Automated Automobiles

Energy and Emissions Implications of Vehicle Automation Scenarios

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Background

Vehicle automation will have a significant impact on mobility, fuel use, and CO_2 emissions.

Transportation emissions are defined using the “ASIF” equation:

CO_2 Emissions = **A**ctivity Level
X Modal **S**hare
X Energy **I**ntensity
X **F**uel Carbon Content

Wadud et al. 2016* evaluated factors for Activity Level (how many miles traveled) and Energy Intensity (fuel needed per mile traveled).

Activity Level (Demand)

- Cost of time
- New users
- Car sharing

Energy Intensity (Efficiency)

- Platooning
- Congestion
- Eco-driving
- Performance
- Crash avoidance
- Right sizing
- Highway speeds
- Increased features

Purple items apply to HDV & LDV
Black only applies to LDV

Motivation & Methods

- Need to understand the impact of automated vehicles on the broader US energy system and the environment
- Dynamic interaction of transportation with fuel cost and supply is evaluated with MARKAL energy system model
- Fuel choice and upstream emissions are calculated
- Scenarios based on fractional changes in demand and efficiency are derived from Wadud et al. 2016*

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Summary

- **Automated vehicles** will change how people & goods move
- **Fuel switching** is an important factor in emissions changes
- Large shifts in demand will change **fuel prices**
- System **feedbacks** further influence future transportation
- Potentially extreme increases in fuel use may be mitigated by fuel or technology choice (**cost of time vs. cost of fuel**)
- **Using an energy system model shows coordination between sectors, which may mitigate negative impacts**

Scenarios*

Stuck in the middle
Weaker response

Have our **cake** and eat it too
Emissions benefits without the drawbacks

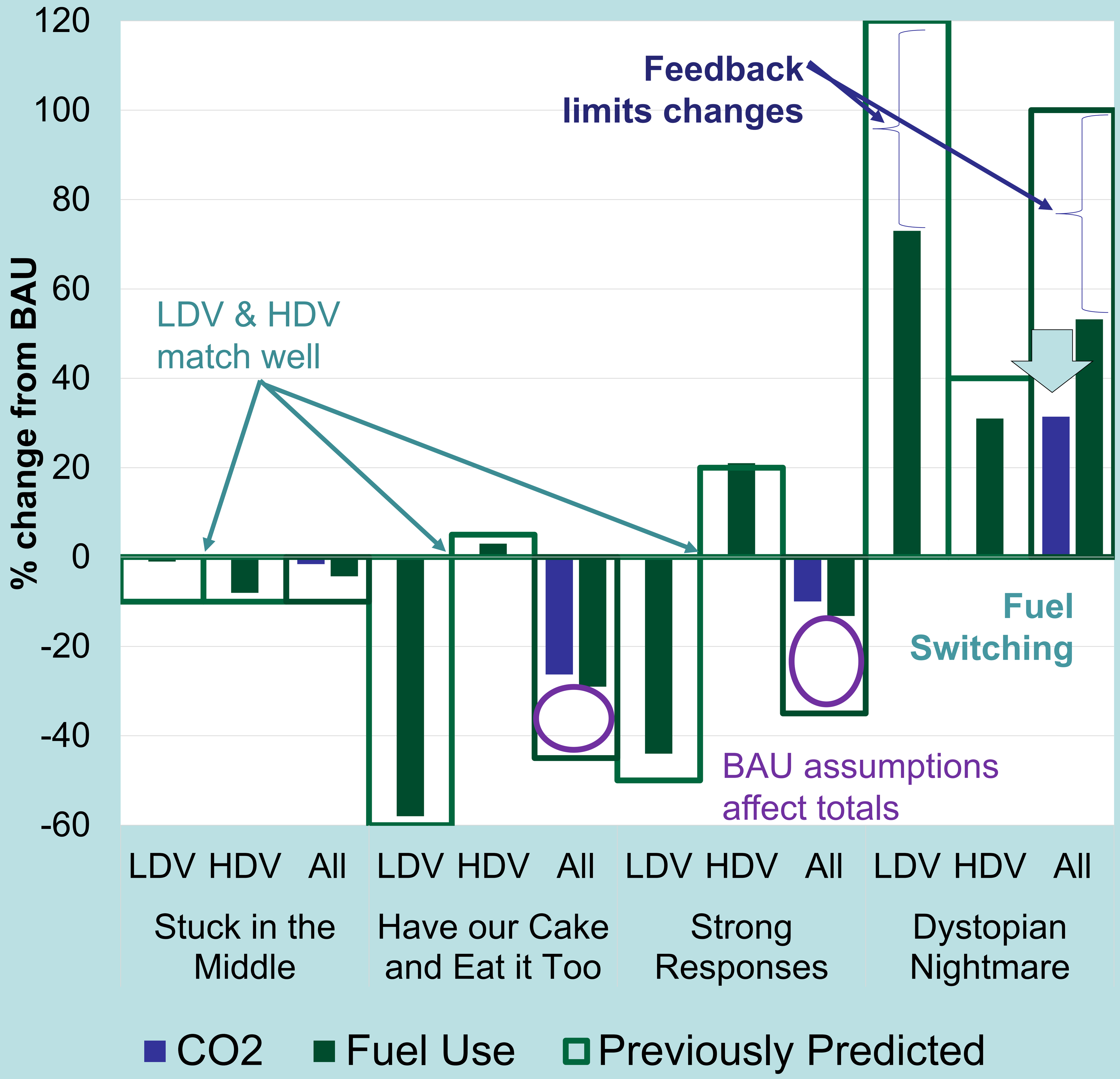
Strong responses
Emissions benefits of ‘cake’, but with some changes that **increase emissions** as well

Dystopian nightmare
Significant changes, **mostly increasing emissions**

BAU no automated vehicles

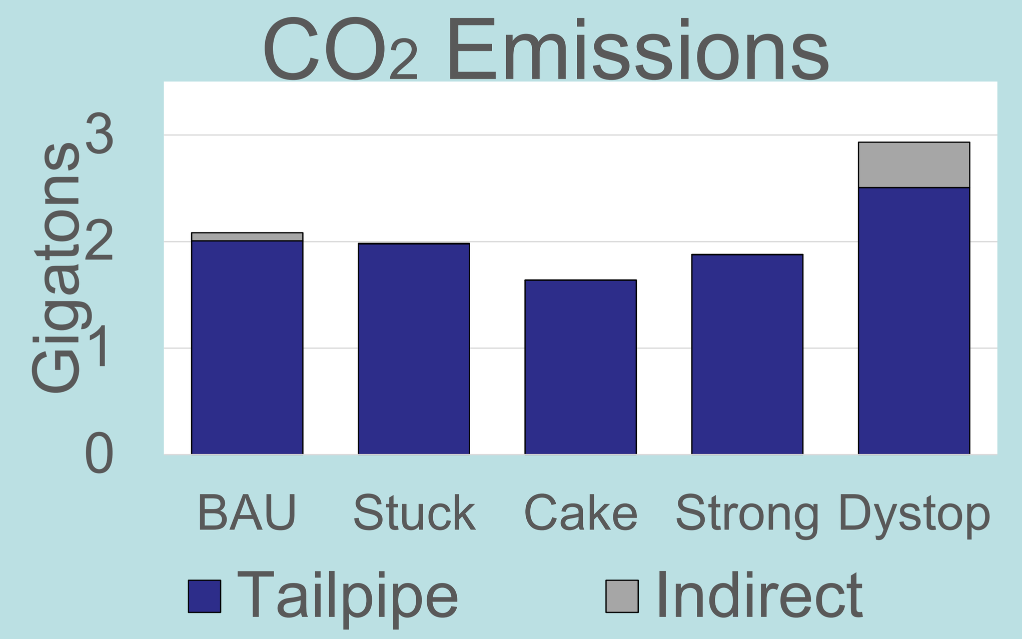
Results

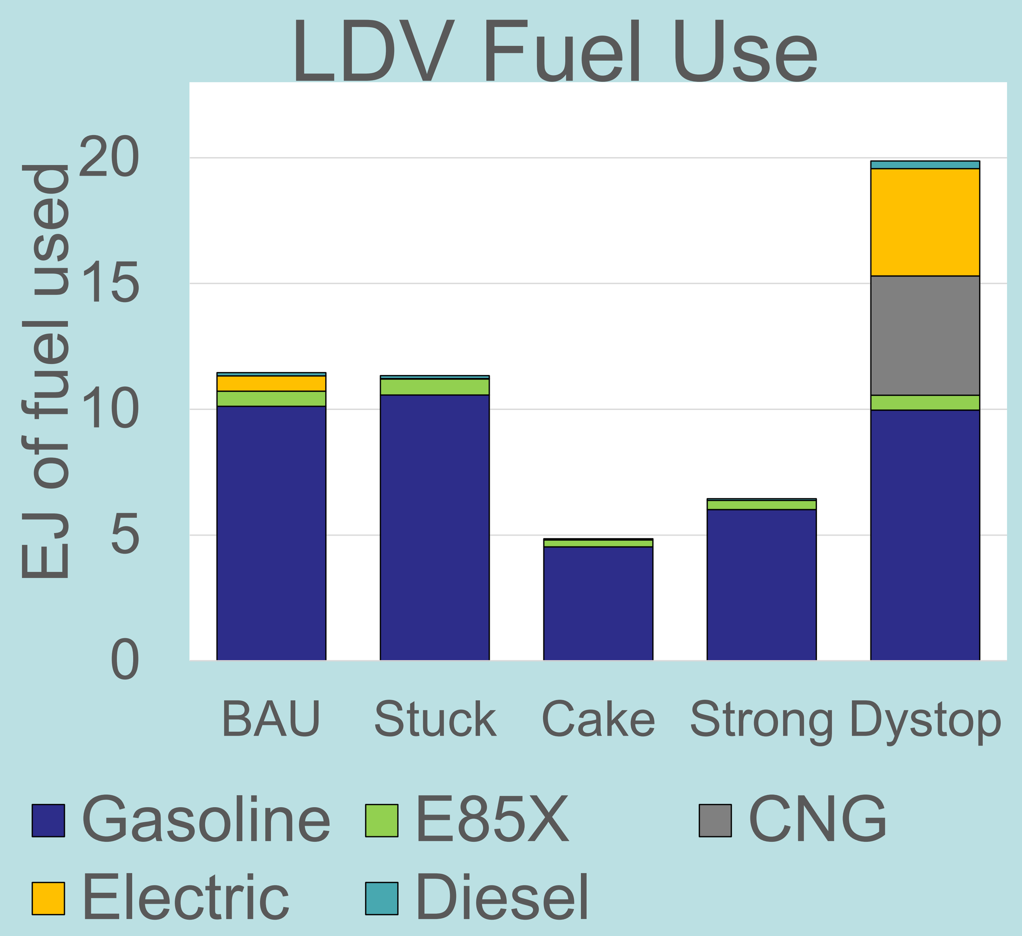
Comparison of Energy Model Results to Transportation-only Model Results*



HDV = Heavy Duty Vehicles (think 18-wheelers); LDV = Light Duty Vehicles (think passenger cars)
BAU = Business as Usual (no automation)

Results in 2050 with complete penetration of automation. Indirect emissions from electricity generation. CNG = compressed natural gas, E85X = flexible ethanol gasoline mixture.





High demand
→ expensive fuel
→ choose alternatives

Low demand
→ Cheap fuel
→ stick with oil

*Previously Predicted Outlines & Scenario definitions from Wadud, MacKenzie & Leiby. 2016. Help or hindrance? The travel, energy and carbon impacts of highly automated vehicles. *Transportation Research Part A*. https://doi.org/10.1016/j.tra.2015.12.001