Decarbonizing Medium & Heavy-Duty On-Road Vehicles

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Intro & Motivation

• Medium & heavy-duty vehicles (MHDVs) emit 21% of U.S. transportation GHG emissions
• Decarbonization of MHDVs is necessary to achieve U.S. net zero goals and zero-emission vehicles (ZEV) offer a viable pathway

We explored the following questions:
• When do ZEVs become cost competitive with conventional diesel vehicles?
• What are the vehicle sales, stock, and emissions implications of the transition to ZEVs?

Results

• Under DOE technology & fuels targets largely vetted with industry (central scenario), ZEVs reach cost parity with conventional technologies in all market segments by 2035.
• Short-range BEVs (150 to 300 miles of range) achieve parity before 2030 in light-medium & medium vehicle classes.
• ZEVs achieve parity in heavy market segments between 2030 and 2035 with FCEVs more competitive in long-haul applications due to faster refueling.

Methods

• The TEMPO model was used to estimate the total cost of driving for different technologies for all MHDV classes and market segments.
• Total cost of driving includes the following:
  • Upfront capital cost
  • Fuel & maintenance costs
  • Monetized cost of charging time (battery-electric vehicles)
  • Financial horizon
• Vehicle sales shares were estimated using a logit formulation
• Vehicle stock, energy and emissions were estimated for each class and market segment

Sales, Stock & Emissions

• Under central assumptions ZEV sales reach 42% by 2030 and 100% by 2046
• Slow stock turnover delays impacts; ZEV stock is 7% of the fleet in 2030 and 80% in 2050.
• FCEV sales are concentrated among heavy long-haul vehicles; BEV sales are greatest in short-haul segments
• Emissions reductions are 69% in 2050 relative to 2019 despite assumed VMT growth of 55%.

Key Takeaways & Areas for Future Research

• ZEV offer an affordable pathway to decarbonize MHDVs. Sales could reach 42% of all MD/HD trucks by 2030, reflecting lower combined vehicle purchase and operating costs
• Multiple technologies are viable for different MHDV market segments, including BEVs and FCEVs, suggesting multiple pathways to decarbonization
• Results are highly sensitive to uncertain technology and fuel assumptions; vehicles driving long distances are particularly sensitive to fuel costs
• Future research should include investigation into manufacturing and supply chain constraints, infrastructure and grid requirements, consistent fuel prices, and improved vehicle operation data to refine real-world costs and adoption decisions