck resale websites
  - Add incremental costs from 2020 Low-NOx Omnibus Staff Report
- ZEV vehicle cost projections calculated by
  - Determining glider cost
  - Adding ZE component costs
  - An additional cost factor representing R&D, potential profit

Battery Costs

- 2019 ACT analysis assumed HD battery prices would follow light-duty with a five-year delay
- Is this assumption still appropriate?
- Are there other data sources?



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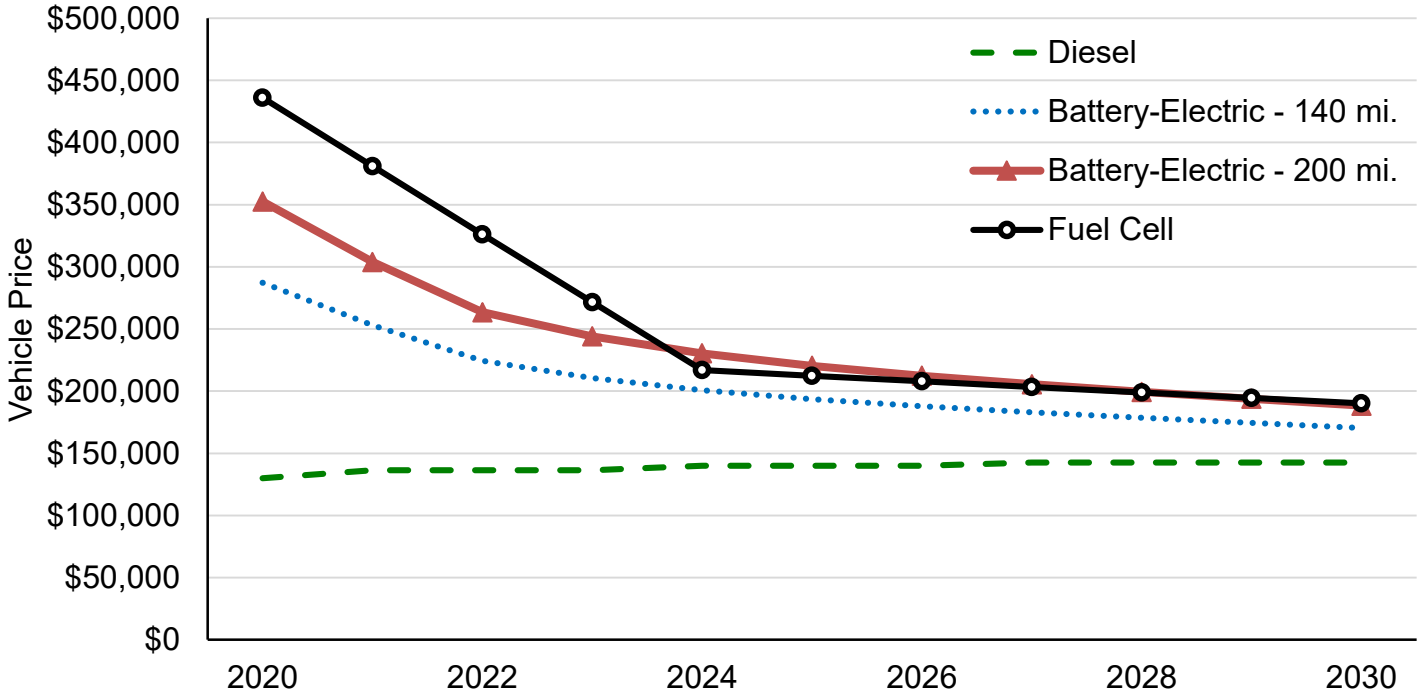
Other Component Costs

- 2019 ACT analysis sources show declining component costs
  - EV components and hydrogen tanks: ICCT “Transitioning to Zero-Emission Heavy-Duty Freight Equipment” https://theicct.org/sites/default/files/publications/Zero-emission-freight-trucks_ICCT-white-paper_26092017_vF.pdf
  - Hydrogen fuel cells: Strategic Analysis “2018 Hydrogen and Fuel Cell Program Review – Fuel Cell Systems Analysis” https://www.hydrogen.energy.gov/pdfs/review18/fc163_james_2018_o.pdf
- Are newer/better sources available?

2019 ACT Analysis
Tractor Cost



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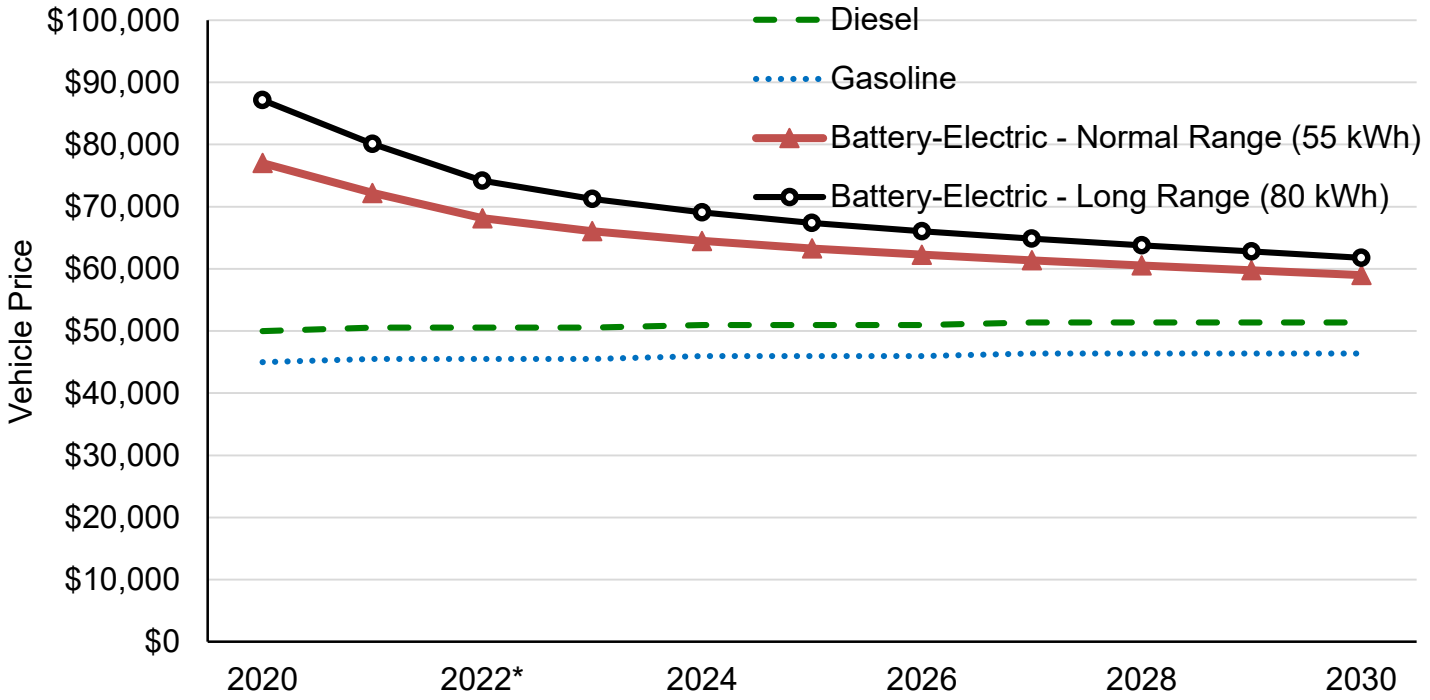
Note: 2019 ACT analysis does not include 2020 Low-NOx Omnibus costs for diesel

2019 ACT Analysis
2b-3 Passenger Van Cost



* 2022 Ford Electric Transit Van – 67 kWh battery, 127 mile range, ~$12,000 incremental cost

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Upfit Body Costs

- How to model costs for differing body types
- Cost of installing a body on a chassis depends on the type of vehicle
- Some bodies could require unique engineering for ZEVs

Class 5 Chassis
$45,000

Class 5 Box Truck
$60,000

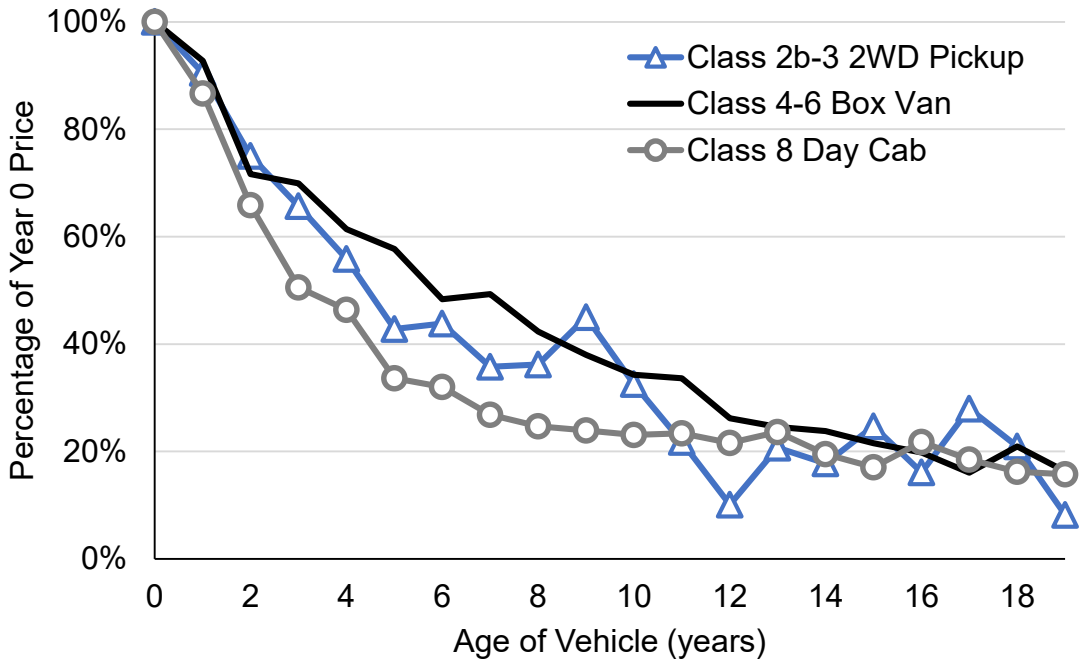
Class 5 Bucket Truck
$150,000

Body Costs (cont'd)

- Vehicle types without power take off
  - Same body installation costs
  - Box trucks, vans, tractors, etc.
- Vehicles with power take off
  - Assume higher costs for EV from 2024-2027 and
  - Same as electric vehicles by 2035
  - Bucket trucks, refuse trucks, etc.

Residual Values

- Primarily for fleet cost analysis
- Diesel/gasoline – measured using online truck marketplaces
- Electric/fuel cell/natural gas – what assumptions to use?



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Taxes and Financing

- Sales tax
  - Statewide average of 8.5%
- Federal excise tax
  - 12% for Class 8 vehicles
- Registration fees
- Financing
  - Five year loans at 5% interest for large fleets
  - Five year loans at xx% for smaller fleets
  - No financing for public fleets
- Depreciation
  - What marginal tax rate to use for different groups?

Maintenance Cost

- Diesel/gasoline maintenance data based on studies or other in-use information
- Previously collected maintenance sources
  - 2019 CARB Draft Total Cost of Ownership paper lists 13 sources

  https://ww3.arb.ca.gov/regact/2019/act2019/apph.pdf
- New sources
  - Argonne National Laboratory "AFLEET Tool"

  https://greet.es.anl.gov/index.php?content=afleet
- Other sources to be aware of?

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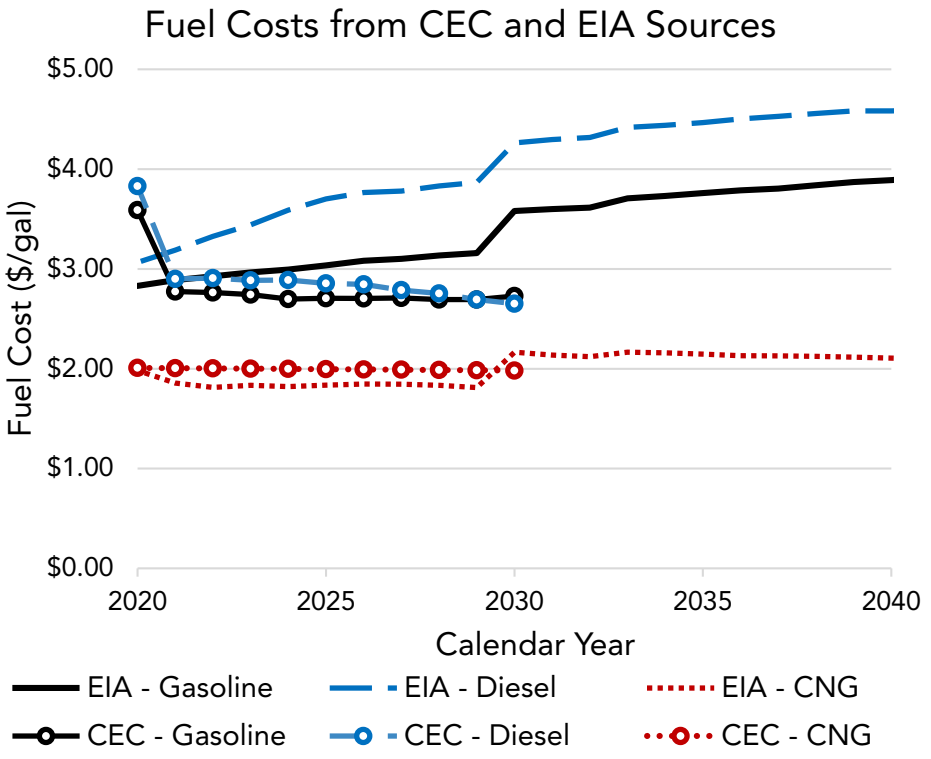
Maintenance Cost (Cont'd)

- ZEV technologies anticipated to have lower maintenance costs than combustion powered vehicles
- 2019 ACT Analysis assumptions
  - Battery-electric – 25% lower than diesel/gasoline
  - Hydrogen fuel cell – same as diesel/gasoline
- Are these still appropriate to use?

Fuel Costs

- Diesel/gasoline/natural gas 2019 ACT analysis
  - California Energy Commission (CEC) from 2018-2030 and
  - Energy Information Administration (EIA) Pacific Region for 2030+
- Update with latest forecasts
  - CEC shows declining costs
  - EIA shows increasing costs



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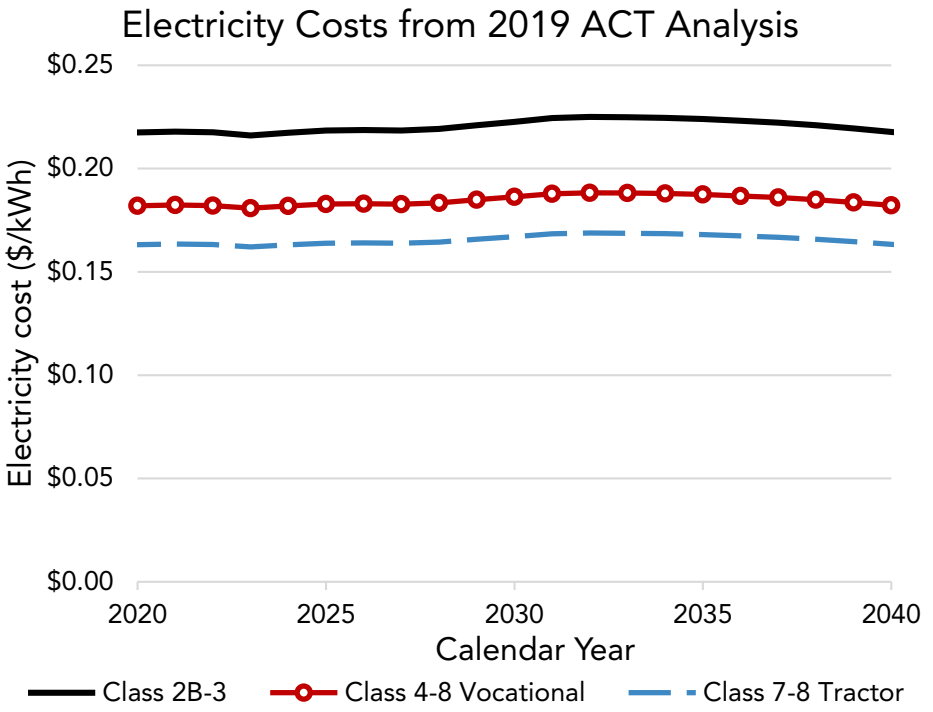
Fuel Costs (Cont'd)

- Electricity – Method calculate starting rate for fleet and model changes over time using CEC and EIA projections
- How to estimate retail charging
- Updating CARB Truck and Bus Charging Cost Calculator
  - New rate schedules approved by CPUC
- Use other released electric vehicle charging calculators



Fuel Costs (Cont'd)

- Hydrogen - 2019 ACT analysis used Trillium estimates for bus refueling
- Other projections are available – what is most appropriate source?

Trillium H_2 Projections	Gaseous Delivery ($/kg)	Liquid Delivery ($/kg)	On-site SMR ($/kg)	On-site Electrolysis ($/kg)
Low Volume (150 kg/day)	$11.49	$10.21	$10.43	$11.05
Intermediate Volume (1,000 kg/day)	$7.67	$6.39	$5.81	$6.46
High Volume (6,000 kg/day)	$5.72	$4.43	$4.21	$4.90

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Retail ZEV Fuel Costs (Cont'd)

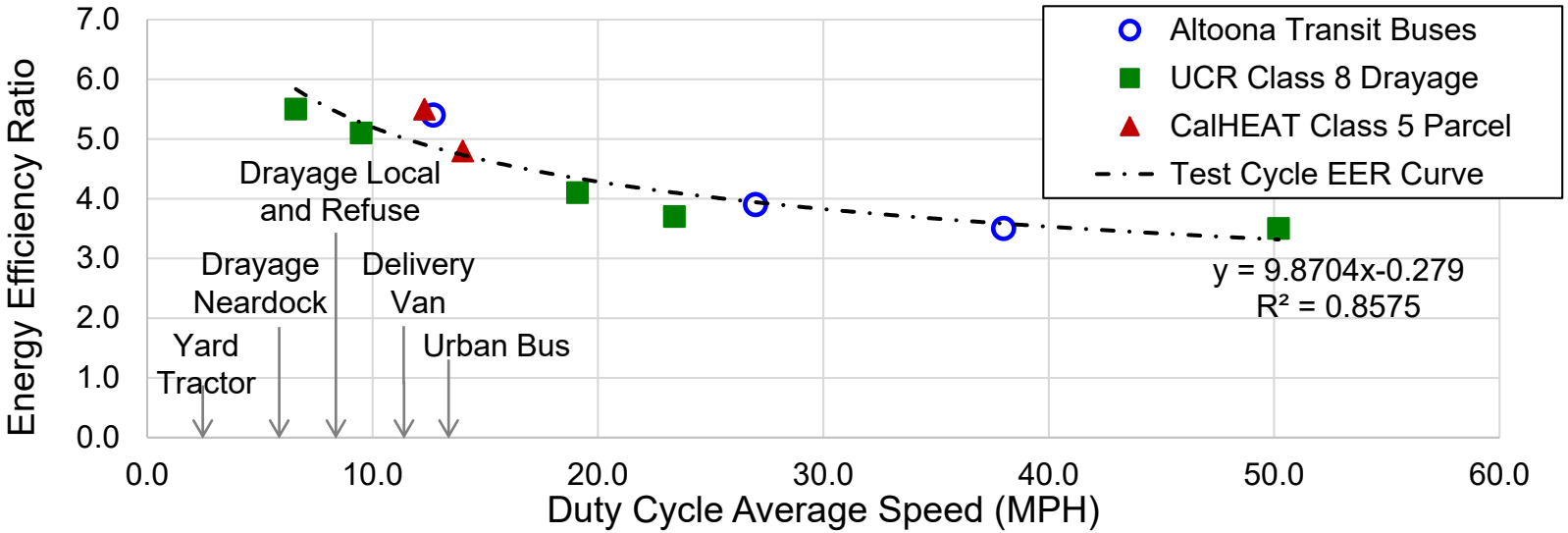
- How to estimate costs to fleet for each kWh or kg dispensed?
- Should the differing infrastructure installation costs associated with hydrogen and electric fueling be considered?
- Should parameters such as maintenance, location, and time of refueling be considered?
- How should staff model LCFS credit revenue to station owner?

Fuel Efficiency

- Gasoline/diesel – combination of in-use testing, EMFAC data, and other sources
- Battery-electric and fuel cell electric
  - Limited in-use data currently
  - Can combine in-use data with values derived from LCFS Energy Economy Ratios
- Assume slight efficiency increase over time for all technologies

Battery-Electric Vehicle Efficiency

- Battery-electric vehicles have higher efficiency than their diesel counterparts, especially in lower speed applications



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Fuel Efficiency Values used for 2019 ACT Analysis

	2018-2020 MY	2021-2023 MY	2024-2026 MY	2027+ MY
Class 2b-3 – Diesel (mpg)*	20.8	21.3	23.0	24.8
Class 2b-3 – Gasoline (mpg)*	9.8	10.0	10.9	11.7
Class 2b-3 – BEV (mi/kWh)*	1.7	1.9	2.0	2.1
Class 4-5 – Diesel (mpg)	11.4	12.7	13.7	14.3
Class 4-5 – BEV (mi/kWh)	1.0	1.1	1.2	1.3
Class 6-7 – Diesel (mpg)	7.9	8.8	9.5	9.9
Class 6-7 – BEV (mi/kWh)	0.67	0.74	0.80	0.83
Class 8 – Diesel (mpg)	6.2	7.1	7.7	8.1
Class 8 – BEV (mi/kWh)	0.50	0.57	0.62	0.65
Class 7-8 Tractor – Diesel (mpg)	7.0	8.1	8.8	9.2
Class 7-8 Tractor – BEV (mi/kWh)	0.48	0.55	0.60	0.63
Class 7-8 Tractor – FCEV (mi/kg)	13.3	15.3	16.7	17.5

Low Carbon Fuel Standard

- The Low Carbon Fuel Standard (LCFS) regulation decreases the carbon intensity (CI) of California's transportation fuels
  - Producers of low carbon fuels such as electricity and hydrogen can generate credits to sell to high carbon fuel producers
- Allows fleets using low carbon fuels to offset their fuel costs
- Credit price assumption from 2019 LCFS Amendments
  - $200 until 2022
  - $100 from 2024-2027
  - $110 from 2028 onwards

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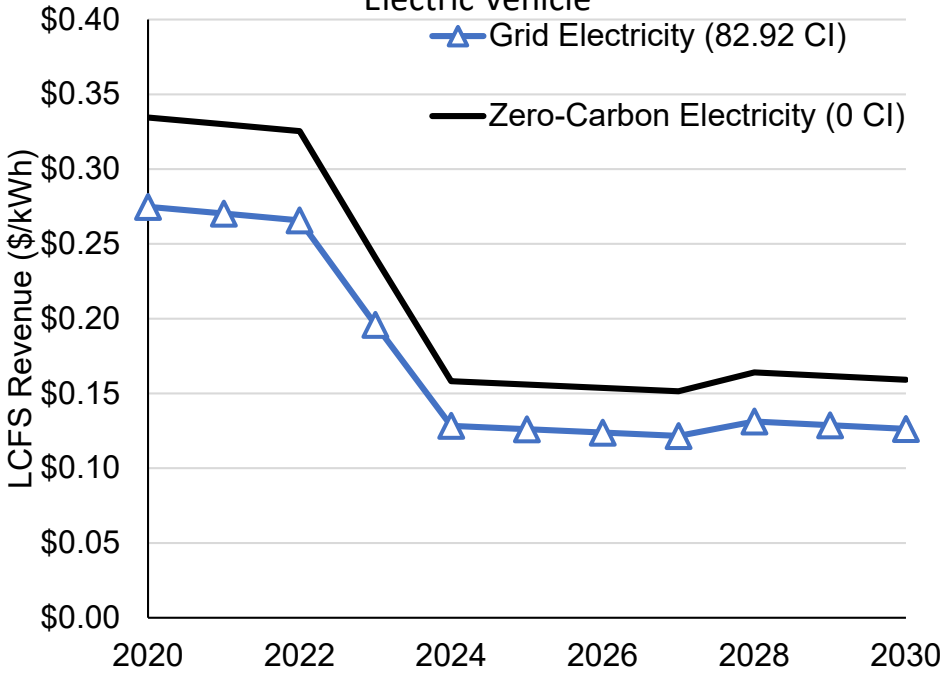
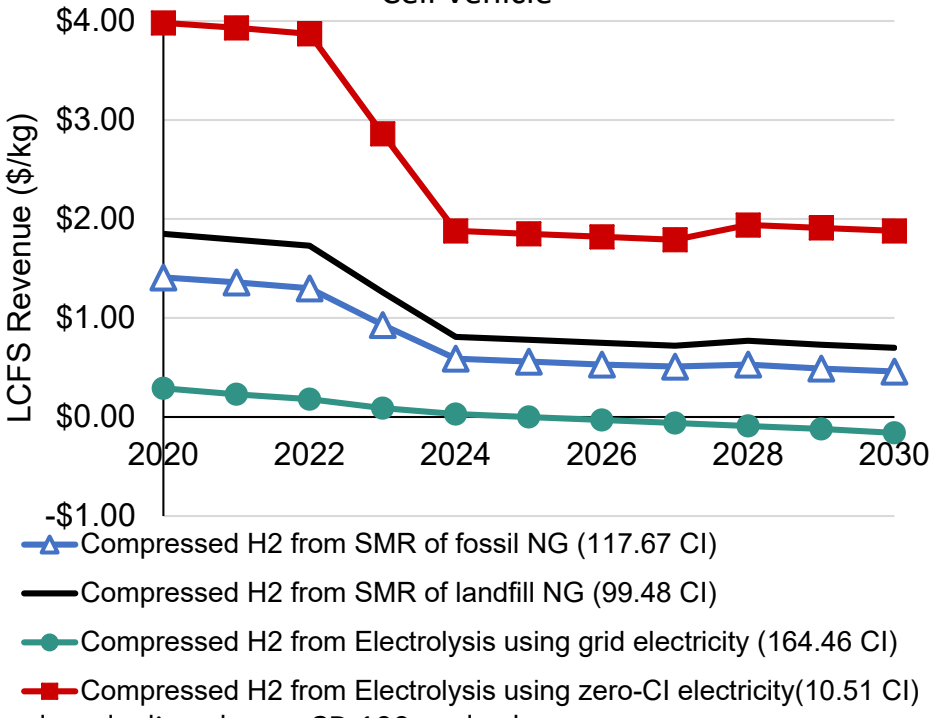
Low Carbon Fuel Standard (Cont'd)

LCFS Revenue generated from a Class 4-8 Battery-Electric Vehicle



LCFS Revenue Generated from a Class 4-8 Fuel Cell Vehicle



SMR: Steam Methane Reformation

Note: The CI of grid electricity is expected to decline due to SB 100 and other California policy

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Example Battery Electric Fuel Cost Saving with LCFS

Electric vs Diesel	Airport Shuttle	Package Delivery	Local Drayage
Assumptions	BEV: 0.6 kWh/mi. Diesel: 22 mpg	BEV: 1.0 kWh/mi. Diesel: 10 mpg	EV: 2.1 kWh/mi. Diesel: 6 mpg
Fuel Savings	40%	50%	40%
Fuel Savings with LCFS	**75%**	**100%**	**100%**

Note: Example assumes average fuel prices of $3.70/gal., $0.18/kWh (includes transmission, energy, fixed fees, and demand charges), and LCFS credit value at $125 per credit.

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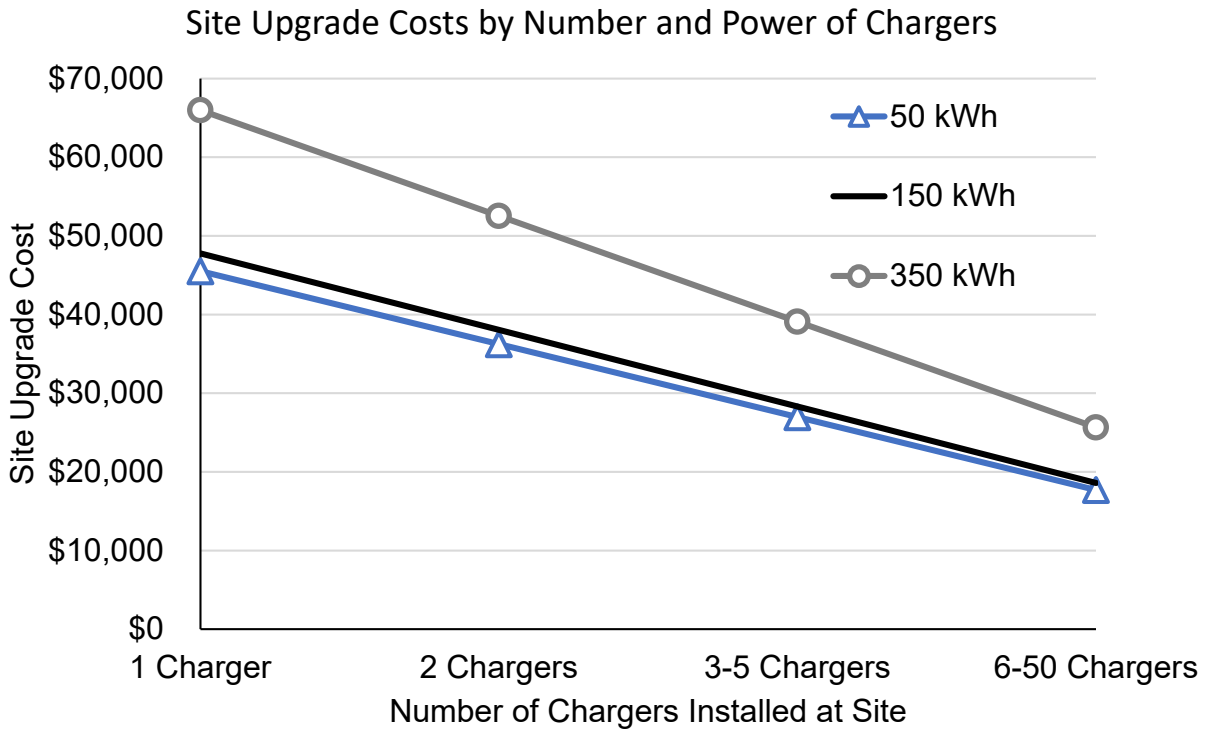
Infrastructure

- Infrastructure costs for diesel, gasoline, and hydrogen included in fuel price
- Battery-electric – 2019 ACT analysis used information from utility's SB 350 utility programs and the Innovative Clean Transit rulemaking
- Staff is collecting more up-to-date information
  - 2019 ICCT report
  - Reviewing recent demonstrations/pilots funded by CARB and other agencies

Infrastructure (Cont'd)



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Midlife Costs

- Engine rebuilds, battery replacements, fuel cell refurbishments
- Prior methodology
  - Diesel/gasoline – Rebuild base on mileage, costs 25% of vehicle cost
    - Longer useful life due to Low-NOx Omnibus
  - Battery electric – Replacement at 300,000 miles, cost based on battery size and battery price at time of replacement
  - Hydrogen fuel cell – Refurbishment every 7 years, costs 1/3 of fuel cell cost at time of refurbishment
- Is methodology still appropriate?

Other Cost Elements

- Insurance
- Weight/payload effects
  - AB 2061 – 2,000 lb. exemption for alternative fuels
- Diesel exhaust fluid consumption
- Vehicles with power takeoff

Individual Fleet Costs – Case Studies

- Planning case studies of individual fleet examples
  - Public
  - Local delivery
  - Drayage/regional
  - Utility
  - Refuse
  - Buses
  - Other

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Next steps

- Seeking feedback on cost assumptions
- Feedback requested by January 8
  - Send to zevfleet@arb.ca.gov
- Drayage workgroup starts later today at 1:00 PM
- Workshops and workgroups in early 2021

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