



Modeling Range & Infrastructure Limitations for BEVs

Sandia National Laboratories and Ford Motor Company
Garrett E. Barter, Michael A. Tamor, Dawn K. Manley, Todd H. West
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Motivation

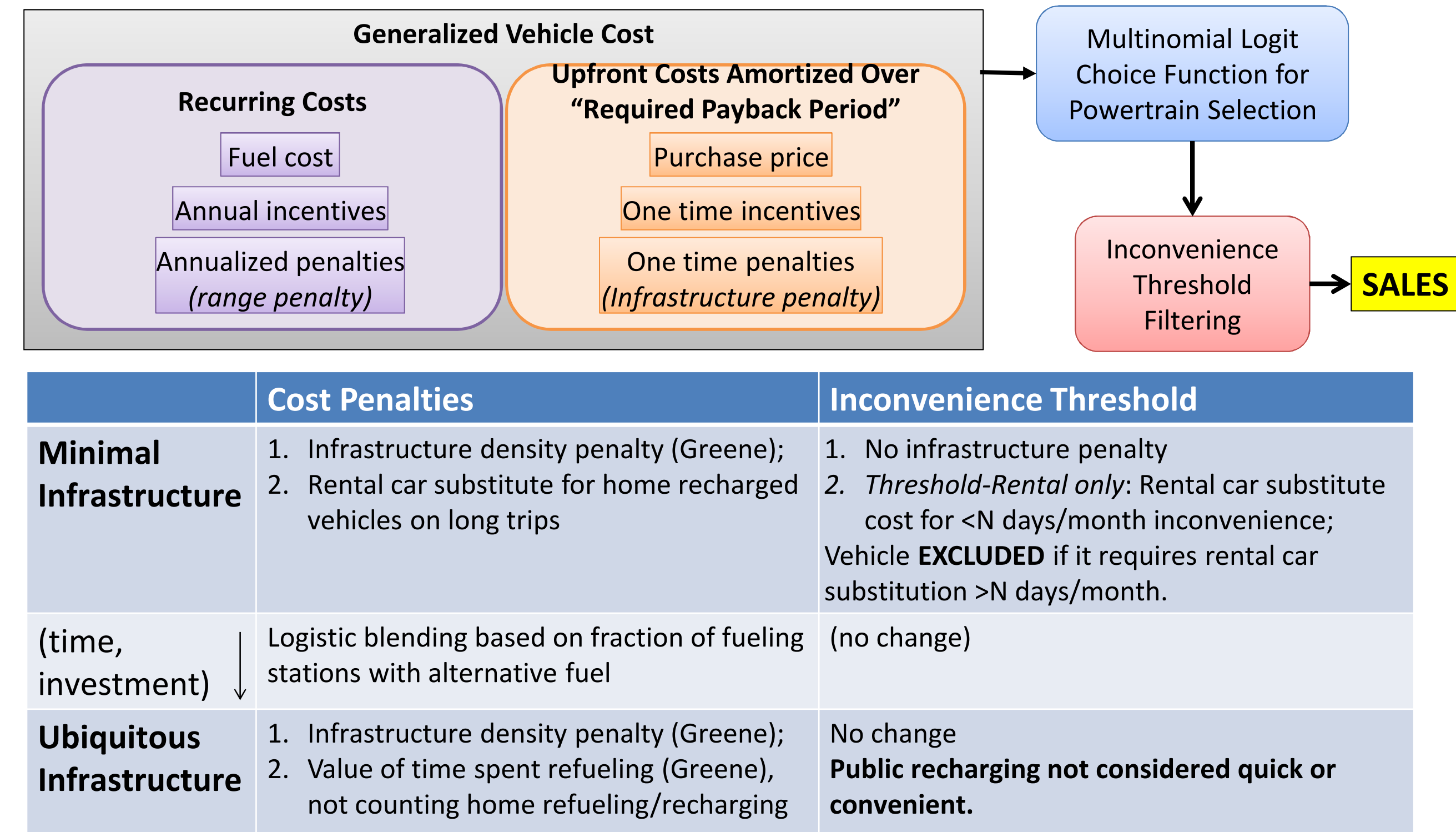
- New AFV powertrains can have performance limitations (i.e. range) and/or refueling infrastructure limitations that are difficult to capture in a consumer adoption model
- Two General approaches to capturing these factors:
 - Penalty approach:** Calculate an additional cost to consumers representing reduced utility, lost opportunity cost of frequently refueling, rental substitution, or other forms of loss.
 - Threshold perspective:** Consumers categorically exclude powertrains that are too inconvenient to operate. There is a threshold of tolerance for days of inconvenience per month or year
- Which approach taken can have impact on analysis results and influence decision makers devising means to encourage adoption of AFVs

Objectives

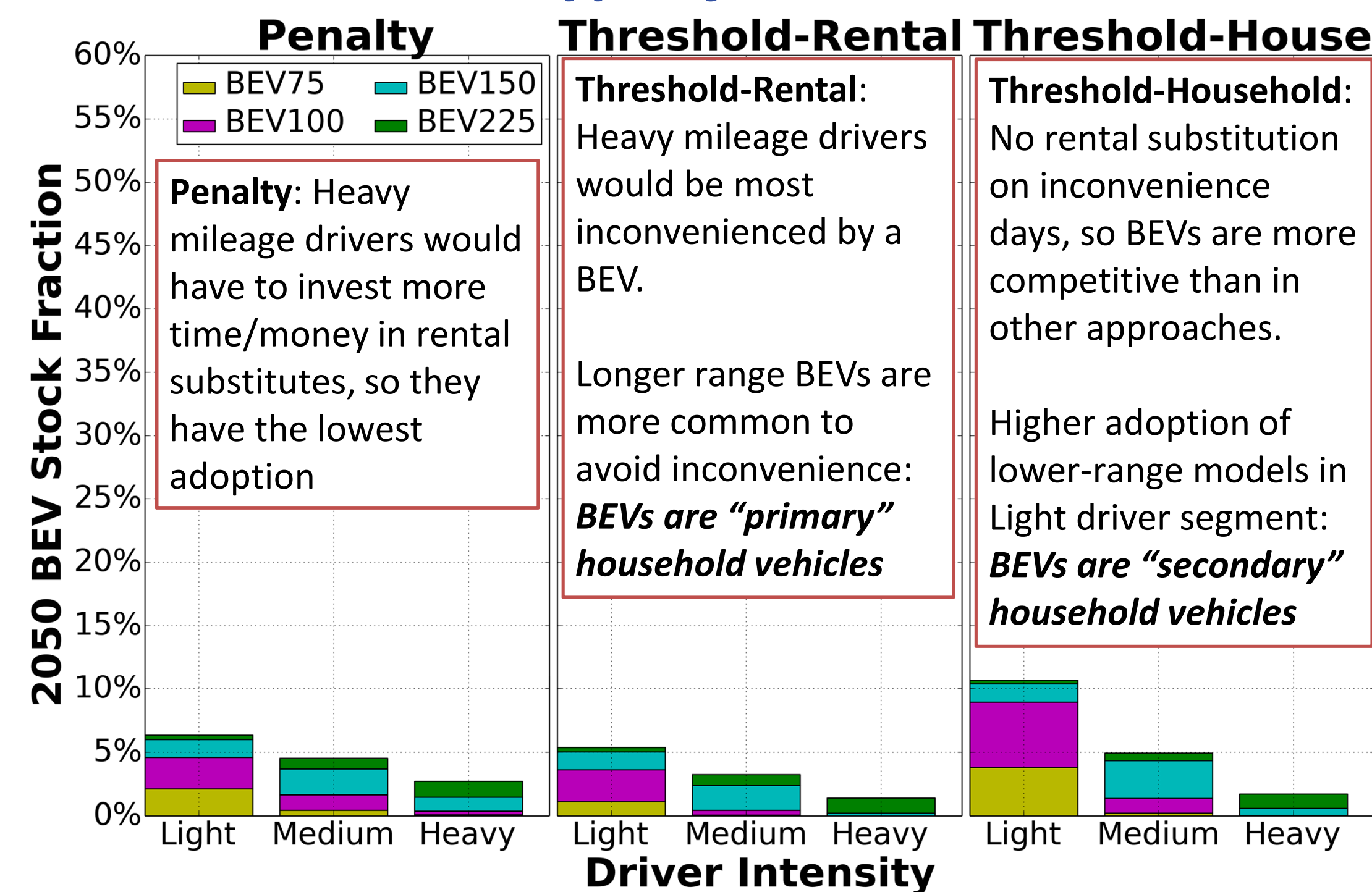
This study compares BEV market share under different perspectives of range and infrastructure limitations

- Three different approaches to BEV limitation modeling:
 - A detailed model of cost penalties is implemented as an option in the model
 - Another model option is the use of hard inconvenience thresholds that excludes powertrains from consideration. A rental car must be used on inconvenienced days.
 - A third option uses hard inconvenience threshold, but assumes that an alternative vehicle is available (trading cars within a household) for the inconvenienced days.
- Actual driving data is acquired to establish daily driving (trip chain) distributions
- Analysis assumes that current driving habits are good predictors of future driving habits, even with a completely different powertrain vehicle

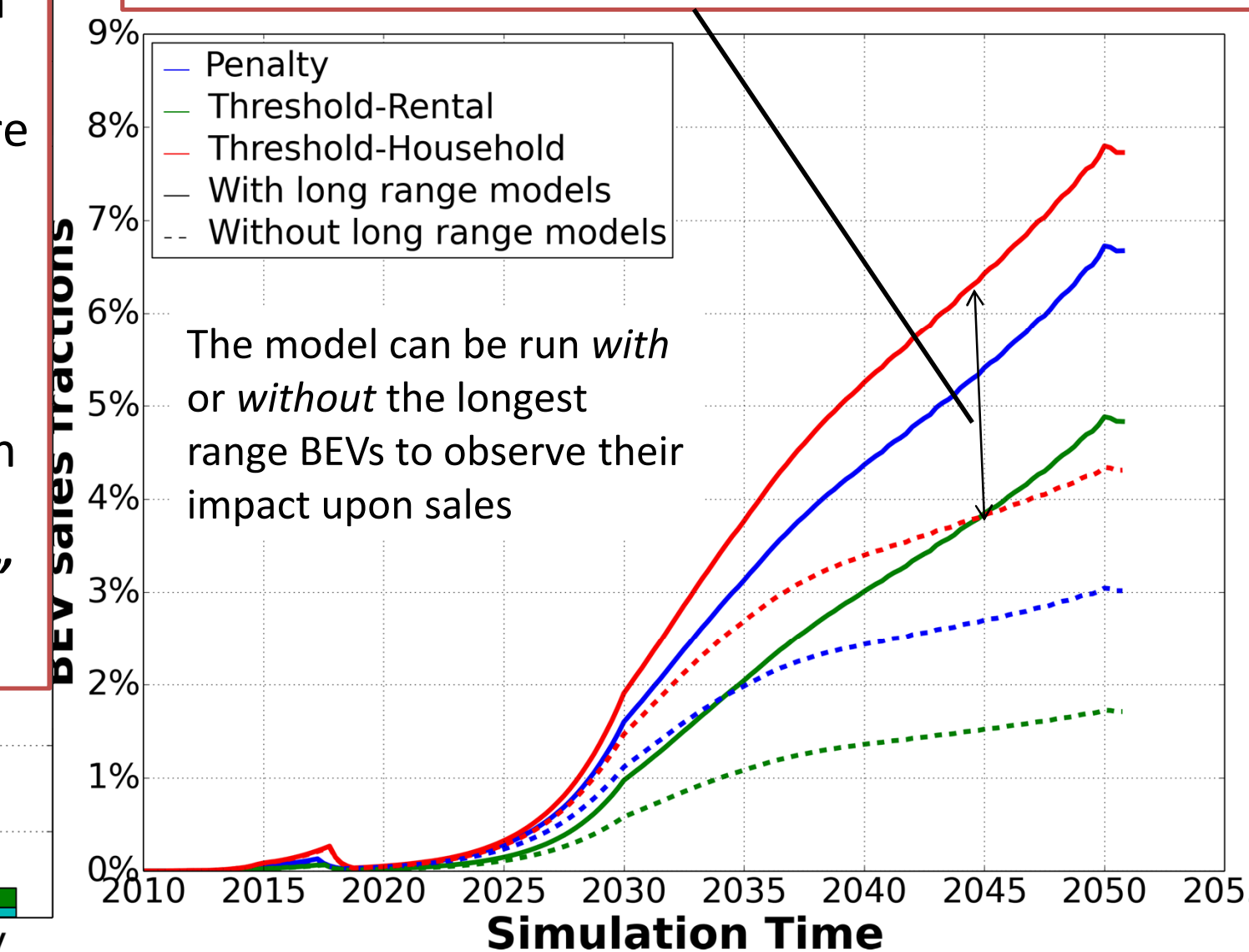
Approach



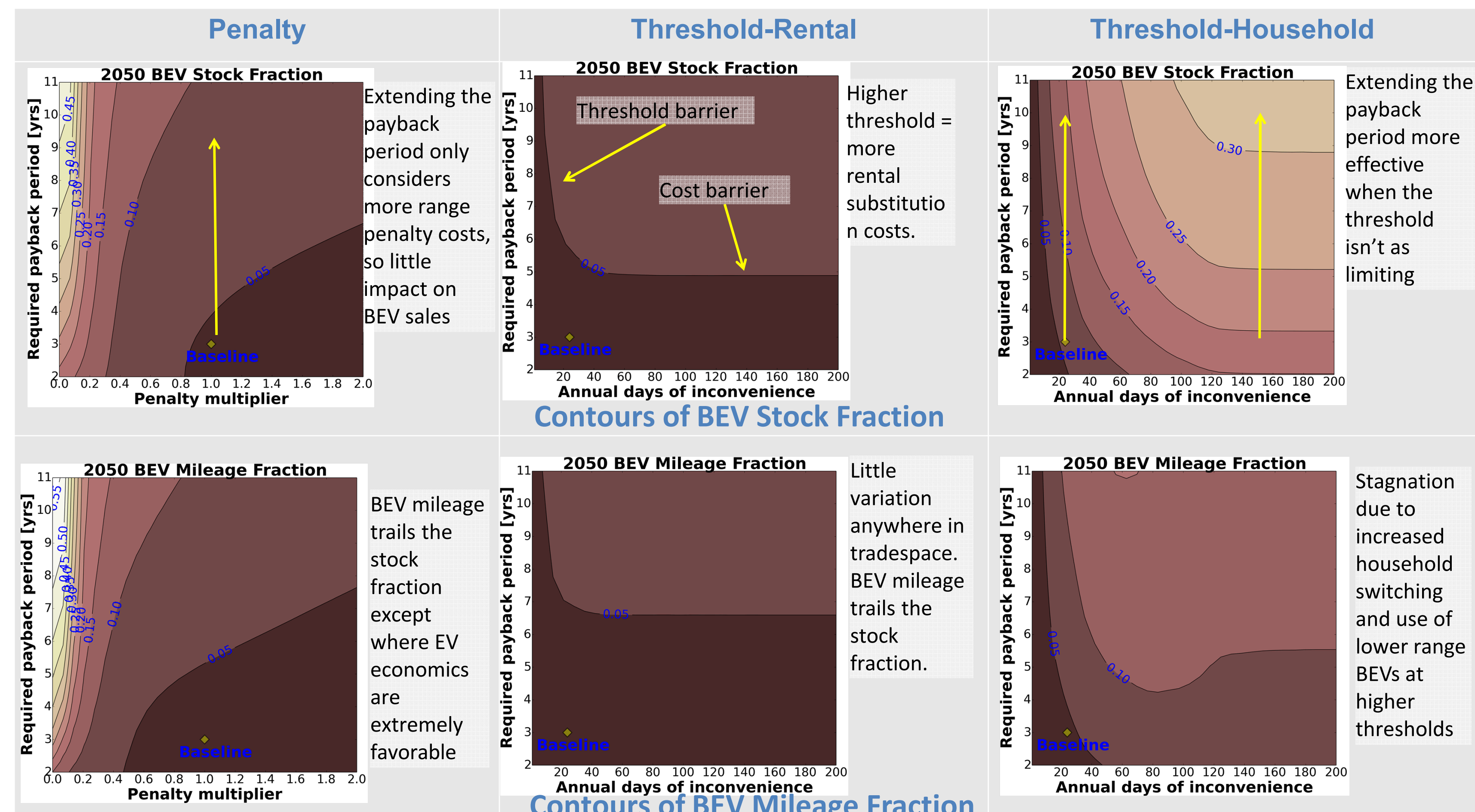
Who drives what type of BEV?



The 150mi and 225mi BEVs are responsible for 40-60% of BEV sales in all modeling approaches



What are the sensitivities to the penalty and threshold values?

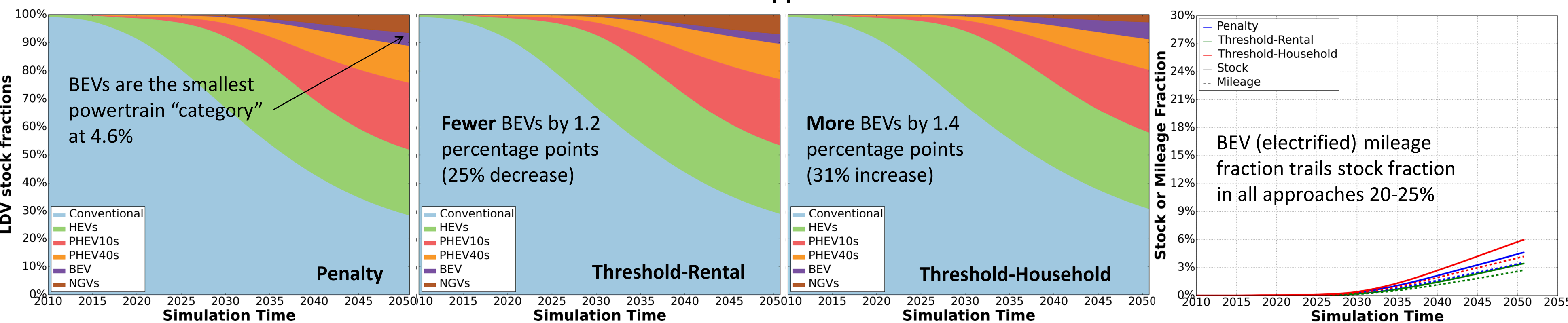


Key Conclusions

- Under baseline assumptions, BEV powertrains are only expected to be ~5% of the LDV vehicle stock in 2050, regardless of penalty/threshold perspective
 - Under some extreme parameter values, the Penalty approach can yield unrealistic results (i.e. consumers in apartment buildings buying BEVs)
- Longer range BEVs may play role as *primary* household vehicle while shorter range BEVs are *secondary* household vehicles.
- The policy levers that could be applied to promote BEVs would be different for the different perspectives
 - Penalty: Financial incentives and public infrastructure investment are most effective
 - Threshold: Incentives help, but have to introduce longer range BEVs (like the Tesla)
- Technology investment to reduce battery costs are not enough- investments must address the non-cost barriers to BEV adoption
 - Allowing for household-switching of vehicles to avoid BEV limitations can have a significant impact on expected adoption rates
 - Introducing 200-300 mile range BEVs doubles sales projections
 - Extended range BEV technology (BEVx) is projected to be successful by this analysis
- BEV mileage fraction consistently trailed stock fraction in all results.
 - Replacing a gasoline vehicle with a BEV does not reduce GHGs as much as one might think

Analysis: How many BEVs are on the road and how much are they used?

Baseline Stock Fraction Results for all 3 Approaches



BEVs generally suffer both from being **expensive vehicles** in their own right and the **additional range/infrastructure limitations** imposed upon them in a choice model.

Fraction of all LDV miles traveled by BEVs trails stock fraction by 20-25% due to:

- Use of substitute rental or household vehicle for long range trips
- Likely skewed adoption towards Low and Medium intensity drivers