The Role of Electric Vehicles in U.S. Climate Policy

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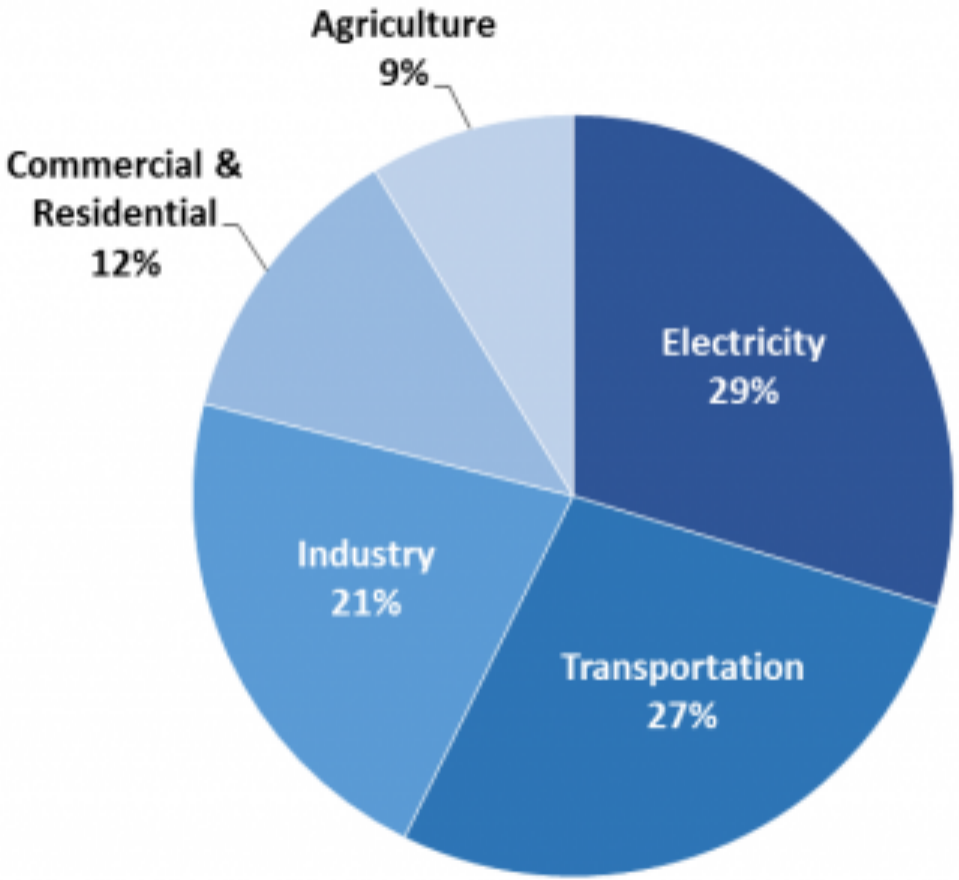
Outline

Motivation

The transportation sector accounts for almost $\frac{1}{3}$ of U.S. greenhouse gas emissions as of 2015.

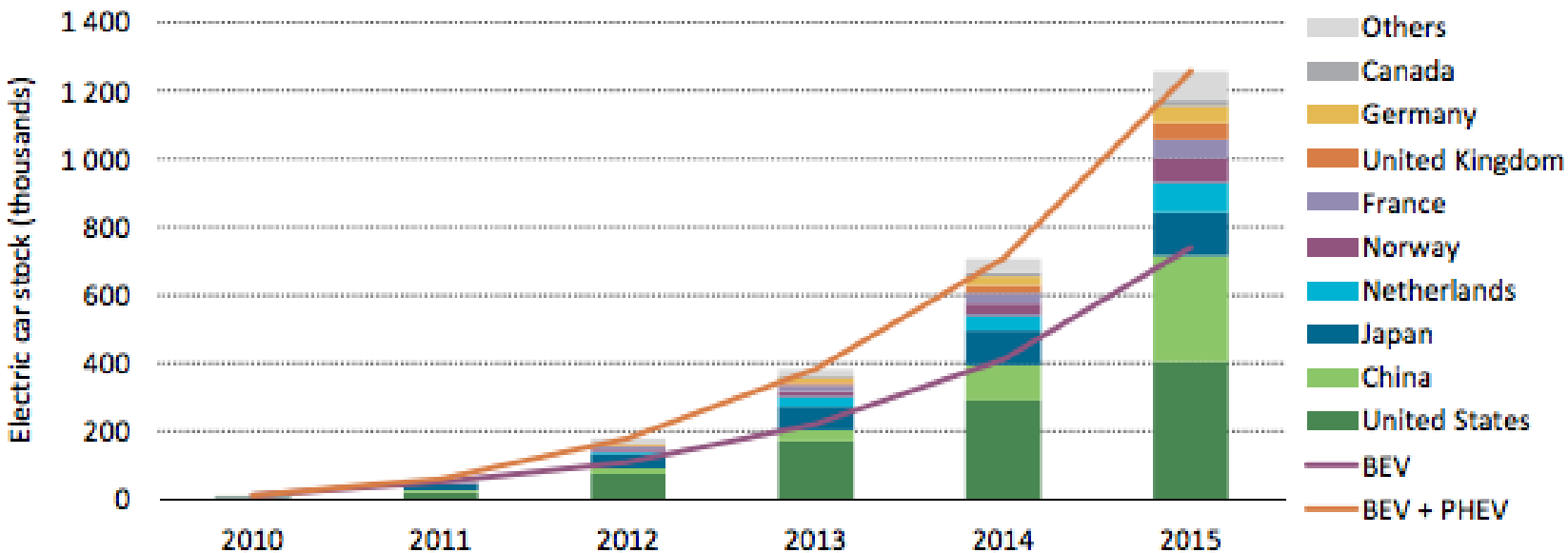


Source: U.S. Environmental Protection Agency (2017). Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2015.

Motivation

Electric vehicles (EVs) are widely regarded as a means of reducing the transportation sector's emissions.
EV penetration is increasing due to

1. Policy interventions
2. Technological progress



Source: International Energy Agency (2016). Global EV Outlook 2016.

Motivation

There is some evidence that EVs are not the environmental panacea many believe.

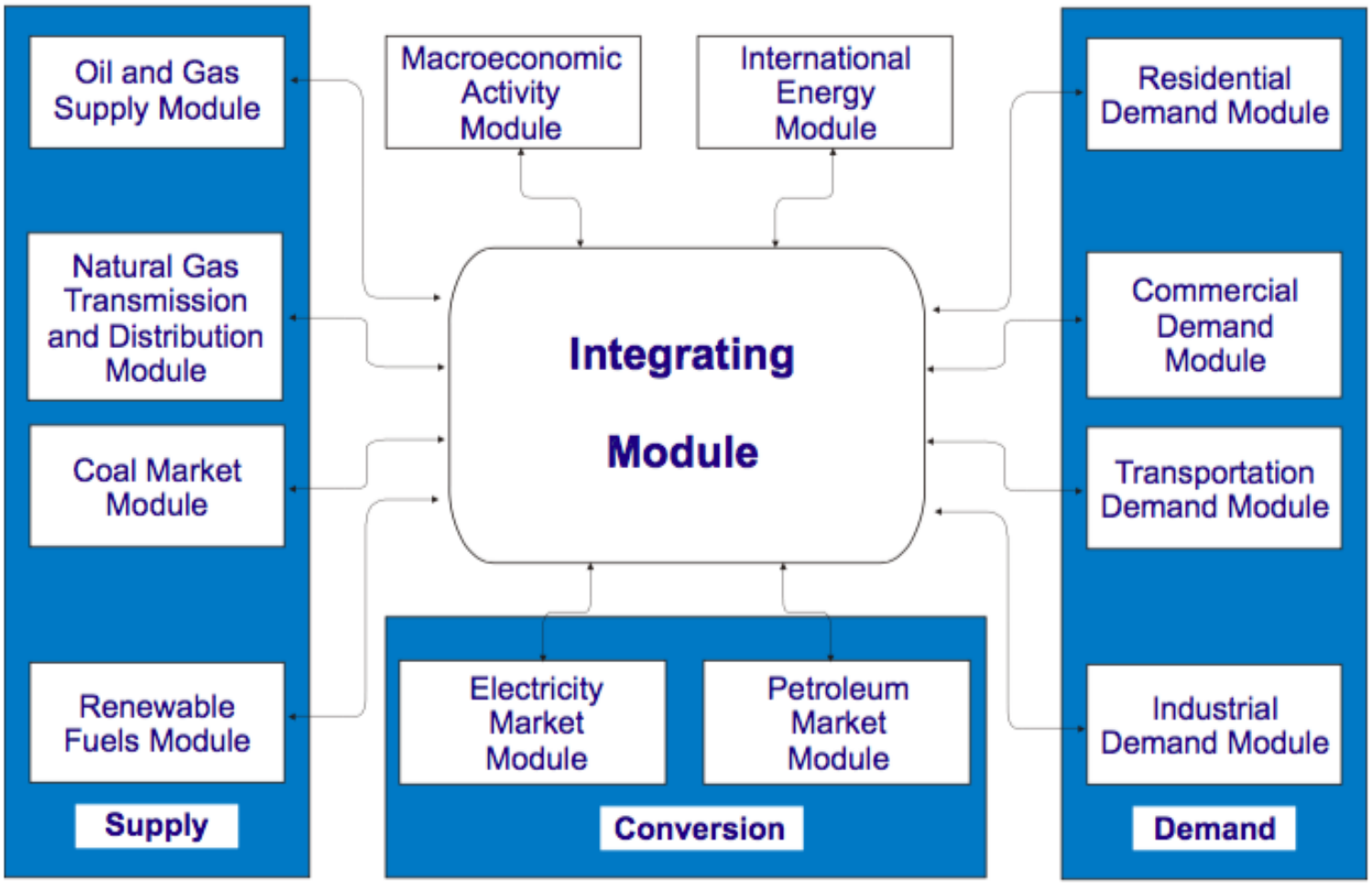
- EV production is more resource-intensive than production of conventional vehicles, so environmental benefits are sensitive to assumptions about vehicle lifetimes and battery replacement (Hawkins et al, 2013)
  - Battery manufacturing is a major source of emissions (Tessum et al, 2014)
- EV-associated emissions are dependent on the local marginal generators as well as climate factors that affect range (Michalek et al, 2011; Graff-Zivin et al, 2014; Yuksel and Michalek, 2015; Tamayao et al, 2015; Archsmith et al, 2015)

Research Question

- What role can increased EV deployment play in U.S. CO_2 emissions reduction?

National Energy Modeling System (NEMS)

NEMS is an engineering-economic model developed by the U.S. Energy Information Administration (EIA) to examine U.S. energy supply, demand, and prices through 2050.



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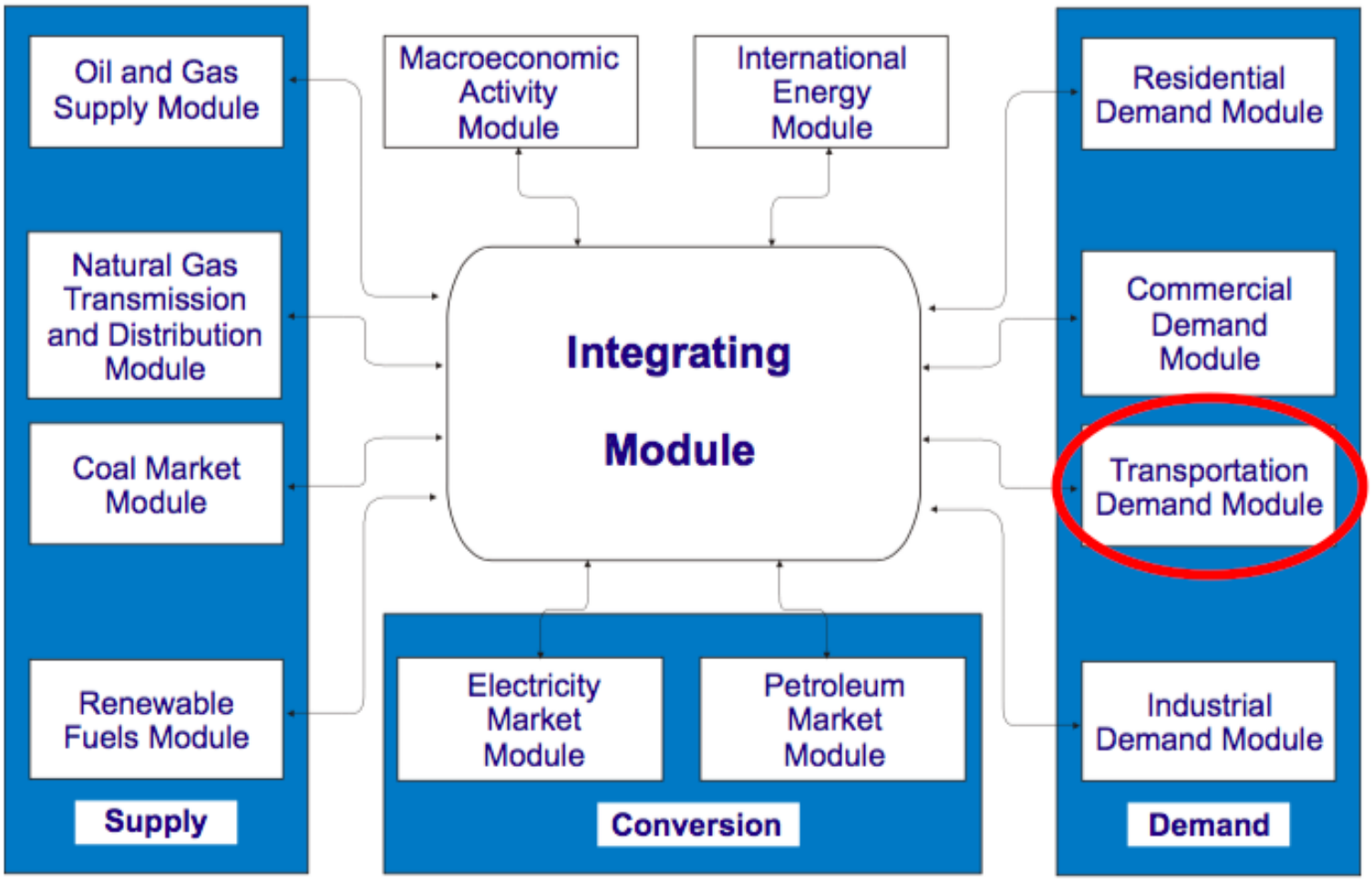


Light-Duty Vehicle Submodule

The light-duty vehicle (LDV) submodule is a component of the overall transportation demand module.

- Determines retirement of existing vehicles and demand for new vehicles
- Projects new vehicle attributes based on consumer demand, technological progress, and CAFE requirements
- Uses multistage discrete choice model to estimate market share for vehicles of each fuel type
- Calculates fuel use based on vehicle stock attributes and demand for travel

Vehicle Choice Modeling

Multi-stage logit determines market share for each vehicle group and each type within the group.

Conventional	Hybrid Electric	Dedicated AFVs	Fuel Cell	Electric
Gasoline Diesel Flex-fuel ethanol Bi-fuels CNG Bi-fuels LNG	Gasoline Diesel	CNG LNG LPG	Gasoline Methanol Hydrogen	100-mile 200-mile

Level 3: Proportion of travel in which flex/bi-fuel vehicles use gasoline vs. alternative fuels
Level 2: Market shares of AFV technologies within major fuel-type groups
Level 1: Market shares for aggregate fuel-type groups

Vehicle Choice Modeling

Level 2:

$$UISUM_{jt,class} = X21_{vt,class} \times PSPR_{vt,class,yr} + X22_{vt,class} \times FLCOST_{vt,class,yr} + X23_{vt,class} \times \frac{1}{VRNG_{vt,class,yr}} + X24_{vt,class} \times BRCOST25_{vt,class,yr} + \cdots + X210_{jt,class}$$

- jt = vehicle technology within vehicle group
- jg = vehicle group
- $class$ = car or light truck
- $PSPR$ = purchase price
- $FLCOST$ = fuel cost per mile
- $VRNG$ = vehicle range in miles
- $BRCOST25$ = battery replacement cost

Vehicle Choice Modeling

Level 2 share:

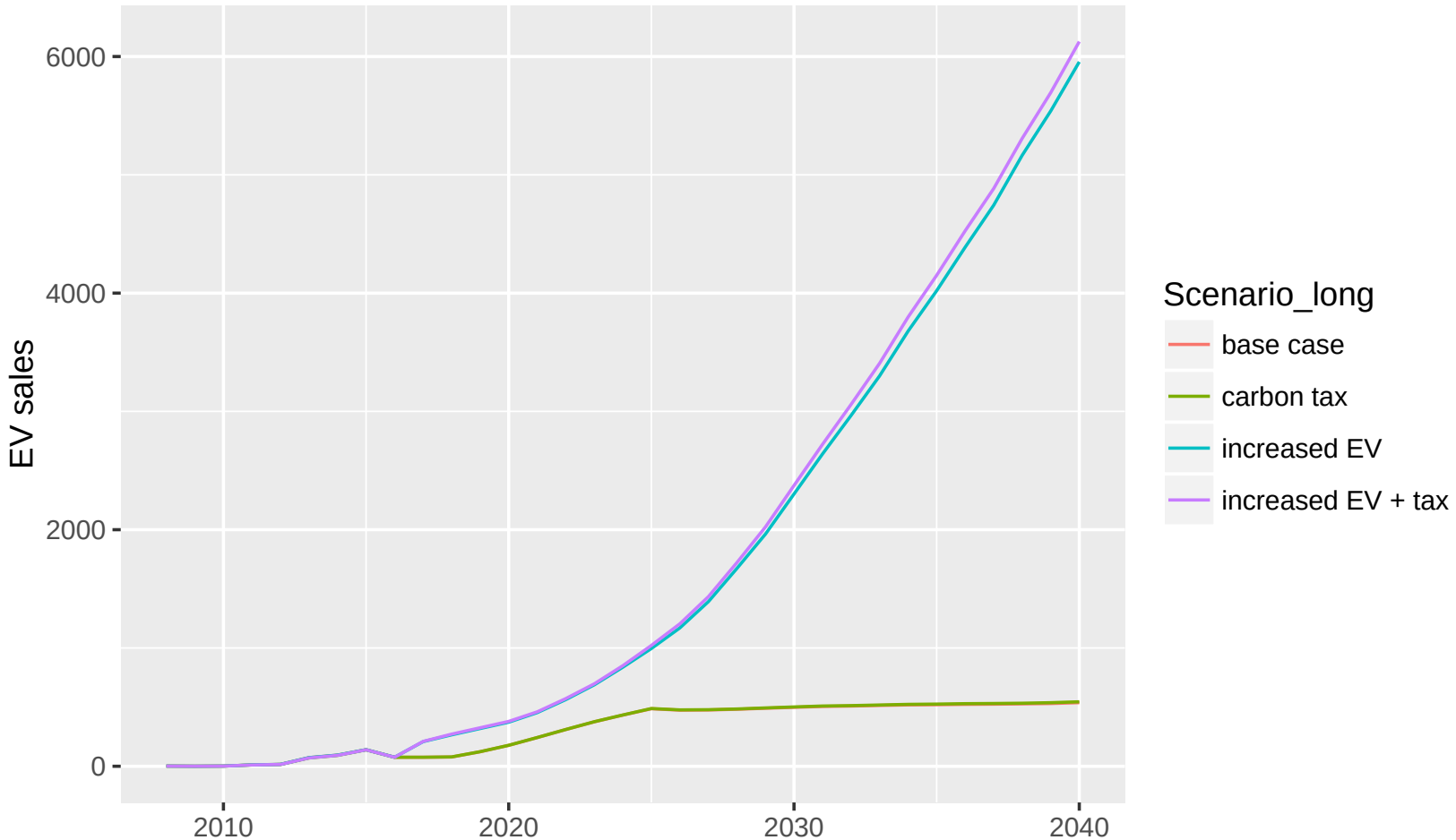
$$XSHARE_{jg,jt,yr} = \frac{e^{UISUM_{jt,class,yr}}}{\sum_{jt' \subset jg} e^{UISUM_{jt',class,yr}}}$$

Level 1 share: Calculate "aggregated cost" for group jg and calculate analogous utility value $\rightarrow$ share

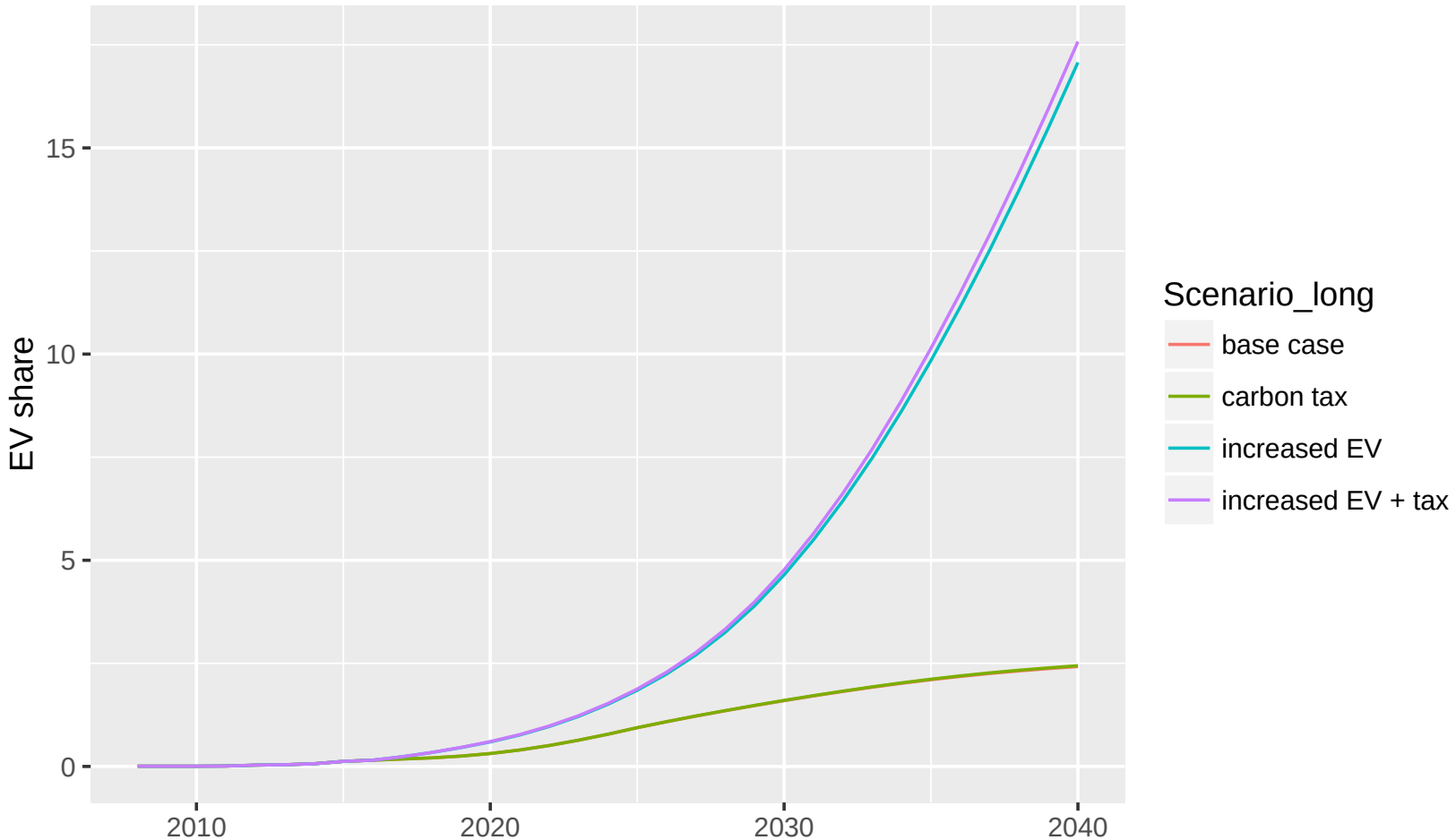
Scenarios

- **Reference Case**: the AEO 2016 without implementation of the Clean Power Plan
- **Economy-wide carbon tax**: starting in 2017, tax of $40/ton C, increasing at 5%/yr
- **Increased preference for electric vehicles**: utility adder for electric vehicles in multi-stage logit that makes EVs relatively more attractive, increasing over time
- **Economy-wide carbon tax + increased EV preference**

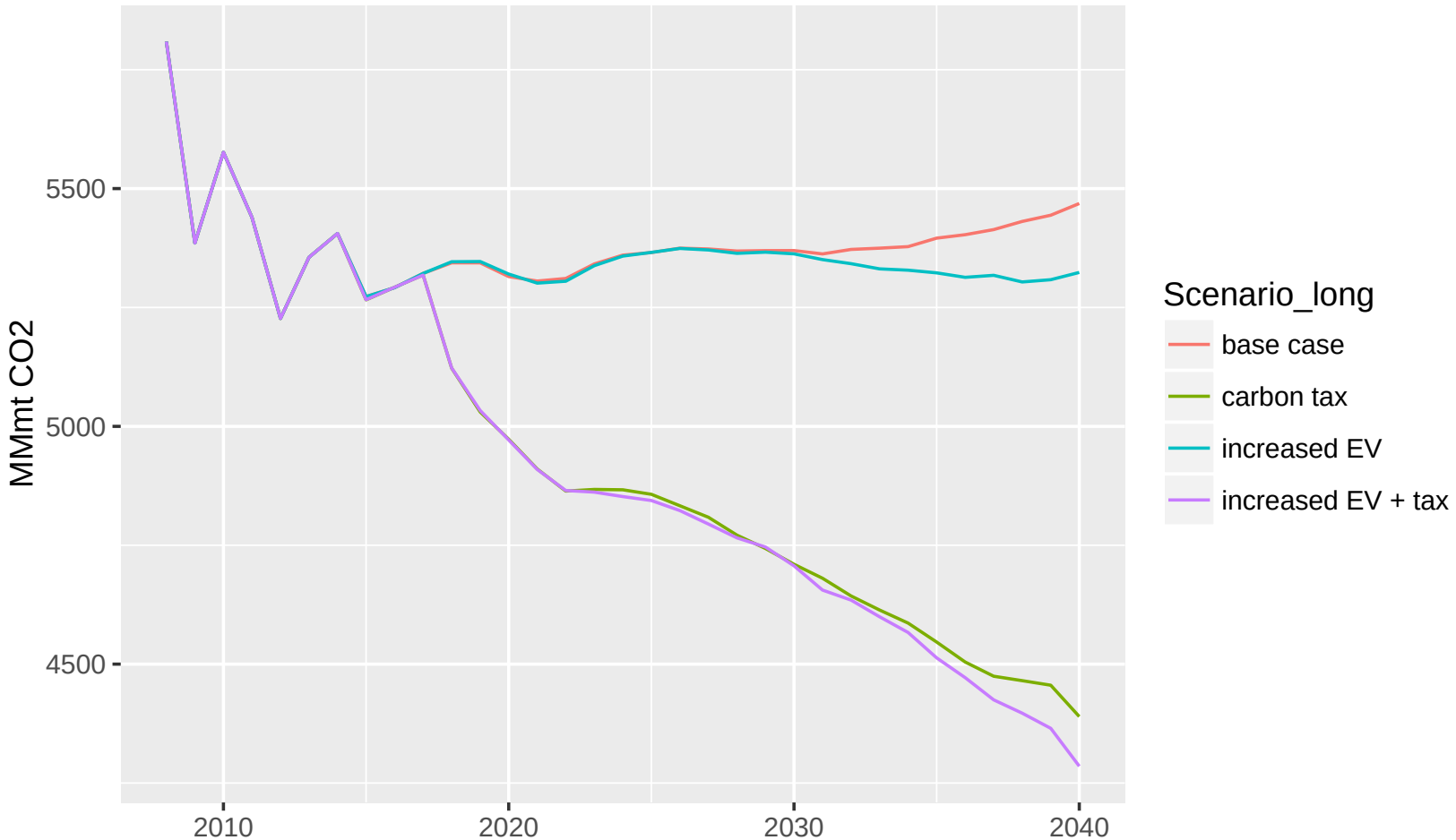
EV Sales (all LDVs)



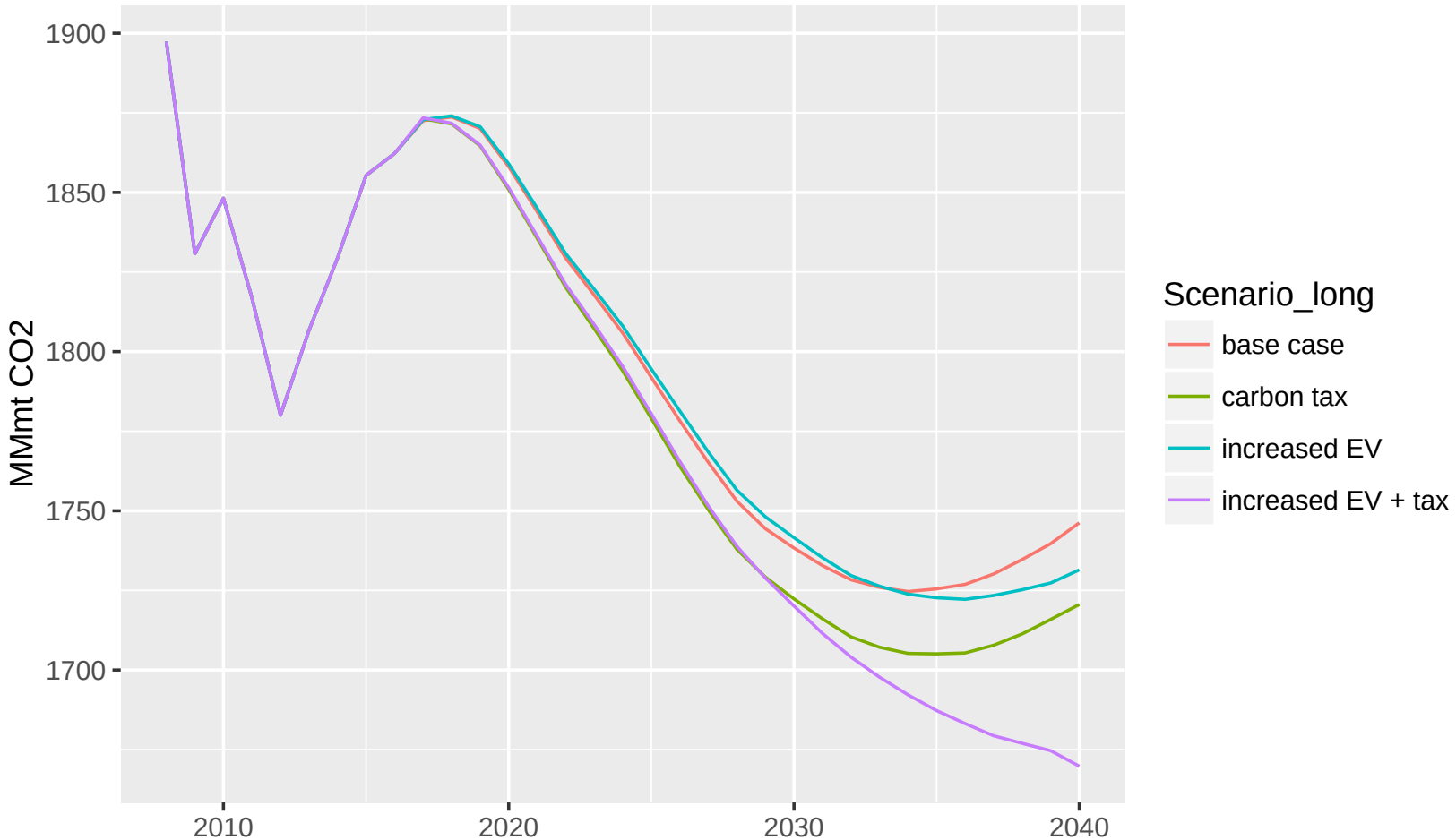
EV Market Share



CO_2 Emissions–Economy-Wide



CO_2 Emissions–Transportation Sector



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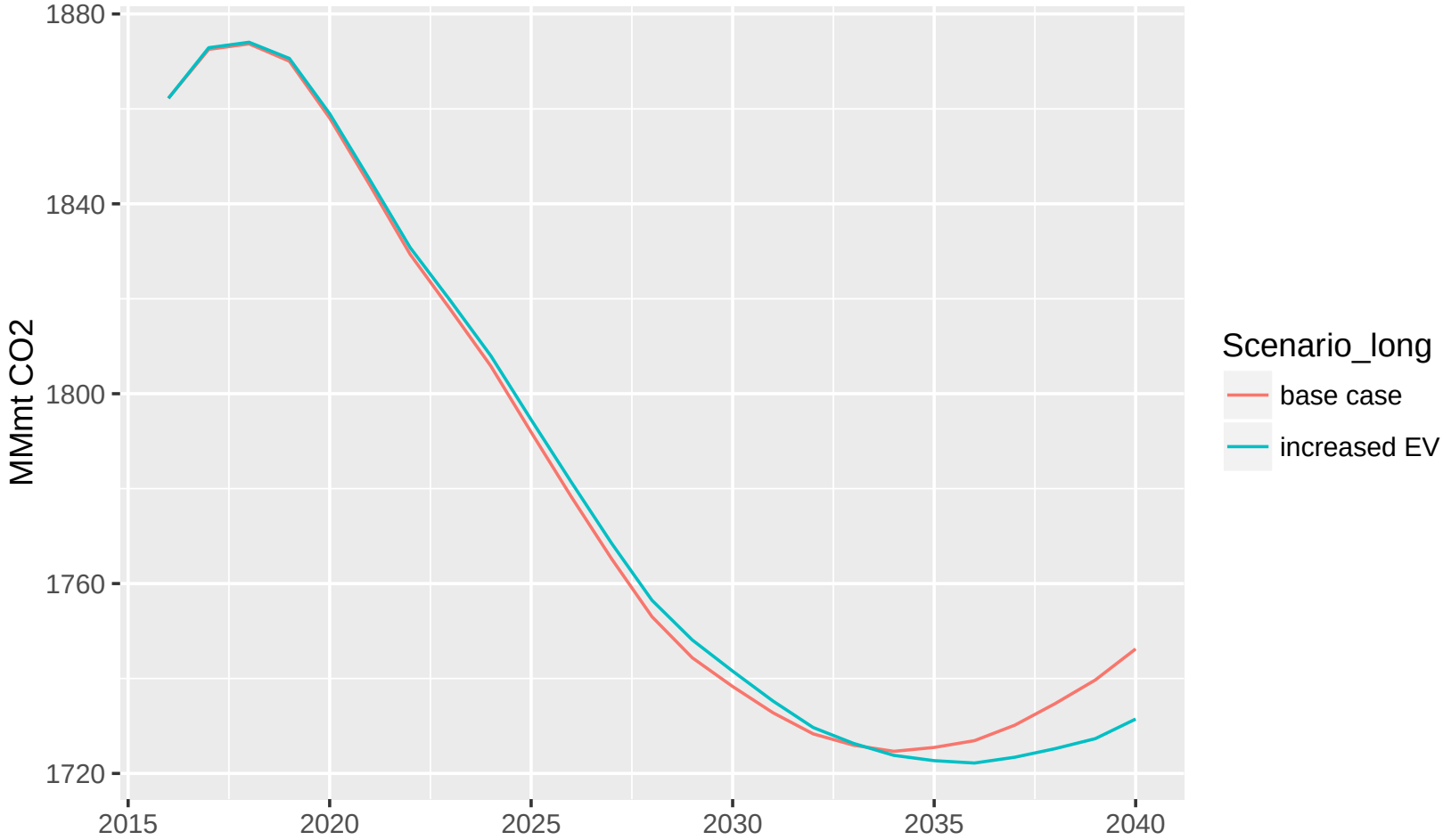

Discussion

- Increased EV penetration may increase transportation sector GHG emissions in the near term
- Later in the time frame, there is a positive interaction effect between a carbon tax and increased EV penetration

Next Steps

- Try to get more regional and time-specific electricity generation and emissions data from the model
- Estimate more detailed regional emissions effects of electric vehicles
- Sensitivity tests (time path of EV adoptions, degree of EV tech progress)

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