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Government Performance Result Act (GPRA) / Portfolio Decision Support (PDS)

Project ID # vss_09_pagerit

2009 DOE Hydrogen Program and Vehicle Technologies Annual Merit Review

May 19, 2009

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Argonne National Laboratory

Sponsored by Lee Slezak

U.S. Department of Energy
Energy Efficiency and Renewable Energy
Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable

Project Overview

Timeline

- Start – October 2008
- End – July 2009
- 75% Complete

Budget

- Total Project Funding
  - FY08 $ 300k
  - FY09 $ 400k

Barriers

- Assess benefits of entire FreedomCAR patnership
- Provide guidance on R&D strategies

Partners

- All FreedomCAR members
  - Technical Teams
  - National Laboratories
- Additional experts
  - Academia
  - PSAT users…

Main Objectives

CAFÉ
Fuel Economy Standards

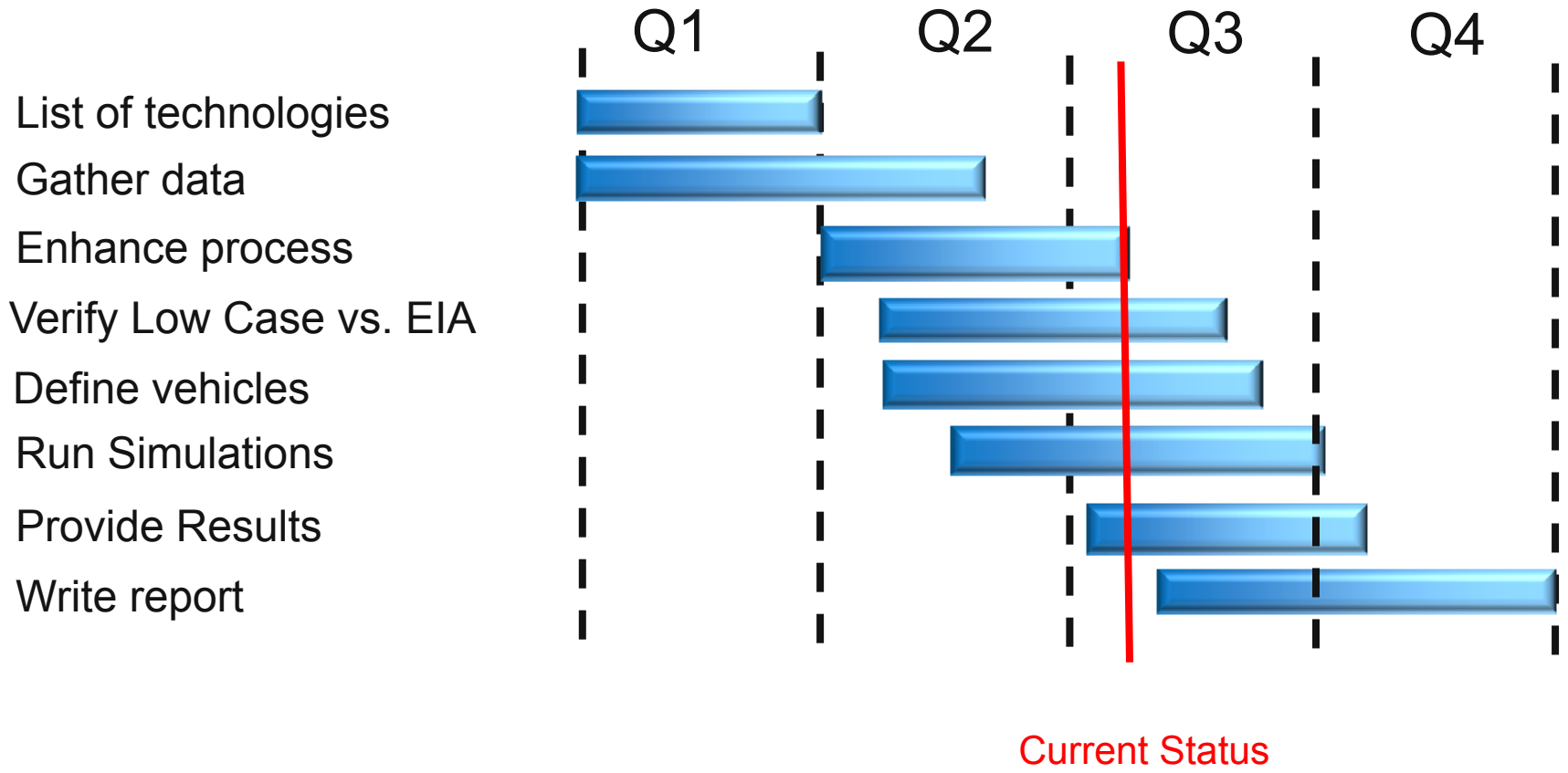
Baseline

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

Milestones



EIA = *Energy Information Administration*

Approach

Component & Vehicle Assumptions

Veh Classes

Timeframe

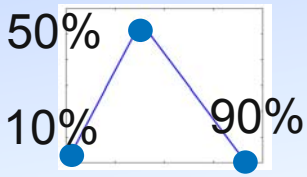
2010
2020
2030
2045

Powertrain

Fuels

Gasoline
Diesel
Ethanol
Hydrogen

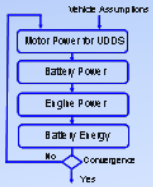
Uncertainties



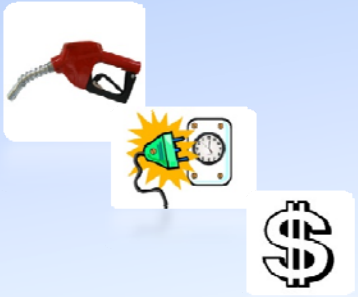
Vehicle Definition & Simulation

Vehicle Technical Specifications

Sizing

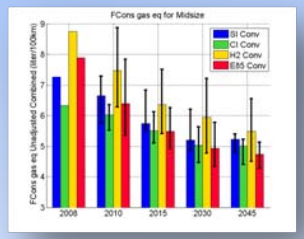


Simulation



Results Analysis & Validation

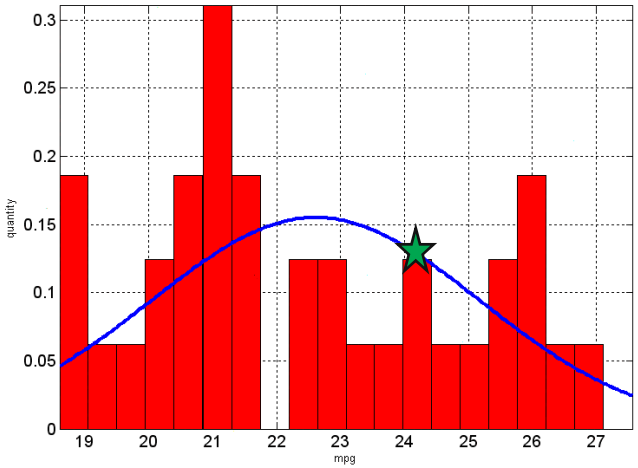
Results



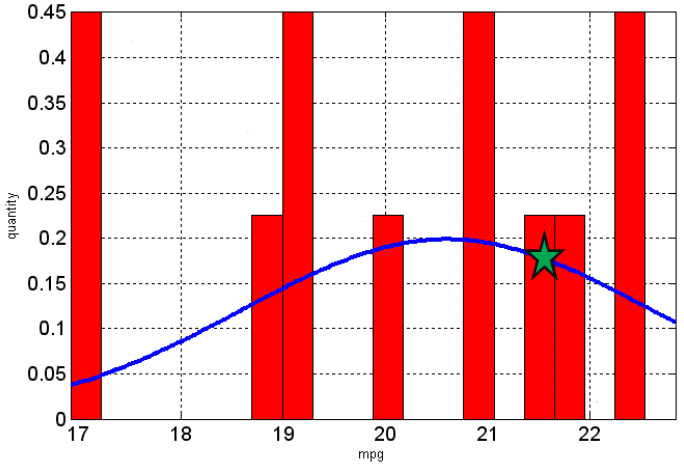
Validation

Reference Vehicles Fuel Economy Compared to Entire Class

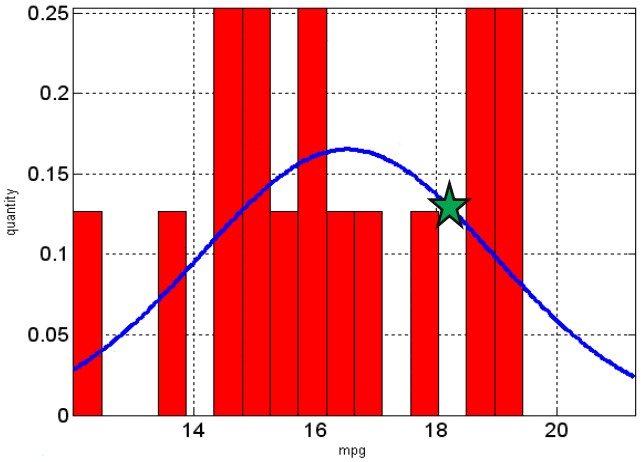
Midsize Car



Small SUV

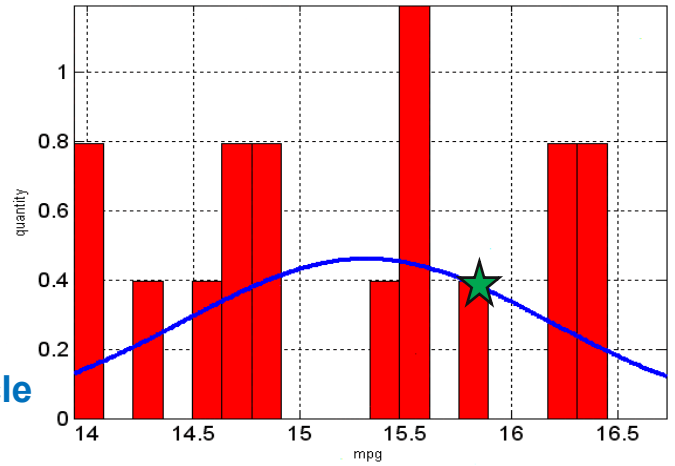


Midsize SUV



= Ref. Vehicle

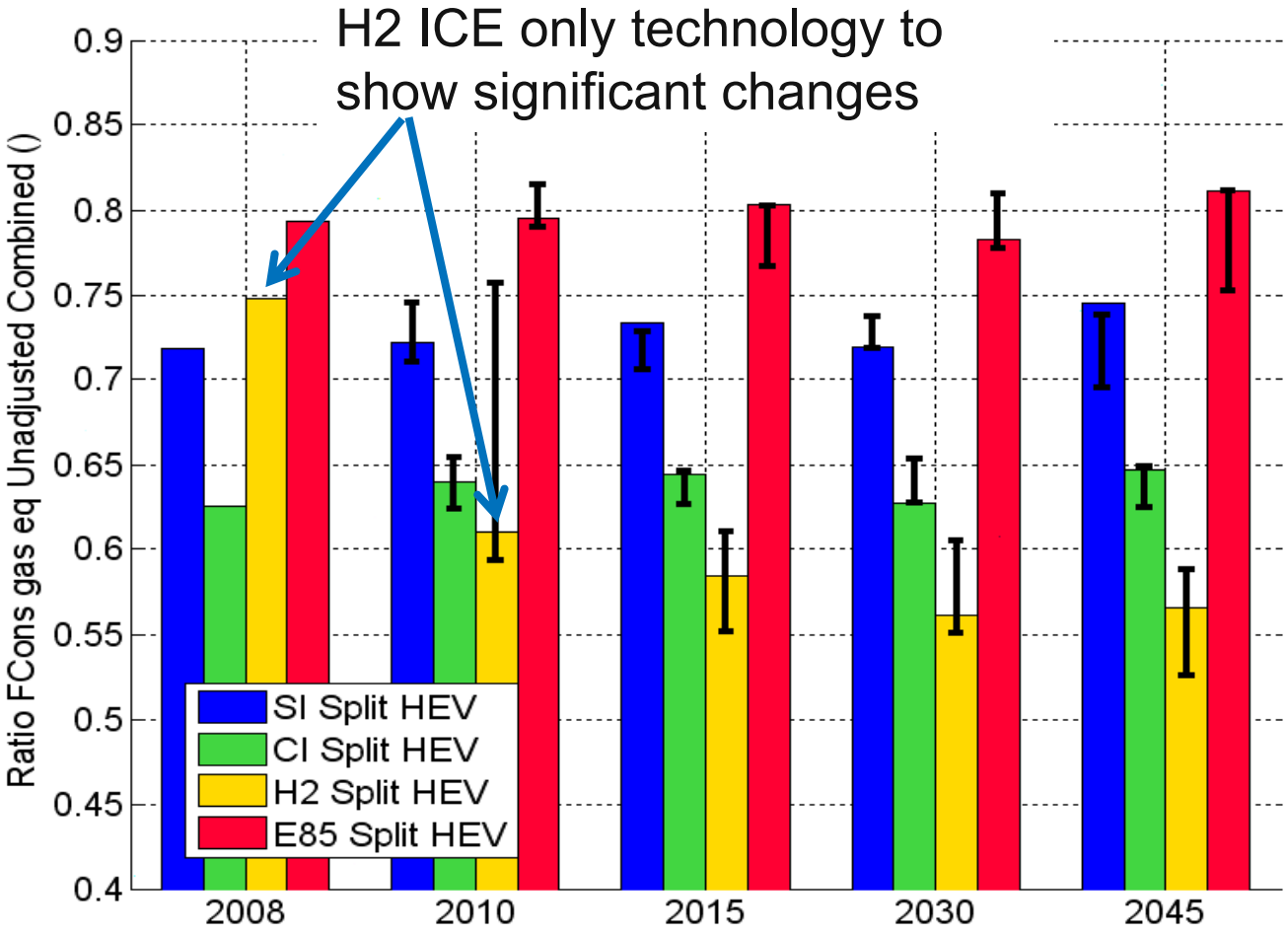
Pickup Truck



GPRA/PDS 2008 Results

EPA 2008 Adjusted Values – Including Cold Start Penalty

HEVs Fuel Consumption Remains Fairly Constant Compared to Conventional



Pickup Truck

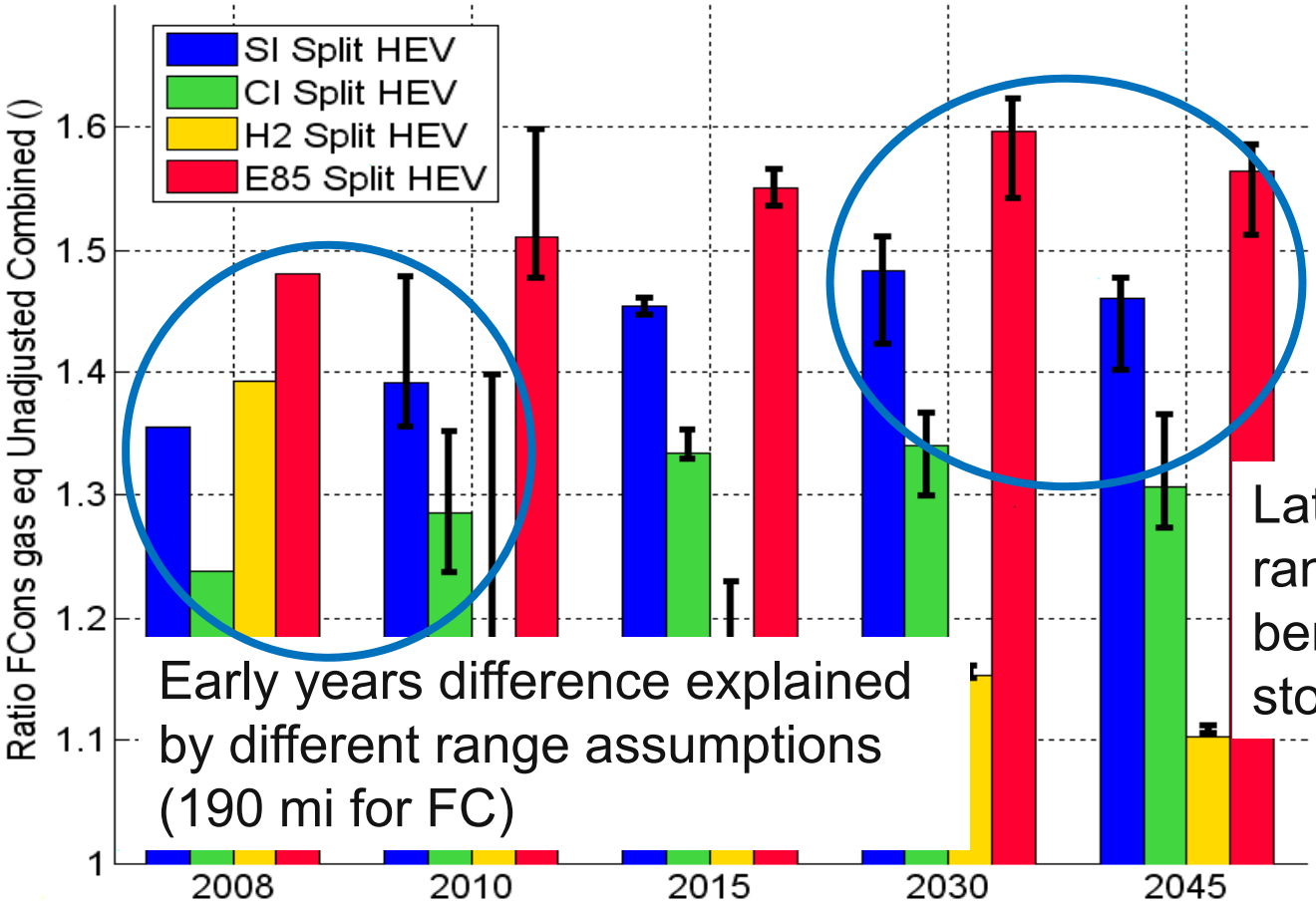
$$\text{Ratio} = \frac{\text{HEV}}{\text{Conv SI}}$$

Variable
HEV fuel

Input Split Configuration Used

GPRA/PDS 2008 Results

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



Early years difference explained by different range assumptions (190 mi for FC)

Midsize Car

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

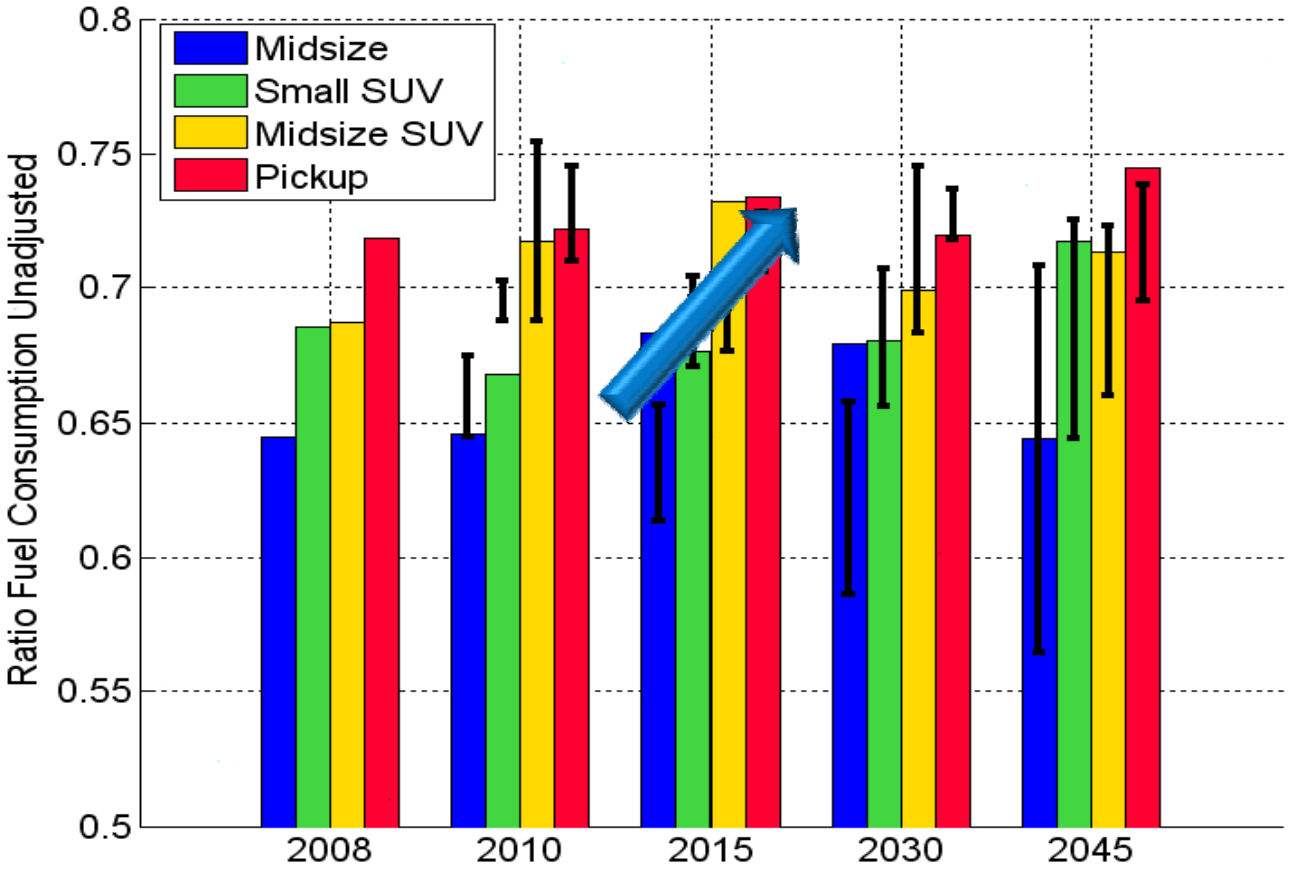
Variable
HEV fuel

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

Input Split Configuration Used

GPRA/PDS 2008 Results

Hybridization Benefits Based on Ratio Reduced with Larger Vehicle Class



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

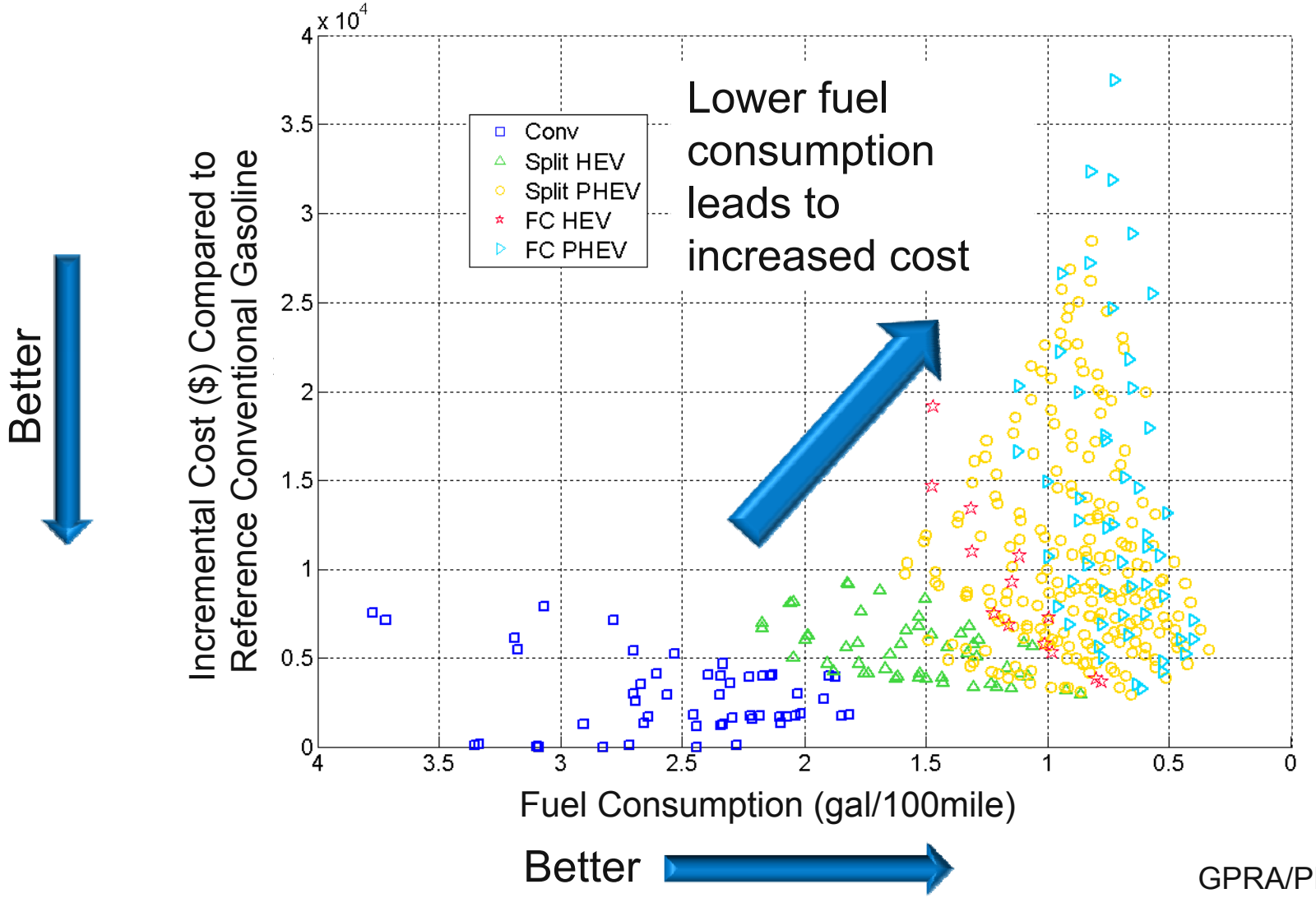
Variable
Vehicle Class

Input Split Configuration Used

GPRA/PDS 2008 Results

Trade-off Between Cost & Fuel Efficiency

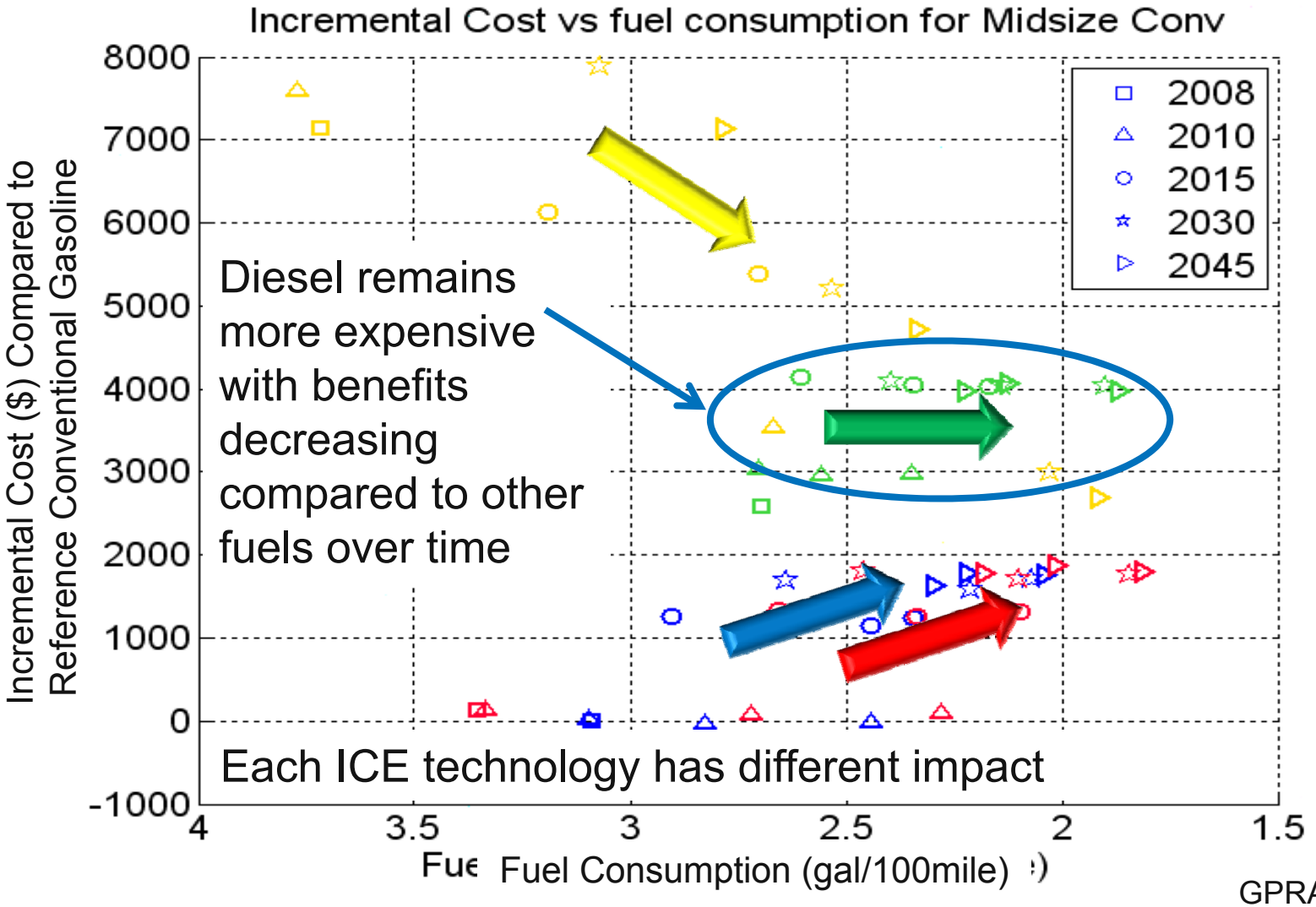
All Vehicles



GPRA/PDS 2008 Results

Trade-off Between Cost & Fuel Efficiency

Conventional Vehicles



Gasoline

Diesel

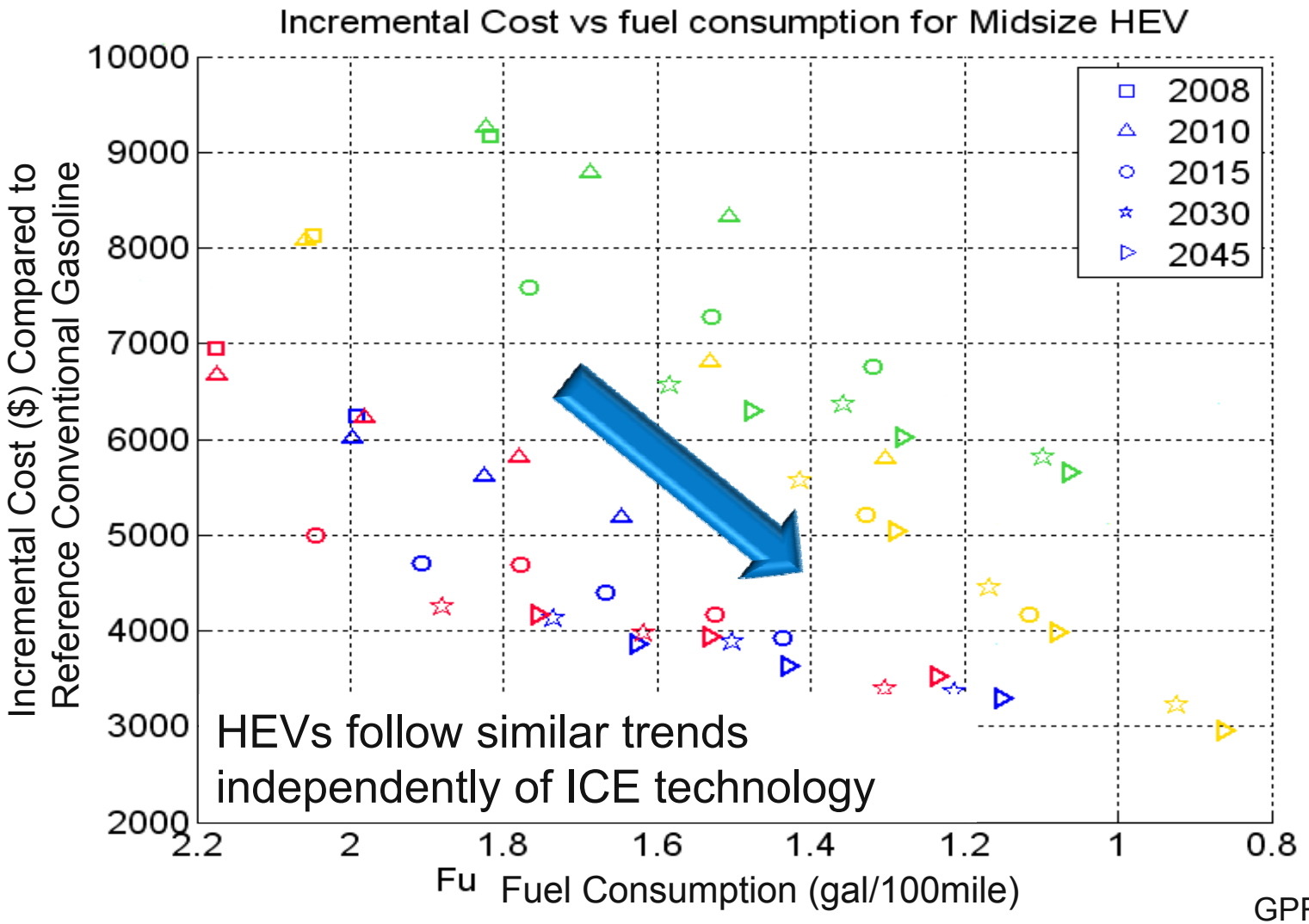
Hydrogen

Ethanol

GPRA/PDS 2008 Results

Trade-off Between Cost & Fuel Efficiency

ICE-HEV Vehicles



Gasoline

Diesel

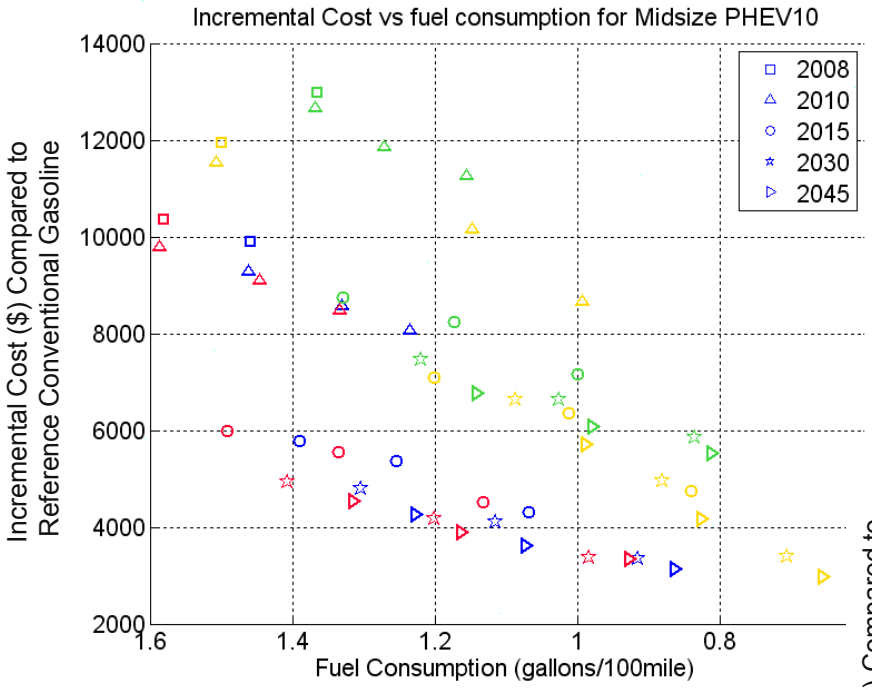
Hydrogen

Ethanol

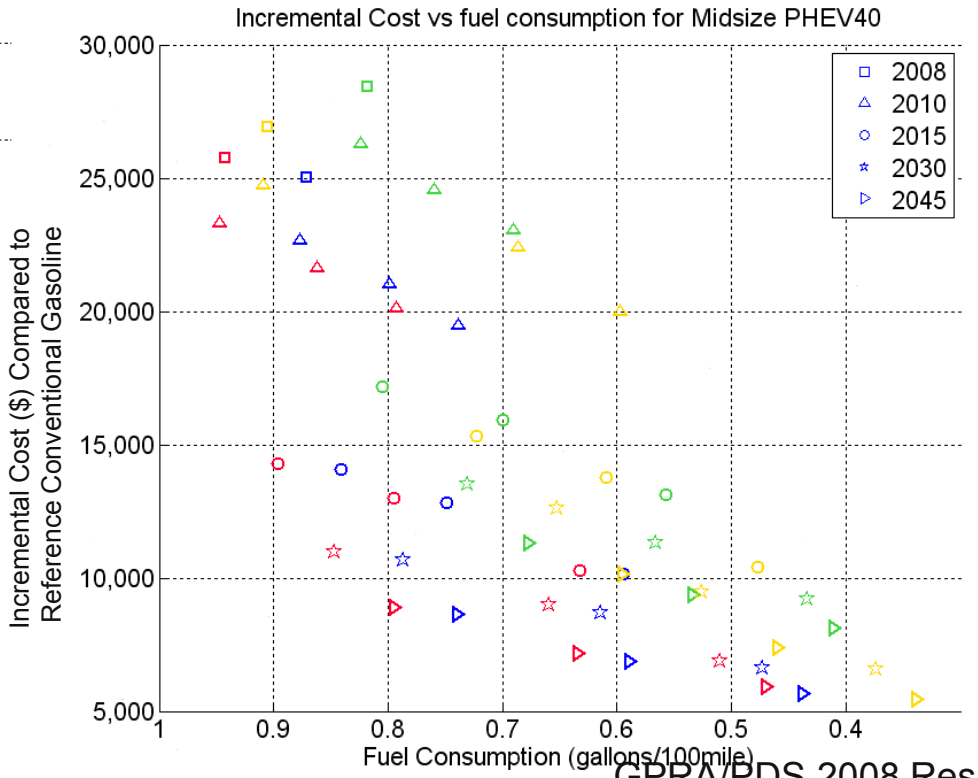
GPRA/PDS 2008 Results

Trade-off Between Cost & Fuel Efficiency

ICE-PHEV Vehicles



Higher efficiency ICEs offer less benefits than for HEVs and Conventional



Gasoline

Diesel

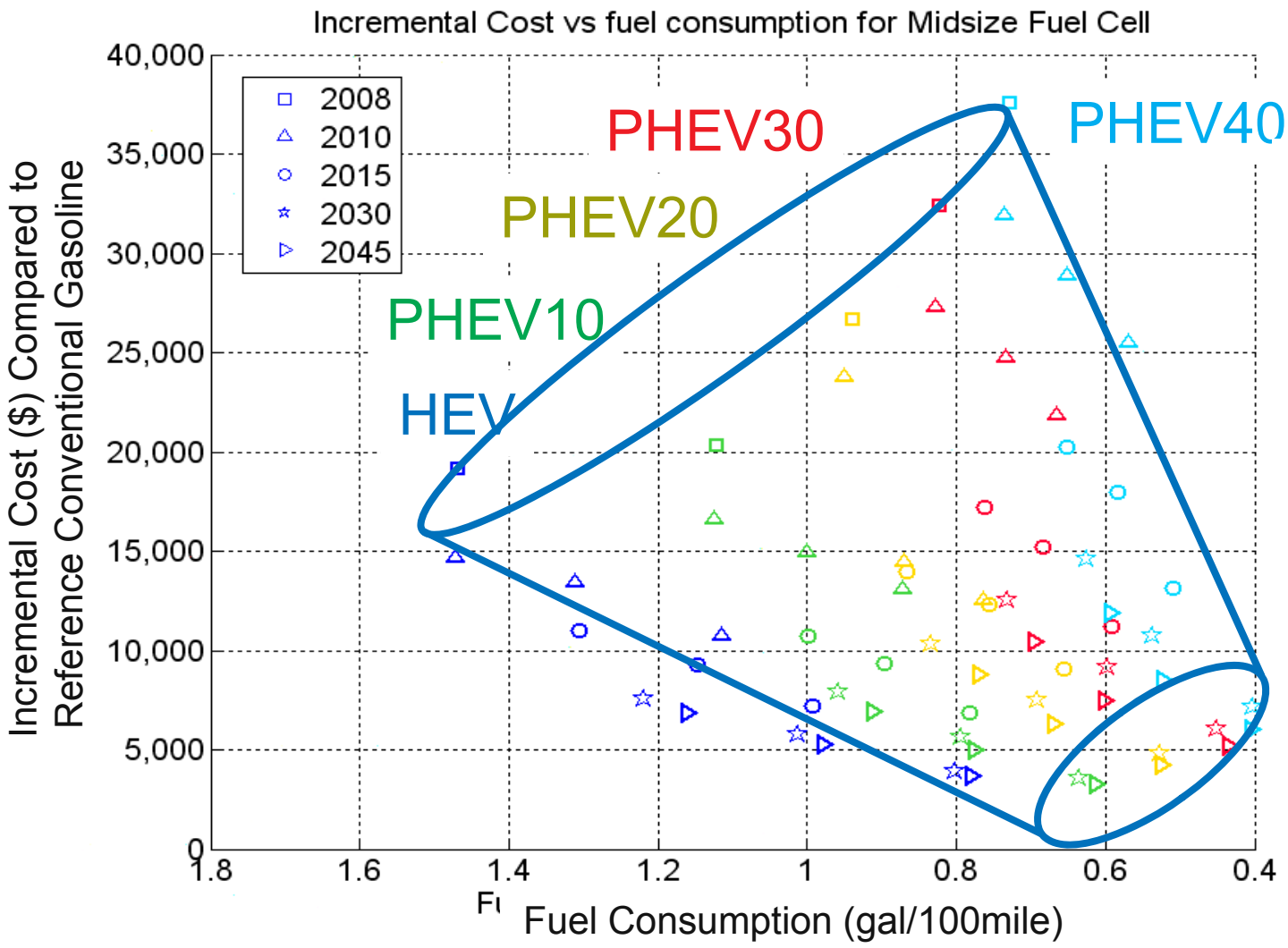
Hydrogen

Ethanol

GPRA/PDS 2008 Results

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

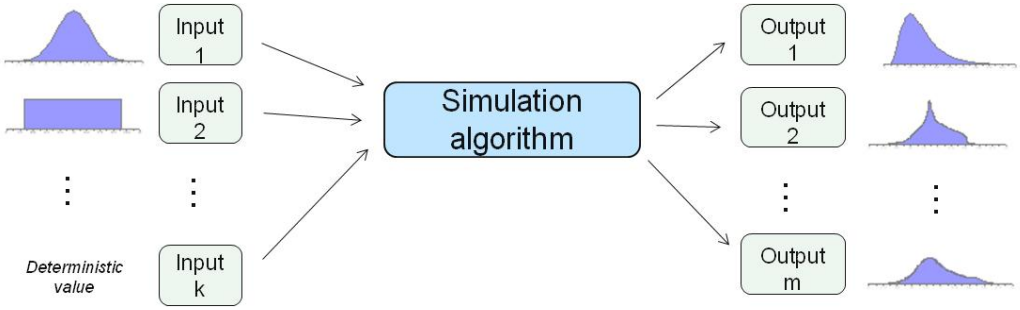
GPRA/PDS 2008 Results

In Addition to GPRA/PDS, the Results Are Used to Support Other Studies

- Component requirement uncertainties
- Fuel efficiency improvement of different
  - Fuels
  - Configurations
- Cost benefit analysis of each technology
- Provide inputs to
  - GREET (i.e., PHEV effort funded by Fred Joseck)
  - HyTrans Model
  - …

MonteCarlo Analysis Implemented and Evaluated on a Single Vehicle

- Uncertainty is modeled by a probability density function (pdf)
- How is the uncertainty propagated?



- PHEV 10 miles All Electric Range (AER) midsize used as reference case

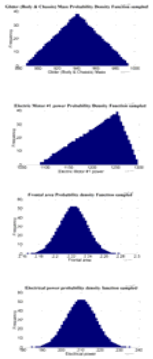
Inputs

Cd

FA

Crr

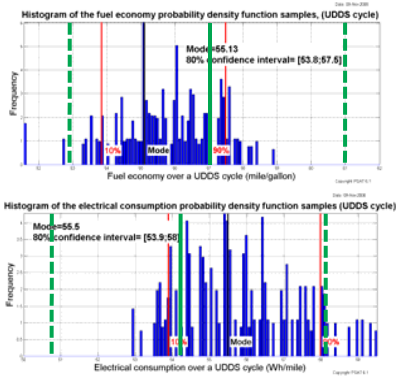
Weight



Sampling

Monte Carlo (MC),
Latin hypercube (LHS),
Median Latin hypercube (MLHS)
Quasi Monte-Carlo

Results



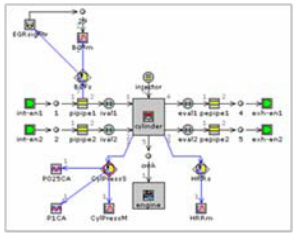
Future Activities

GPRA/PDS Studies Will Require Increased Complexity

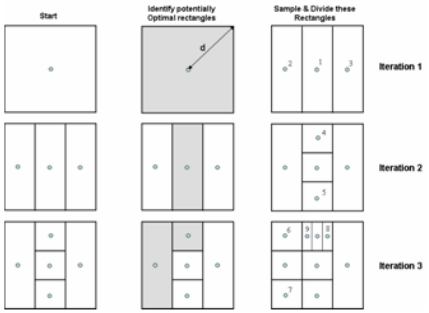
New Vehicle Classes

New Fuels

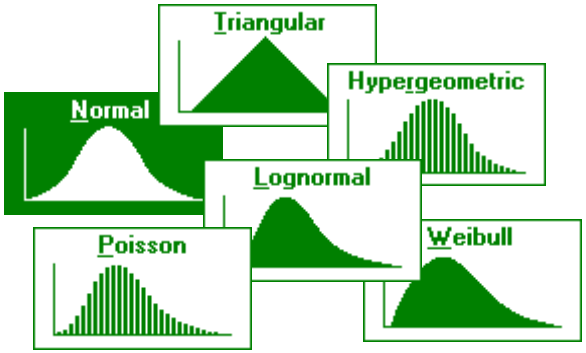
Detailed models required to represent future technologies

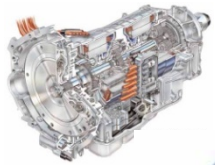


Use of optimization tool for component sizing and control strategy tuning



Monte-Carlo Risk Analysis





New Powertrain Configurations

New Vehicle Test Procedures

$$City\ FE = 0.905 \times \frac{1}{Start\ FC + Running\ FC}\ , \text{where}$$

$$StartFC\ (gallons\ per\ mile) = 0.33 \times \left(\frac{(0.76 \times StartFuel_{75}) + (0.24 \times StartFuel_{20})}{4.1} \right)$$

Summary

- GPRA/PDS study evaluates the benefits of the entire FreedomCAR and Fuels partnership in terms of petroleum displacement.
- The study assesses technology potential to guide future research and development by evaluating the benefits of the latest technologies both from a component and a control point of view.
- 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 results of the study are used to support numerous studies within DOE.

References

- G. Faron, S. Pagerit, A. Rousseau, “ Evaluation of PHEVs fuel efficiency and cost Using Monte Carlo Analysis”, EVS 24, Norway, May 2009
- A. Delorme, S. Pagerit, P. Sharer, A. Rousseau, “ Cost benefit analysis of advanced powertrain from 2010 to 2045, EVS 24, Norway, May 2009
- A. Elgowainy & Co, “Well-To-Wheels Energy Use and Greenhouse Gas Emissions of Plug-in Hybrid Electric Vehicles”, SAE 2009-01-1309, World Congress, April 2009
- A. Rousseau, “ Evolution of Hydrogen Fueled Vehicles Compared to Conventional Vehicles from 2010 to 2045”, SAE 2009-01-1008, World Congress, April 2009
- A. Delorme, A. Rousseau, S. Pagerit, “ Fuel Economy Potential of Advanced Configurations from 2010 to 2045 “, IFP HEV Conference, Paris, Nov 2008