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Fuel Economy Potential of Advanced Configurations from 2010 to 2045

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Study Objectives

CAFÉ
Fuel Economy Standards

Baseline

Additional Improvements

Mandated by Congress

- What are the benefits of the FreedomCAR & Fuel Partnership in terms of petroleum displacement?
- How much additional petroleum could be displaced with additional funding?
- Assess technology potential to guide future research and development

Approach

Component & Vehicle Assumptions

Veh Classes

Timeframe

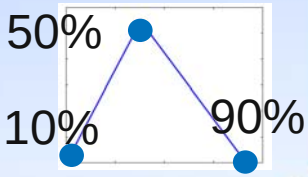
2010
2020
2030
2045

Powertrain

Fuels

Gasoline
Diesel
Ethanol
Hydrogen

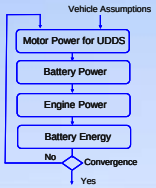
Uncertainties



Vehicle Definition & Simulation

Vehicle Technical Specifications

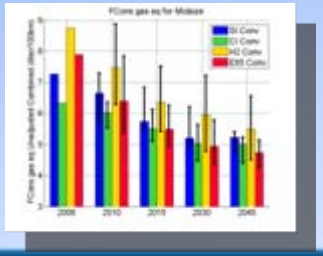
Sizing



Simulation

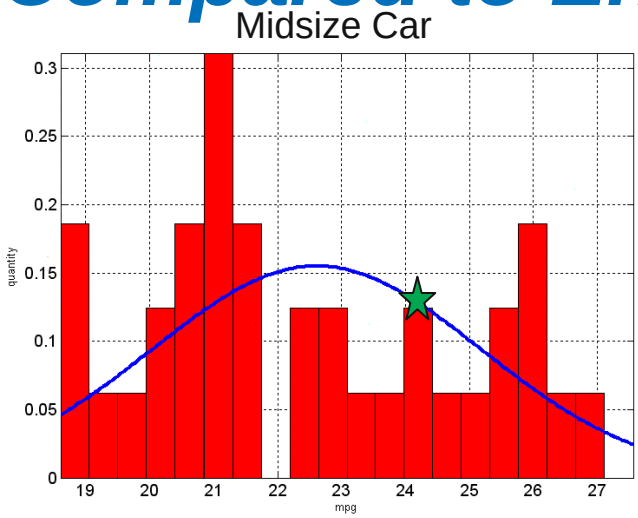
Results Analysis & Validation

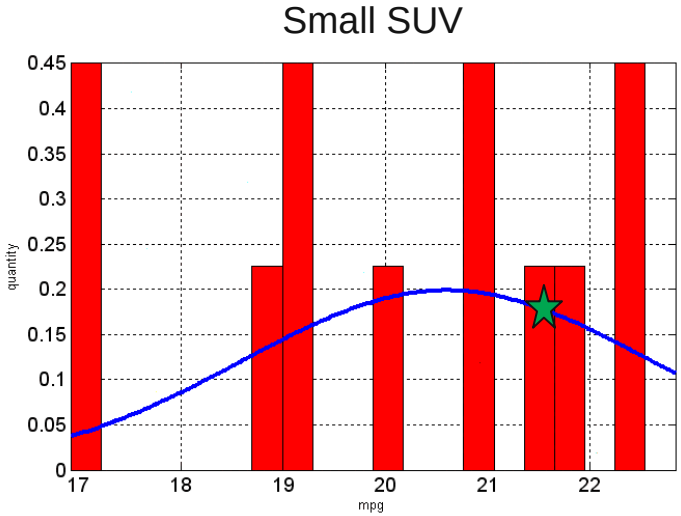
Results

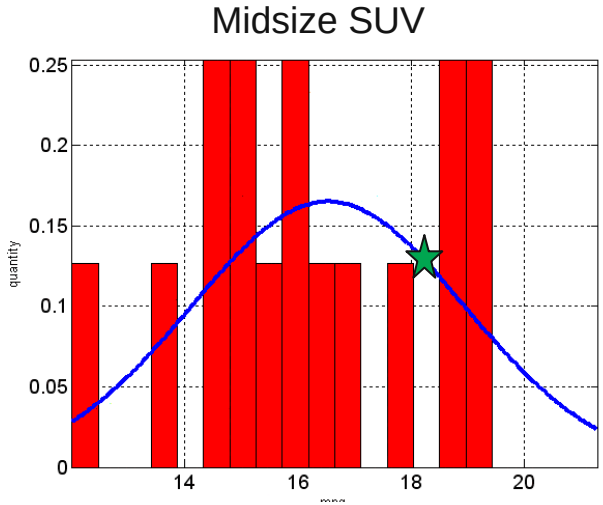


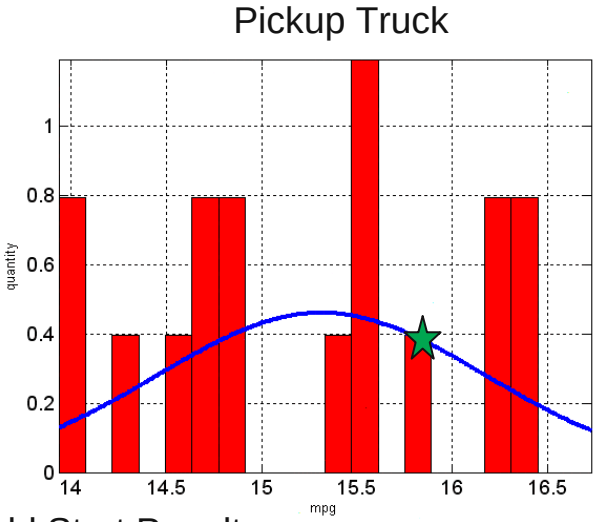
Validation

Reference Vehicles Fuel Economy Compared to Entire Class



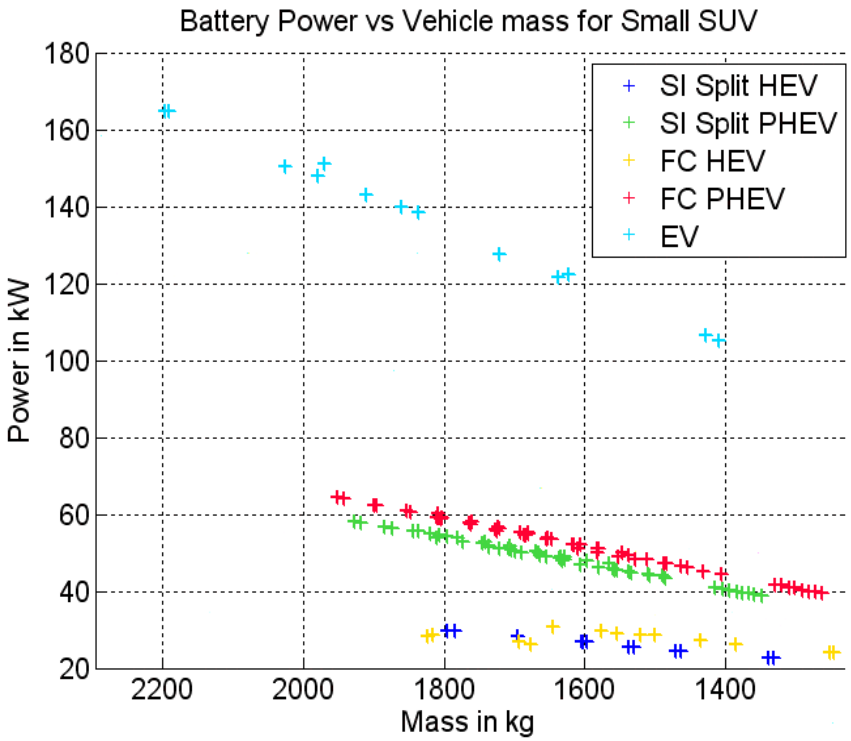


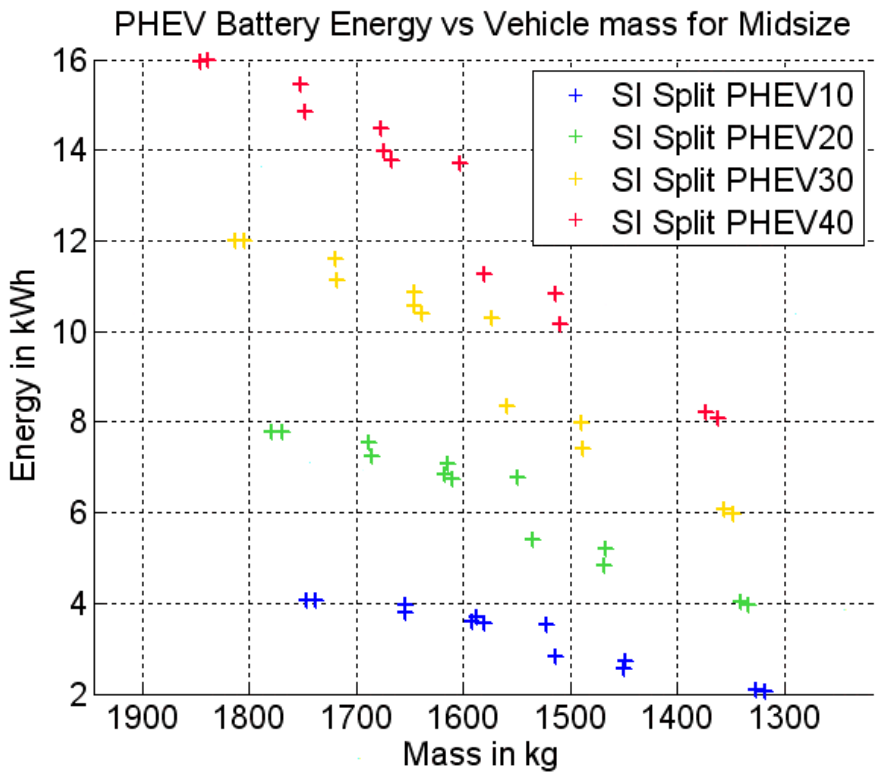




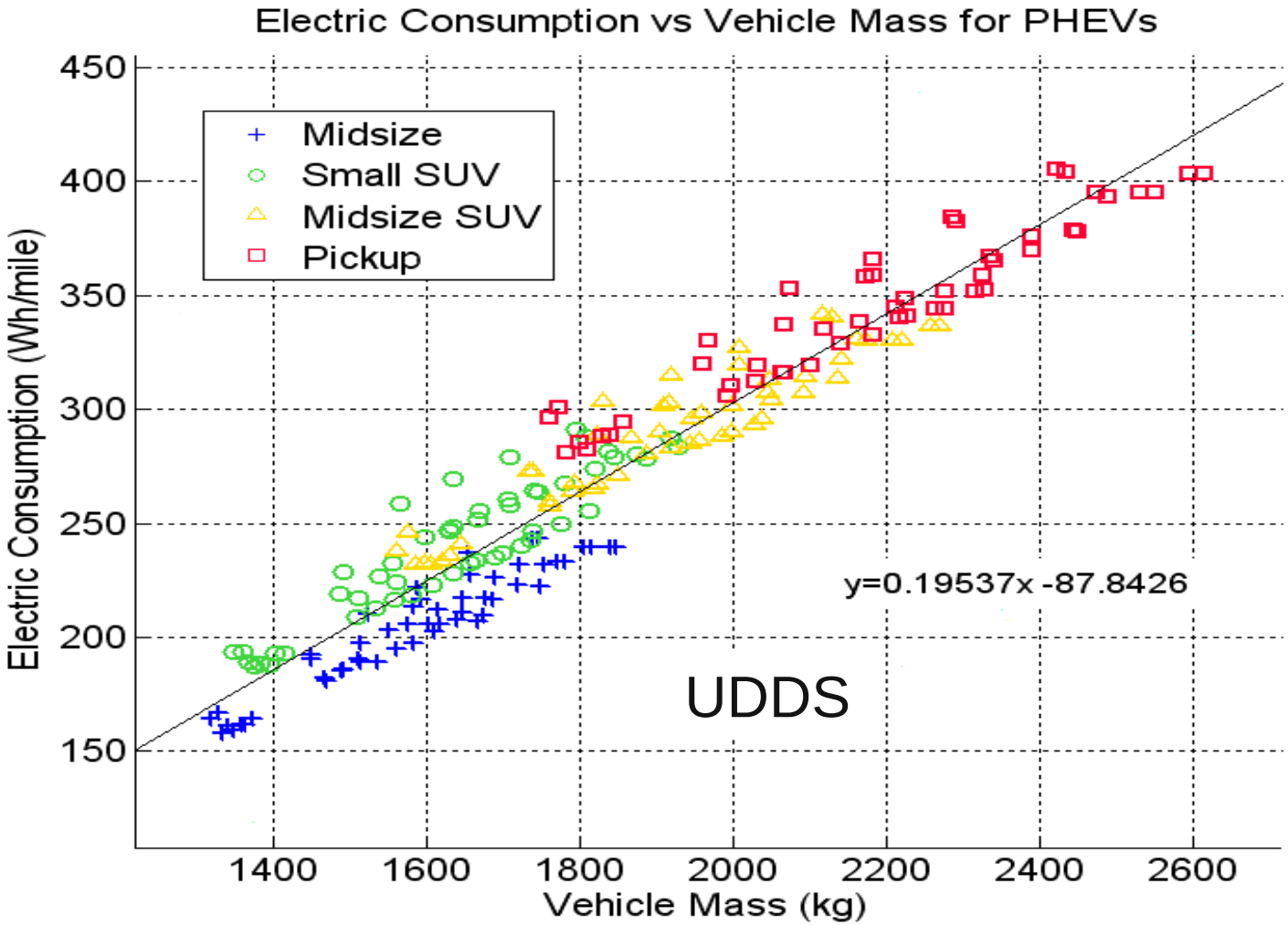
EPA 2008 Adjusted Values – Including Cold Start Penalty

Battery Power and Usable Energy Requirement as a Function of Vehicle Mass

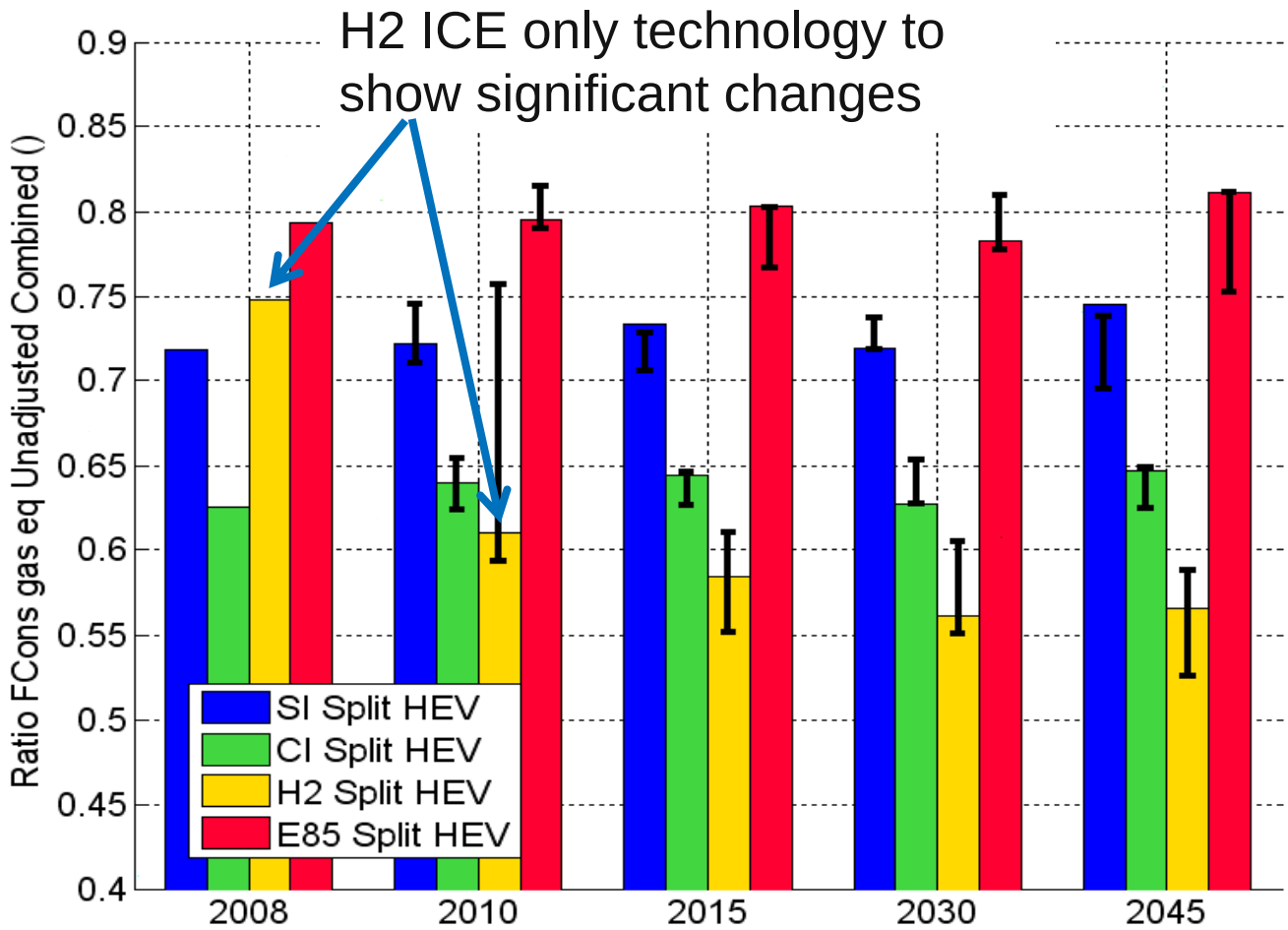




Vehicle Mass is a Major Factor Influencing Electric Consumption



HEVs Fuel Consumption Remains Fairly Constant Compared to Conventional



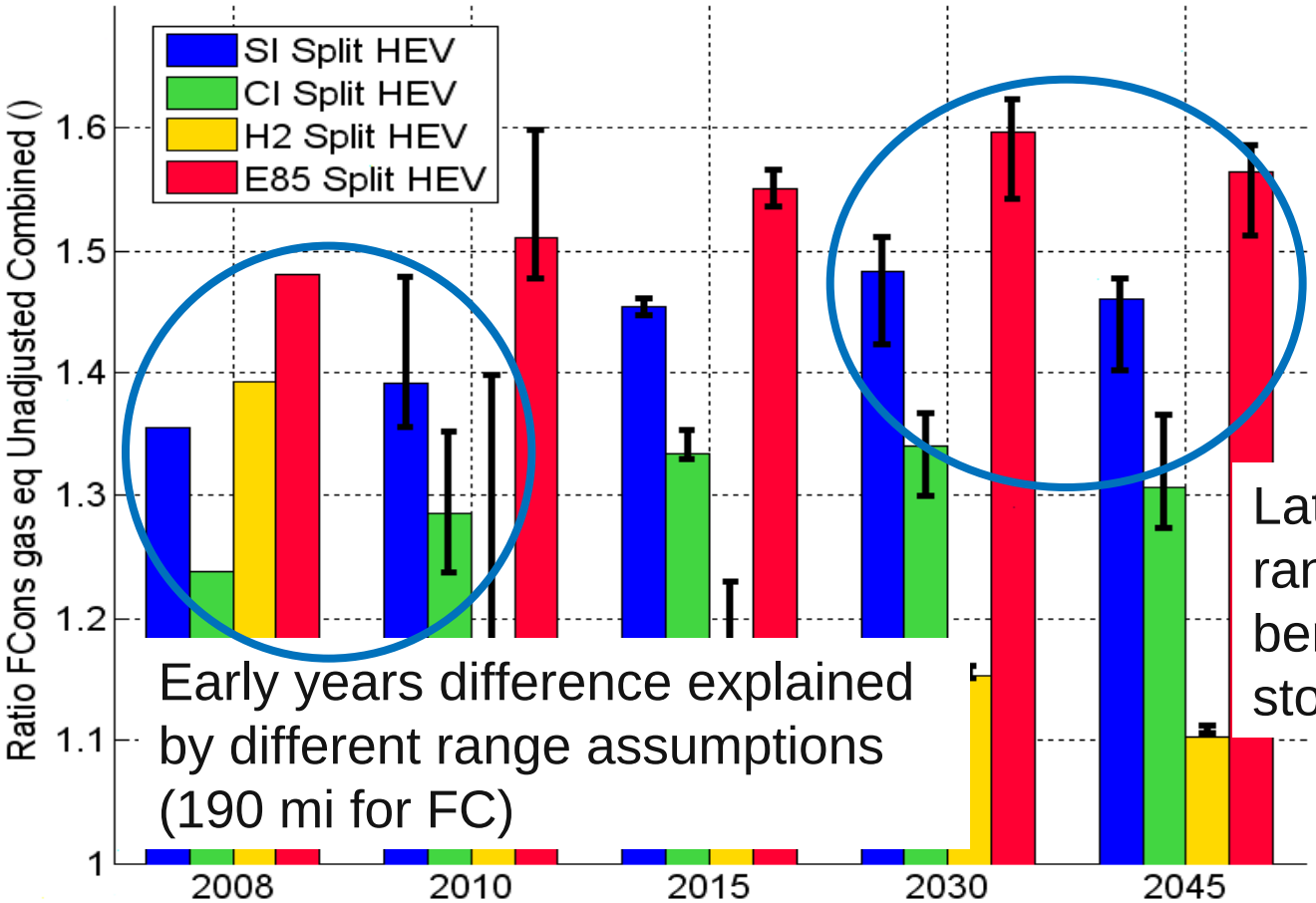
Pickup Truck

$$\text{Ratio} = \frac{\text{HEV}}{\text{Conv SI}}$$

<u>Variable</u>
HEV fuel

Input Split Configuration Used

FC-HEVs Fuel Consumption Compared to ICE-HEVs Shows Largest Uncertainties



Midsize Car

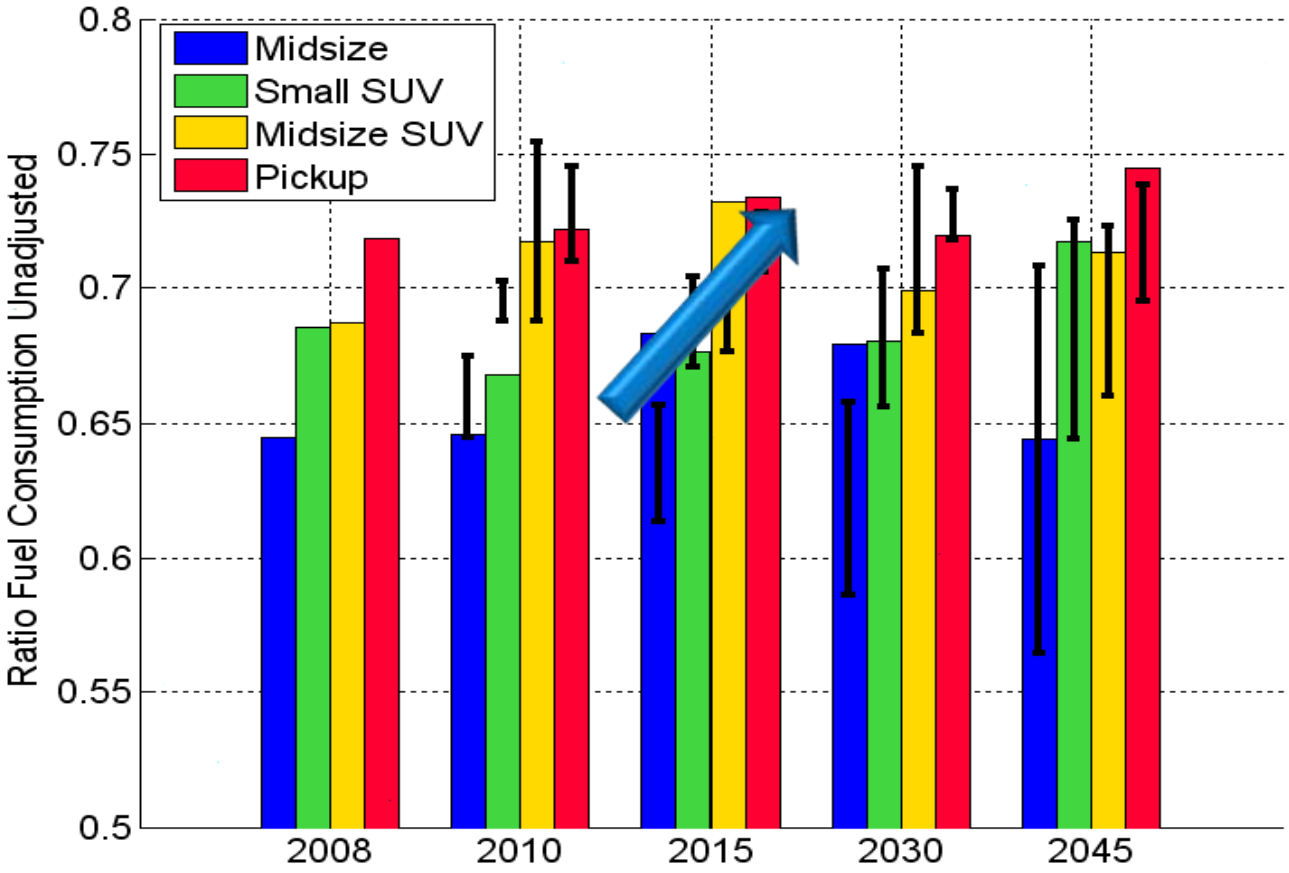
$$\text{Ratio} = \frac{\text{FC HEV}}{\text{ICEHEV}}$$

<u>Variable</u>
HEV fuel

Later, with same range, FC maintains benefits due to storage improvements

Input Split Configuration Used

Hybridization Benefits Based on Ratio Reduced with Larger Vehicle Class



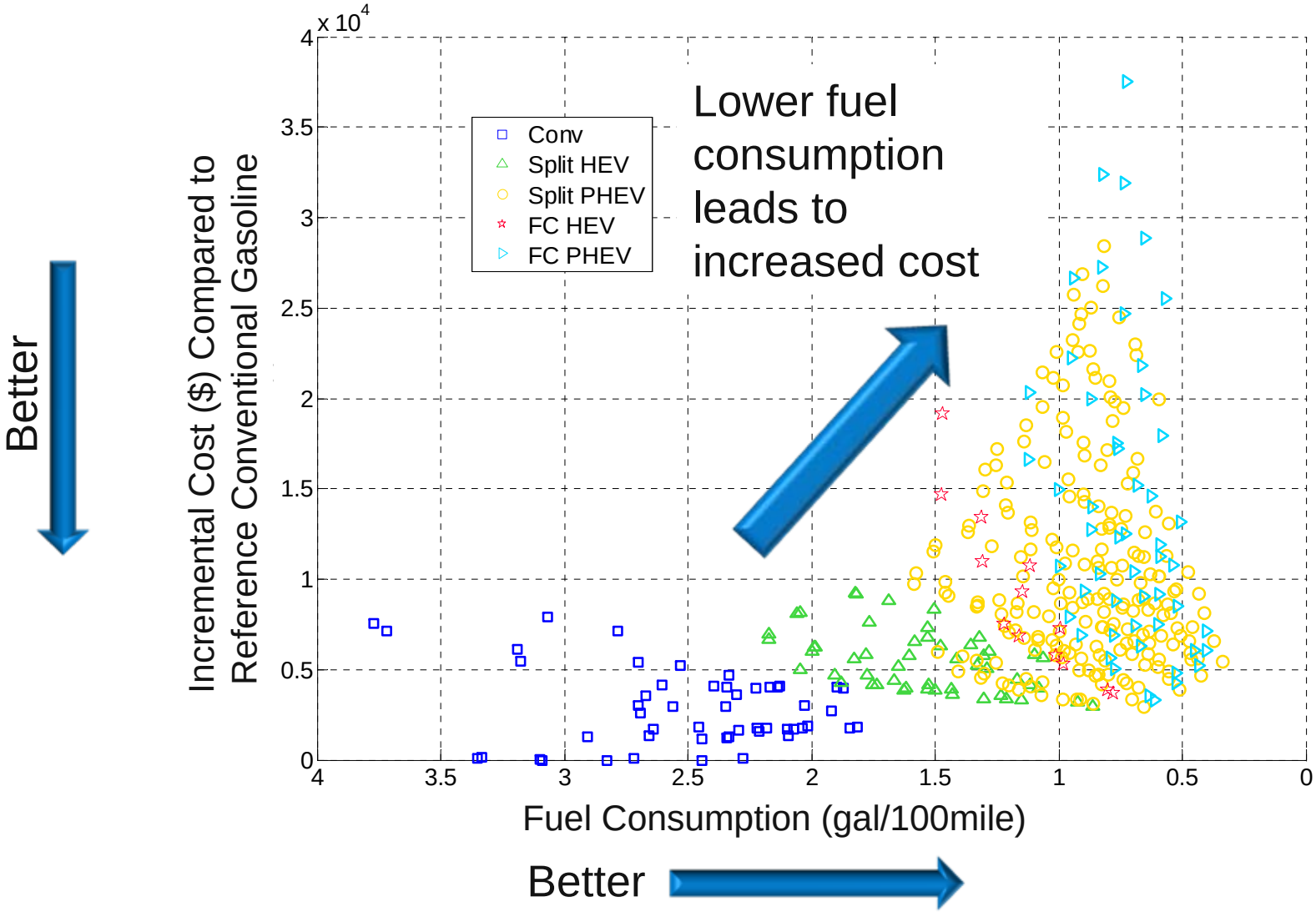
$$\text{Ratio} = \frac{\text{SI HEV}}{\text{Conv SI}}$$

<u>Variable</u>
Vehicle Class

Input Split Configuration Used

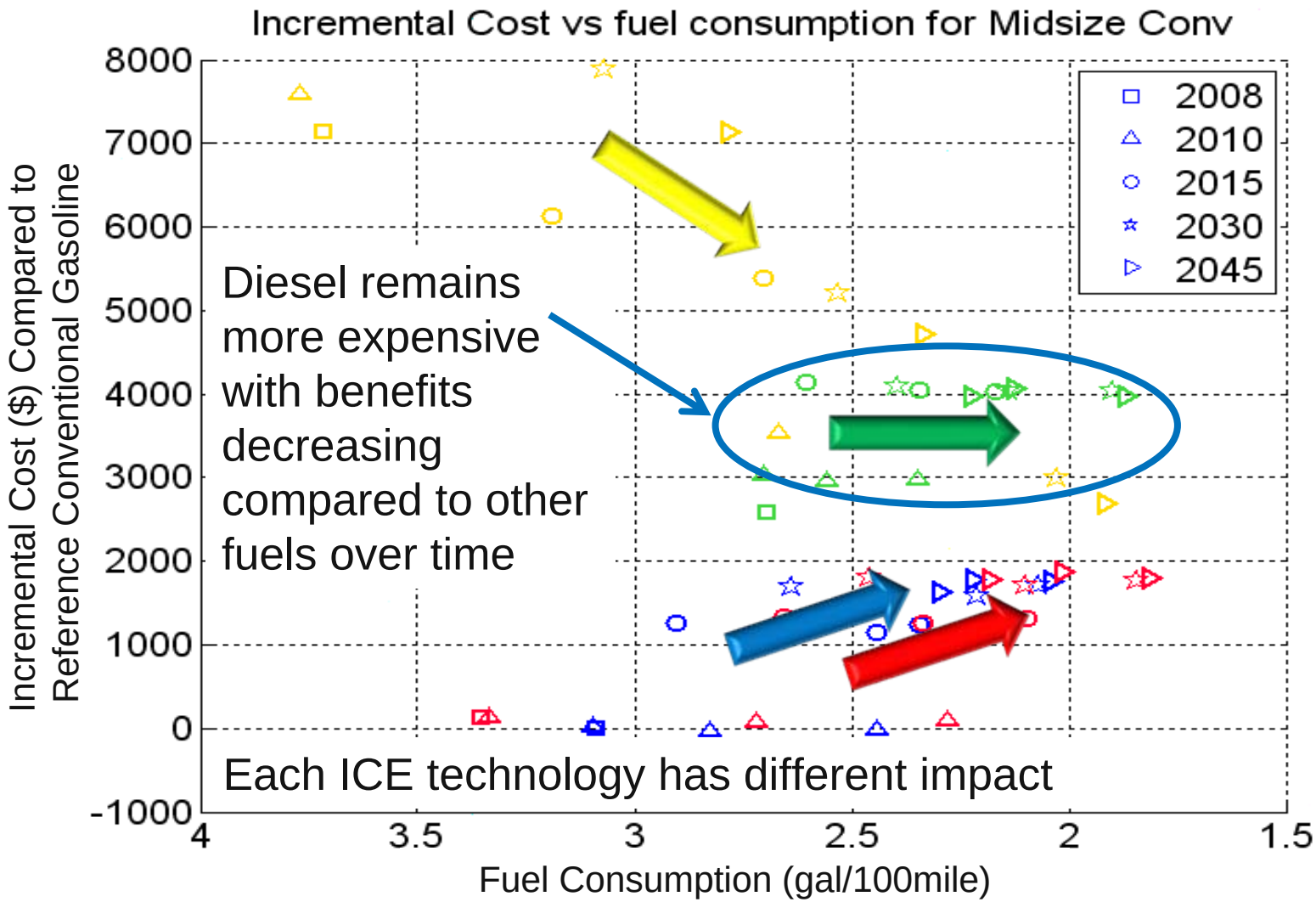
Trade-off Between Cost & Fuel Efficiency

All Vehicles



Trade-off Between Cost & Fuel Efficiency

Conventional Vehicles



Gasoline

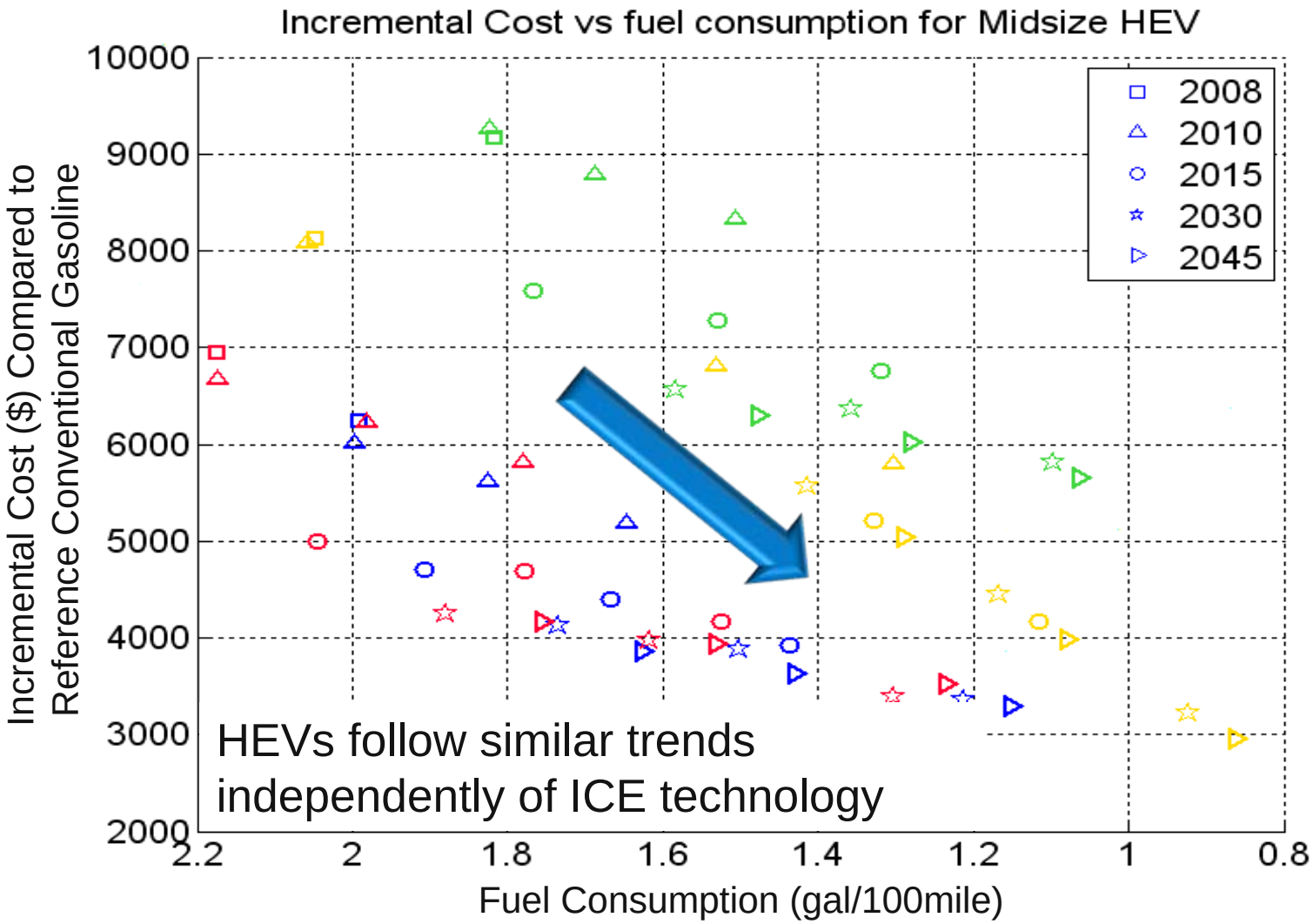
Diesel

Hydrogen

Ethanol

Trade-off Between Cost & Fuel Efficiency

ICE-HEV Vehicles



Gasoline

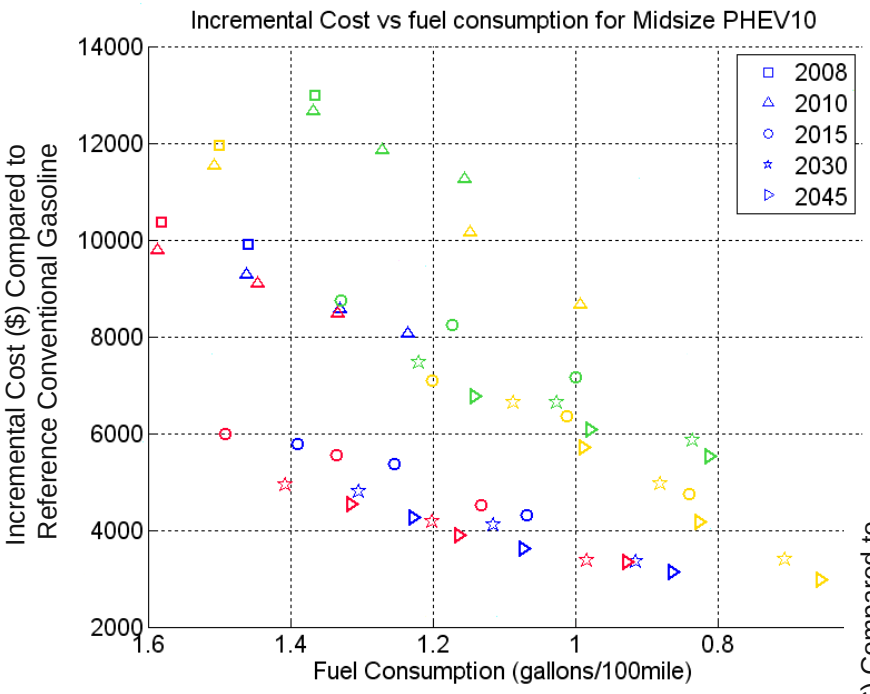
Diesel

Hydrogen

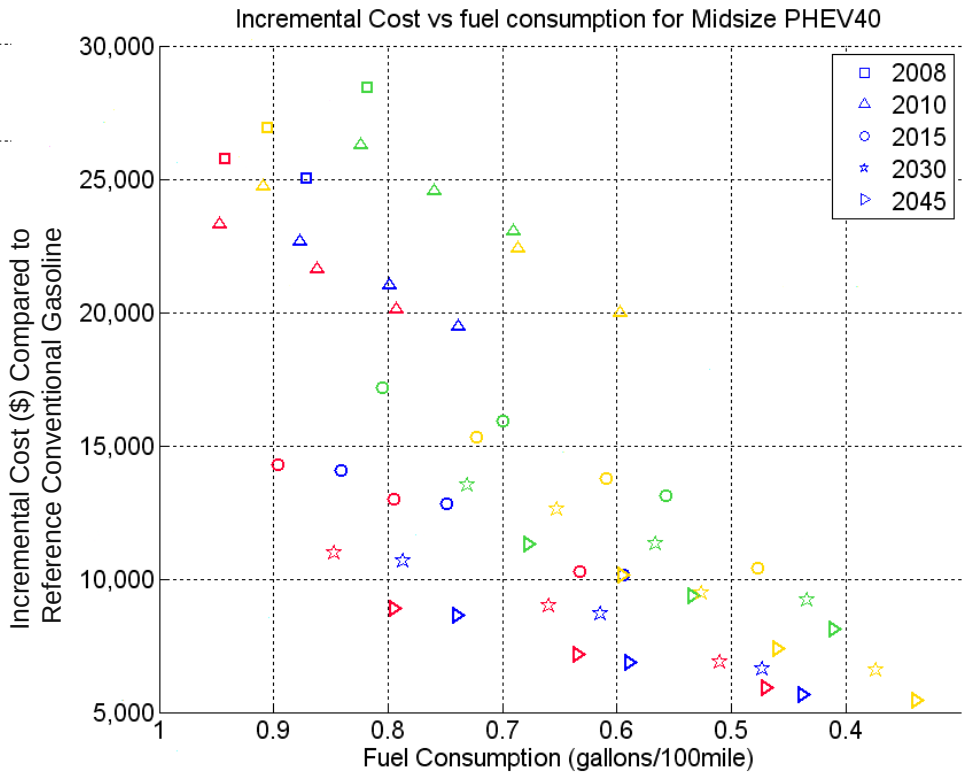
Ethanol

Trade-off Between Cost & Fuel Efficiency

ICE-PHEV Vehicles



Higher efficiency ICEs offer less benefits than for HEVs and Conventional



Gasoline

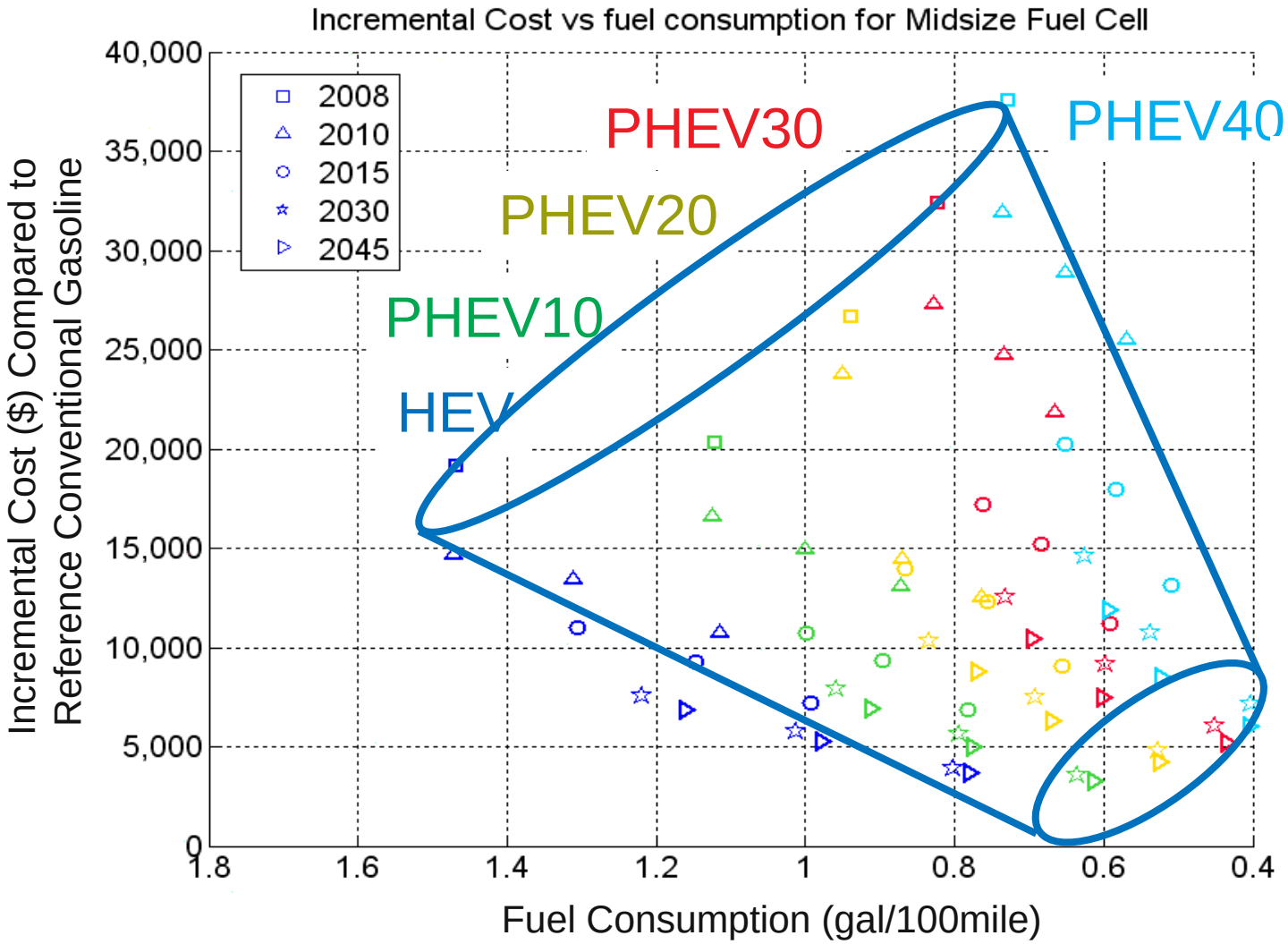
Diesel

Hydrogen

Ethanol

Trade-off Between Cost & Fuel Efficiency

FC-HEV Vehicles



Based on the test procedure used, advanced powertrain do not benefit as much of high battery energy as current technologies

Conclusions

- More than 600 vehicles were simulated for different timeframes (up to 2045), powertrain configurations, and component technologies.
- Both their fuel economy and cost were assessed to estimate the potential of each technology. Each vehicle was associated with a triangular uncertainty.
- The discrepancy between gasoline and diesel engine for conventional vehicles is narrowing with the introduction of new technologies, such as VVT and low temperature combustion.
- From a fuel-efficiency perspective, HEVs maintain a relative constant ratio compared to their conventional vehicle counterparts. However, the cost of electrification is expected to be reduced in the future, favoring the technology's market penetration.
- PHEVs offer significant petroleum reduction potential.
- Hydrogen engine HEVs, through direct injection, will offer significant fuel improvements and appear to be a bridging technology towards fuel cell.