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An Assessment of Electric Drive Vehicle Deployment Through Mid-Century

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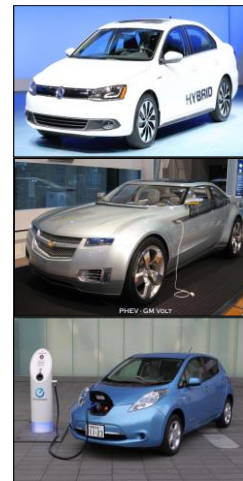
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Background and Motivation

Electric Drive Vehicles (EDVs): Vehicles that derive a portion of their motive power from a battery

→ hybrids, plug-in hybrids, and battery electric vehicles

1. Increasing concerns regarding U.S. oil imports, anthropogenic climate change, and urban air quality
2. Current U.S. policies, tax credits, and incentives promote electric drive vehicles (EDVs)
3. High uncertainty about the future market penetration of EDVs and the consequent effect on emissions despite the potential benefits over competing vehicles



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Research Goals

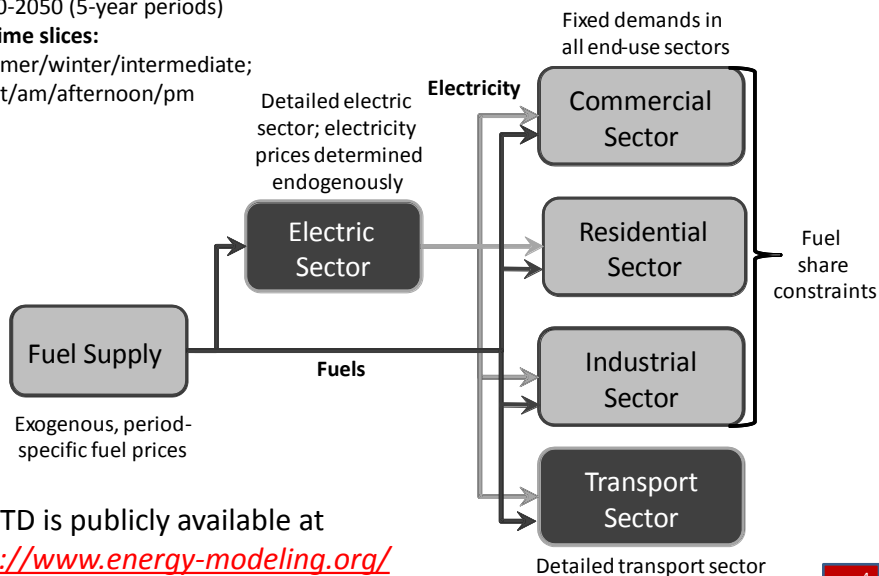
Use the TIMES model generator with a VEDA-compatible US dataset to address the following:

1. Assess the circumstances under which EDVs achieve high levels of market penetration
2. Quantify the impact of wide-scale EDV deployment on electric sector planning and system-wide air pollutant emissions
3. Evaluate how different recharging patterns affect fuel consumption and air pollutant emissions

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National US TIMES Database (NUSTD)

- **Model time periods:**
2010-2050 (5-year periods)
- **12 time slices:**
summer/winter/intermediate;
night/am/afternoon/pm



NUSTD is publicly available at
<http://www.energy-modeling.org/>

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NUSTD: Fuel Supply

- ❑ Exogenously specified prices based on unlimited supply (i.e., no supply curves)
- ❑ Prices drawn from the EIA's *Annual Energy Outlook (AEO)*

NUSTD: Electric Sector

- ❑ 32 electric generation technologies
- ❑ 71 emission retrofit technologies to capture CO₂, NO_x, and SO₂ emissions
- ❑ Wind and solar availability factors indexed by time slice
- ❑ The price of electricity is determined endogenously
- ❑ Data based on US EPA (Lennox et al. 2012) with updates based on the AEO

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NUSTD: Transportation Sector

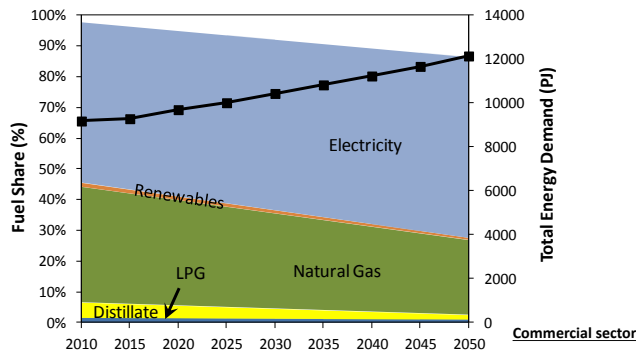
- ❑ Transportation sector: light duty vehicles, heavy duty vehicles, and off-highway technologies
- ❑ **Light Duty Transportation Sector:**
 - 7 vehicle size classes (Mini-compact, Compact, Full, Minivan, Pick-up, Small SUV, Large SUV)
 - 6 fuels types (E10, E85X, Diesel, Electric, CNG, H₂)
 - 13 vehicle types
 - Vehicles cost and performance data is from US EPA; updated based on the AEO
- ❑ The total demand for vehicle miles is drawn from AEO
- ❑ EDVs: hybrid, plug-in hybrid (PHEV20 and PHEV60), and electric (EV160)
- ❑ EDV performance data is based on the GREET model
- ❑ Hurdle rates of 7.8% (hybrid, plug-in hybrid, and diesel vehicles) and 10% (electric, CNG, and hydrogen fuel cell vehicles)

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NUSTD: End-Use Demand Sectors

Commercial, industrial, and residential sectors are comprised of:

- ❑ Single aggregate energy demand (AEO)
- ❑ Fuel share constraints (AEO)
- ❑ Emission factors associated with in-sector fossil fuel combustion (EPA, AEO)



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Baseline Assumptions

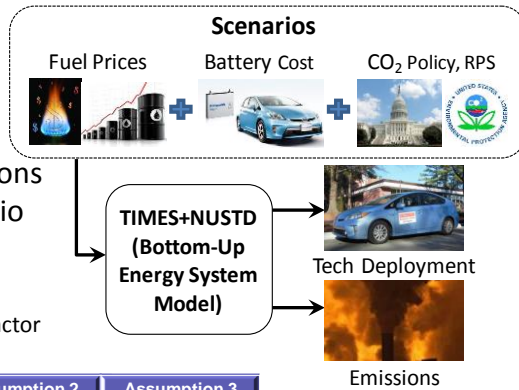
- ❑ **In the electric sector:**
 - Constraints on SO₂ and NO_x emissions based on AEO, Mercury and Air Toxics Standards (MATS), and the Cross-State Air Pollution Rule (CSAPR)
 - The overall minimum share of renewable energy for all states (including state-level RPSs): 2% in 2010 and 13% by 2025.
- ❑ **In the transportation sector:**
 - New CAFE standard and the corresponding GHG emissions rate limit for LDVs: (54.5 mpg and 163 grams CO₂ per mile in model year 2025)
 - Renewable fuel requirements based on the Energy Independence and Security Act of 2007
 - The effect of existing fuel subsidies and tax credits for new vehicles is included in the baseline cost assumptions (AEO).

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Scenario Description

Scenario development is focused on five factors likely to affect the cost-effectiveness of EDVs relative to other vehicle technologies:

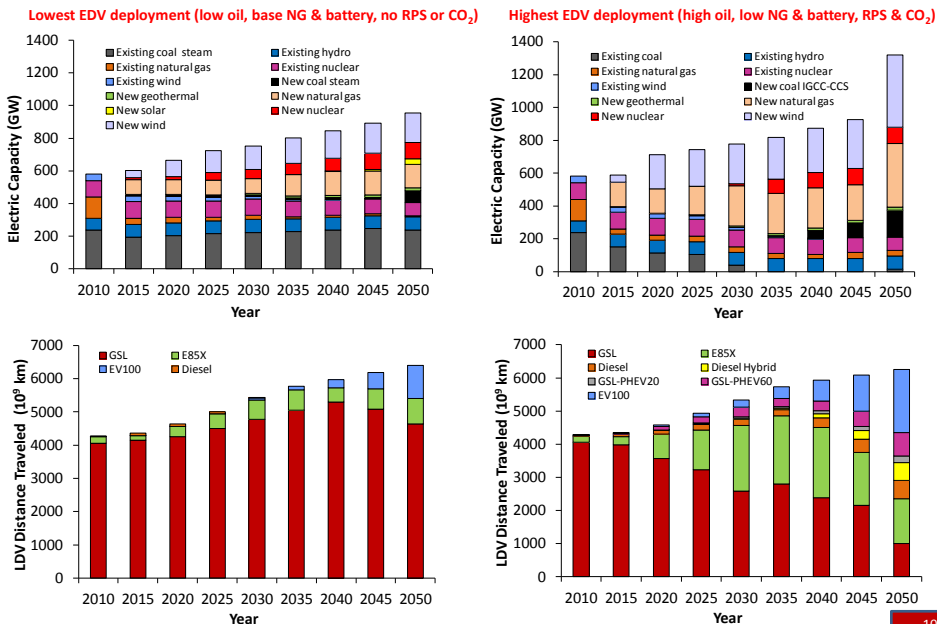
- ❑ Natural gas price
- ❑ Crude oil price
- ❑ EDV battery cost
- ❑ A federal cap on CO₂ emissions
- ❑ A federal renewable portfolio standard (RPS)



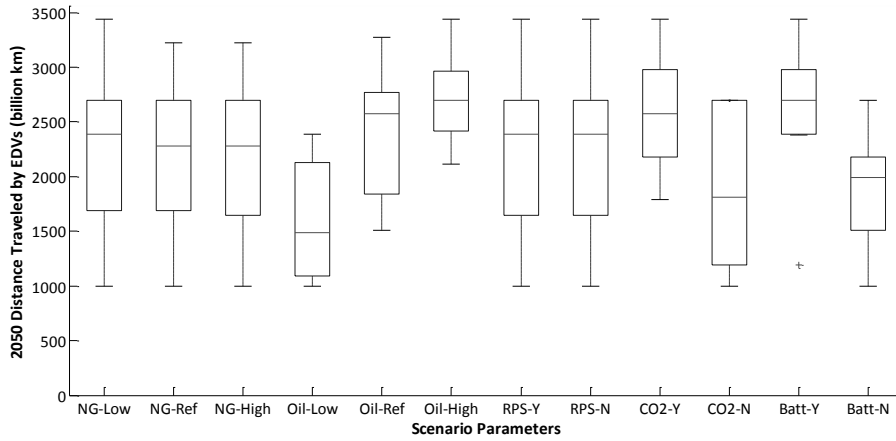
Examined all possible combinations of factor assumptions, resulting in 72 scenarios

Factor	Assumption 1	Assumption 2	Assumption 3
Natural gas price	Reference	Low	High
Crude oil price	Reference	Low	High
Federal CO ₂ cap	No	Yes	
Federal RPS	No	Yes	
Battery development	Reference	Optimistic	

Technology Deployment in Two Extreme Scenarios

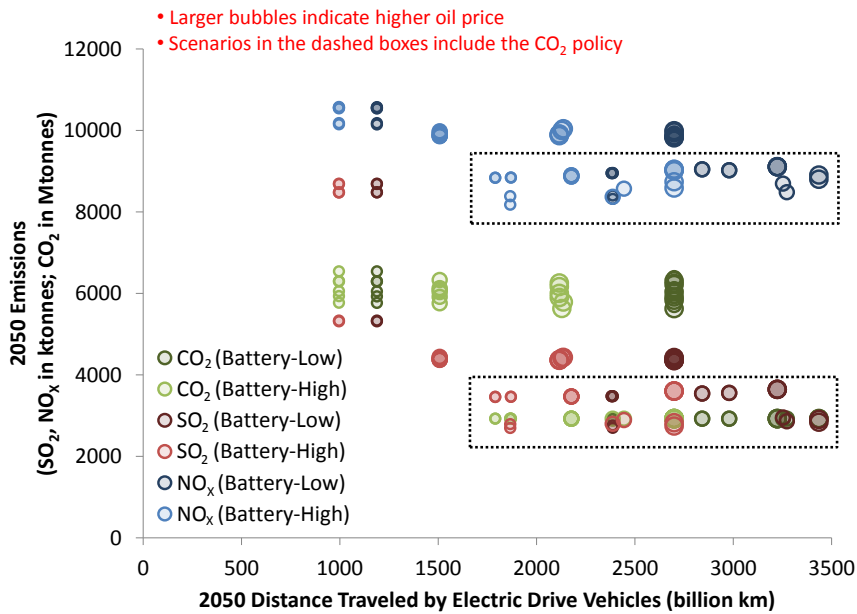


Effect of Scenario Drivers on EDV Deployment



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Effect of EDV Deployment on Emissions



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Modeling Insights

- High oil prices, the CO₂ policy, and low EDV battery costs are the strongest drivers of EDV deployment.
- The model consistently chooses to deploy PHEV60s and EV160s over other EDVs (contingent on battery cost reductions).
- EDV deployment produces only a small effect on system-wide CO₂, SO₂, and NO_x emissions.
- The strongest driver of lower emissions overall is the CO₂ policy.

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Next Steps

- Investigate the use of behavioral hurdle rates; update and resubmit current analysis for publication
- Determine the effect of charging time on EDV deployment and emissions
- Conduct a broader sensitivity analysis to determine the effects of key input parameters on outputs of interest

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Questions and Comments ...?