Technology and Fuel Scenarios in the California Trucking Sector

Marshall Miller
Institute of Transportation Studies
University of California, Davis

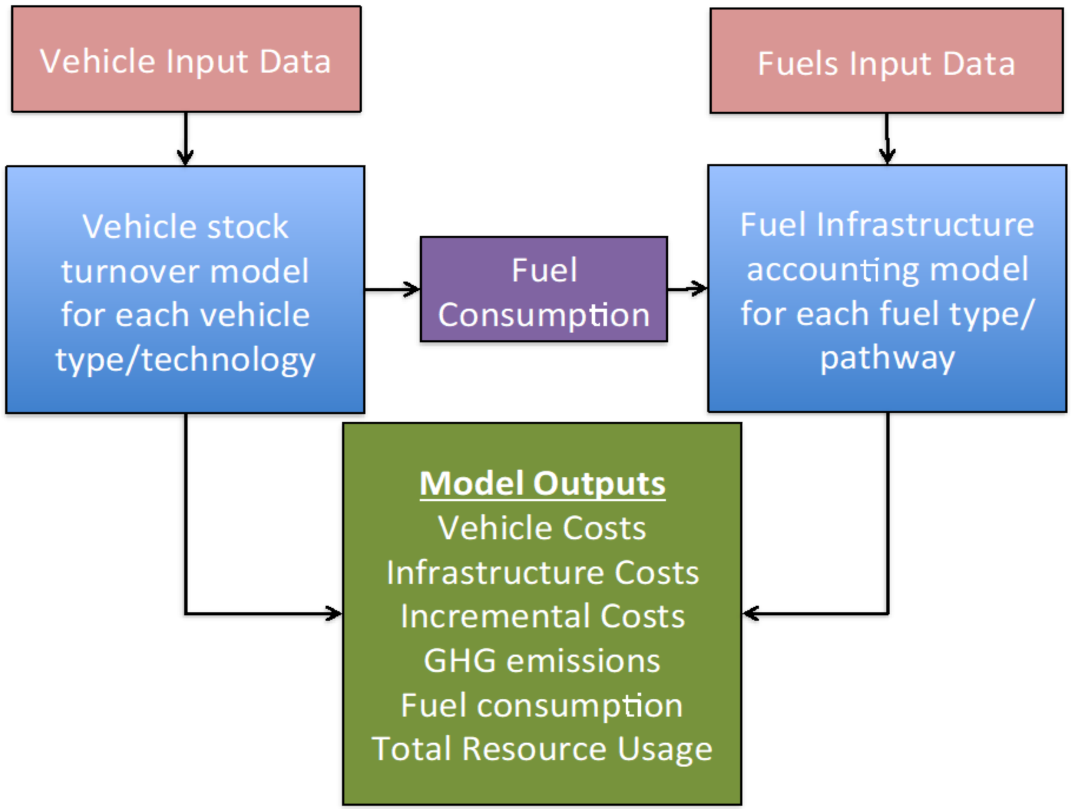
April 24, 2019
MoZees Conference

ITS-Davis Overview

- Institute of Transportation Studies at University of California, Davis
  - Multidisciplinary group studying various aspects of transportation (technology, policy, behavior)
- Sustainable Transportation Energy Pathways
  - Research consortium
  - 4 year programs first started in 2007
  - Truck and auto manufacturers, energy companies, government entities
- Sustainable Freight Research Center
  - Vehicles and fuels
  - Urban logistics and delivery

Transition Scenario Modeling Framework (CA)

- Spreadsheet-based model
  - Specify vehicle technologies (sales mix, fuel consumption, cost)
  - Specify fuel supply (production/delivery pathways, carbon intensity, cost)



Vehicle Types

- Light-duty vehicles
  - Cars
  - light-duty trucks
- Trucks
  - Long-haul
  - Short-haul
  - Medium-duty urban (delivery)
  - Medium-duty vocational (e.g. utility bucket trucks)
  - Heavy-duty vocational (e.g. refuse)
  - Urban buses
  - Other buses (intercity)
  - Heavy-duty pickups and vans

Technology and Fuel types

- Technologies
  - ICE (conventional)
  - Hybrid (conventional and PHEV)
  - Fuel Cell (FCV)
  - Battery Electric (BEV)
- Fuels
  - Diesel, gasoline
  - Biofuels (ethanol, HEFA, renewable diesel)
  - Natural gas (including renewable natural gas)
  - Hydrogen (NG reformation, electrolysis)
  - Electricity (present grid, more renewable toward 2050)

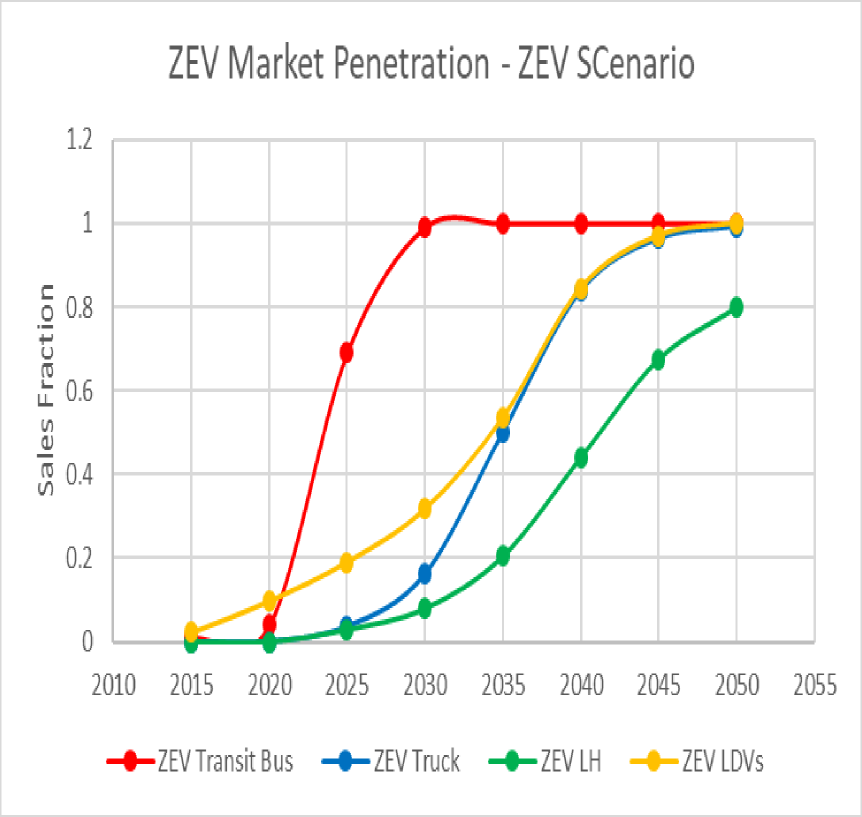
Truck Choice Model

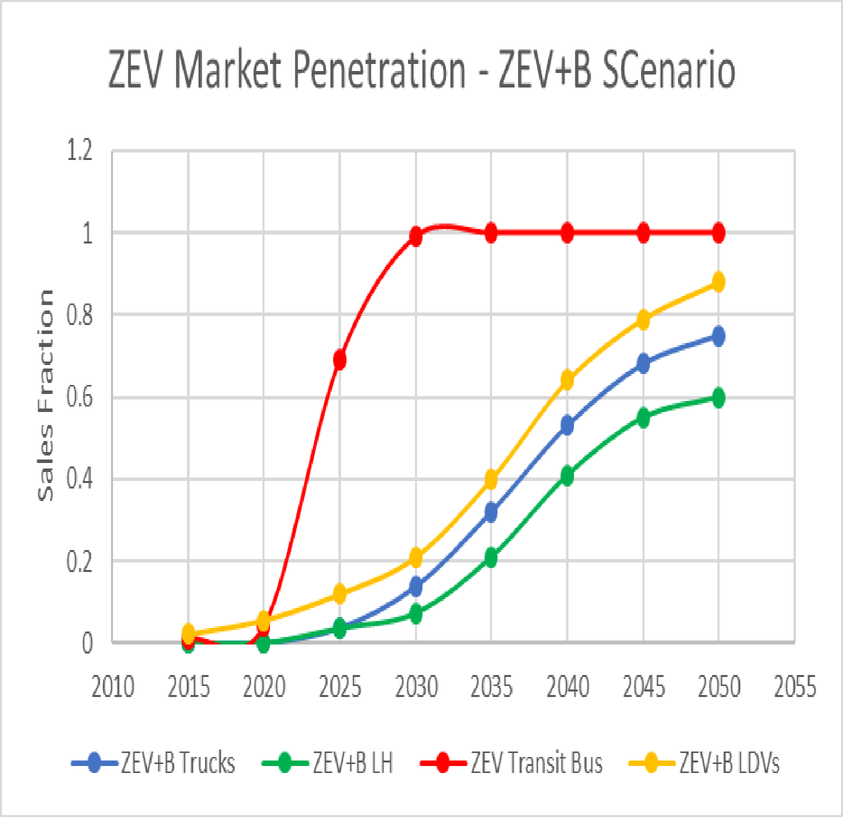
- Fleet choice determines market share based on various decision factors (multinomial logit model)
- Same truck types as Transition Scenarios, 3 fleet types – early adopter, later adopter, in-between
- Factors (monetized and summed to create generalized cost)
  - Capital and Operating costs (payback period)
  - Green PR
  - Uncertainty (reliability, secondary market sales, technology stability)
  - Incentives / Carbon Tax
  - Model availability
  - Refueling Inconvenience (Vehicle Range, Refueling Time, Station Availability)
- Increase incentives to meet ZEV mandate

Scenarios

- Specify percentage of sales every year through 2050
- Not endogenous, “What if” market penetration
- Business as Usual (BAU)
  - LDVs meet early regulations and ZEV mandate through 2030
  - Trucks assume little advanced technology market penetration except transit buses
- ZEV
  - Significant fuel cell and PEV sales (LDVS, trucks ~ 100% 2050, Transit buses 100% in 2030, both sectors 80% GHG reduction in 2050)
- ZEV + Biofuels (ZEV+B)
  - Reduce ZEV market penetration, increase biofuels blend percentage (ethanol 60%, diesel biofuels 90% in 2050). Both sectors 80% GHG reduction in 2050)

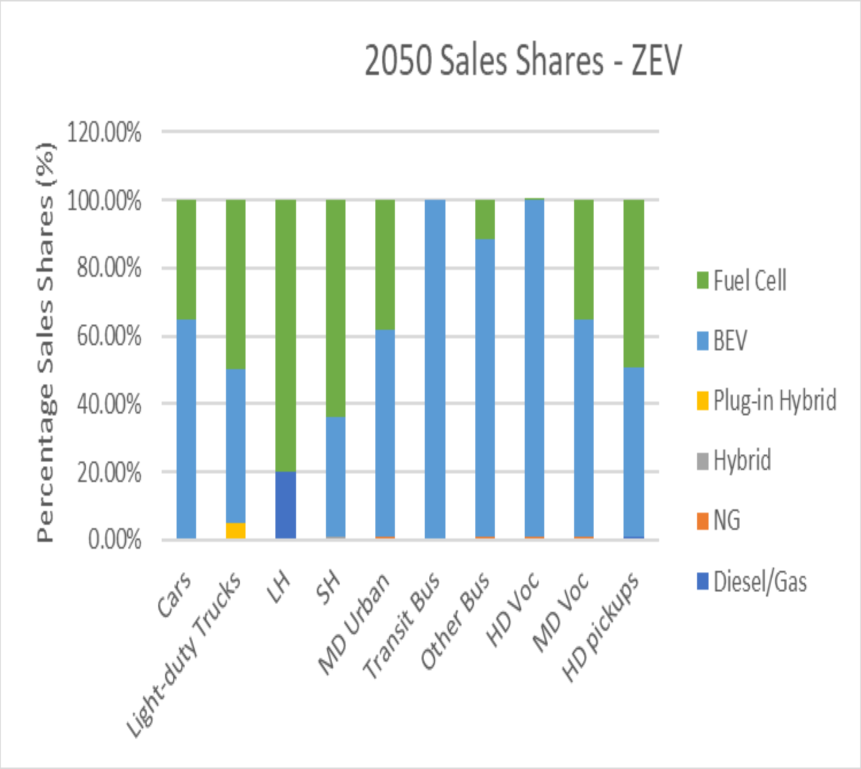
ZEV Market Penetration

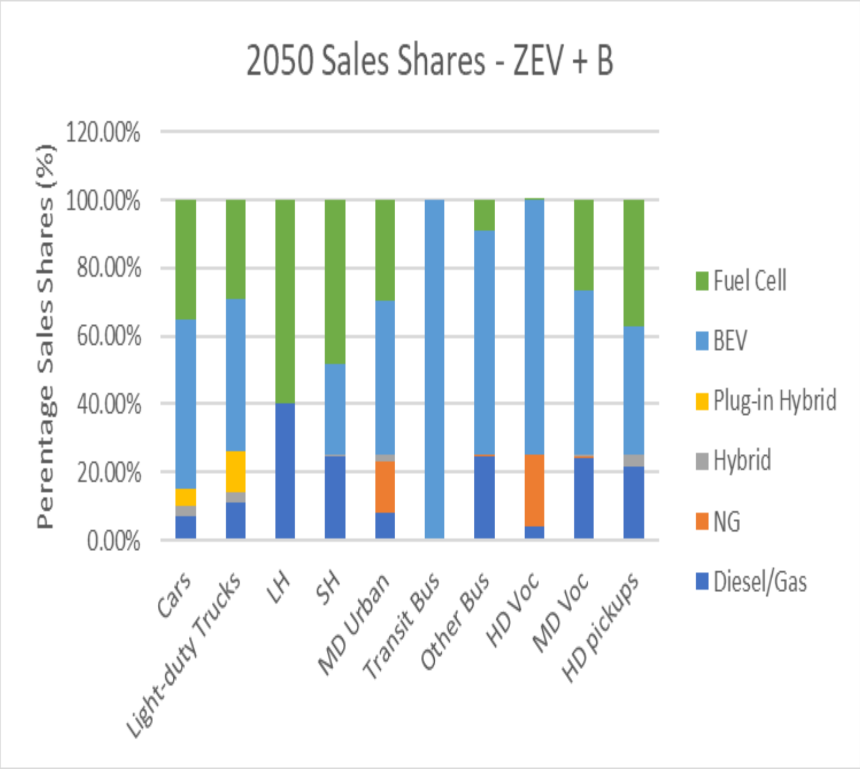




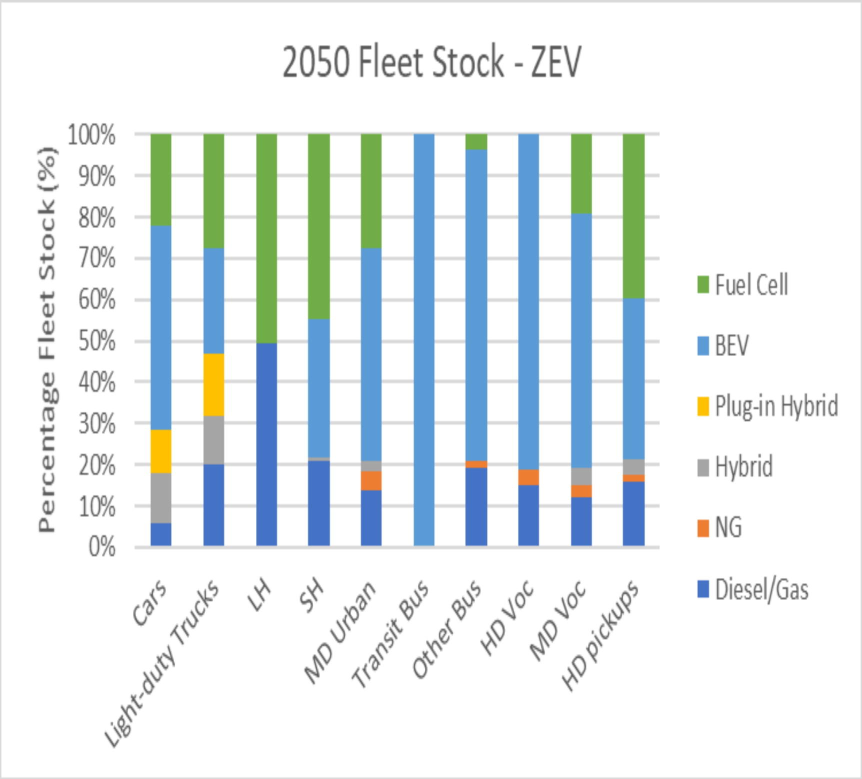
NOTE: CARB proposed mandate – Class 4-8 vocational 50% in 2030

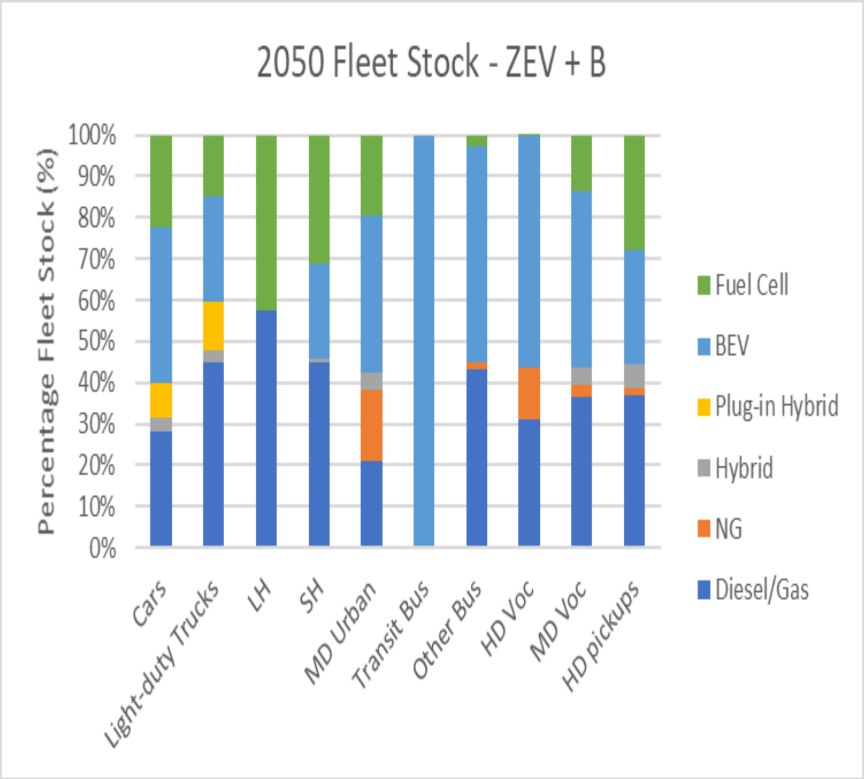
2050 Sales Shares



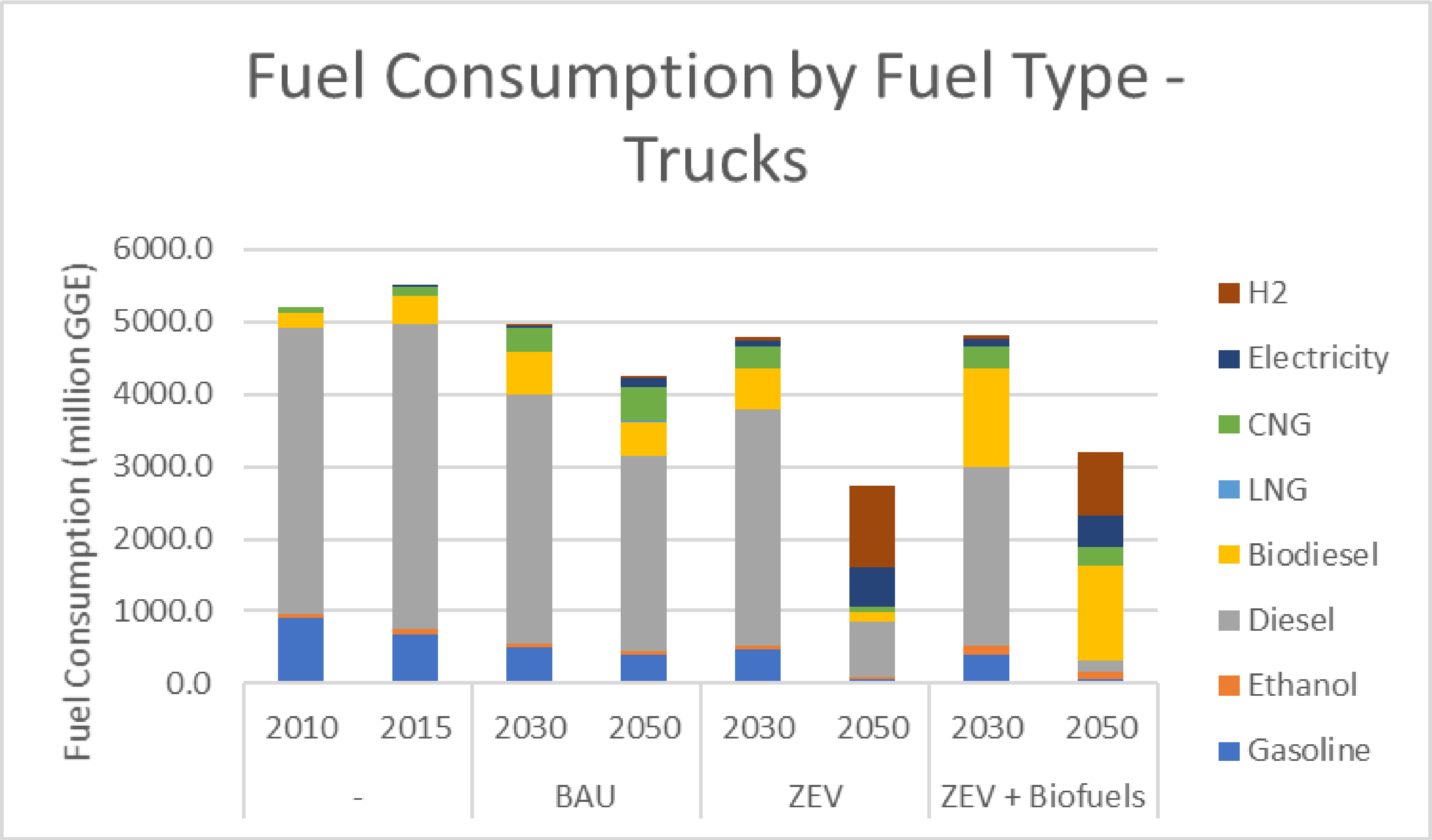


2050 Fleet Stock

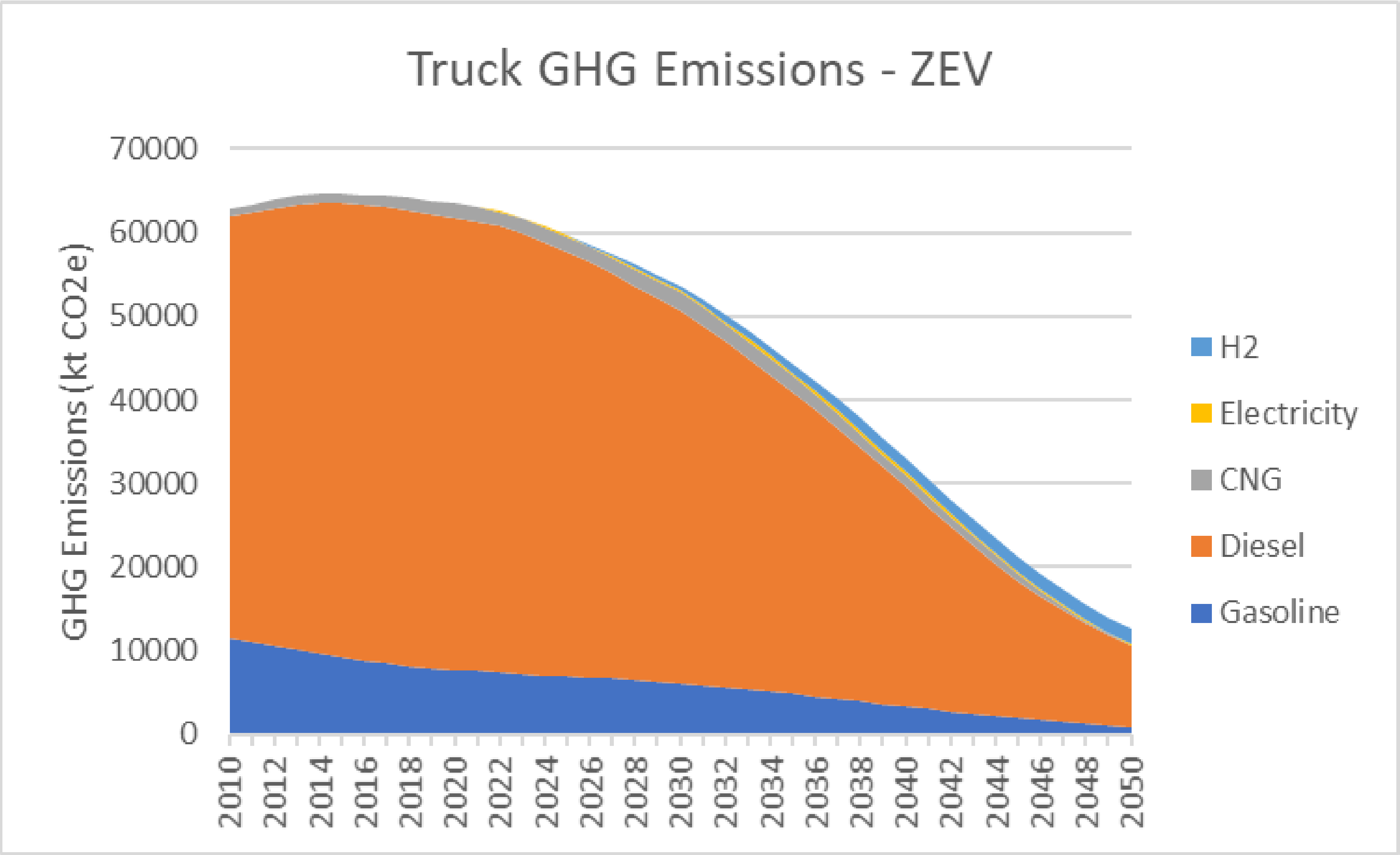




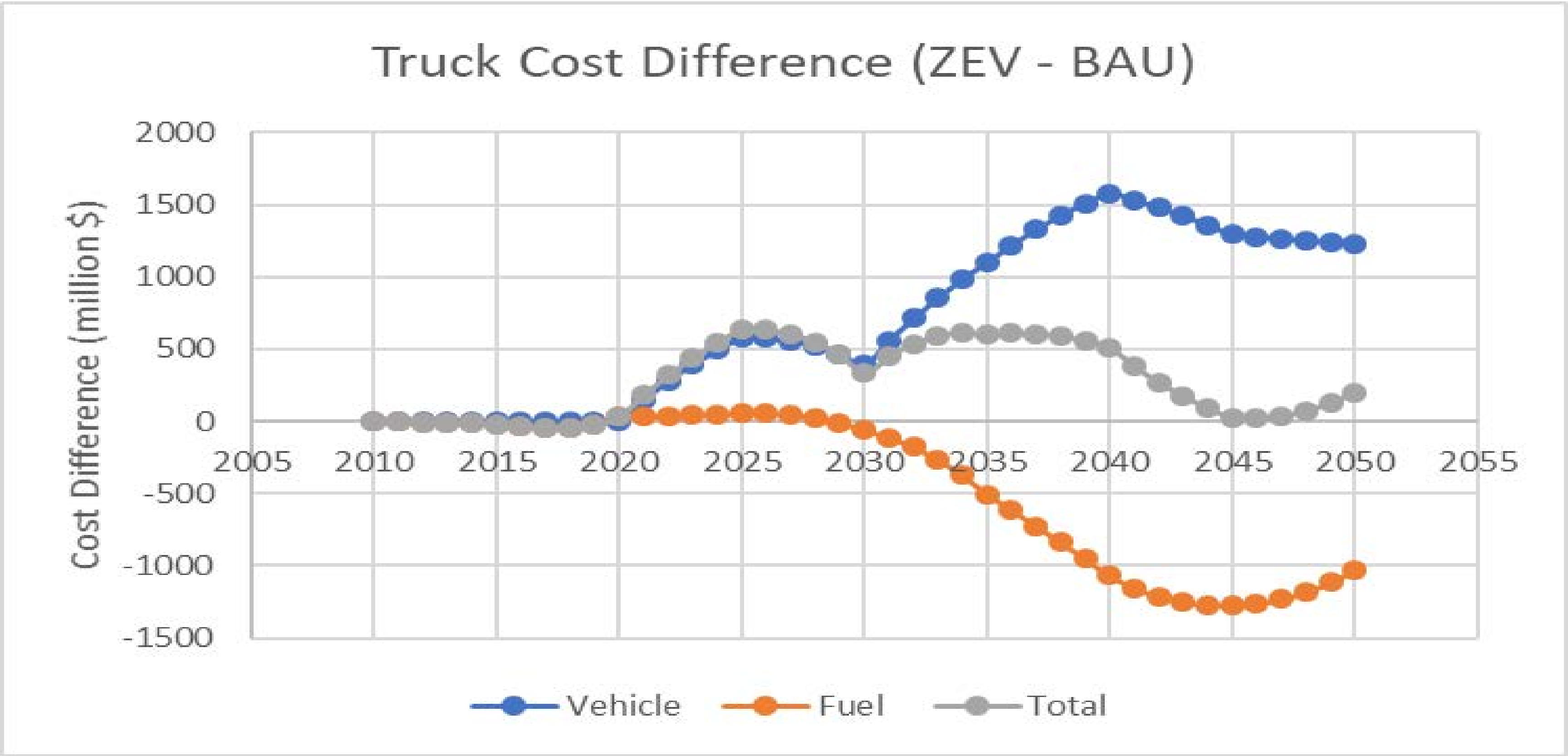
Fuel Consumption



GHG Emissions

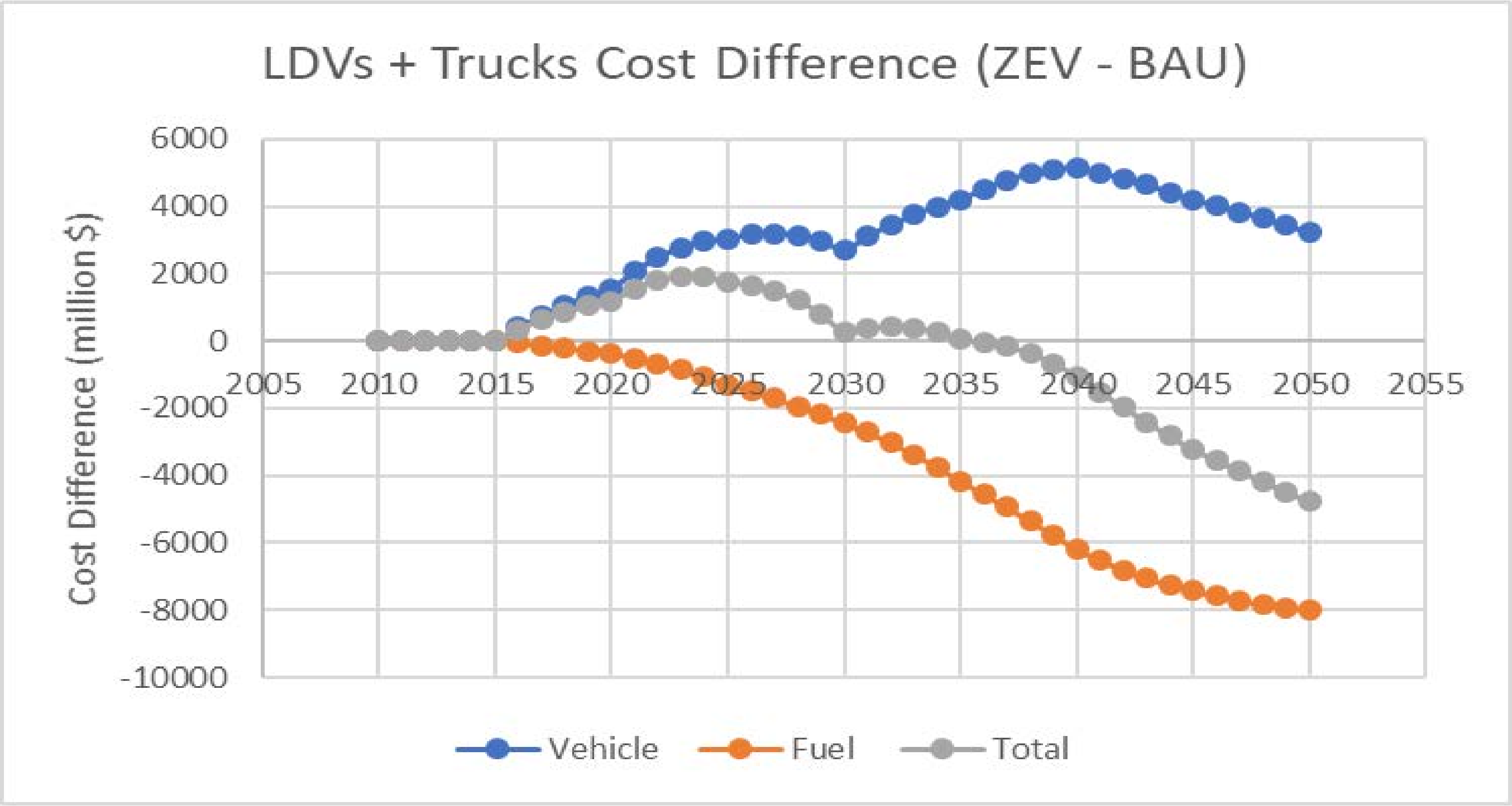


Scenario Costs



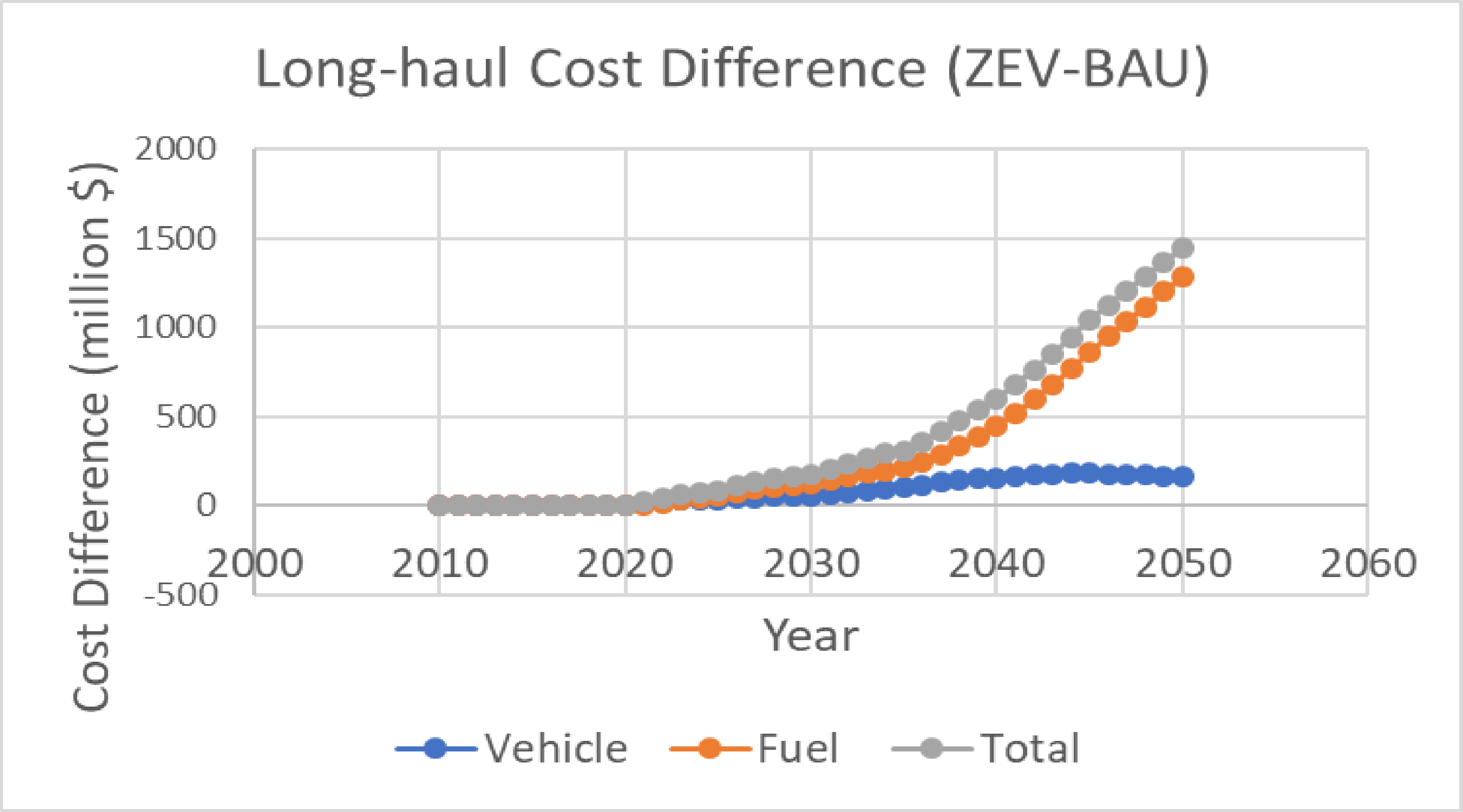
2050 fuel cost: electricity \$0.15/kWh, H2 \$5.60/kg (2030) \$5.95/kg (2050)

Scenario Costs



2050 fuel cost: electricity $0.15/kWh, H2 $5.60/kg (2030) $5.95/kg (2050

Scenario Costs



Long-haul fuel economy ~ 1.2 diesel

Long-haul Truck Issues

- Fuel cell long-haul truck – significantly more expensive
  - Fuel economy increase ~ 20-30%
  - Fuel cost increase ~ 40% reformation NG, 65% renewable electrolysis
- Battery electric truck
  - Tesla truck 500 mi (800 km) range
  - 1130 kWh, 6000 kg, reduces payload (too much?)
  - $100/kWh battery, $0.15/kWh electricity, 200,000 km/yr
  - Payback ~7.5 years

Long-haul Solution?

- Smaller pack with catenary charging
  - ~ 200 - 250 kWh
  - catenary chargers spaced out along highway
- Potential Problems
  - Would catenary charging on highways coupled with smaller battery pack allow full coverage for trucks
  - Infrastructure for catenary charging expensive
  - Is ramp up period to high utilization of catenary chargers too expensive to eventually reach economic feasibility?

Thank You