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Transportation Energy Pathways

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The Transportation Energy Model's differentiating capability is **parametric analysis**

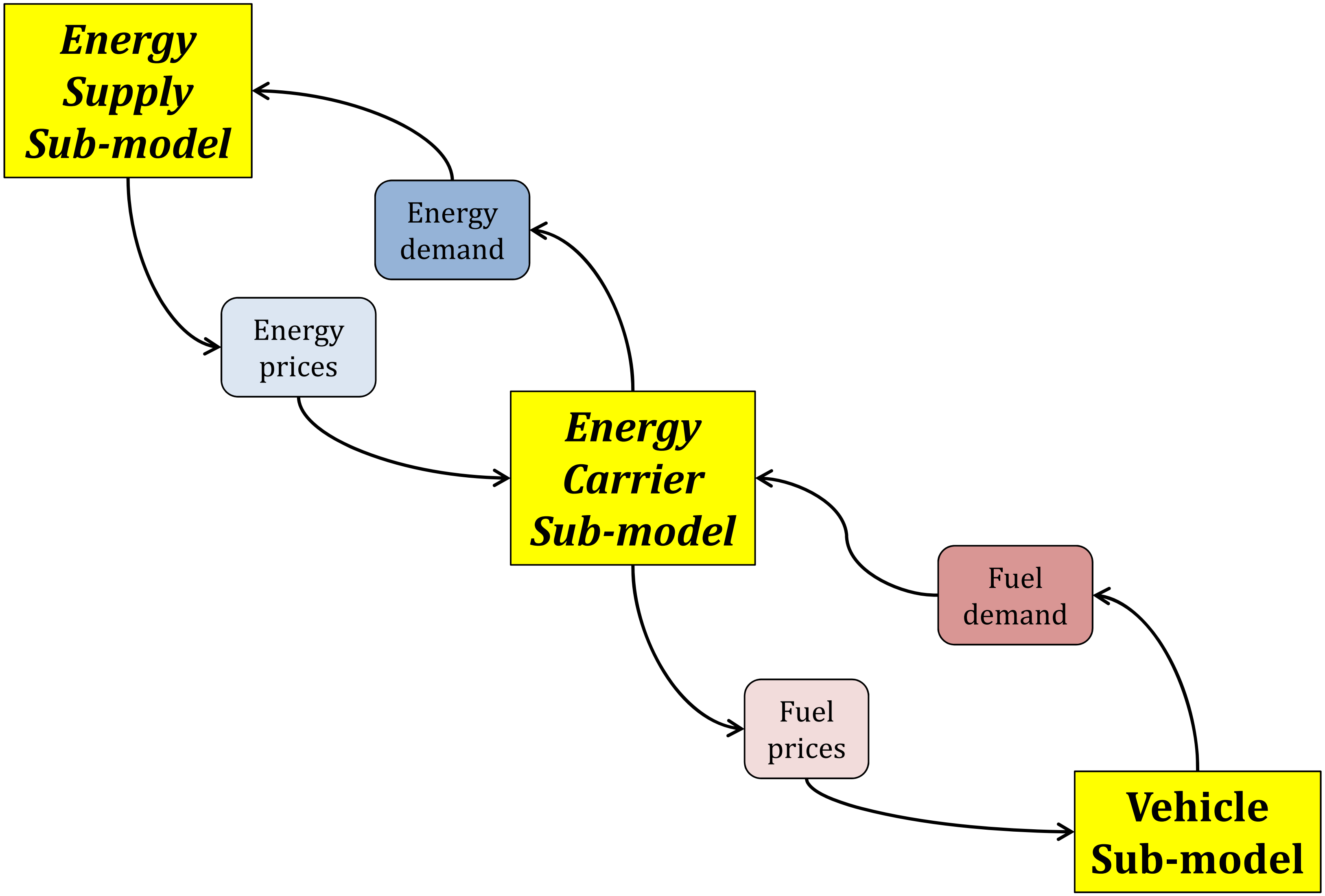
- Other performers/models (ORNL, EPA, ANL) are hypothetical scenario-focused

- The Transportation Pathways Model does more than just hypothetical scenarios; **parametric analyses** allow for:
  - Tradeoffs between concepts such as technology and market incentives
  - Sensitivity analyses of market, technology and model uncertainty

- Model the **dynamics and competition** in the transportation sector using **regional-level** feedback loops from vehicle use to energy source

- **Guide research and investment decisions** by simulating which technology improvements or market incentives have the greatest impact on transportation energy

The high-level model diagram depicts the feedback loop of energy supply<-->energy carrier<-->vehicle



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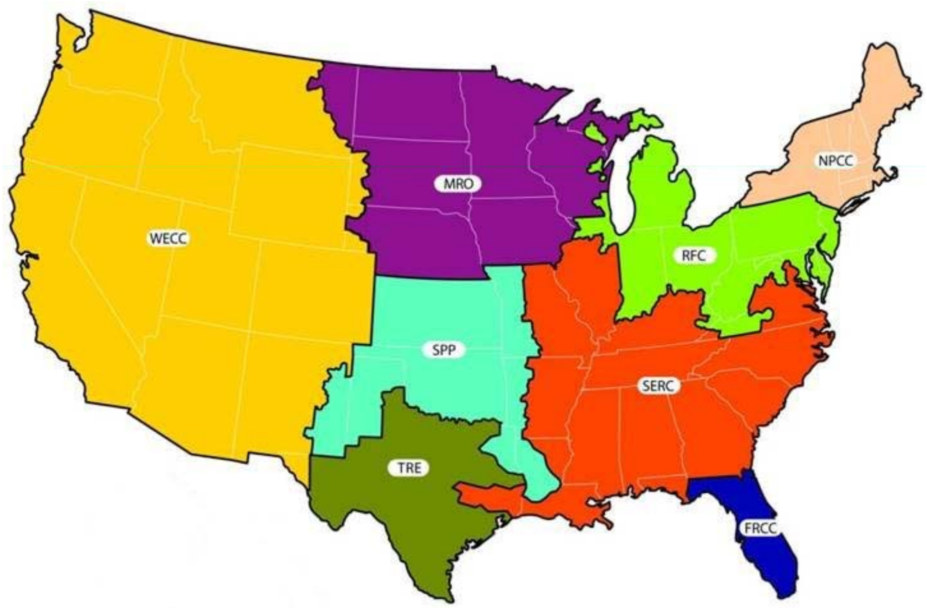
Energy supplies, fuels, and vehicle mixes vary by region

- Model currently divided into the North American Electric Reliability Corporation (NERC) regions
  - Variations in electricity generation mix are important to capture

Regional variations:

- Vehicles
  - Numbers, classes, drive-train mixes
- Driver demographics
  - VMT intensity, urban-suburban-rural divisions, infrastructure development
- Fuels
  - Costs, electricity generation mix
- Energy supply curves (as appropriate)
  - Biomass



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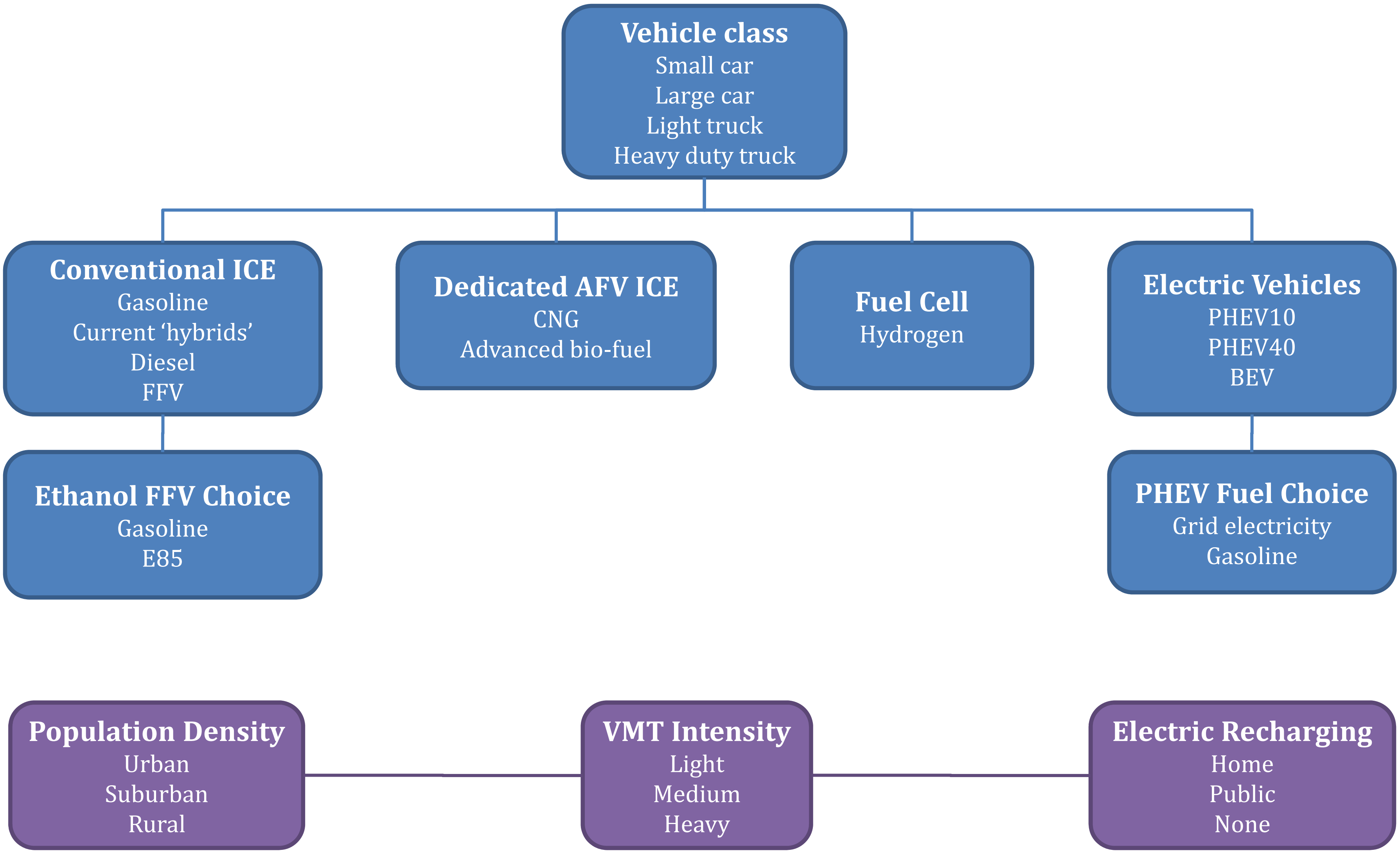
Model structure includes a range of descriptive parameters for vehicles, fuels, and driver



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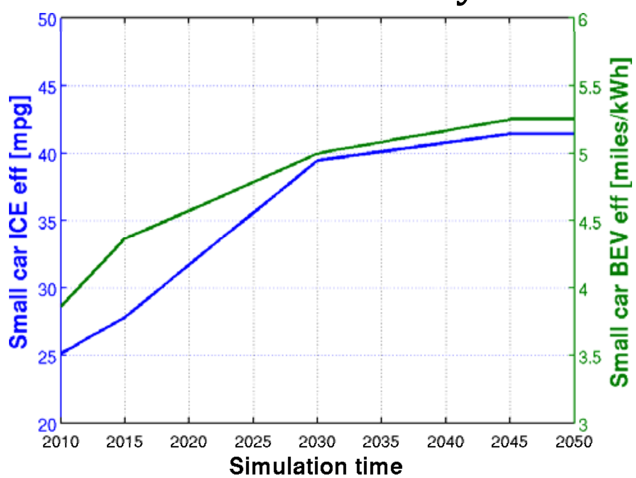
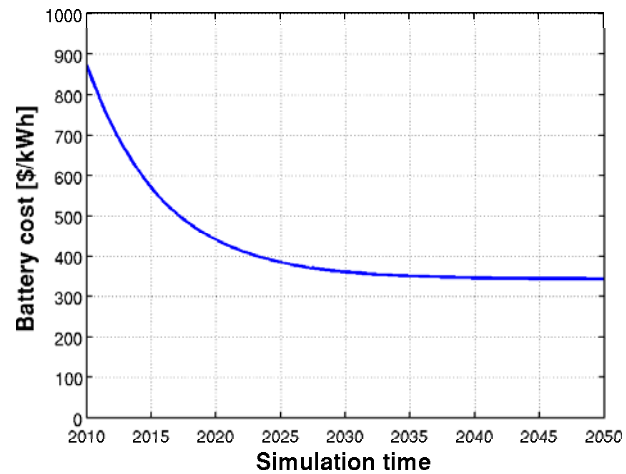
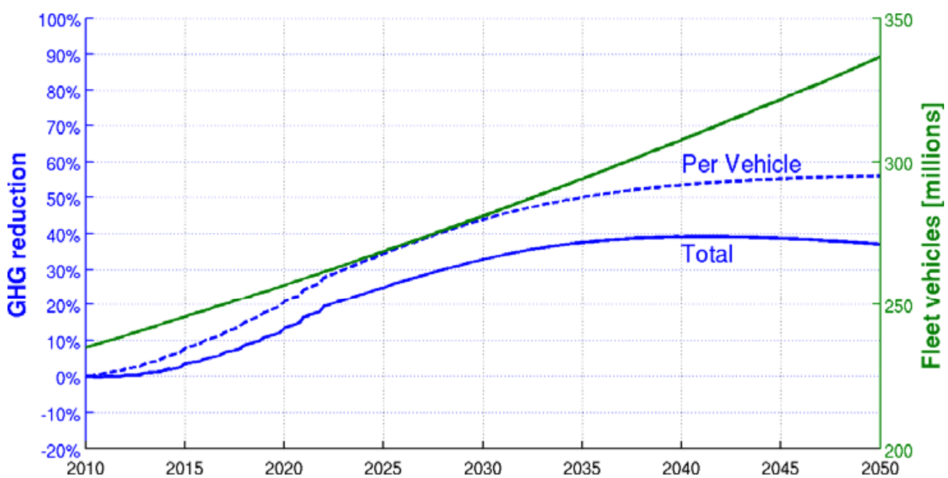
Model baseline

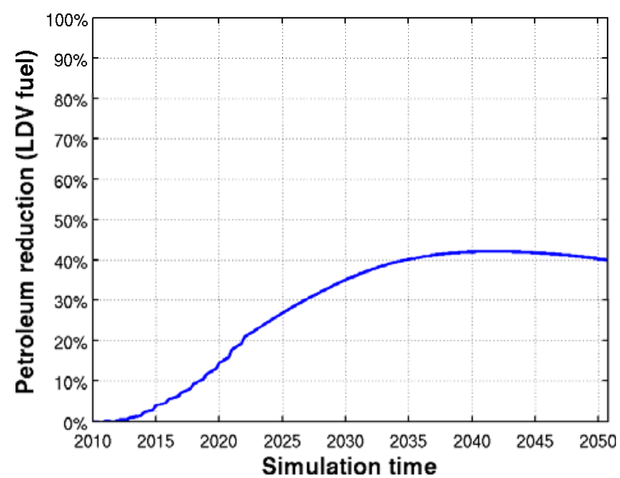
- Consumers are “mostly” rational, cost-based deciders
- Range and recharging infrastructure penalties applied to BEVs only
- Electric grid energy sources do not change over time
- Efficiencies and battery cost change over time





- Significant reduction in GHG emissions and LDV petroleum demand from 2010 to 2050





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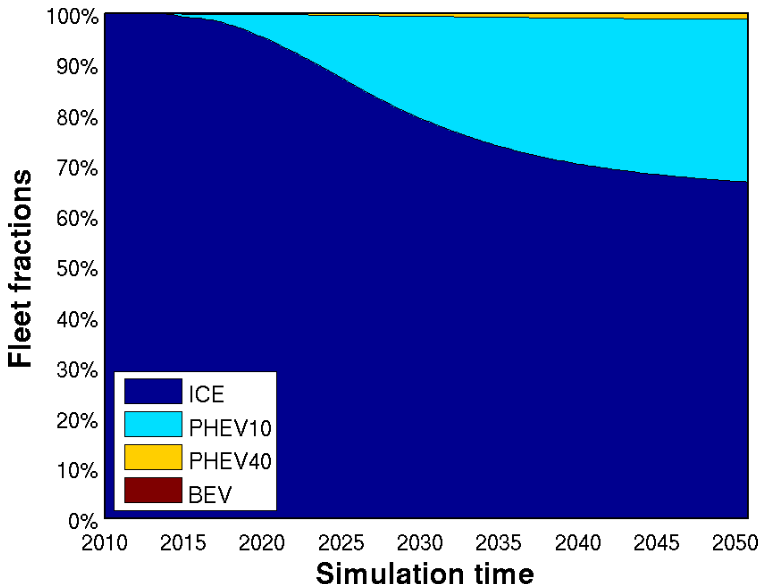
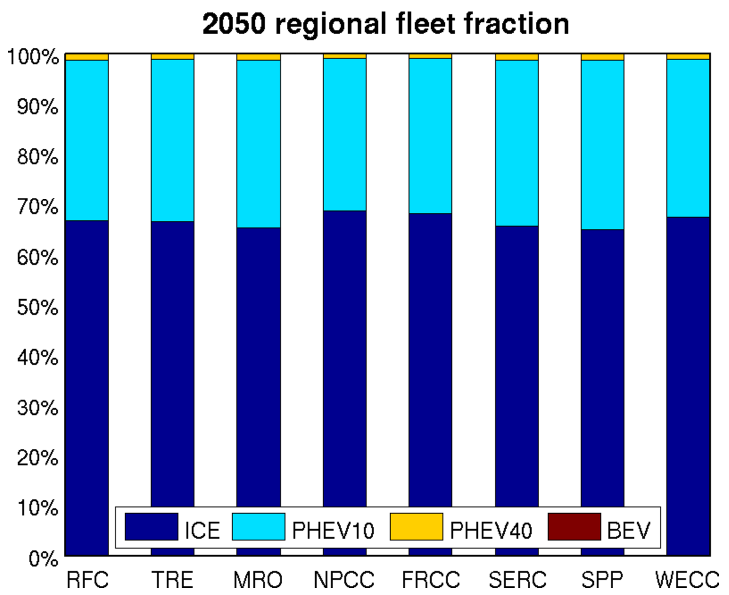
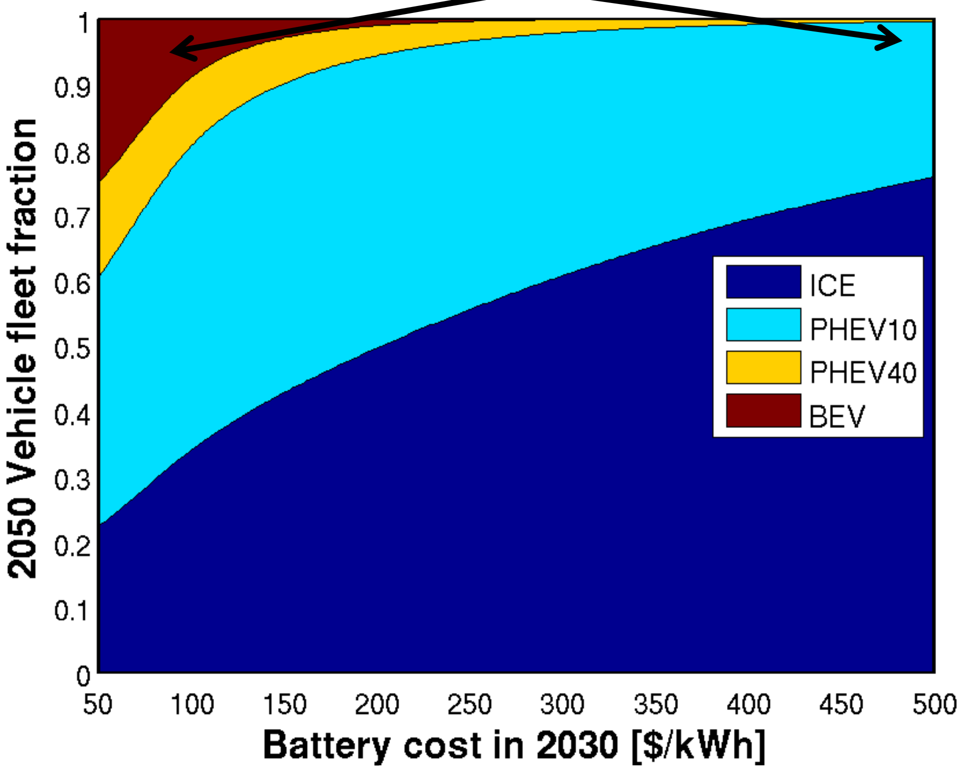
Outputs (ex: fleet fractions) can be examined over simulation time, by region, and also through parametric variation





Model verification: When batteries are cheap, the fleet consists of more EVs than when they are expensive



'*Battery cost in 2030*' captures the pace of battery technology development

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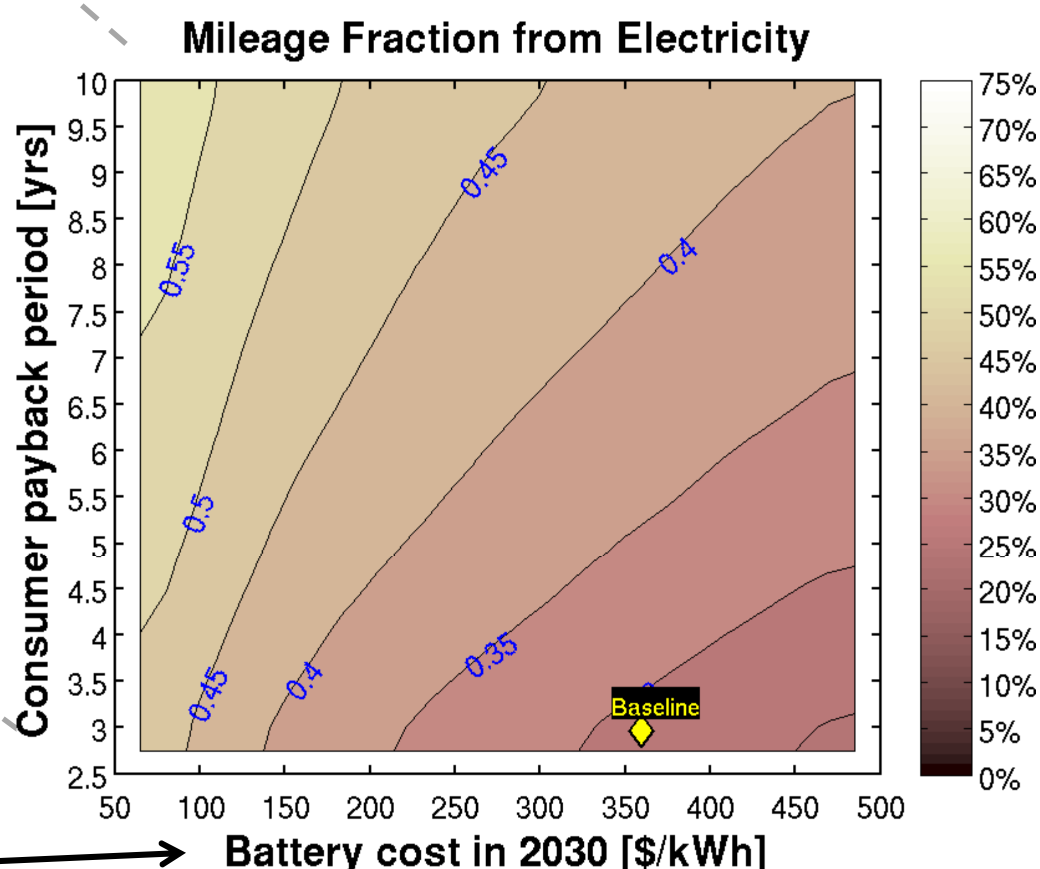
Trade space is sampled hundreds of times to understand iso-performance tradeoffs

Parameter space is sampled 1000 times to explore tradeoffs

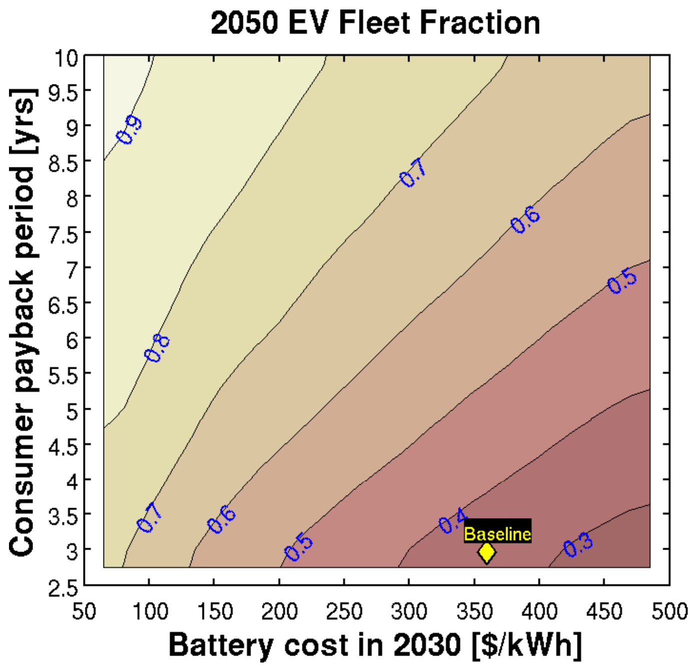
*How much **grid-supplied electricity** contributed to total miles traveled?*



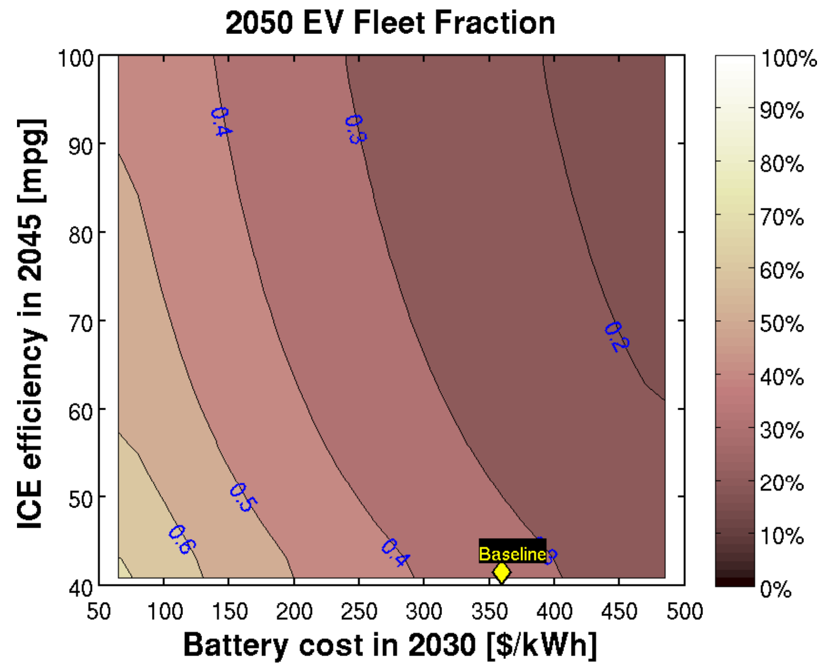
Tradeoff between technology investment and market incentives

Buying incentives or consumer education can nearly double EV adoption rates, even in the case of expensive batteries

Extending the consumer perceived payback period alone to 10 years can double the number of EVs



If batteries are more expensive than projections, then EV penetration will be limited



Improving ICE efficiency does not dramatically harm EV adoption rates because PHEVs benefit as well

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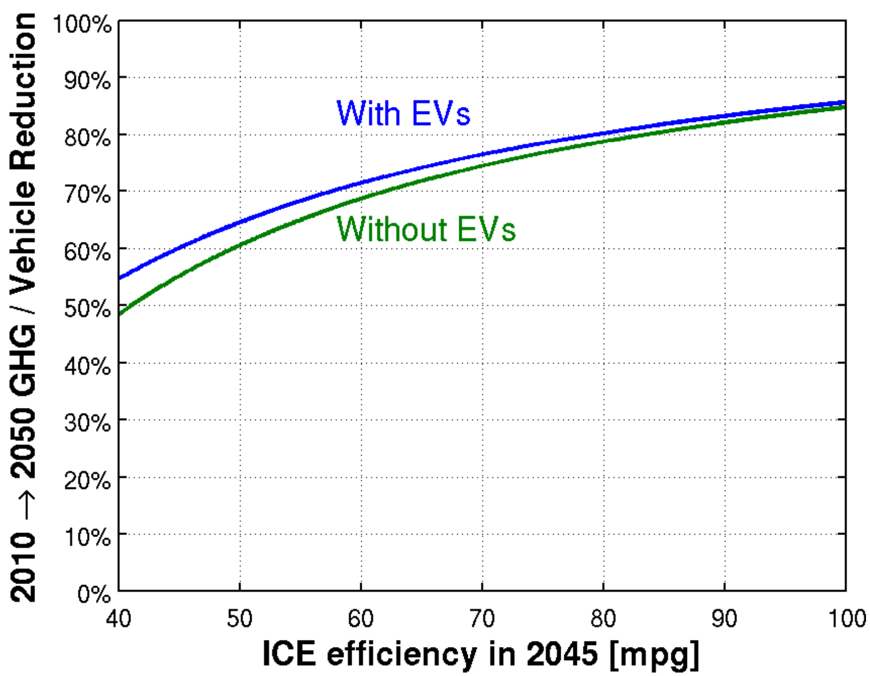
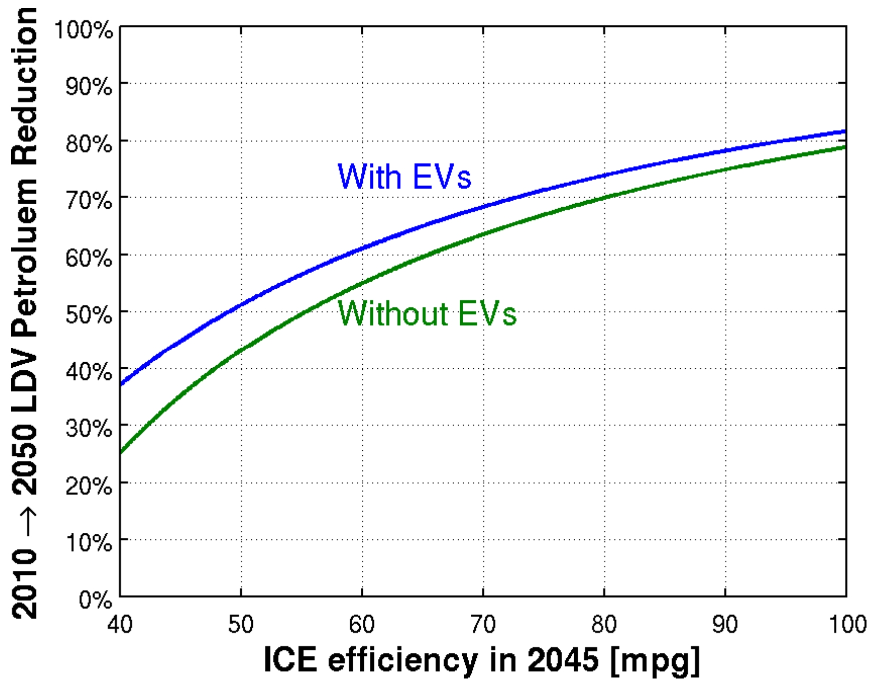
Are EV market targets a worthy means to an end (for environmental and security goals)?

- By turning EVs *on* or *off* in the model, can evaluate what their overall contribution is to meeting environmental and security energy goals.



EVs have minimal impact on GHG/vehicle reduction due to carbon-based electricity power sources



EVs can reduce petroleum demand by ~10% over 2010 levels

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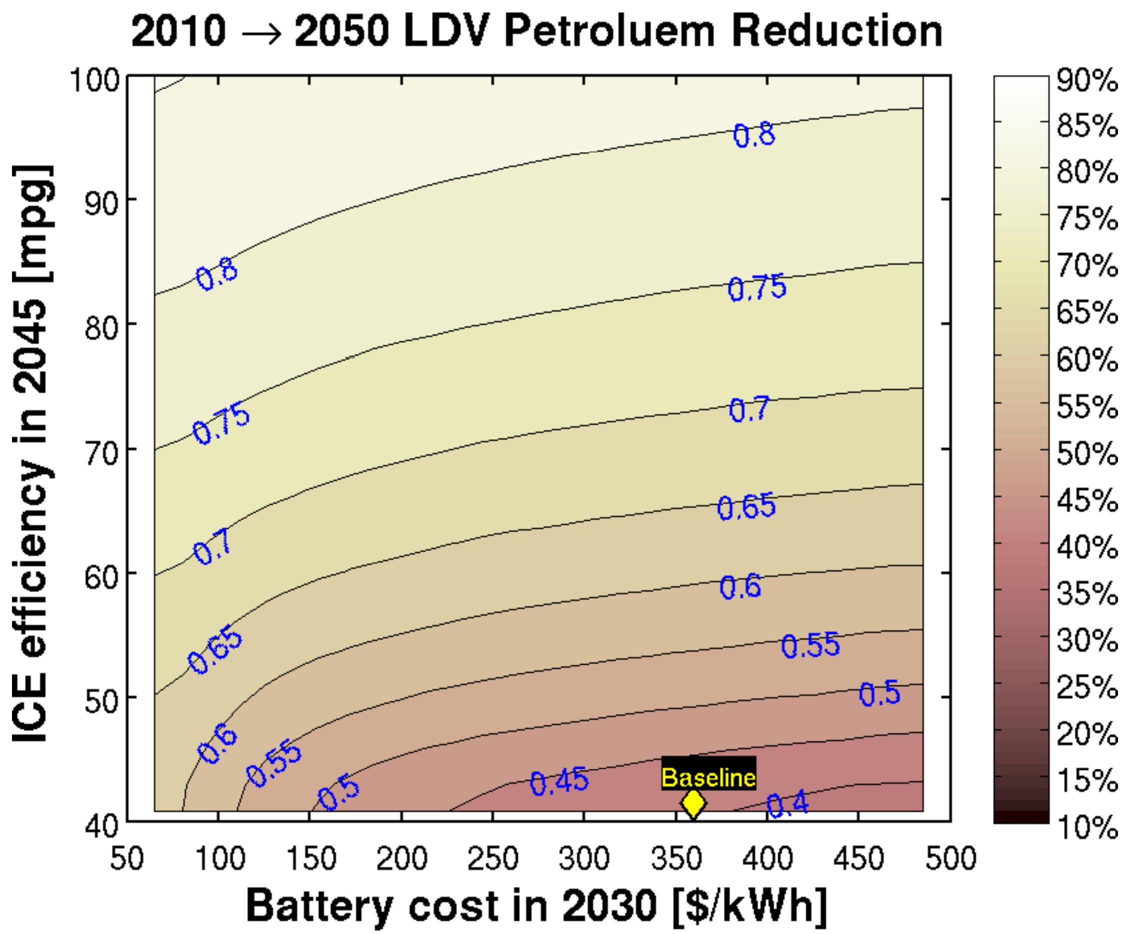
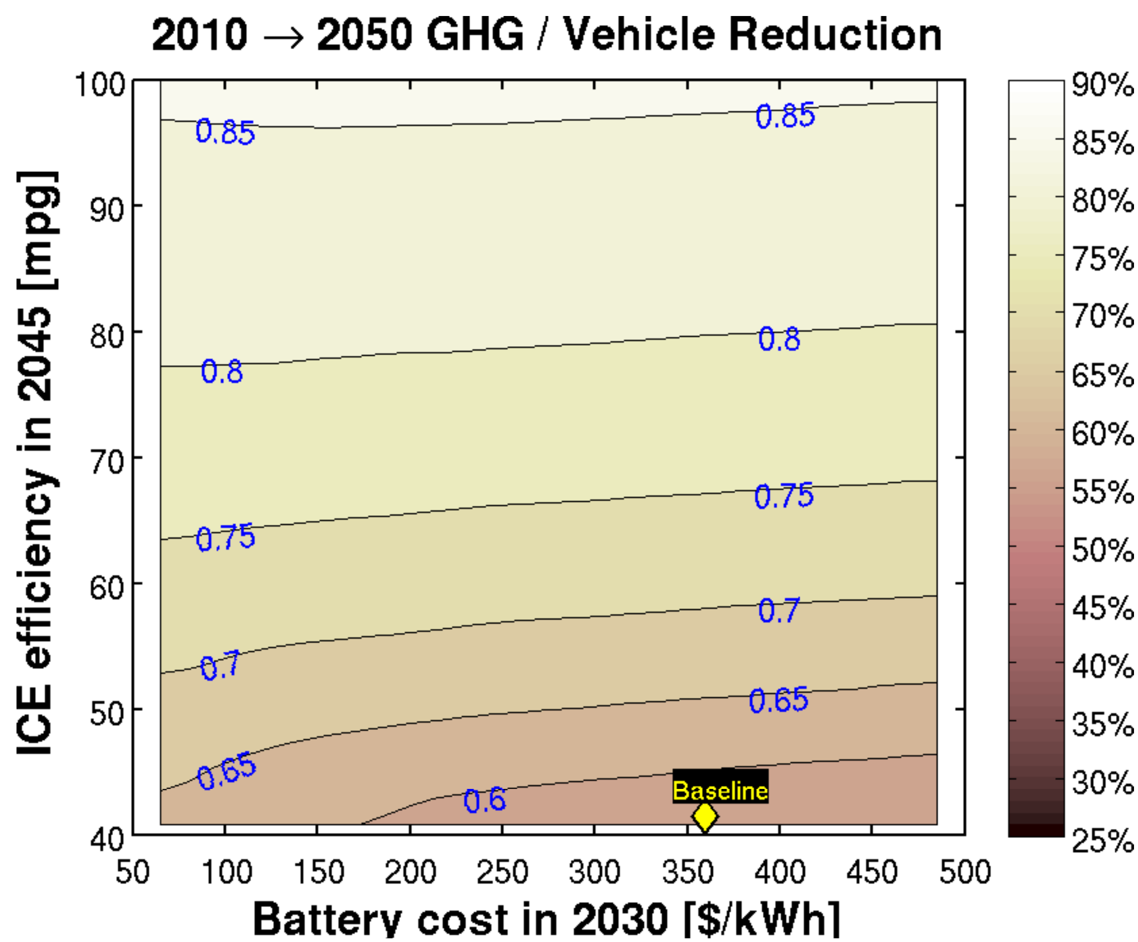
If ICEs do not improve beyond CAFE guidelines then alternative technologies, like batteries, become key to meeting petroleum reduction targets



Cheap batteries can more significantly reduce LDV petroleum demand when ICE efficiency is poor

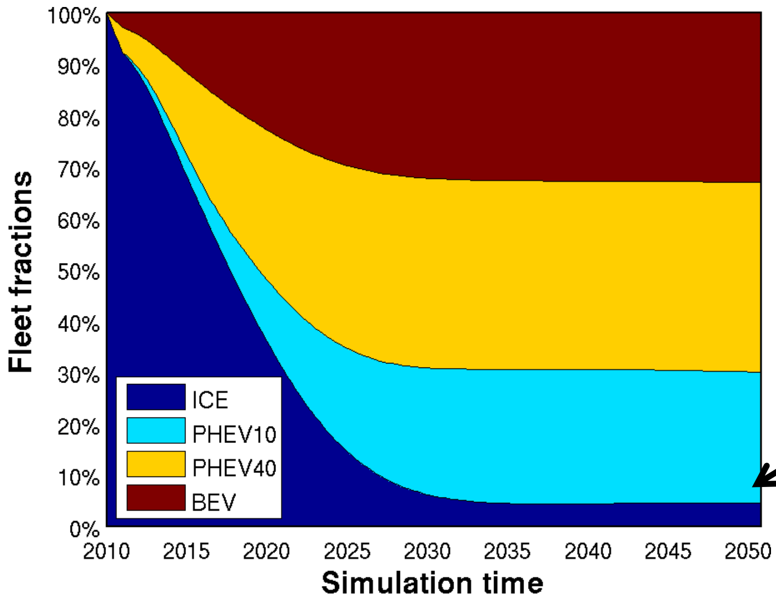
ICE improvements well-beyond CAFE guidelines can meet most aggressive GHG per vehicle reduction targets (>80%) in 2050

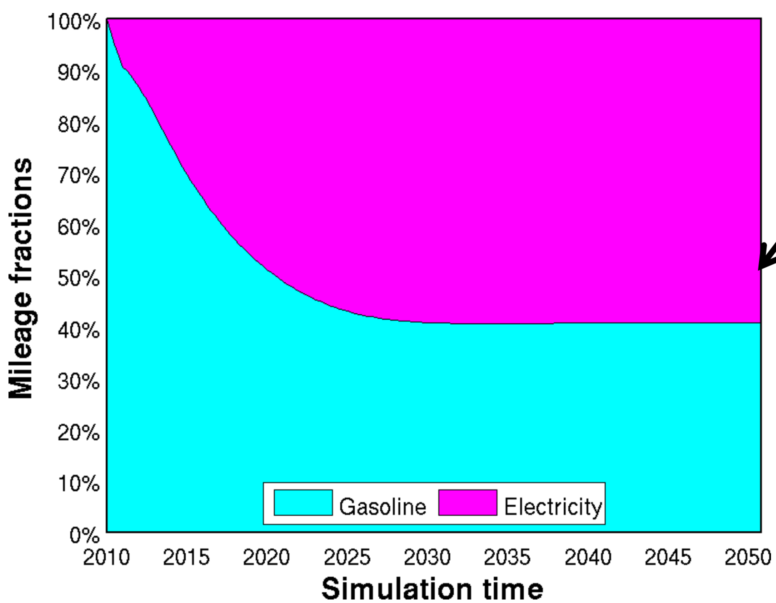
Key Assumption: Energy sources for the electricity generation that feed the EVs do NOT change



Battery cost modestly impacts GHG emissions because of limited fleet penetration and carbon-based fuels for electricity generation

ICE efficiency improvements are important even under the most favorable conditions for EVs*



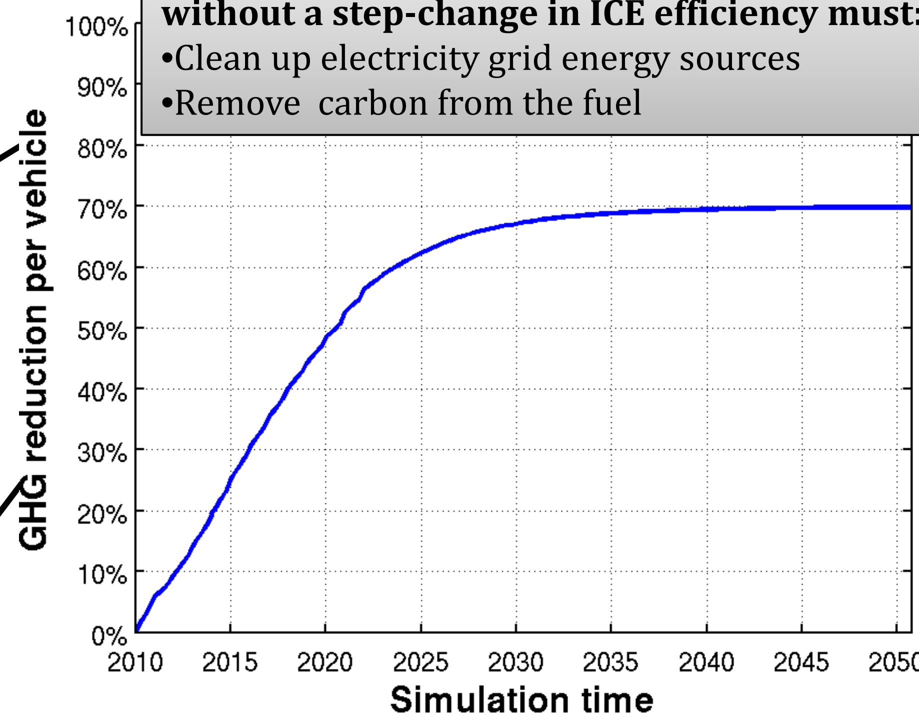


With only 5% ICEs in the fleet, much of the transportation energy still comes from gasoline due to the PHEVs

To achieve aggressive 80% GHG reduction targets without a step-change in ICE efficiency must:

•Clean up electricity grid energy sources

•Remove carbon from the fuel



**Favorable EV conditions include*

- *Free batteries*
- *No range or recharging cost penalties*
- *High vehicle turnover rate*

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