

# Achieving long term CO2 transitions in CA



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## STEPS<sub>3</sub> Research over 4 years has included...

- Transition Scenarios
- Truck choice modeling, technology analysis
- Studies of H<sub>2</sub> systems and cost
- Electric sector study of Southern California
- EV consumer awareness work
- LCFS tracking and analysis
- Advanced biofuel cost study
- LCA of future ZEV long-haul technologies
- 3R study of travel costs and behavior
- Rail and air travel CO<sub>2</sub> reduction studies
- Factors influencing peak oil
- Global EV market modeling

# STEPS Transition Scenarios

- CA has an 80% CO<sub>2</sub> emissions reduction target for 2050
- STEPS has developed and refined transition scenarios covering 10 classes of highway vehicles (2 LDV, 8 HDV)
- Based on TIMES model runs and a newly developed (and quite detailed) spreadsheet model
- Particular attention to feedstock/fuel transitions, and to costs
- Truck scenarios developed using a truck choice model
  - Trucks modeled across 8 truck classes
  - Track monetary costs and “generalized costs”
- Role of ZEVs vs Biofuels

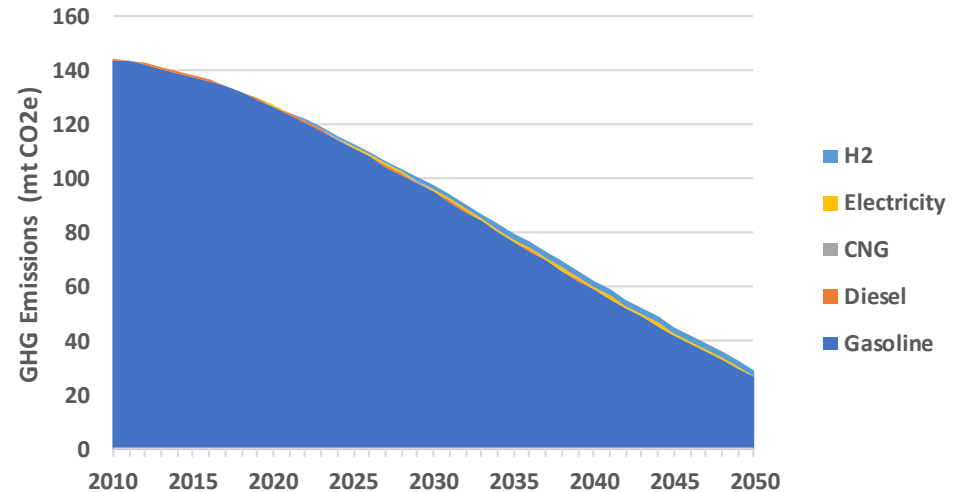
# Scenarios

- Business as Usual (BAU)
  - LDVs meet CAFE standard and ZEV mandate through 2030
  - Trucks assume no advanced technology market penetration except transit buses
- ZEV
  - Significant fuel cell and PEV sales (LDVS ~ 100% 2050, Trucks ~60% in 2050, Transit buses 90% in 2050)
- ZEV + Biofuels (only trucks differ from ZEV)
  - Roughly half the ZEV market penetration as ZEV scenario, diesel biofuels (HEFA, FT) reach 50% blend by 2050

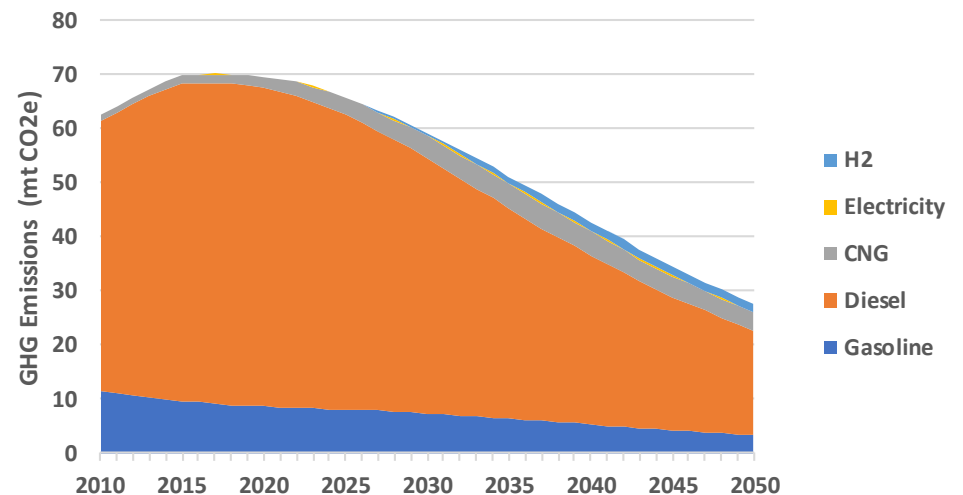
# LDV and truck CO<sub>2</sub> emissions reductions

- Cars achieve about an 80% CO<sub>2</sub> reduction compared to 2010
- Trucks achieve “only” about a 55% CO<sub>2</sub> reduction compared to 2010

LDV GHG Emissions - ZEV



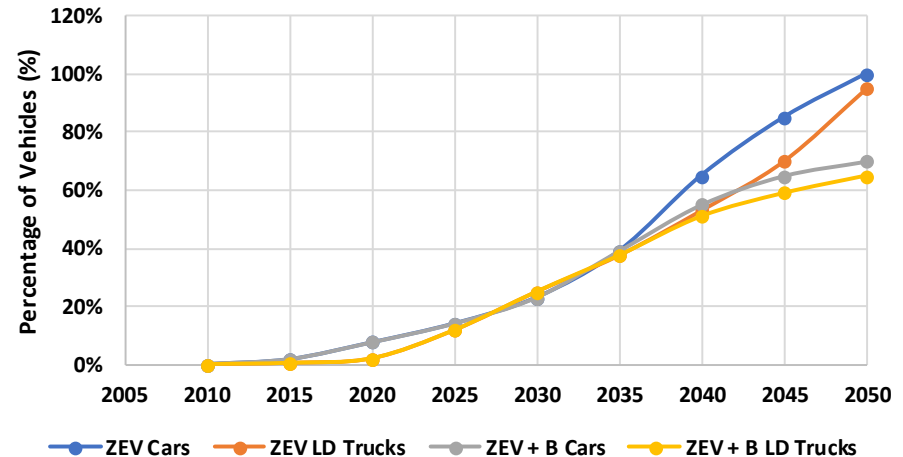
Truck GHG Emissions - ZEV



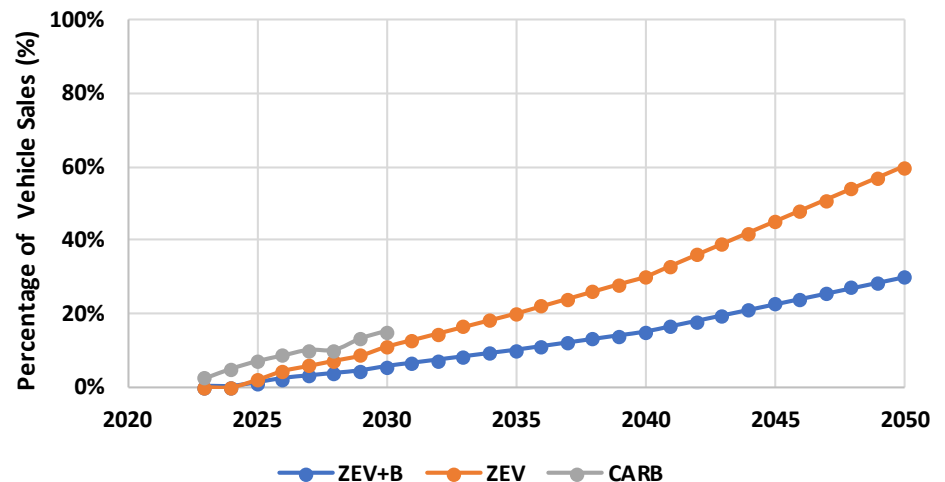
# LDV and Truck Sales Shares

- Cars achieve an 80-100% ZEV market share by 2050
- Trucks achieve “only” about a 60% ZEV market share in ZEV scenario by 2050 (10 years behind cars)
- Possible ARB ZEV truck mandate also shown

LDVs ZEV Scenarios Sales Shares

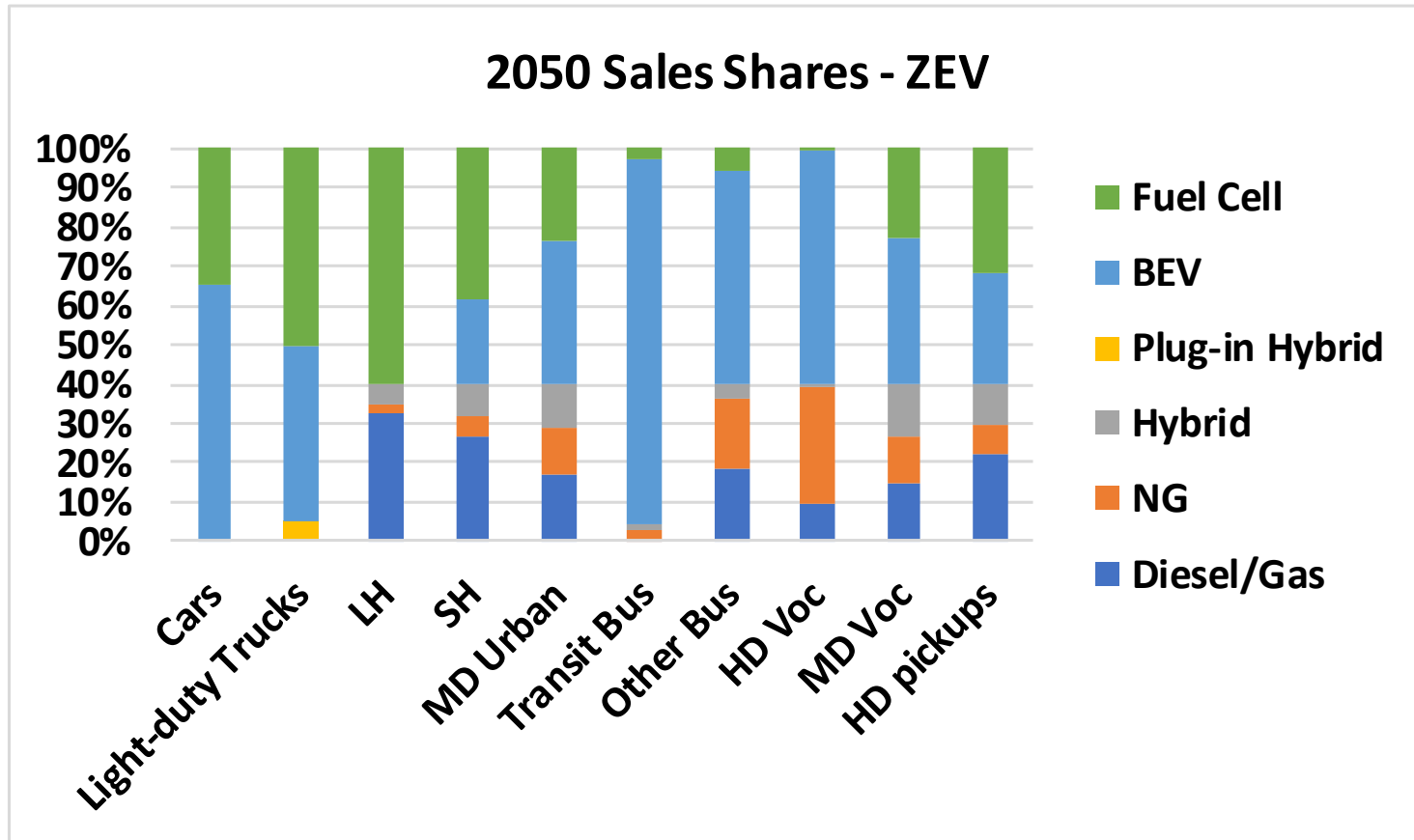


Truck ZEV Scenarios Sales Shares

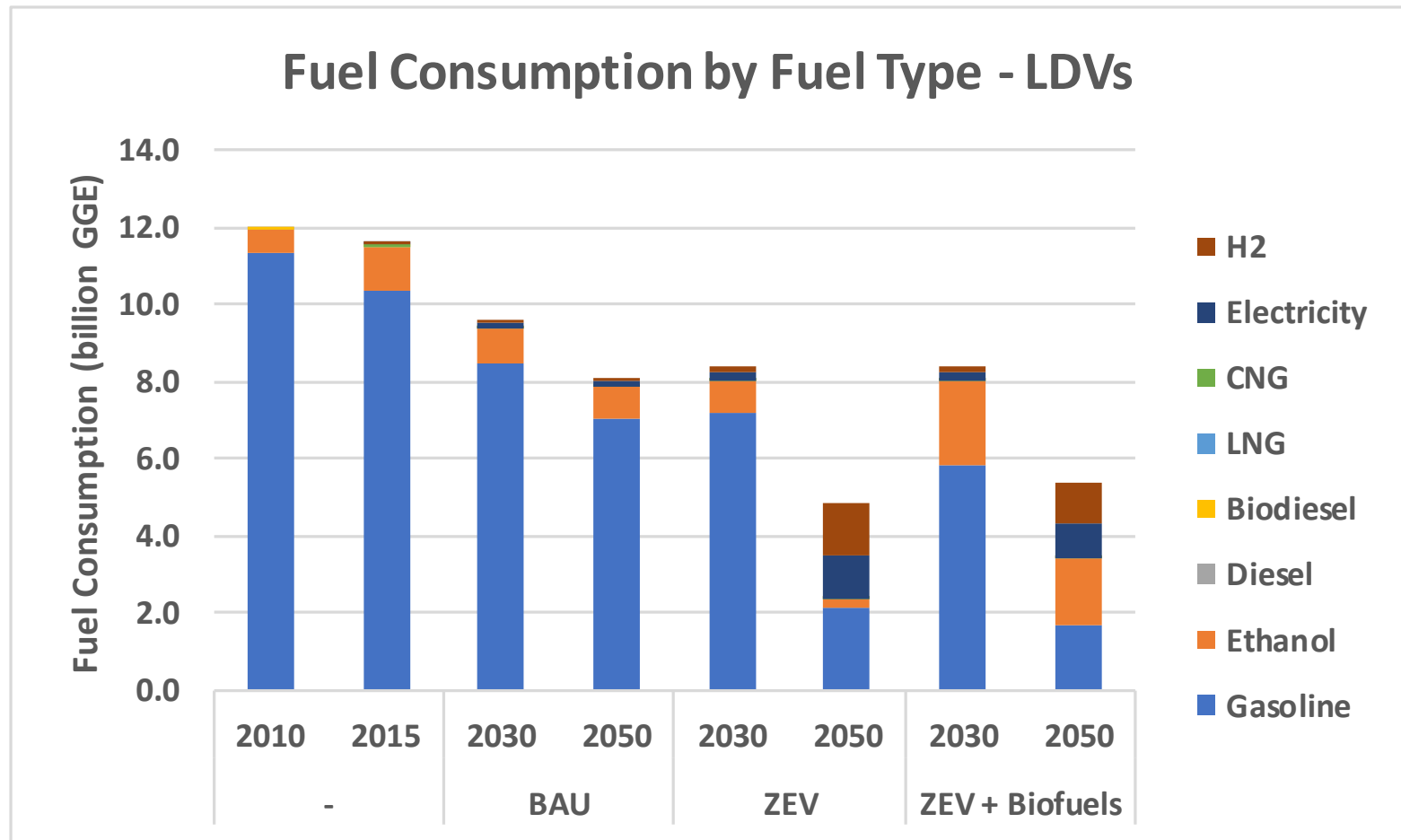


## Sales Shares, ZEV scenario

- Cars achieve nearly 100% market share of FCEV, BEV and PHEV
- Trucks achieve only 60% FCEV and BEV

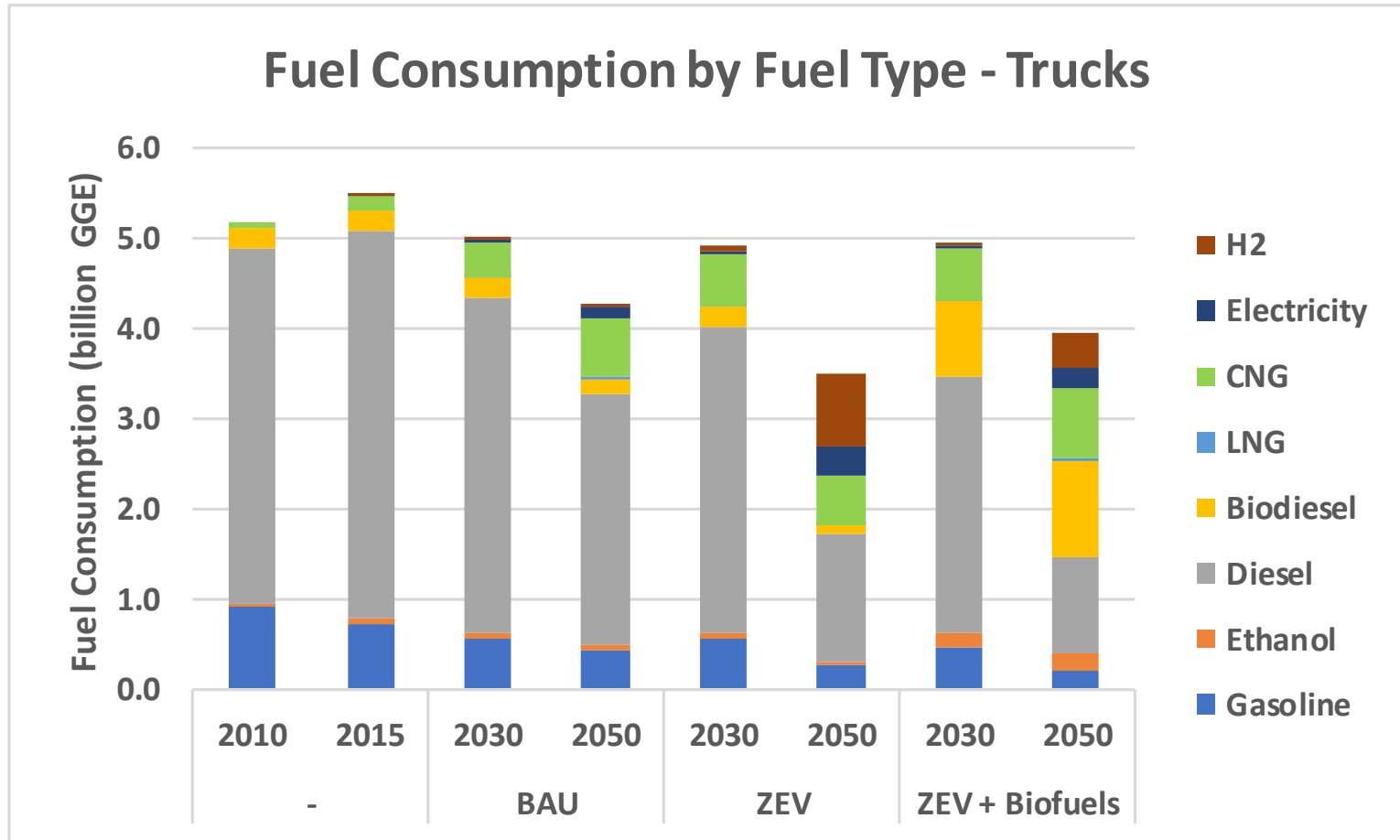


# Fuel Consumption LDVs



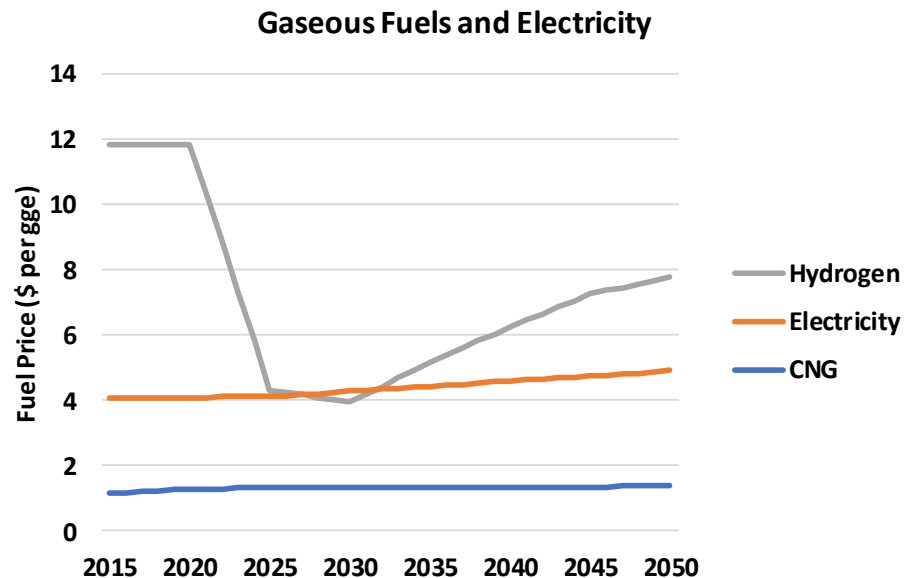
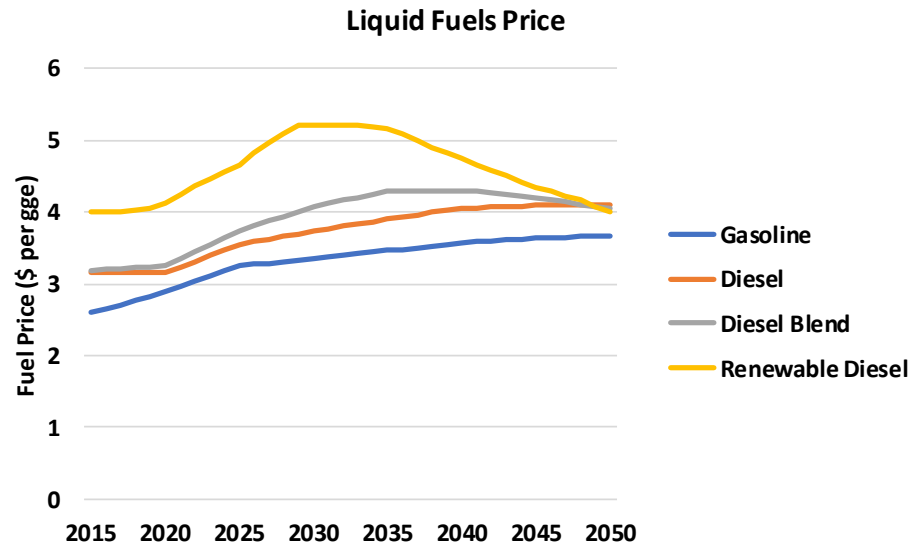


# Fuel Consumption Trucks



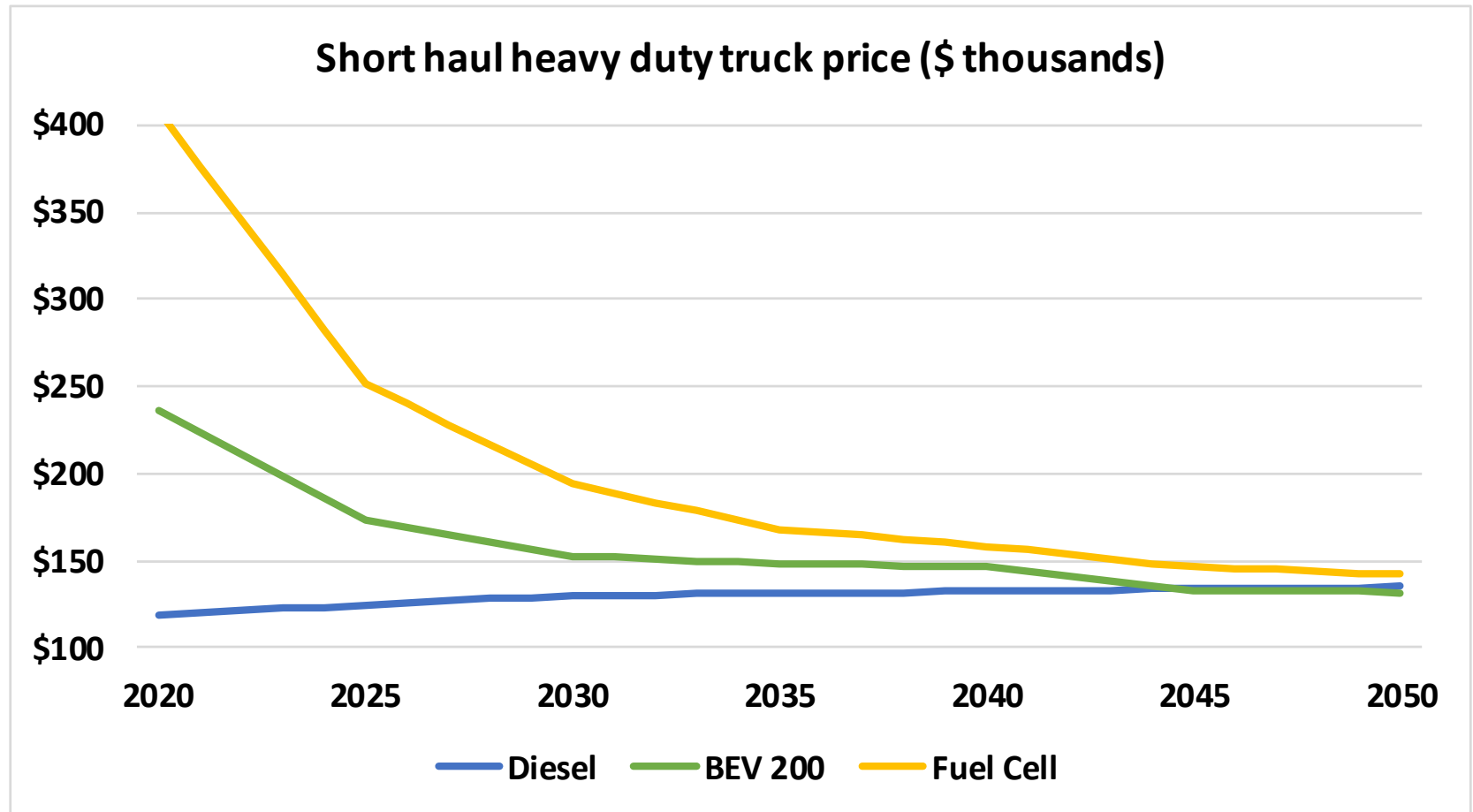
# Fuel cost

- Future renewable diesel price rises then falls as advanced RD is phased in
- Future H<sub>2</sub> price drops then rises as electrolysis is phased in



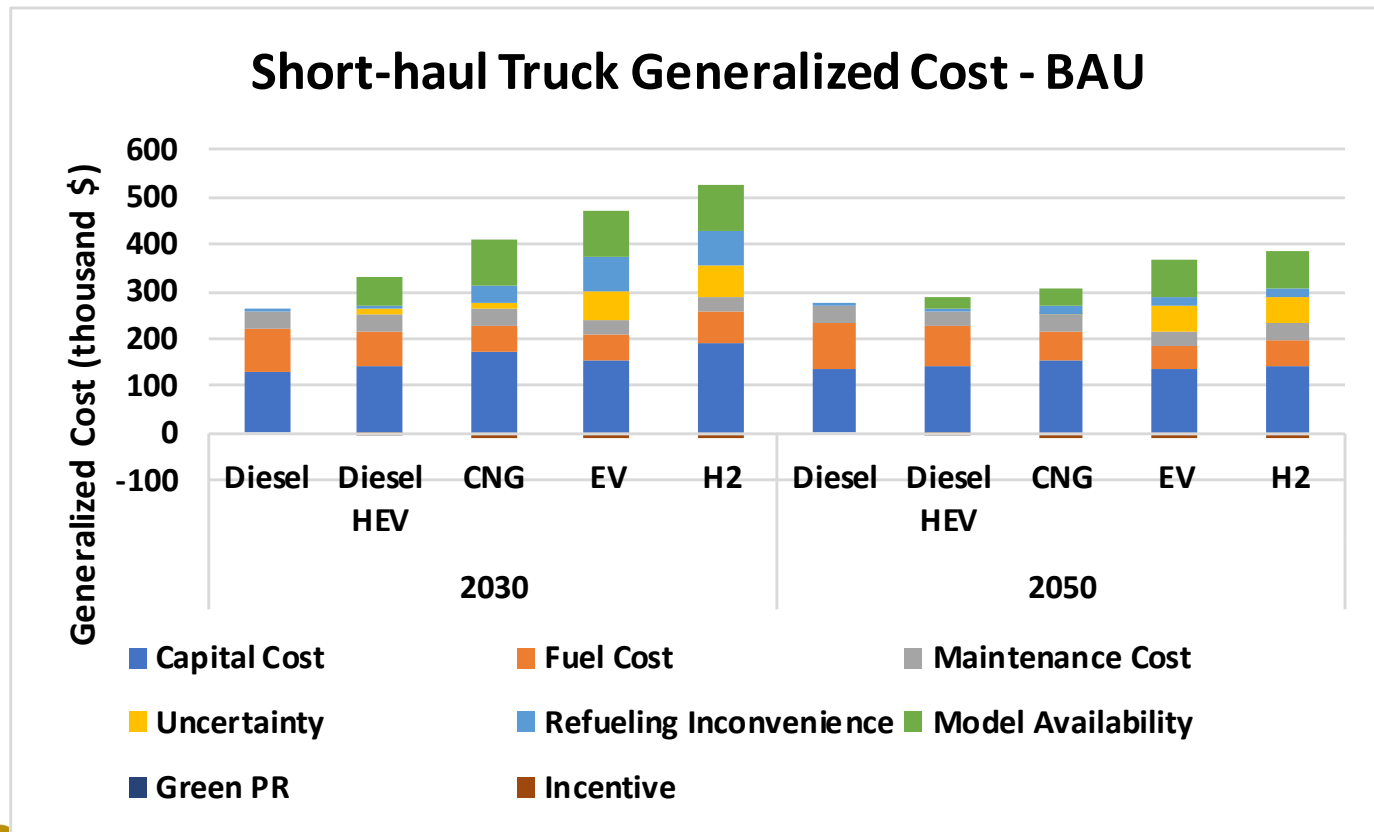
# Truck cost

- All 3 major technologies very close in price by 2040

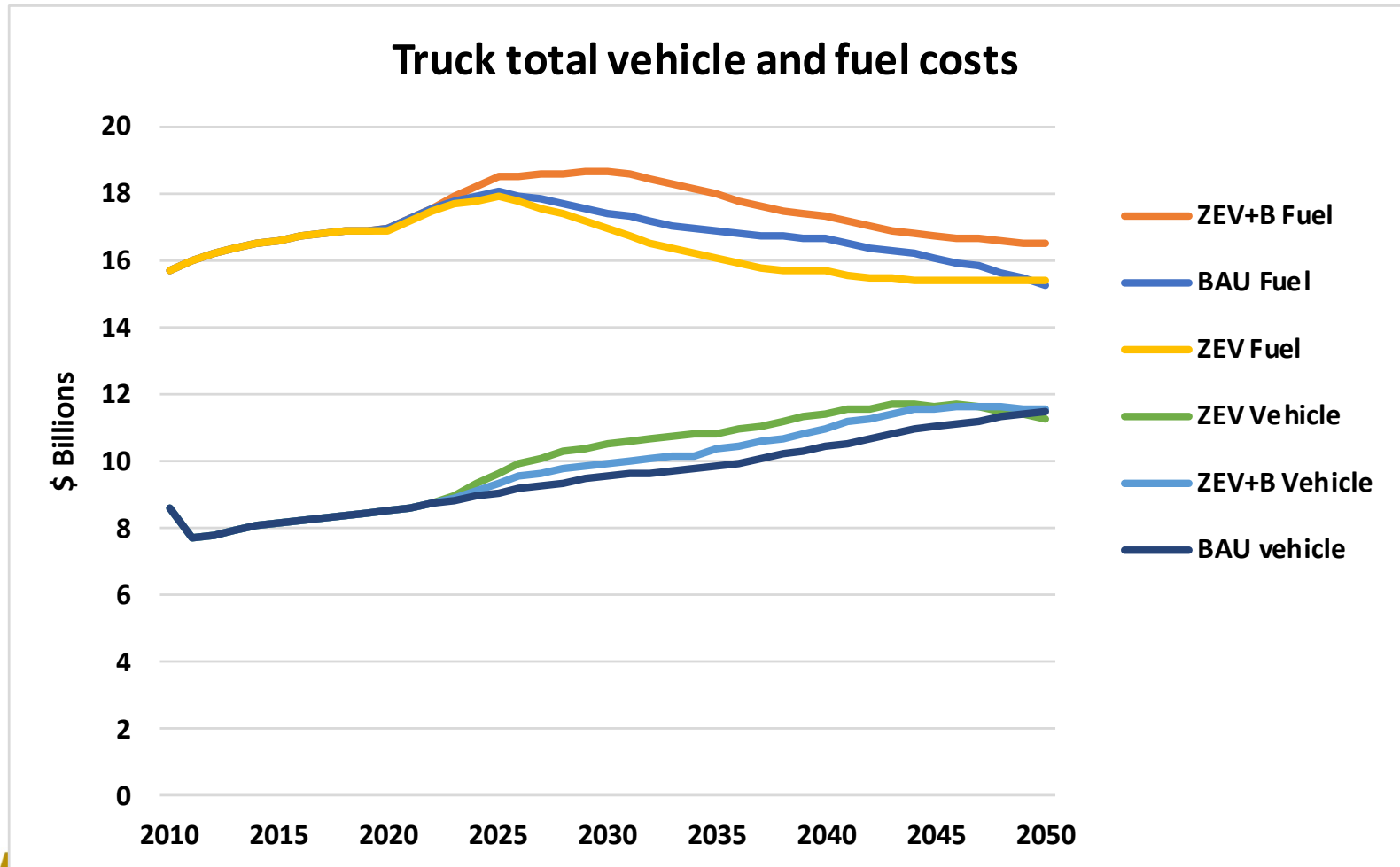


# Effect of Purchase Factors for Fleets

- Generalized cost = monetary + non-monetary factors (e.g. capital, fuel, uncertainty, model availability, etc.)
- Difference can exceed cost of new technology



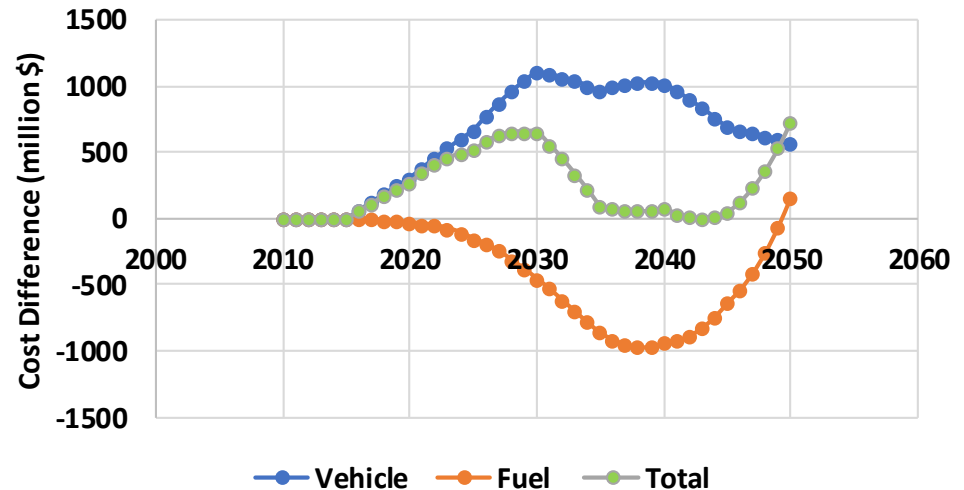
# Truck scenario total vehicle and fuel cost



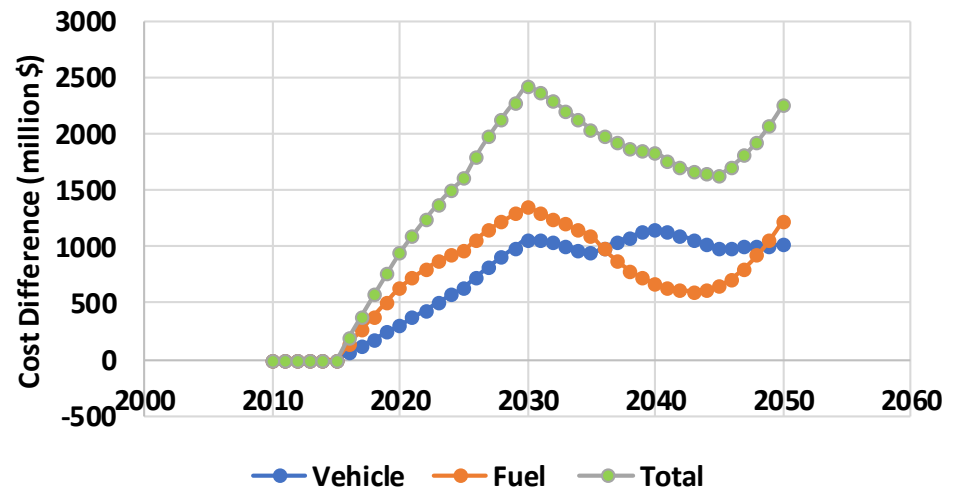
# Truck scenario vehicle and fuel costs vs BAU

- ZEV truck costs higher but plenty of energy cost savings to offset this
- ZEV+B truck costs slightly lower but fuel costs higher, net effect is a more expensive scenario

Truck Cost Difference (ZEV - BAU)

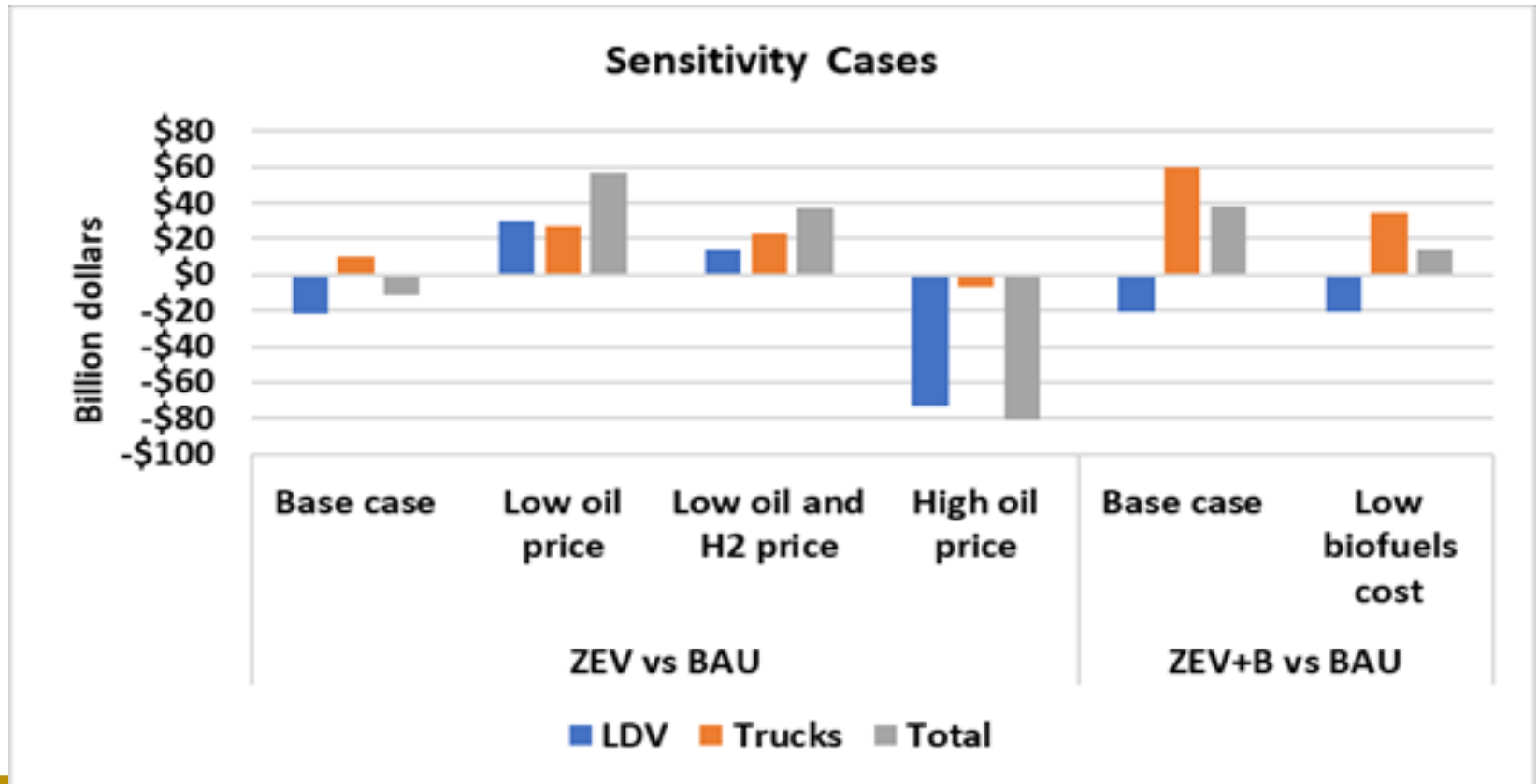


Truck Cost Difference (ZEV+B - BAU)



# LDV and truck cumulative cost and sensitivity cases

- We raise and lower fuel prices by 20% in the various sensitivity cases
- Total effect across cars and trucks is \$10 to 60 billion up or down, 2015-2050 cumulative
- This is relative to a base cost for all cars and trucks (vehicles + fuels) of \$4 trillion over this period. Thus under 2% change in cost.



So, achieving CO<sub>2</sub> targets appears possible at “reasonable” cost...



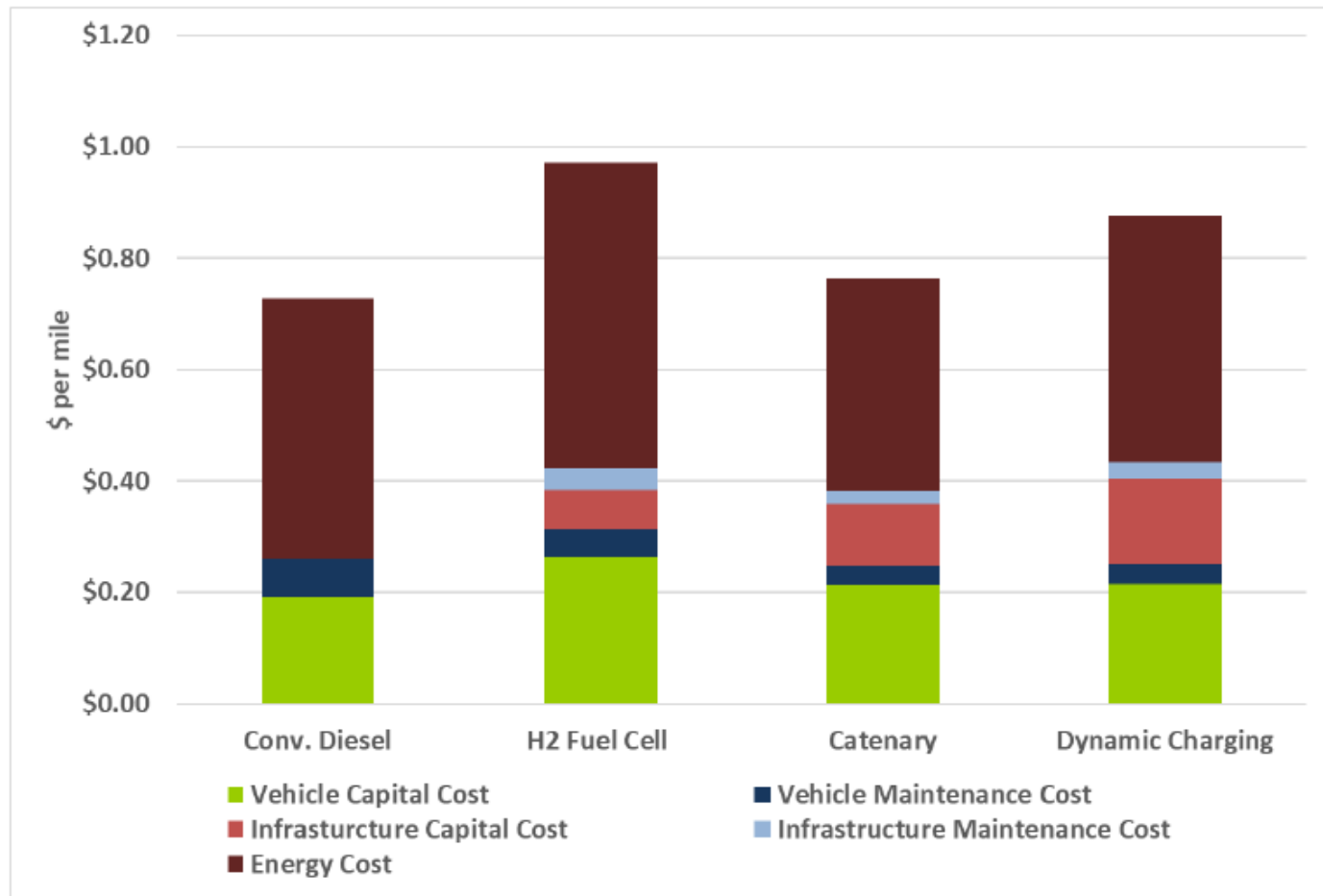
.... BUT: many wildcards...

- Low oil prices
- Electricity and hydrogen costs, prices
- Biofuels costs, availability, and sustainability
- 3 Revolutions in Transportation
- Consumer awareness, willingness to purchase ZEVs

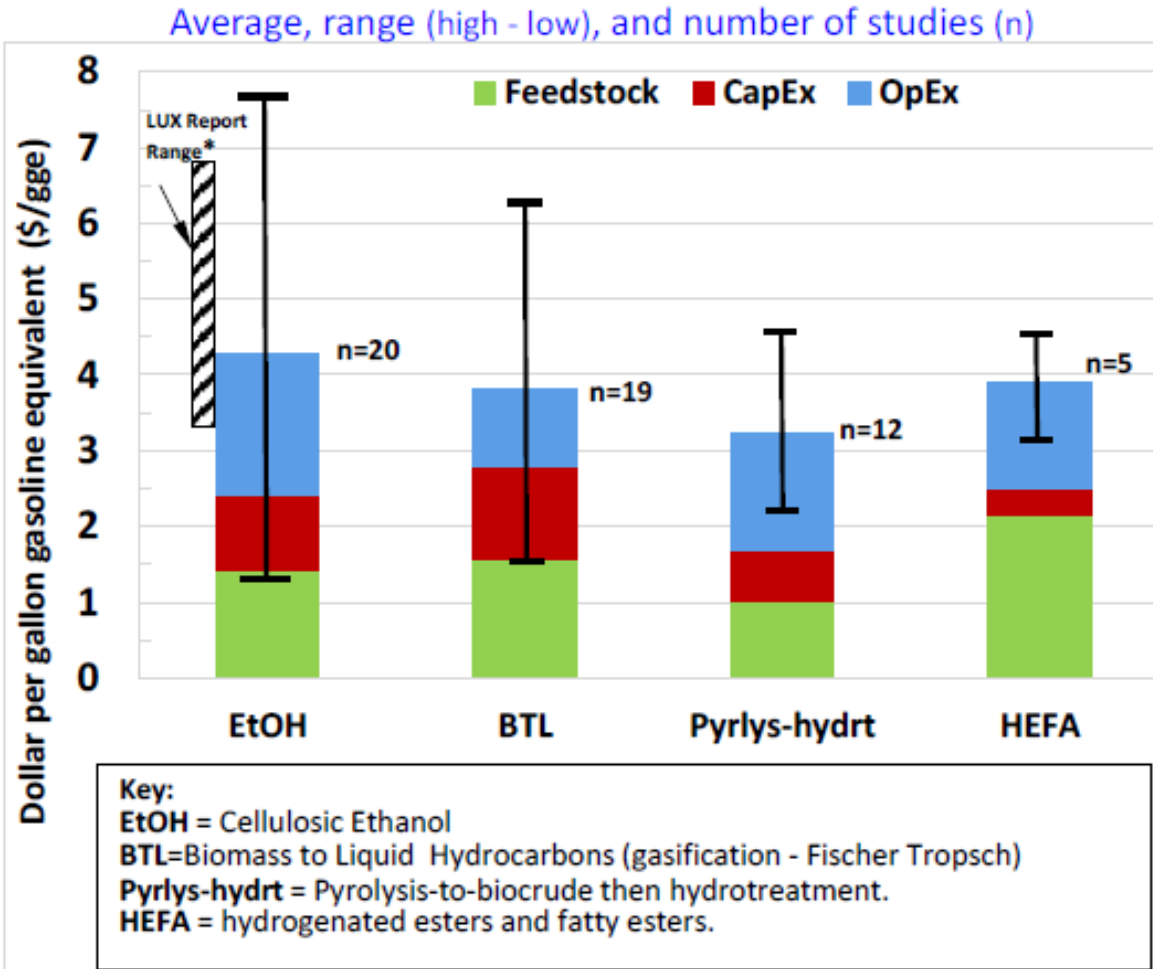


# Wildcard 1: Alternative Long-haul futures

- Catenaries and even dynamic inductive charging may be cost effective, but there are many hurdles



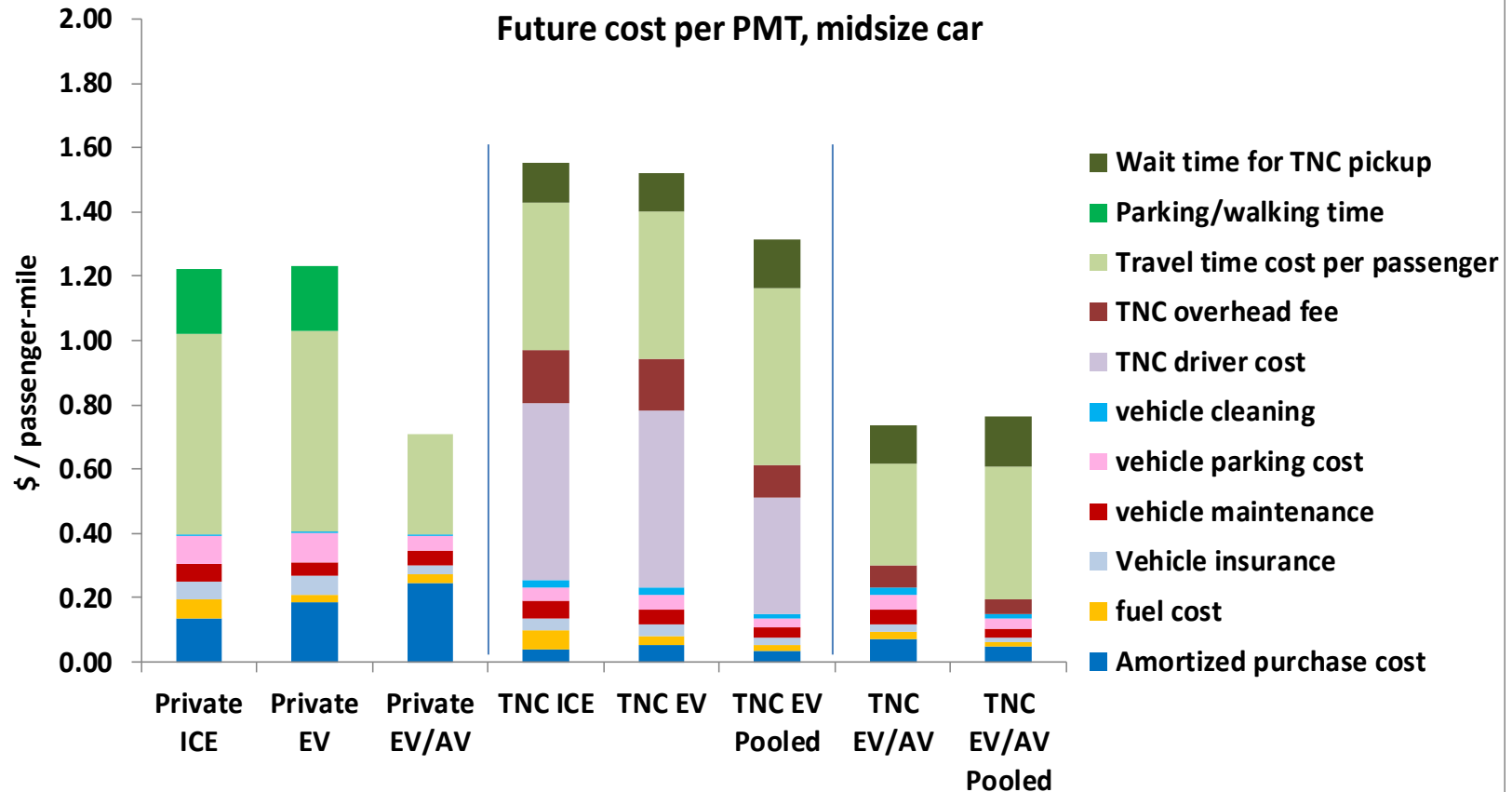
# Wildcard #2: Biofuels costs may remain high for some time



Source: Biofuels cost study for STEPS by Rob Williams

# Wild Card #3: future shared mobility costs may be low

- *Time costs are as big or bigger than out of pocket costs*
- *Automated electric vehicles will be low cost per mile*
- *Shared trips may not be particularly attractive*





# Thank You