Support for Government Performance and Results Act (GPRA)

2012 DOE Hydrogen Program and Vehicle Technologies Annual Merit Review

May 16th, 2012

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Sponsored by David Anderson, Fred Joseck & Jake Ward

Project ID # VAN008

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

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Project Overview

Timeline	Barriers*
Start Date: October 2012 End Date: July 2013 Percent Complete: 60%	• Risk aversion • Constant advances in technology • Cost • Computational models, design, and simulation methodologies *from 2011-2015 VTP MYPP
Budget	**Partners**
Total Project Funding (DOE) • $200,000 (Dave Anderson) • $100,000 (Jacob Ward) • $100,000 (Fred Joseck)	Formal Collaborator • All USDrive Partners Interactions • All USDrive Partners, outside companies (OEMs, suppliers…)

Relevance

CAFE
Fuel Economy Standards

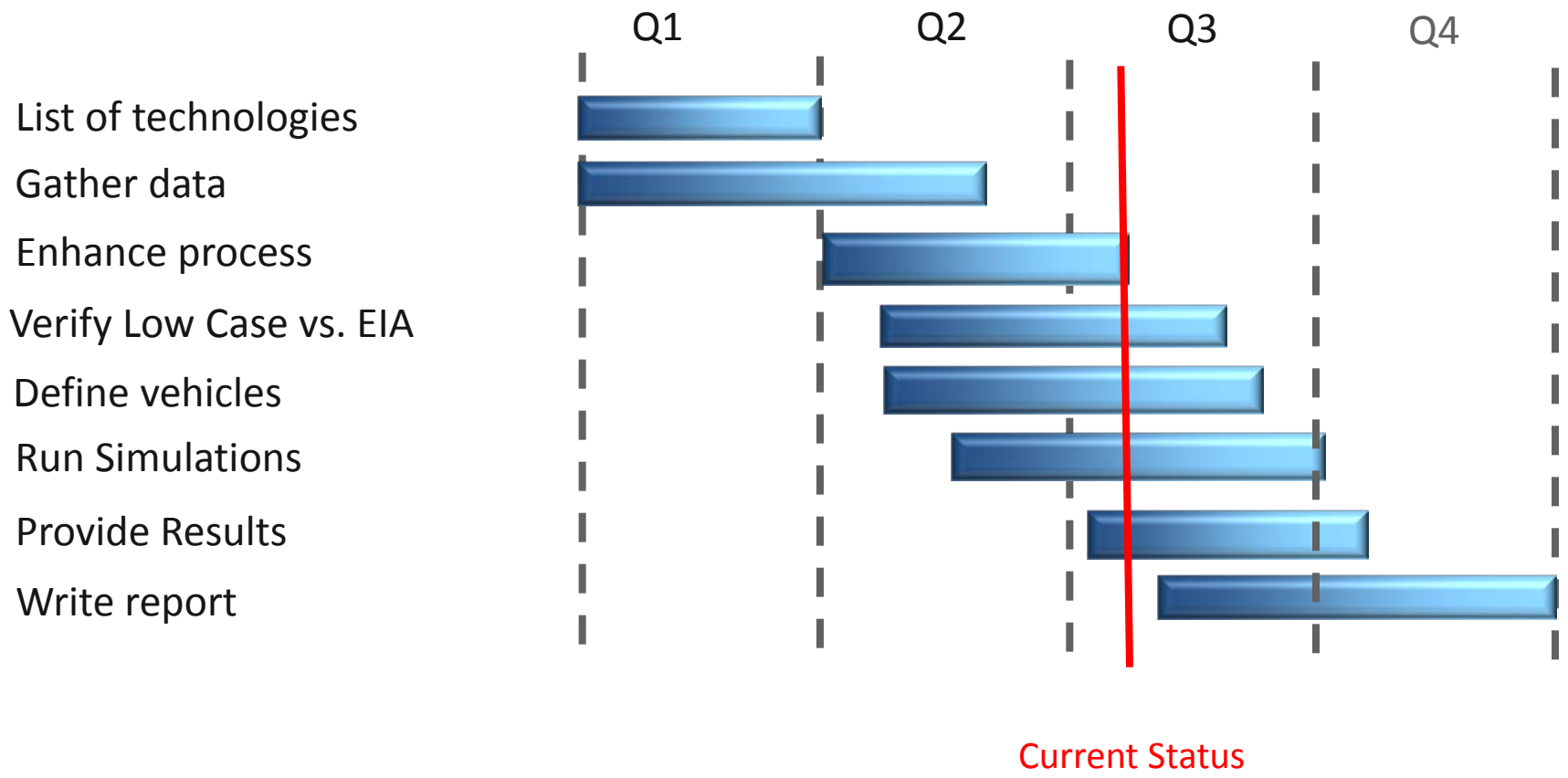
Baseline

Additional Improvements

Mandated by Congress

- What are the benefits of the USDrive 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

Consider All the Technologies Within DOE Portfolio





Timeframes

Current

2015

2020

2030

2045

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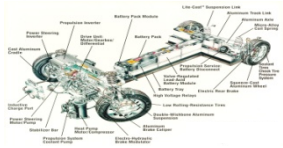
Powertrain Configurations

Conventional 


ICE HEV

PHEV 


Fuel Cell

Electric 

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Fuels

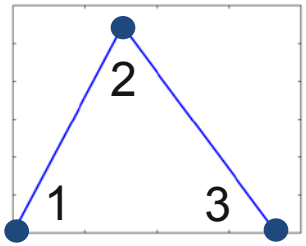
Gasoline 


Diesel

Ethanol 

⊗

Triangular Uncertainty

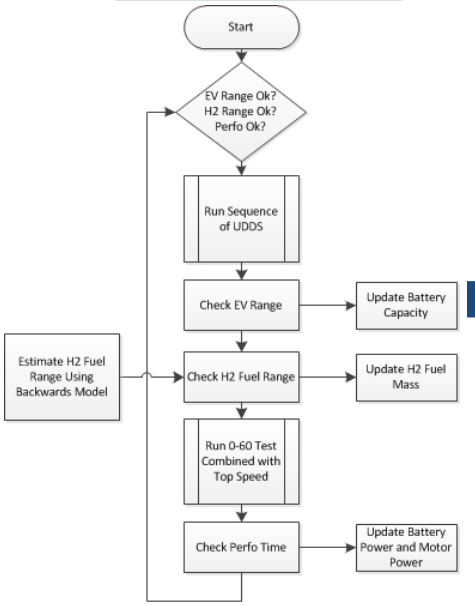


1 = 10%
2 = 50%
3 = 90%

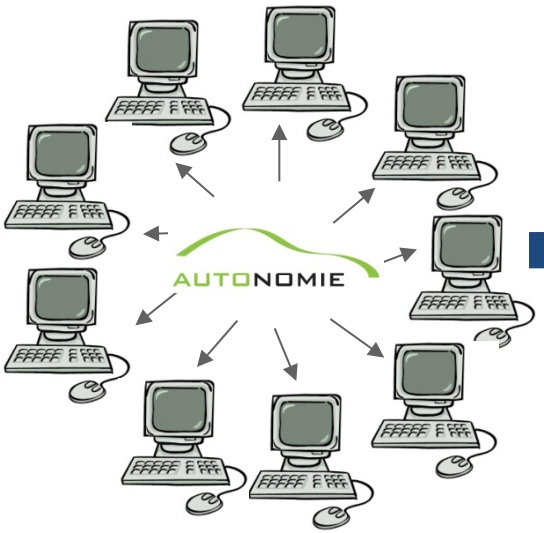
> 4000 Vehicles

Approach
Continuous Improvement of Automated Process Critical for Project Success

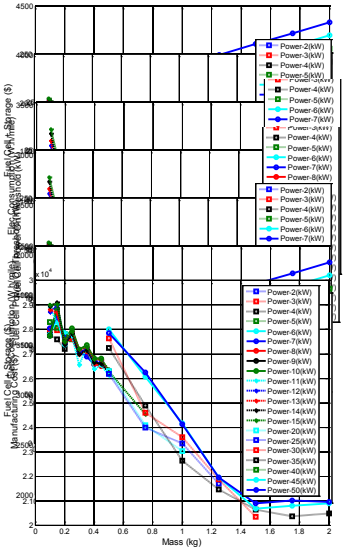
Vehicles Automatically Sized



Distributed Computing

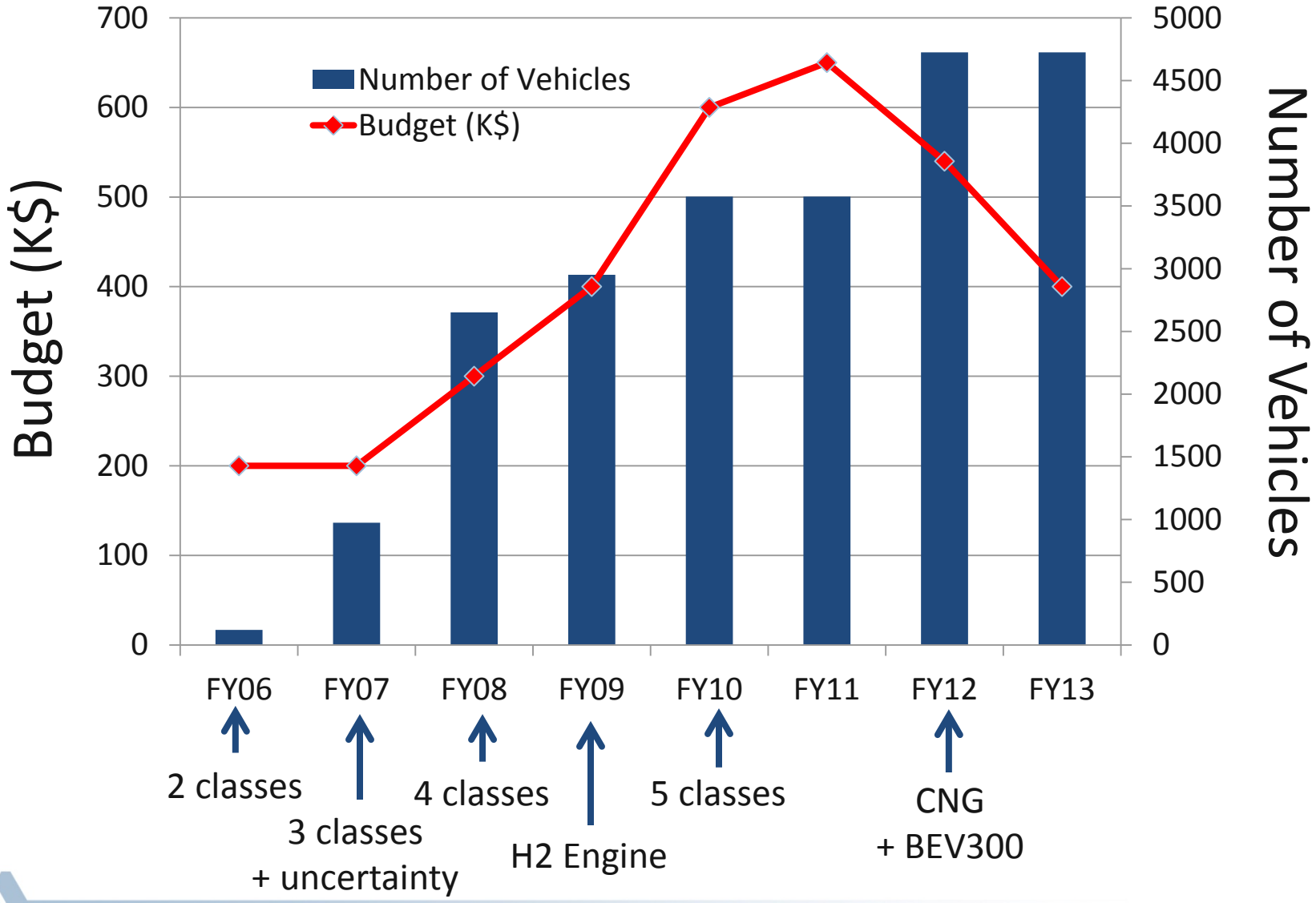


Autonomie Post-processing API



Approach

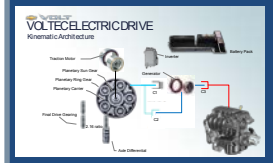
Process Improvement Allows Better Use of DOE Funding



Approach

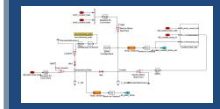
A Very Large Number of Studies Feed into GPRA

Vehicle Powertrain



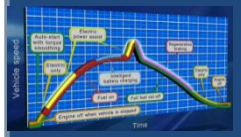
I.e. GM Voltec Development

Component Models



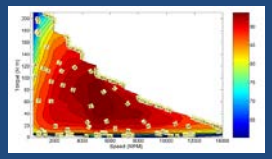
I.e. Advanced Transmission (i.e. DCT)

Vehicle Control



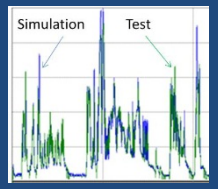
Integrate advanced control algorithms such as instantaneous optimization or route based control

Component Benchmarking



GPRA

Validation

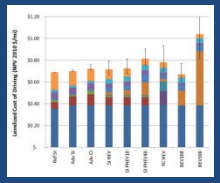


Standard Procedures

Large Scale Simulation

Numerous processes, including vehicle sizing algorithms, distributed computing, parametric study, SOC correction… are used to evaluate a large number of options

Levelized Cost of Driving

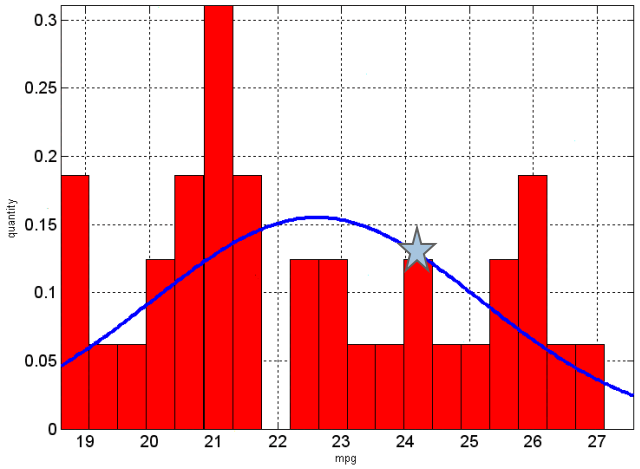


Integrate LCD calculations to evaluate the technology benefits using $/mile

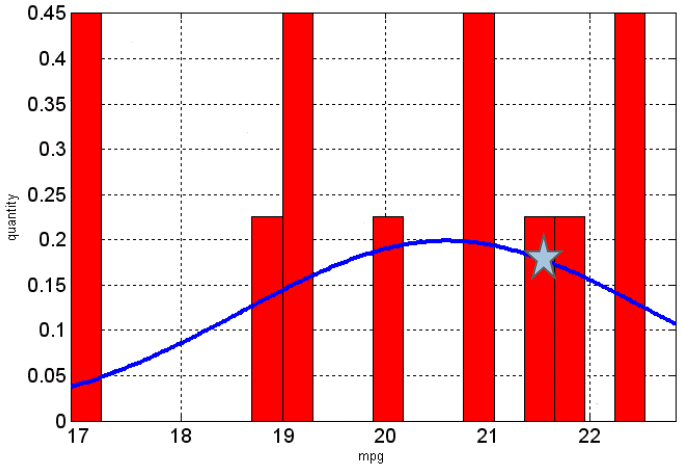
Technical Accomplishments

Reference Vehicles Fuel Economy Compared to Entire Class

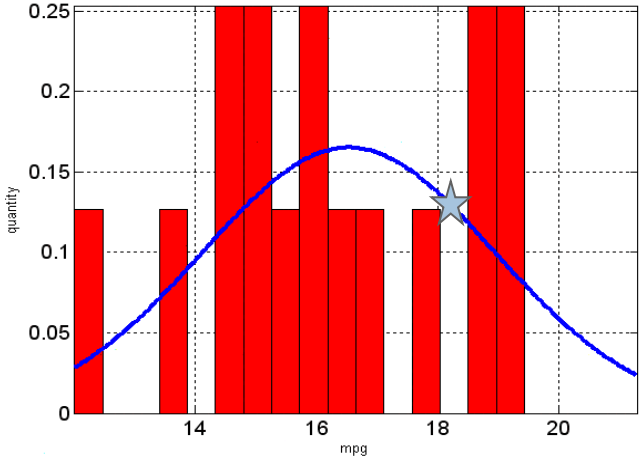
Midsize Car



Small SUV

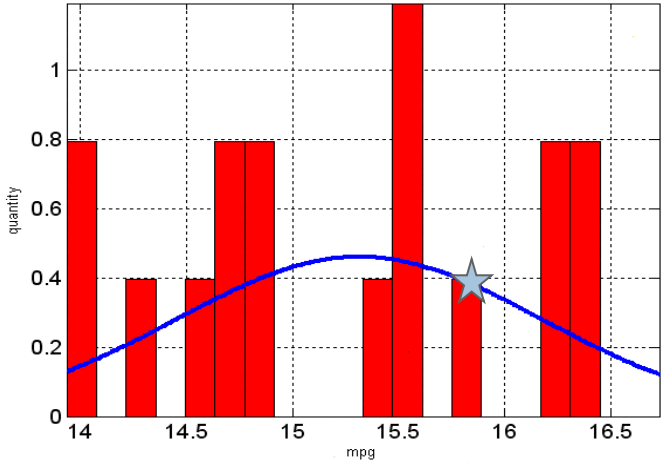


Midsize SUV



= Ref. Vehicle

Pickup Truck

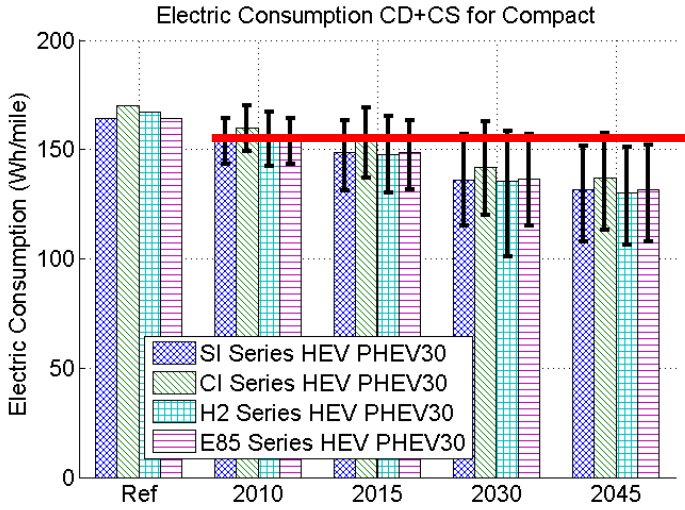


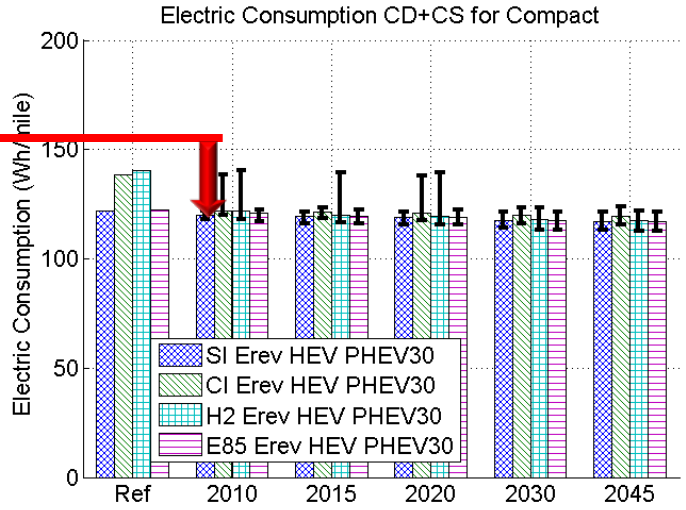
Technical Accomplishments
Main Results - Vehicle Sizing

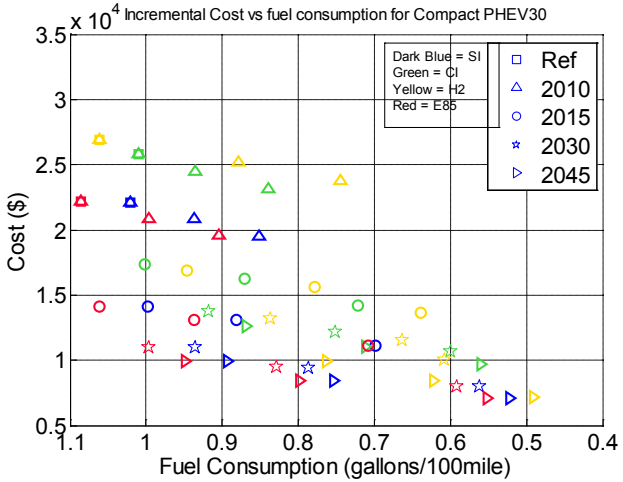
- The difference in **peak efficiency between gasoline and diesel engine is expected to narrow in the future** due to the combination of advanced gasoline engine technologies and the impact of ever more stringent after-treatment for diesel
- Due to **lightweighting** and component efficiencies improvements, **engine and fuel cell systems peak power could be significantly reduced over time** to meet current Vehicle Technical Specifications.
- **Battery peak power is also expected to decrease over time** to meet current vehicle performance. For gasoline engine configurations, the **battery power is expected to decrease up to 34% for HEVs and PHEVs**. For **fuel cell systems, the decrease could be as high as 48%**.
- **Battery total energy will be decreasing significantly** due to other component improvements as well as a wider usable SOC range. **The energy required for PHEVs and BEVs could be reduced from 4 to 60%**.

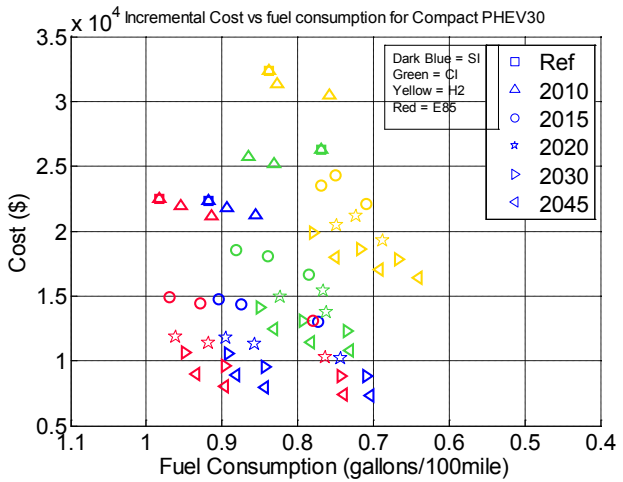
Technical Accomplishments
Understand the Impact of New Assumptions

The E-REV configuration Contributes to a 16.4% Electric Consumption Decrease for SI PHEV30 Compared to a Series PHEV









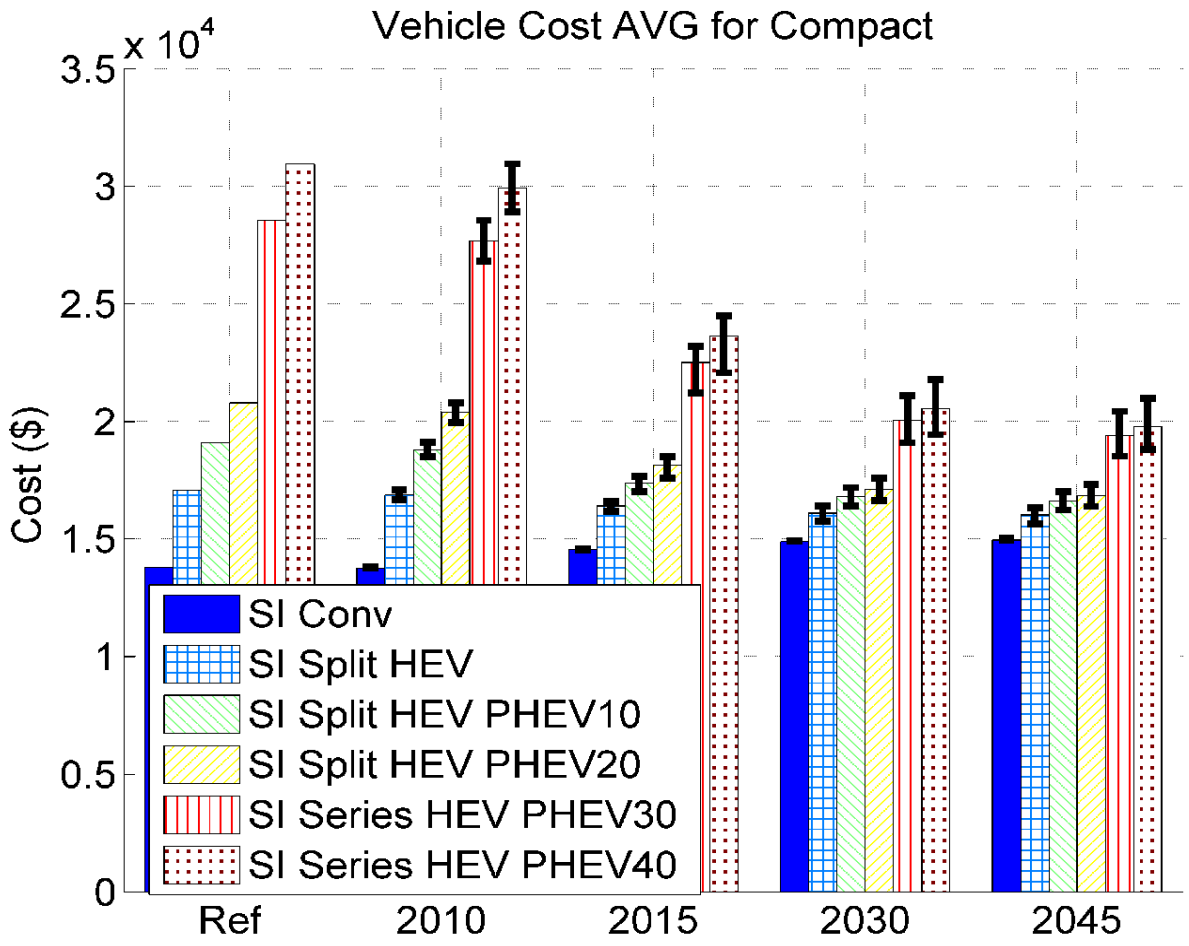
Technical Accomplishments
Main Results - Energy Consumption

- **Fuel consumption improvements due to hybridization over time stay fairly constant** for all power-split HEV
- Gasoline HEVs fuel consumption benefits range from **36 to 40% for compact car, 34 to 40% for midsize car, 60 to 36% for small SUV, 29 to 35 for large SUV and 28 to 33 for pickup trucks**

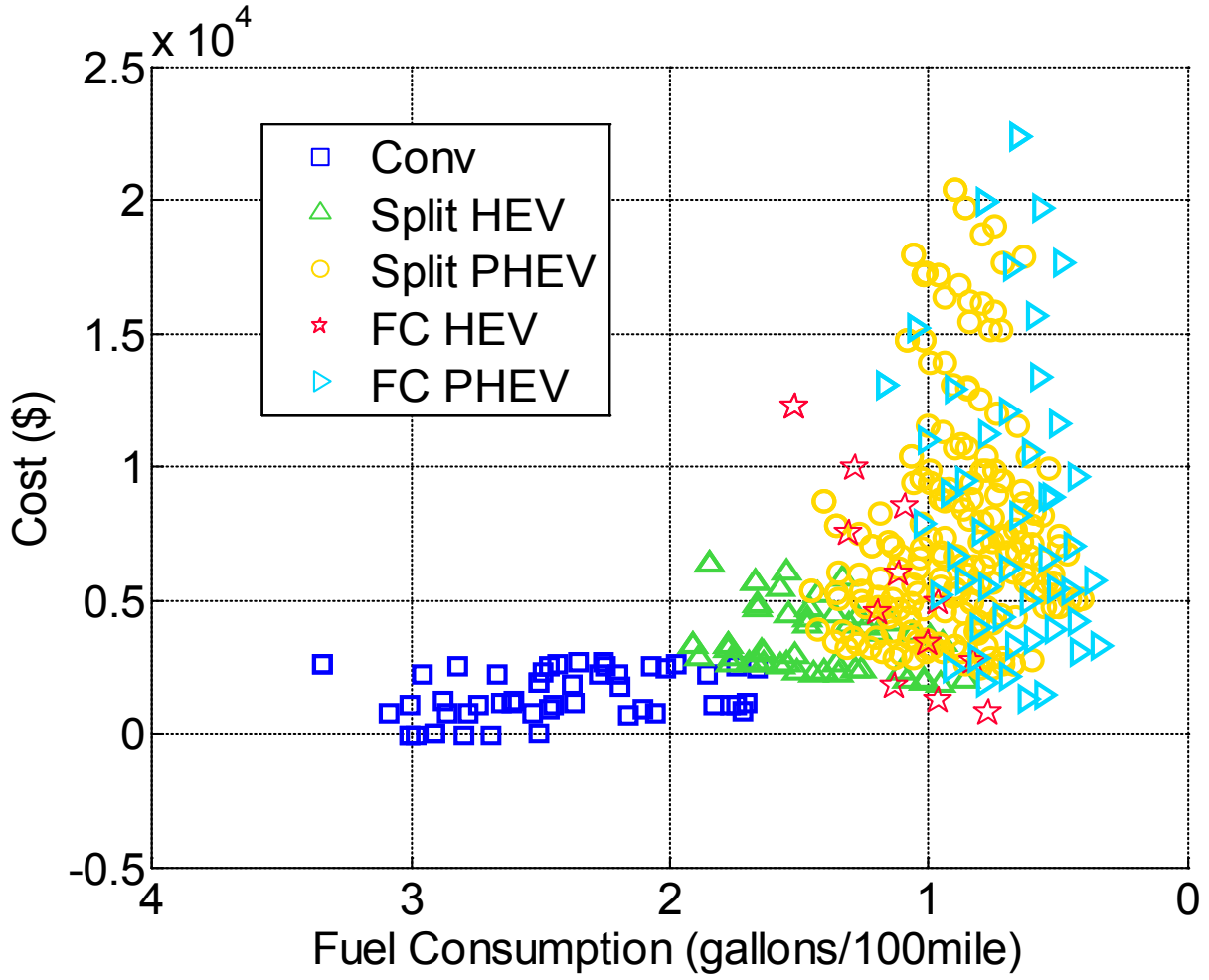
Fuel\Powertrain	Conventional	HEV	PHEV10	PHEV40
Gasoline	2-67	6-63	5-63	5-55
Diesel	5-53	5-44	5-45	6-51
Ethanol	1-60	8-57	7-58	5-51
CNG	3-60	5-64	5-64	2-29
Fuel Cell		5-55	8-49	10-52
Electricity (BEV100)	8-50			
Electricity (BEV300)	39-83			

Percentage fuel consumption improvement for each powertrain by 2045 compared to their respective current status

Technical Accomplishments
Assess Manufacturing Cost Evolution



Technical Accomplishments
Assess Trade-off Between Energy Consumption & Manufacturing Cost



Technical Accomplishments
Study Main Results

- The combination of the technology improvements leads to **significant fuel consumption and cost reduction** across light duty vehicle applications.
- Due to the uncertainty of the evolution of the technologies considered, **research should continue to be conducted in the different area showing high fuel displacement potential**.
- Due to expected improvements, **advanced technologies are expected to have significant market penetration over the next decades**.
- In the **short term**, both **engine HEVs and PHEVs allow for significant fuel displacement** with acceptable additional cost.
- While **electric vehicles** do provide a promising solution, they **will remain expensive in the near future**, which will limit their introduction to the market.
- In the **long term**, **hydrogen engine HEVs** will offer significant fuel improvements and due to lower costs than fuel cell systems, they will **appear as a bridging technology that would help the infrastructure**.

Collaboration and Coordination with Other Institutions

Same Process used to define USDrive Targets

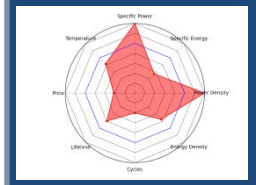
Assumptions, Data

GPRA

Energy Consumption, Cost

Report available online used by numerous researchers

Program Targets

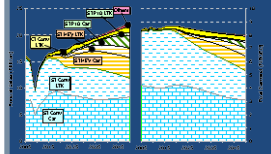


Develop and validate the performance (i.e. power, energy) and cost target of components

Life Cycle Analysis

GREET uses Autonomie outputs to predict GHG, CO2eq…

Market Penetration



Models like MA3T and Vision use outputs from Autonomie

Proposed Future Work

FY13 On going work

- Update component performance data and vehicle level control
- Update vehicle testing procedure (i.e. BEV)
- Improve vehicle sizing algorithms (i.e. battery pack nominal voltage as a function of powertrain electrification…)
- Include energy balance for each vehicle on each cycle
- Develop process to create a database that can be used for other studies (i.e. cost sensitivities)
- Develop & implement process to provide requested data for GREET and Market penetration models

FY14 Potential Activities

- Continue to improve process and represent latest technologies
- Add medium and heavy duty classes

Summary

- The GPRA study evaluates the benefits of the entire USDrive 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 5000 vehicles were simulated for different timeframes (up to 2045), powertrain configurations, and component technologies.
- Both their energy consumption and cost were assessed to estimate the potential of each technology. Each vehicle was associated with a triangular uncertainty.
- The processes developed for the study along with its results are used to support numerous activities within DOE.