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U.S. Department of Energy

UChicago Argonne LLC

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A U.S. Department of Energy laboratory managed by UChicago Argonne, LLC

Fuel Economy Potential of Advanced Configurations from 2010 to 2045

IFP HEV Conference
November, 2008

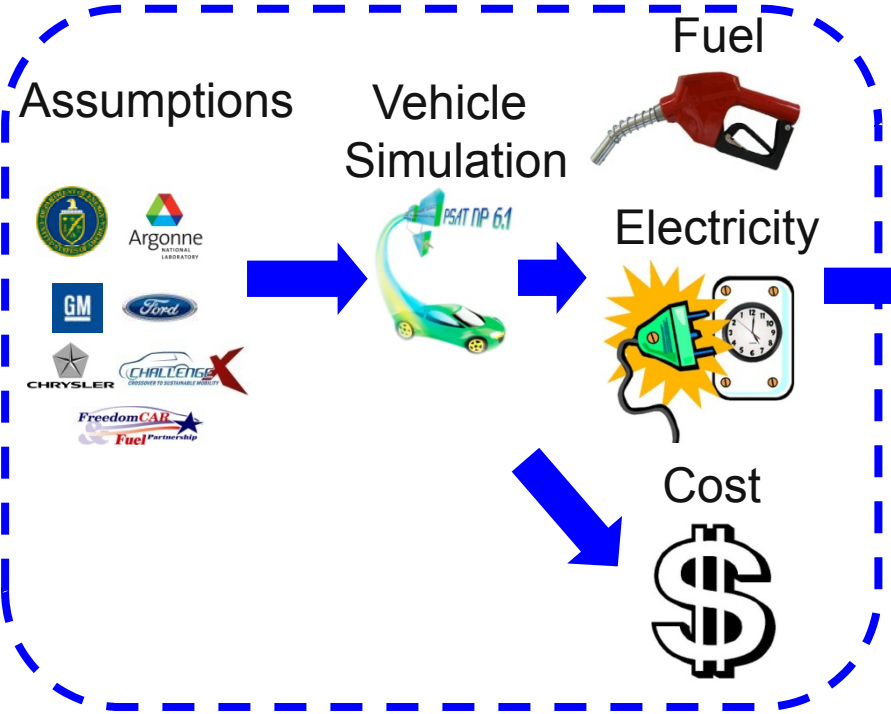
Aymeric Rousseau
Argonne National Laboratory

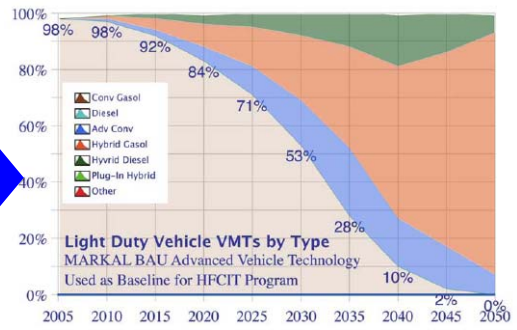
Sponsored by Lee Slezak

U.S. DOE

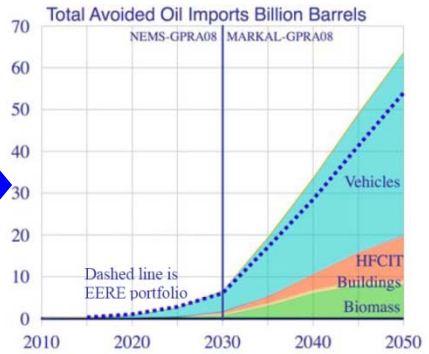
FreedomCAR & Fuel Partnership

Evaluate Vehicle Fuel Economy of Advanced Technologies





Market Penetration



Fuel Saved

Large Number of Technologies…

Vehicle Classes

⊗

Timeframes

Current

2010

2015

2030

2045

⊗

Powertrain Configurations

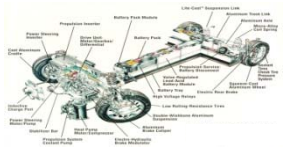
Conventional

ICE HEV

PHEV

Fuel Cell

Electric



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Fuels

Gasoline

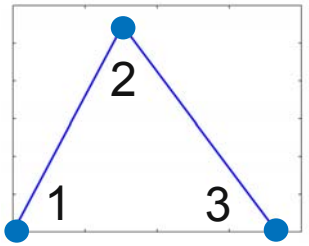
Diesel

Ethanol

⊗

Risk Analysis

Triangular Uncertainty



1 = 10%
2 = 50%
3 = 90%

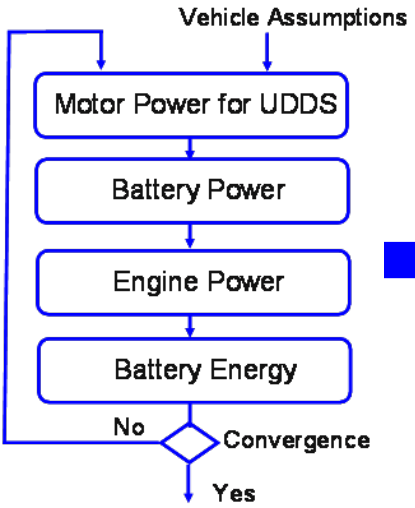
> 1800 Vehicles

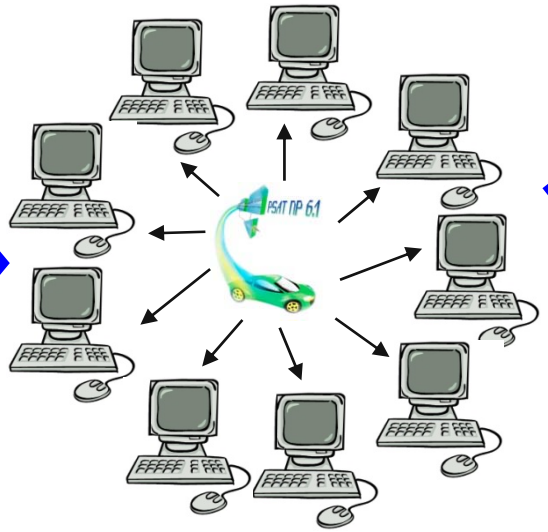
… Requires Development of Process

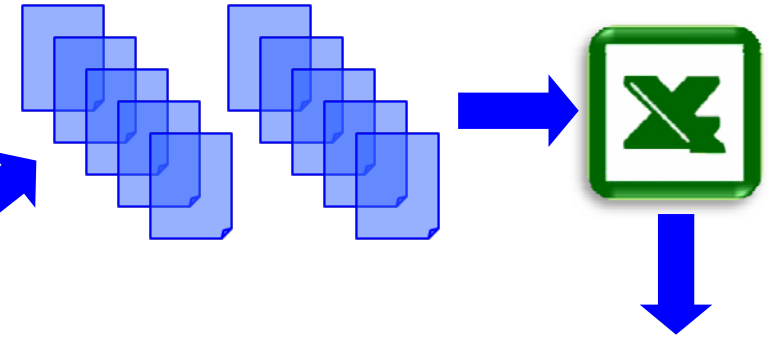
Vehicles Automatically Sized

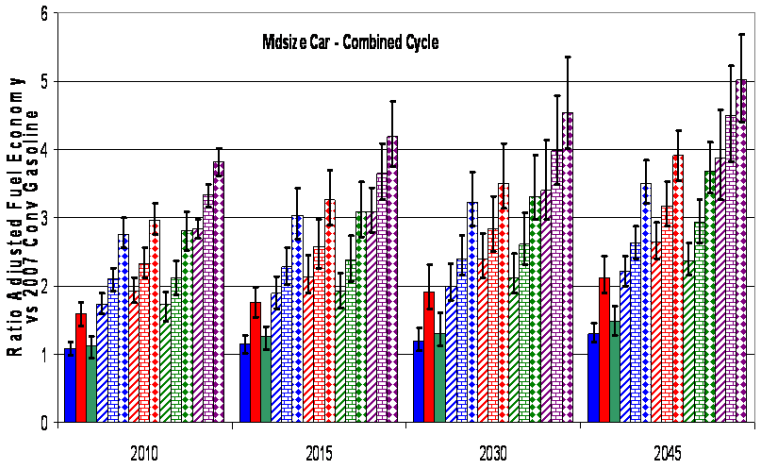
Distributed Computing

Automated Post-processing







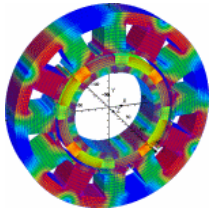


List of Main Assumptions for Each Component

Engine

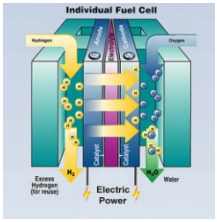
Technology
Fuel
Peak Torque
Specific Power
Efficiency
Time response
Cost…

Electric Machine



Technology
Peak Torque
Specific Power
Efficiency
Time response
Cost…

Fuel Cell



Technology
Specific Power
Efficiency
Time response
Cost…

Transmission

Technology
Gear Number
Mass
Efficiency
Cost…

Energy Storage

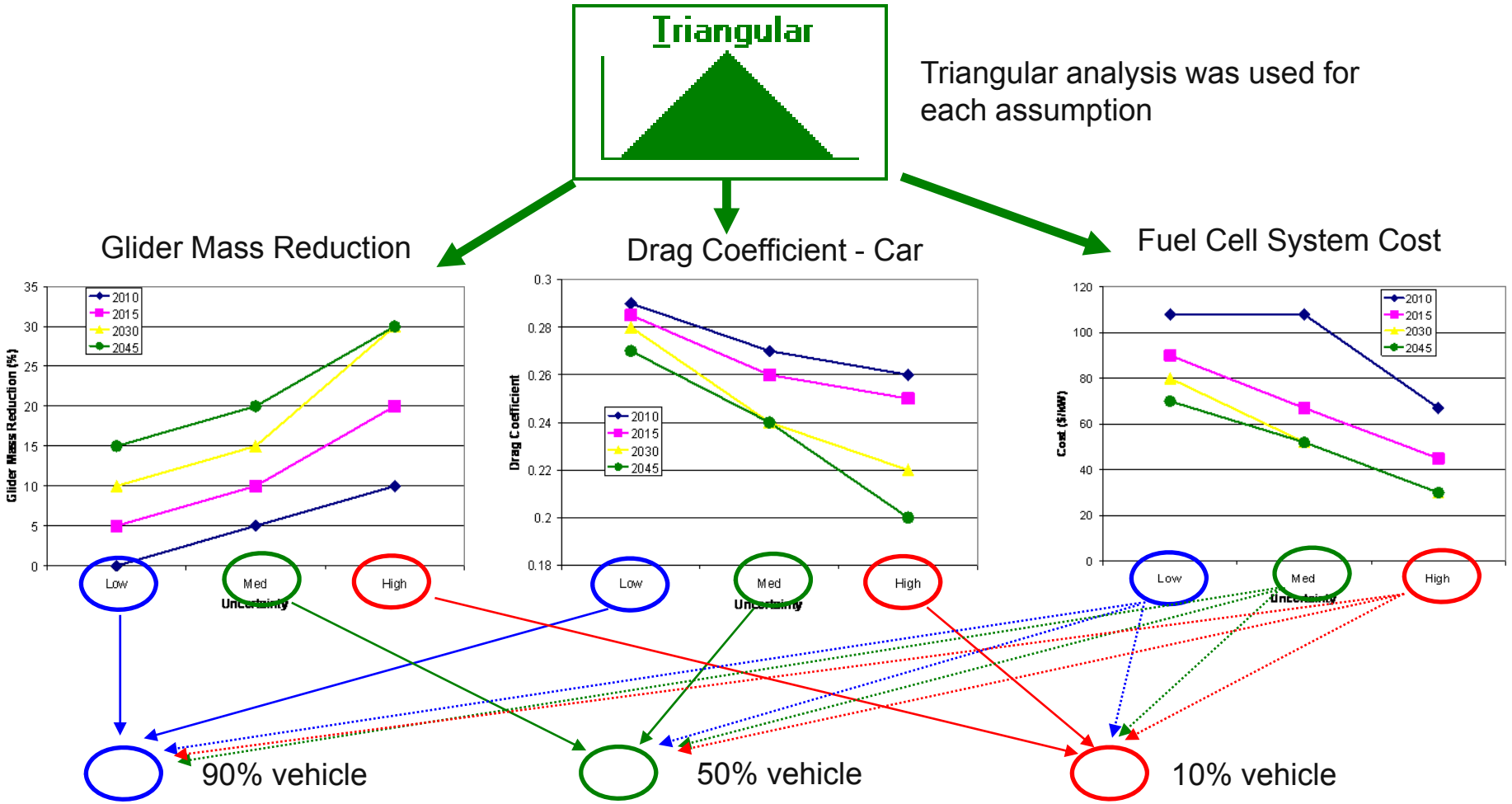
Technology
Specific power
Power and energy oversize
Efficiency (Rint, Voc…)
SOC window
Cost…

Hydrogen Storage

Technology
System Gravimetric Capacity
Cost…

200 to 400 assumptions required to simulate a single vehicle

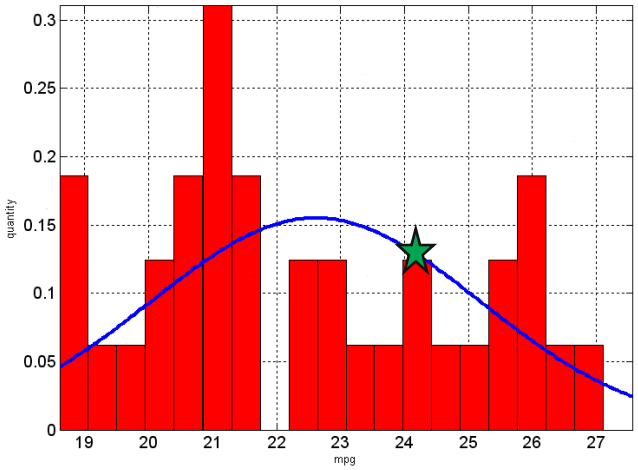
Uncertainty Process



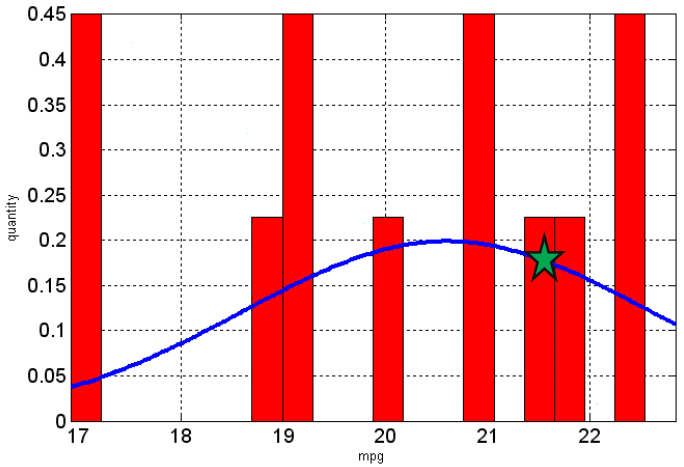
Each vehicle (10, 50, 90%) has three costs values

Reference Vehicles Fuel Economy Compared to Entire Class

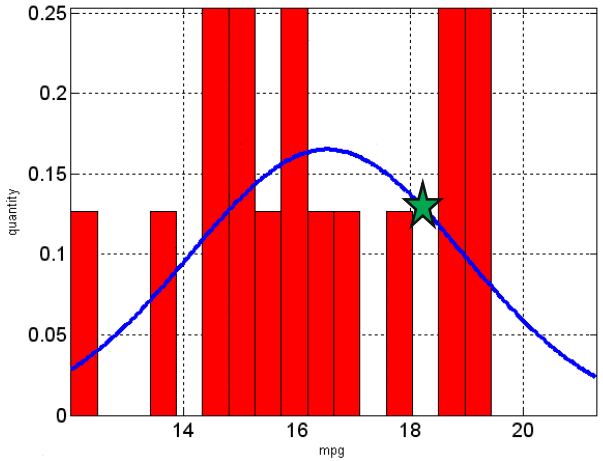
Midsize Car



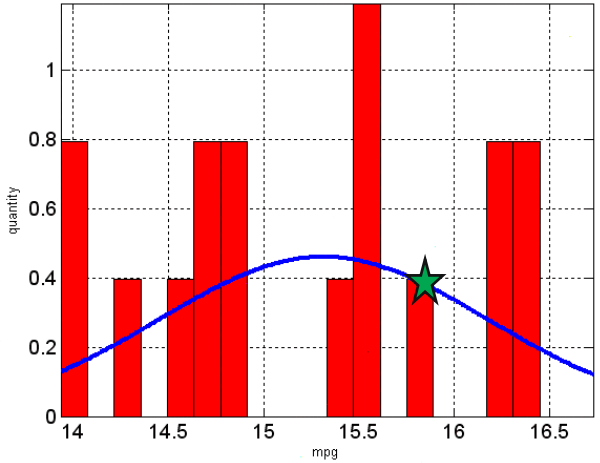
Small SUV



Midsize SUV

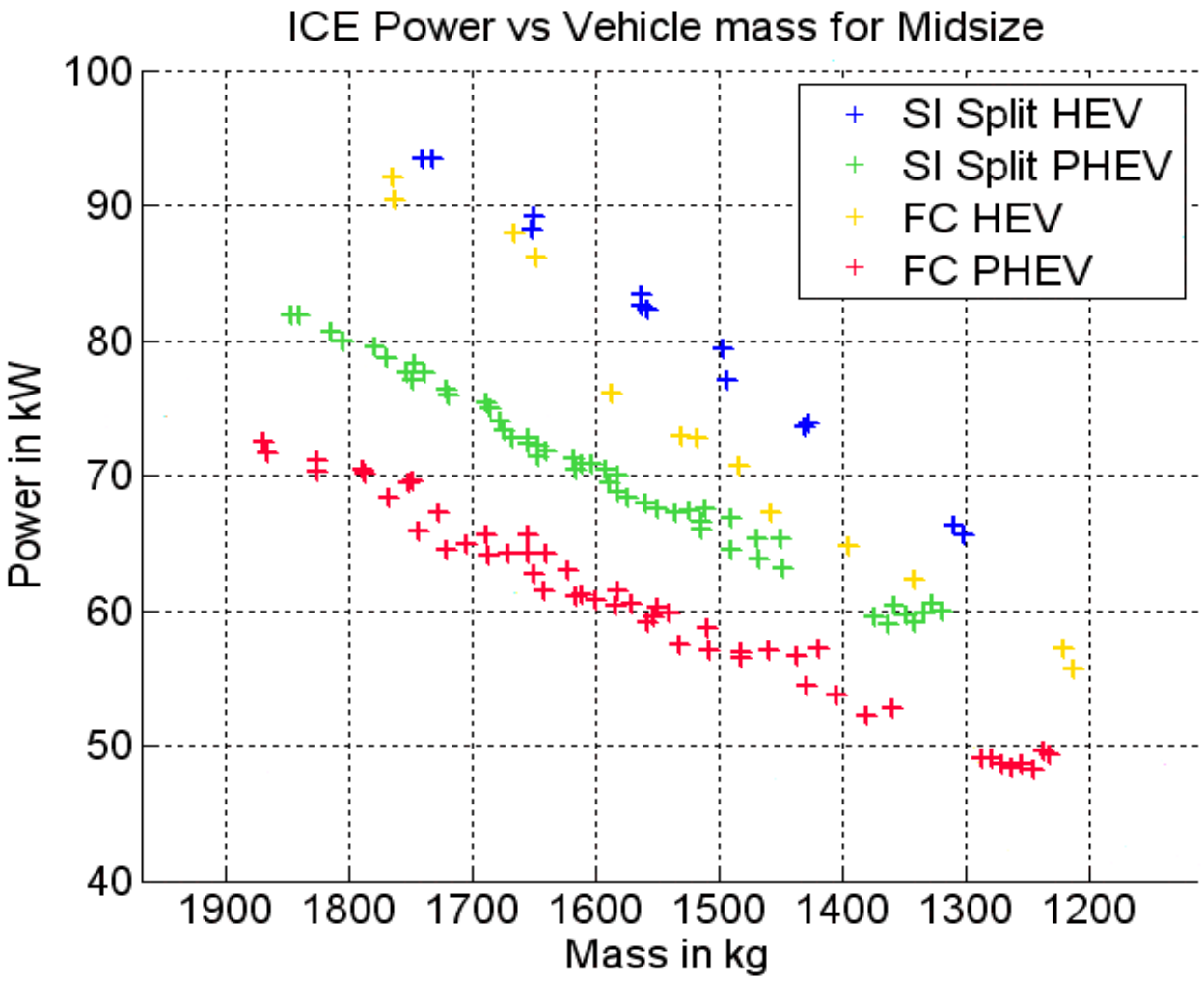


Pickup Truck

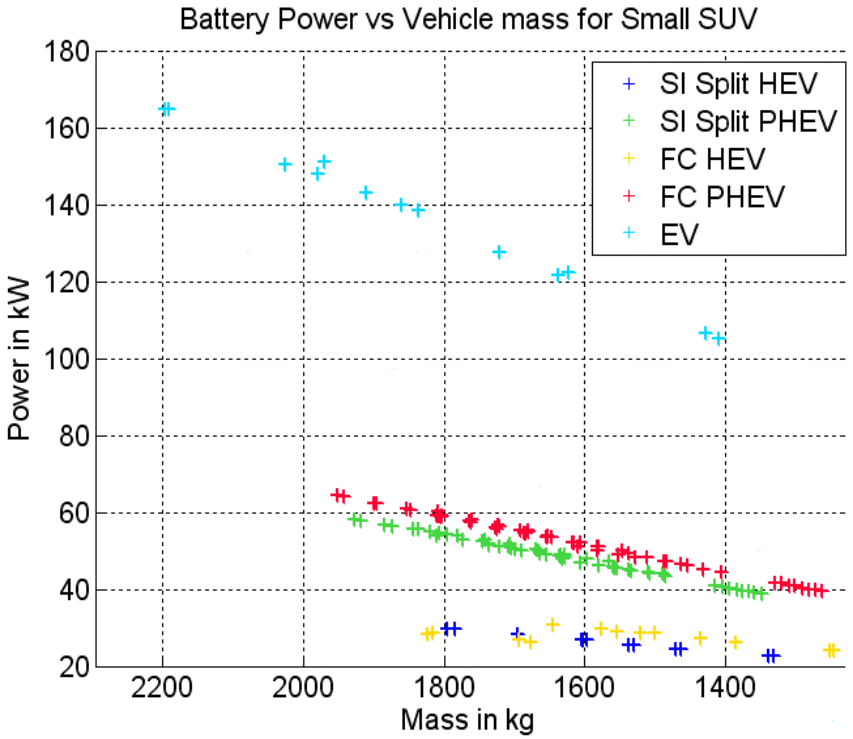


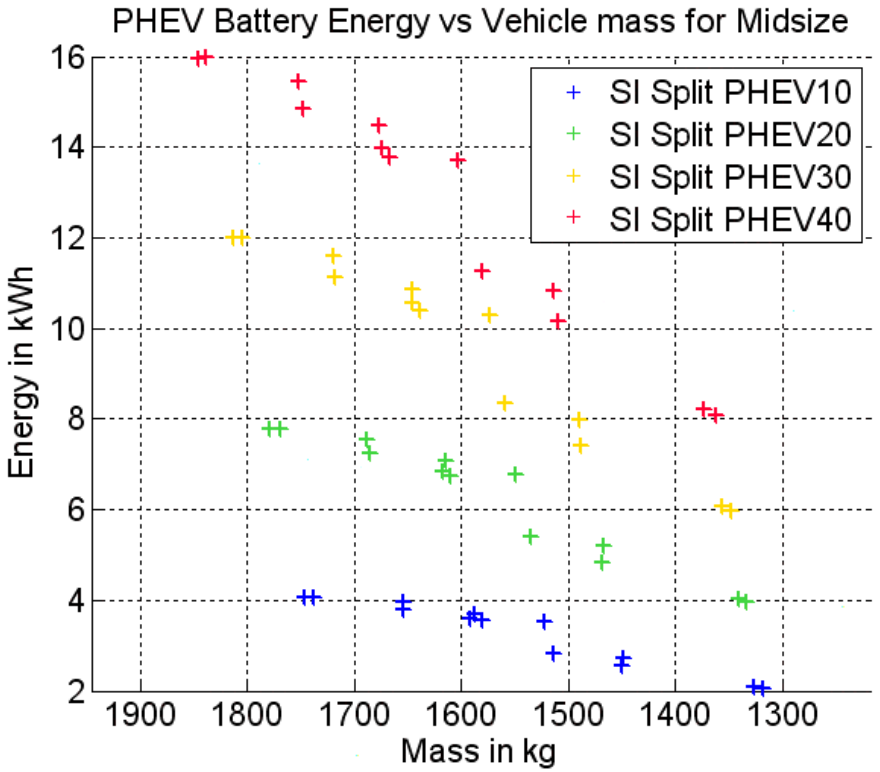
EPA 2008 Adjusted Values – Including Cold Start Penalty

Engine / Fuel Cell Power Requirement as a Function of Vehicle Mass

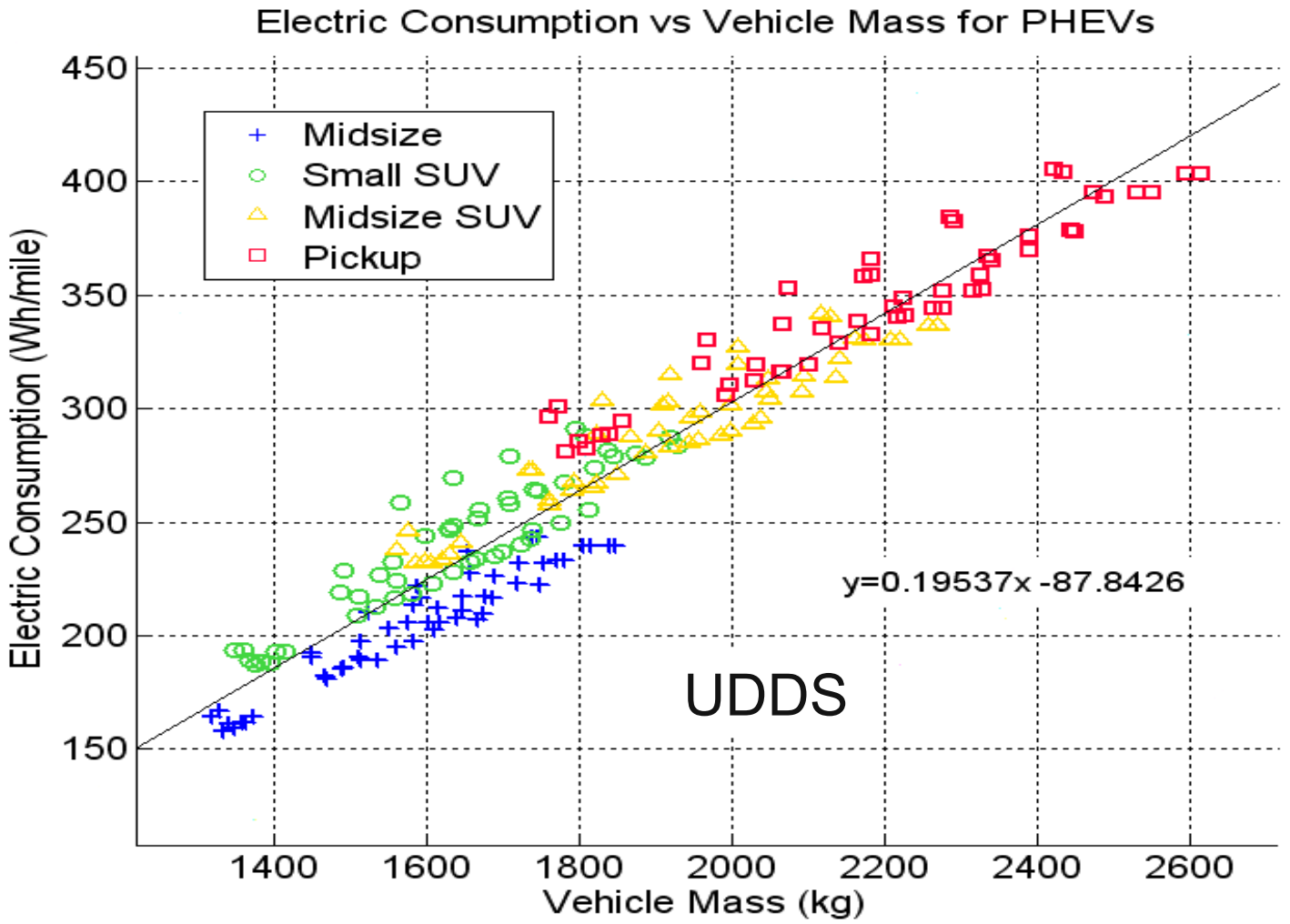


Battery Power and Usable Energy Requirement as a Function of Vehicle Mass

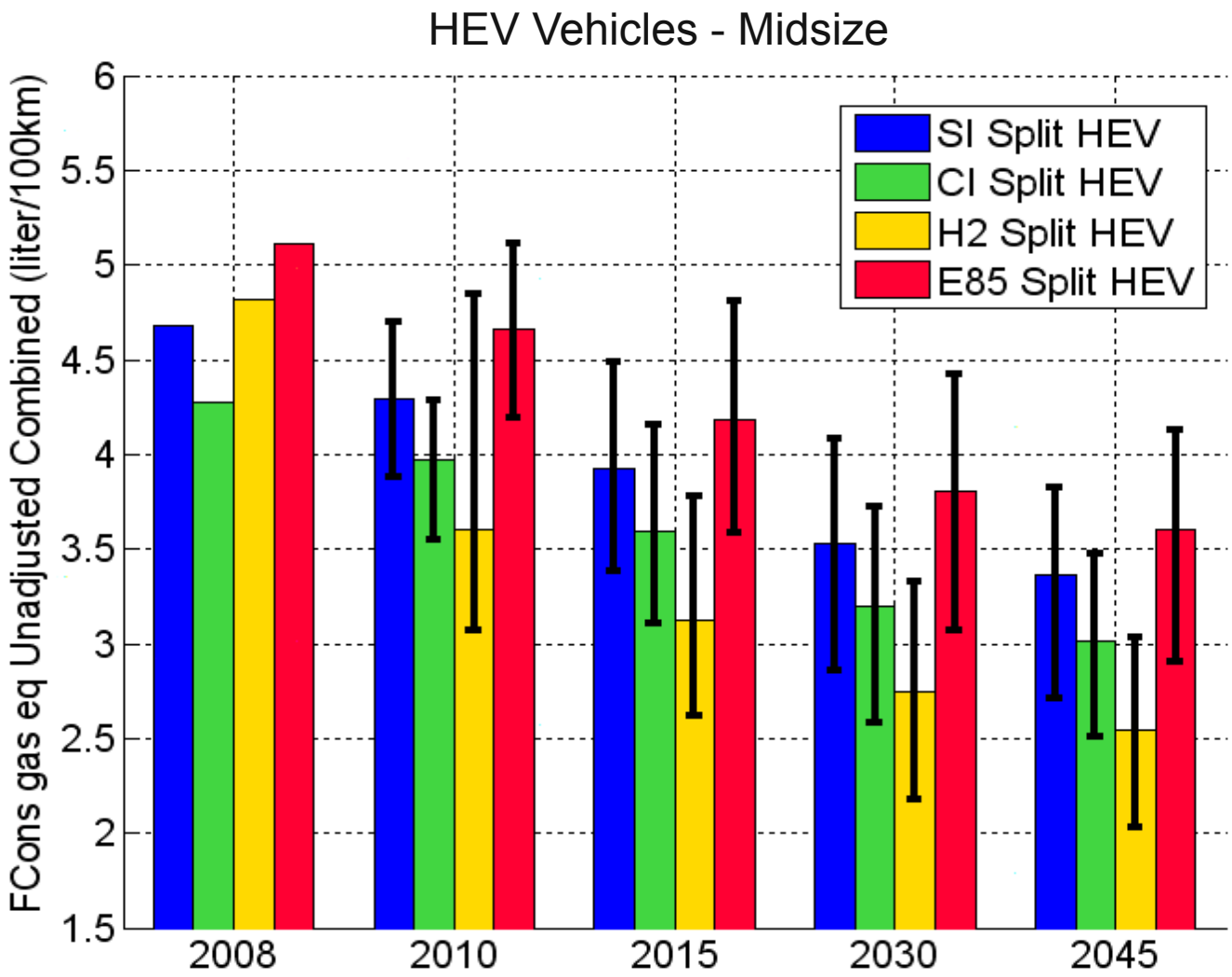




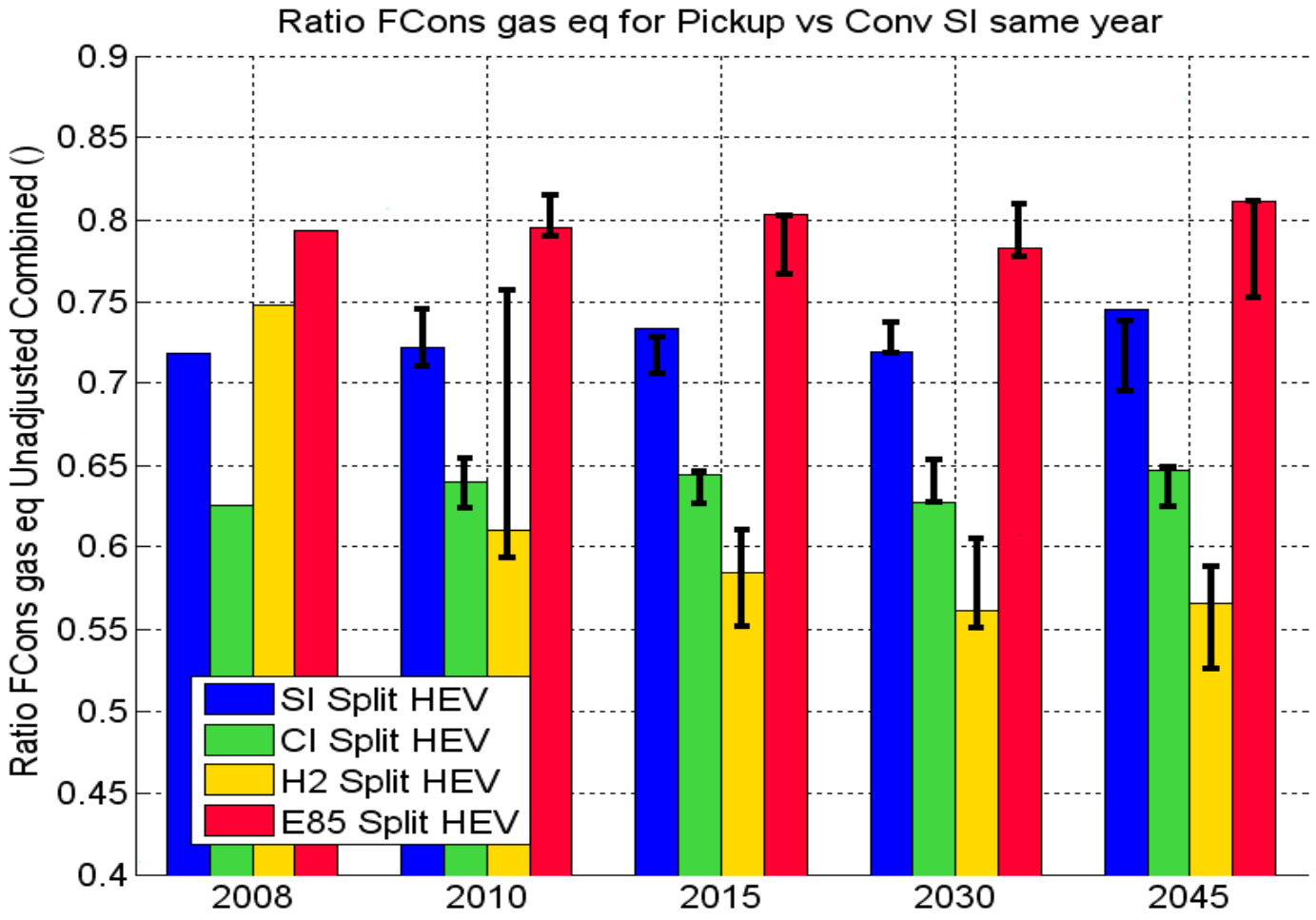
Electrical Consumption Evolution a Function of Vehicle Mass



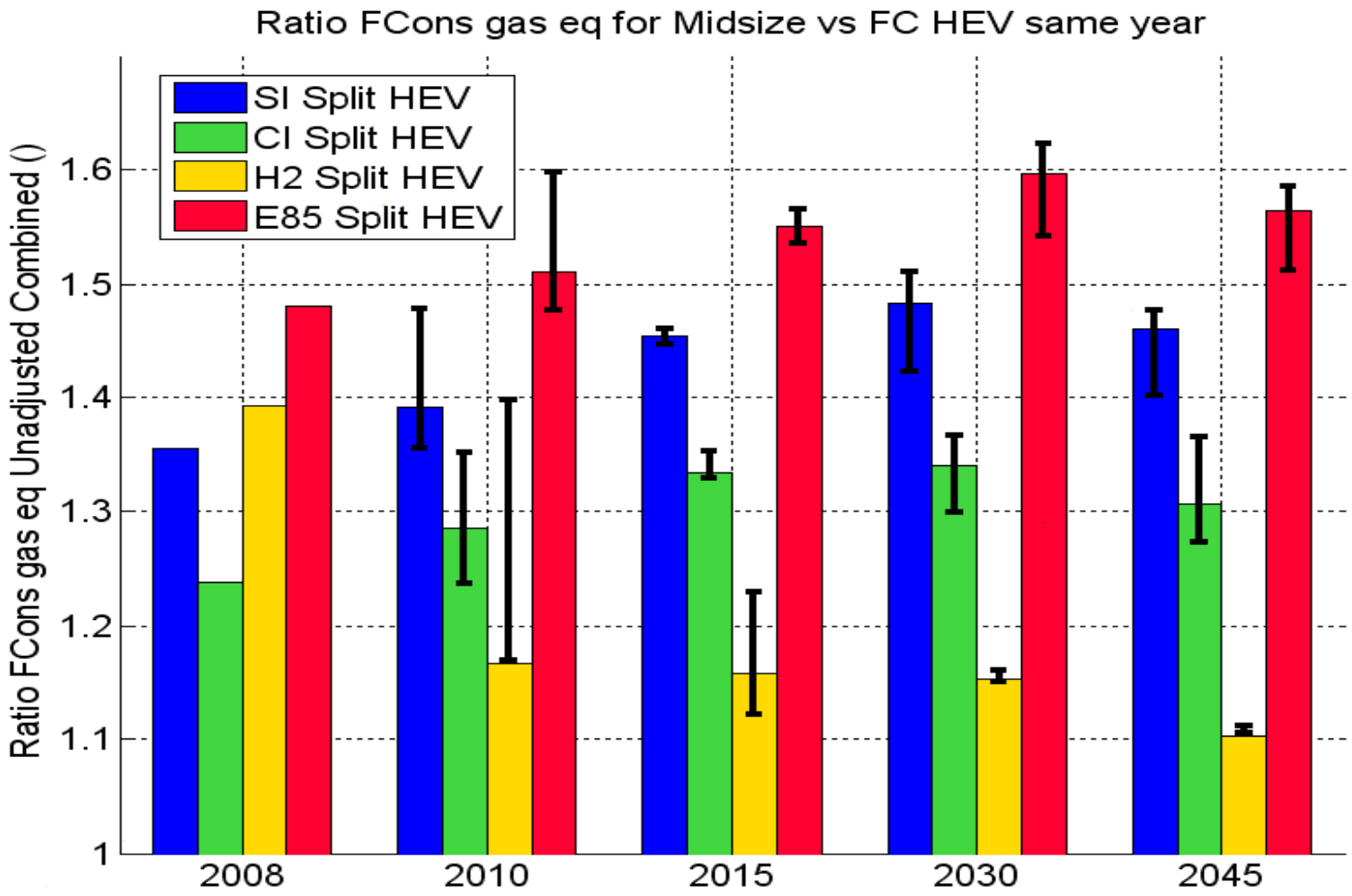
Impact of Fuel Selection on Fuel Consumption



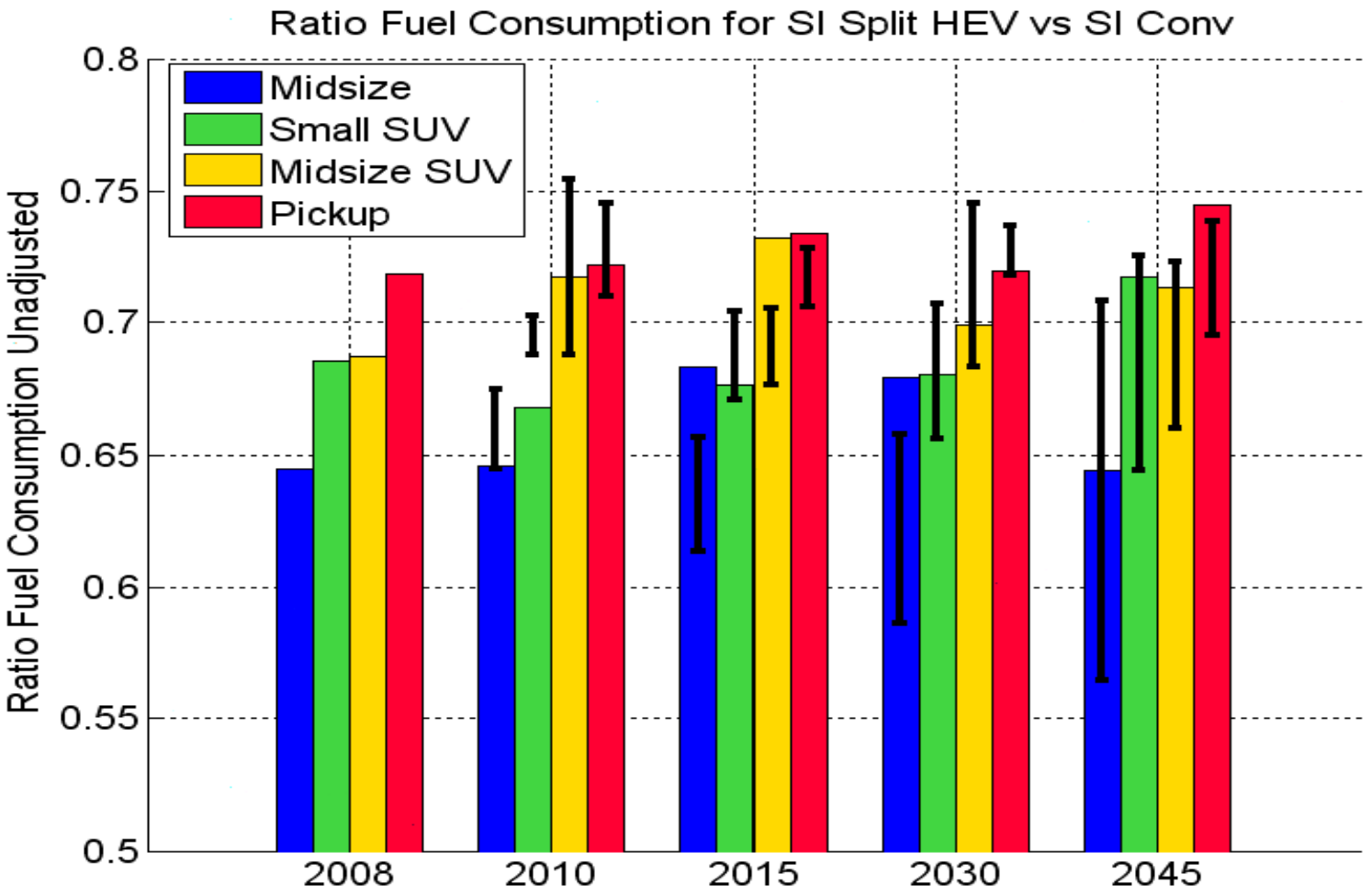
Evolution of HEVs Fuel Consumption Compared to Conventional



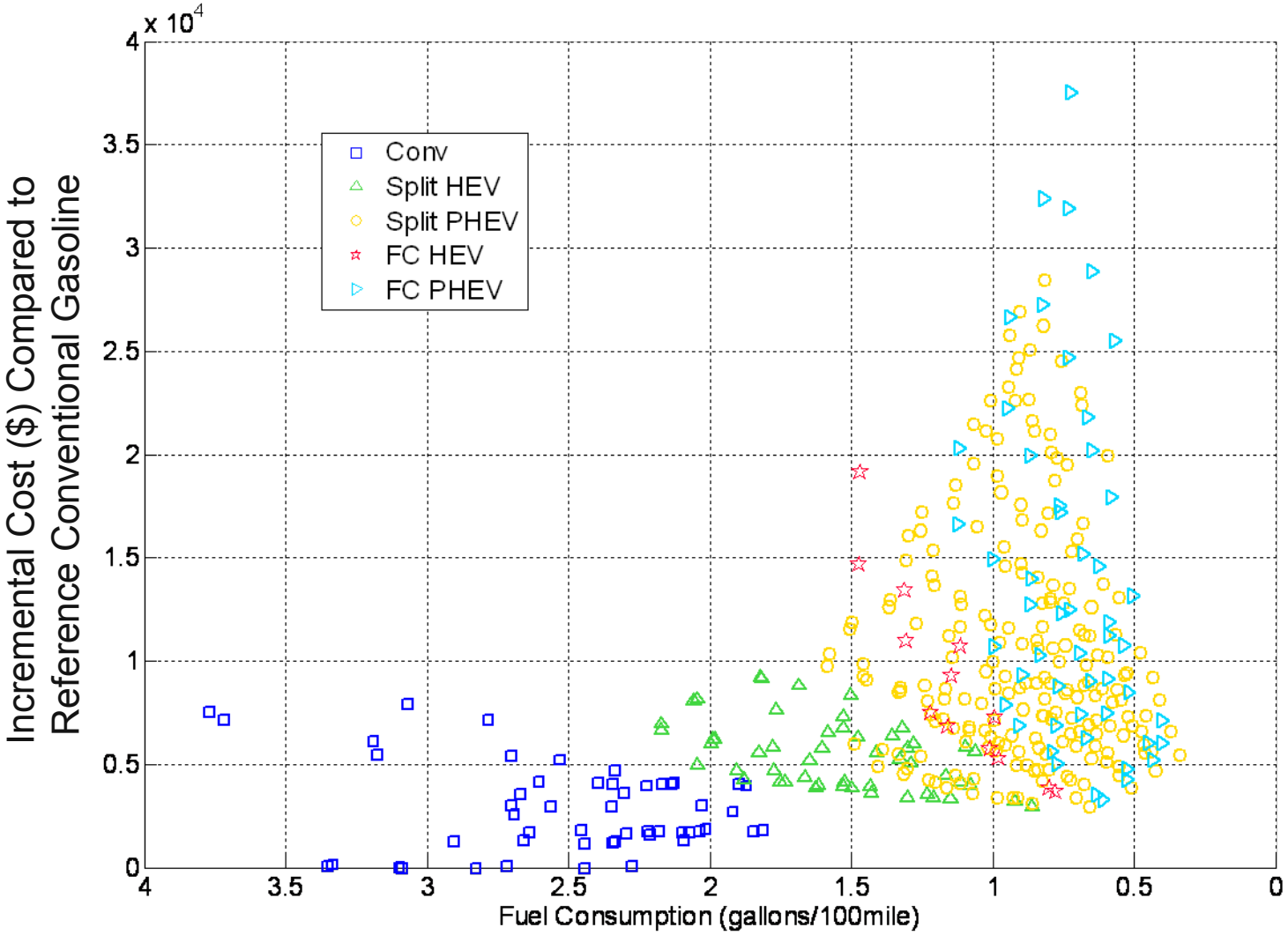
Evolution of FC-HEVs Fuel Consumption Compared to ICE-HEVs



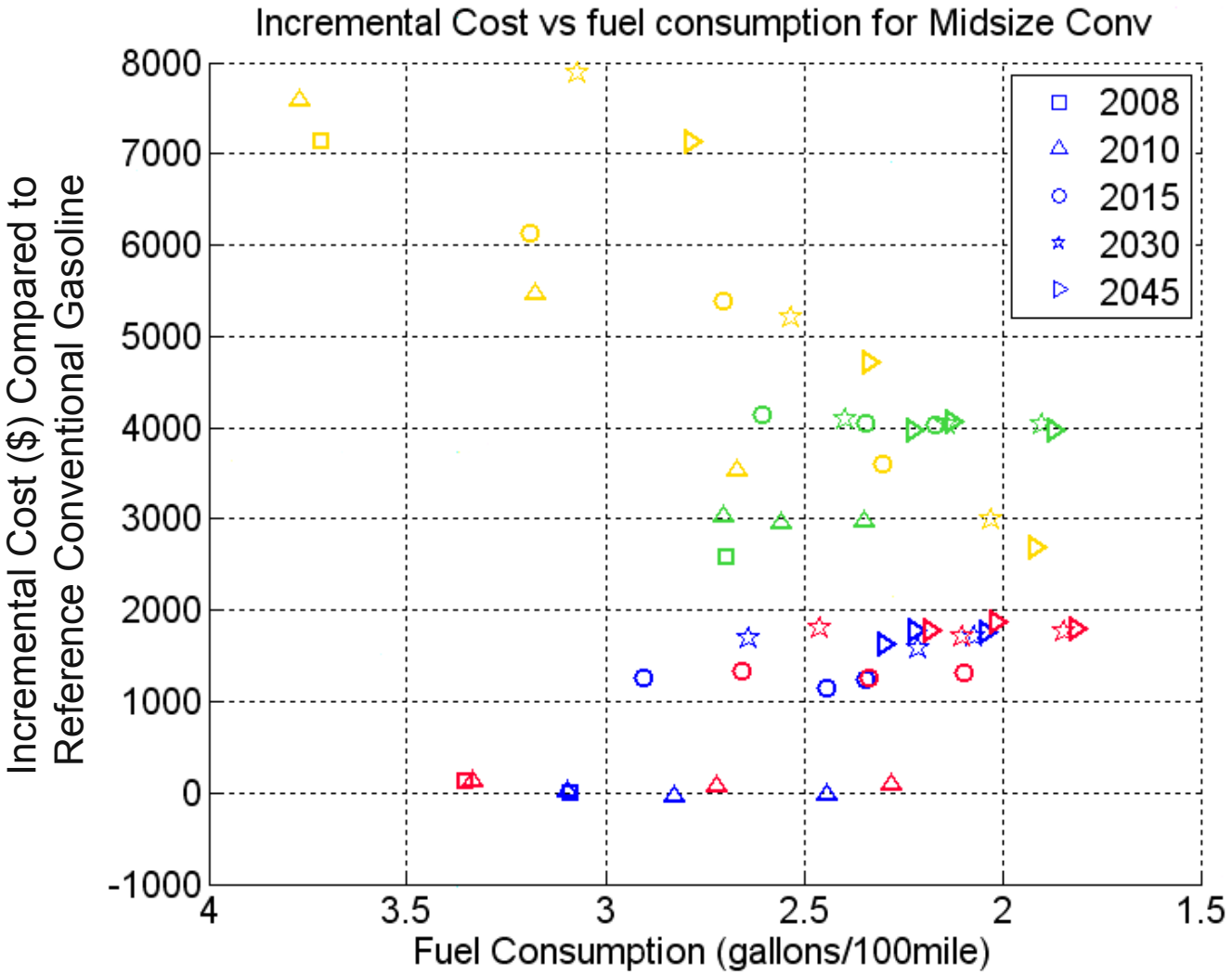
Hybridization Benefits Reduced with Larger Vehicle Class



Trade-off Between Cost & Fuel Efficiency
All Vehicles



Trade-off Between Cost & Fuel Efficiency
Conventional Vehicles



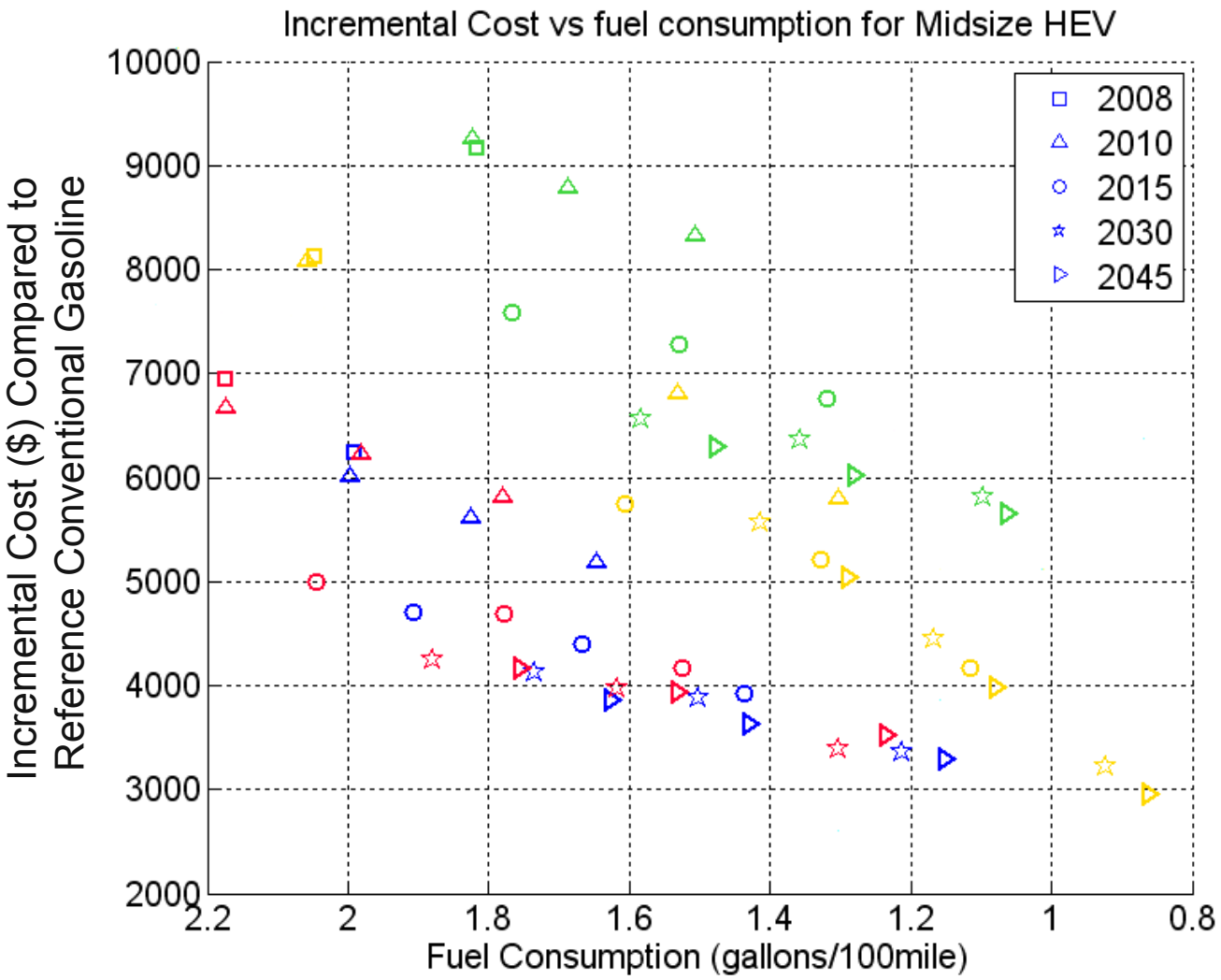
Gasoline

Diesel

Hydrogen

Ethanol

Trade-off Between Cost & Fuel Efficiency
ICE-HEV Vehicles



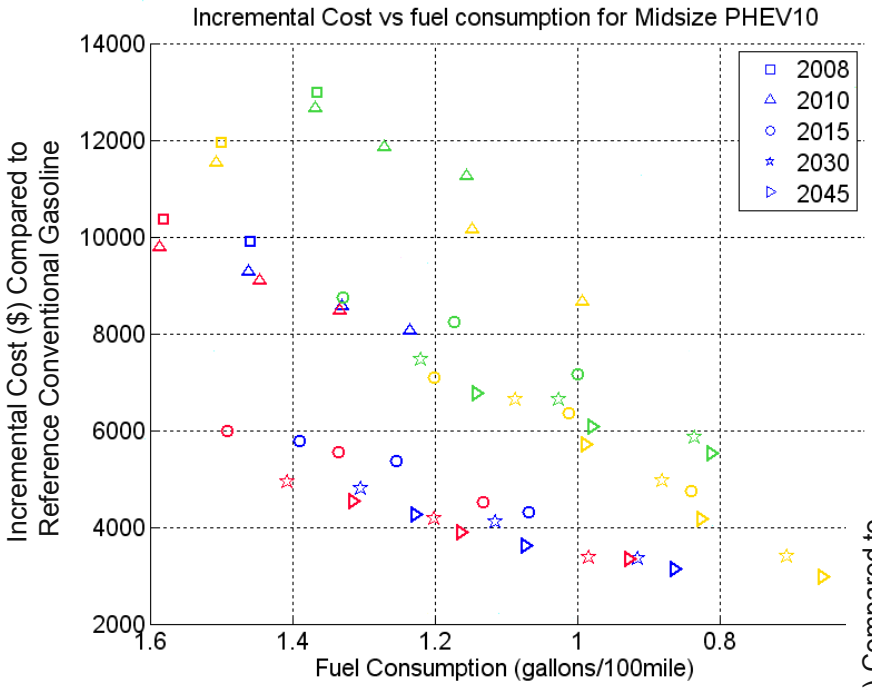
Gasoline

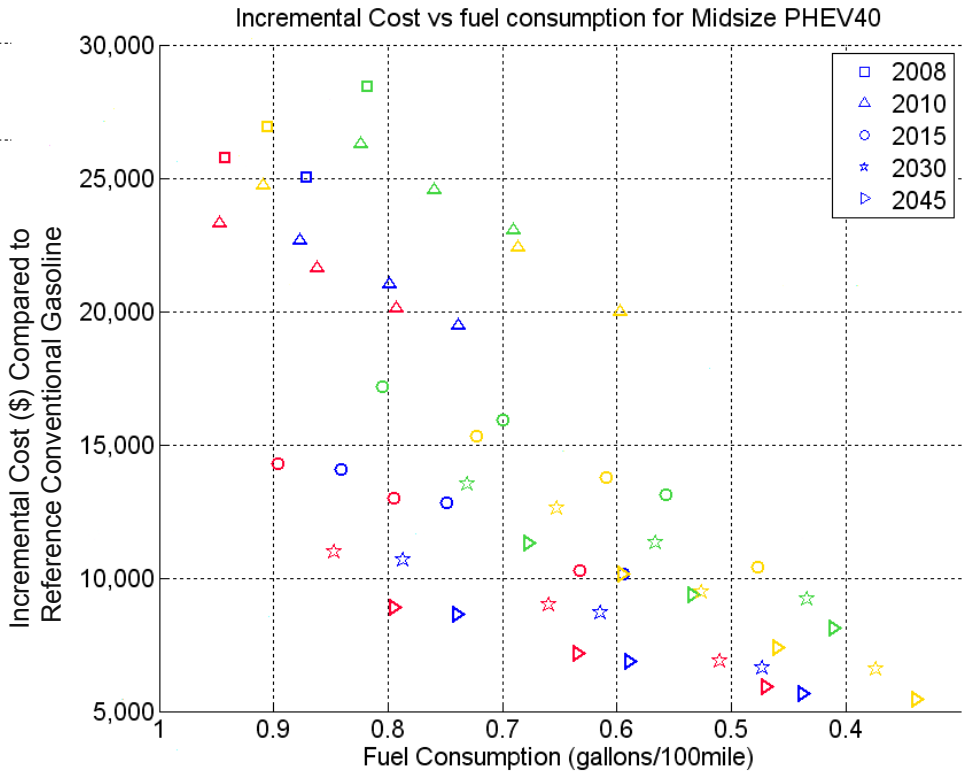
Diesel

Hydrogen

Ethanol

Trade-off Between Cost & Fuel Efficiency
ICE-PHEV Vehicles





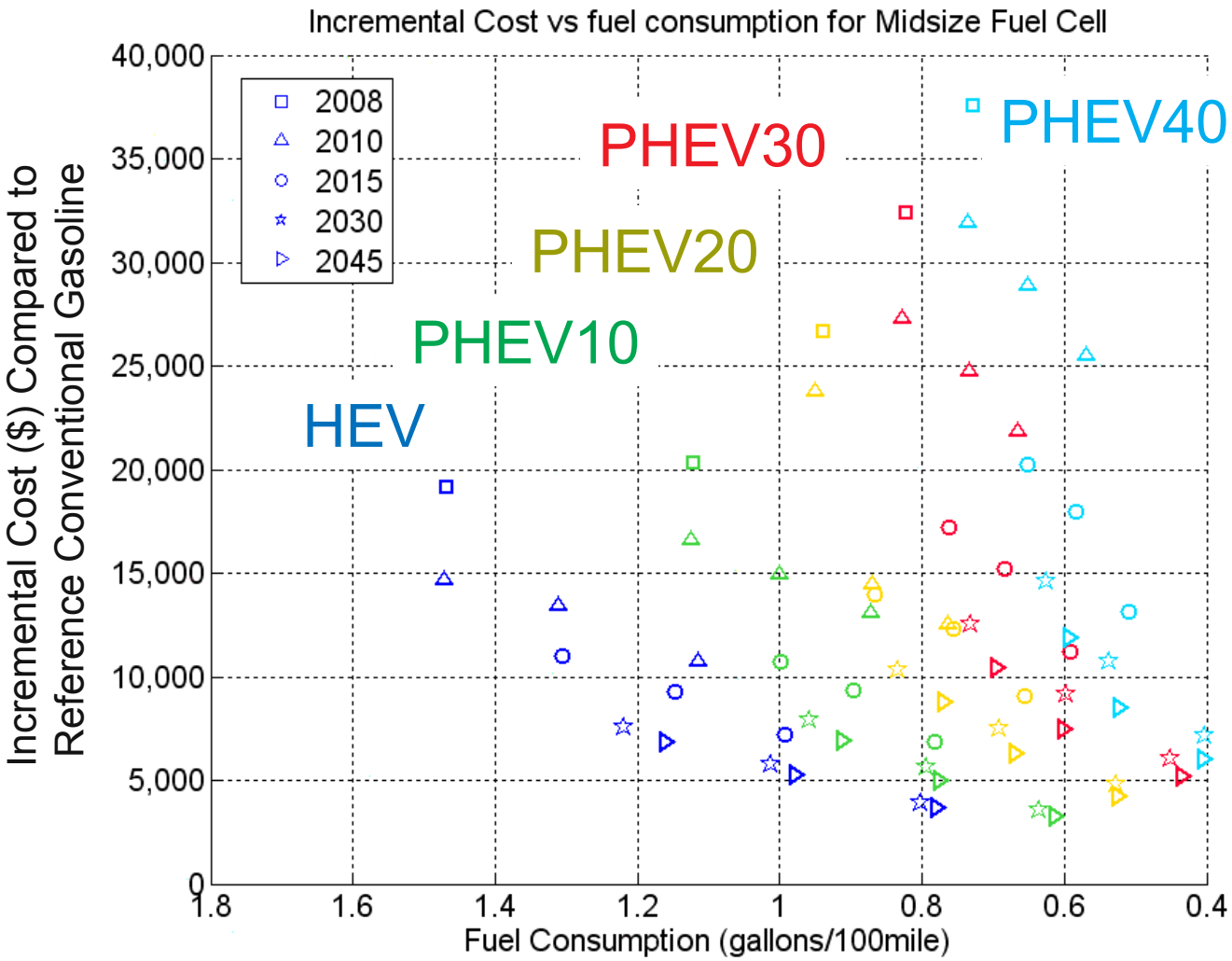
Gasoline

Diesel

Hydrogen

Ethanol

Trade-off Between Cost & Fuel Efficiency
FC-HEV Vehicles



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.
- Fuel cell HEVs have the greatest potential to reduce fuel consumption.
- Hydrogen engine HEVs, through direct injection, will offer significant fuel improvements and appear to be a bridging technology.