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PHEV Vehicle Modeling & Simulation Activities Overview

November 2008

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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

“This presentation does not contain any proprietary or confidential information”

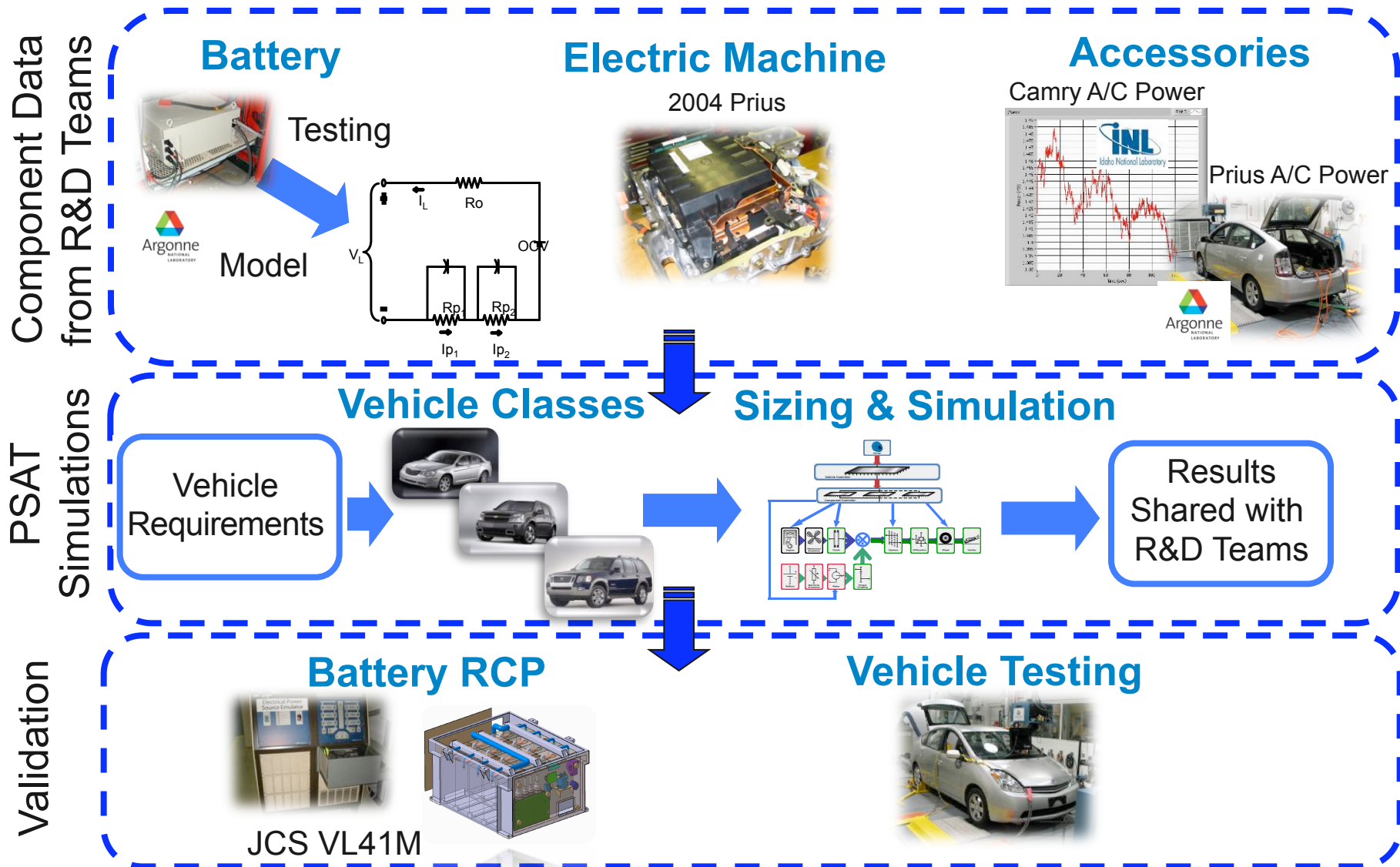
PSAT Simulations Support R&D and Management Decisions

- Primary vehicle model for all FreedomCAR and 21 CTP activities by the U.S.DOE, stating that *“All future code development and enhancements for OFCVT shall focus on PSAT and PSAT-PRO”*
- PSAT has been awarded a R&D100 Award in 2004.
- Support numerous FreedomCAR activities:
 - Component requirements
 - Component technology evaluation
 - Powertrain configuration evaluation
 - Control strategy
- Used by more than 110 companies worldwide (>350 users)
- *“... We need a model that’s intuitive, easy to use, and provides accurate results. PSAT gives us that.”*



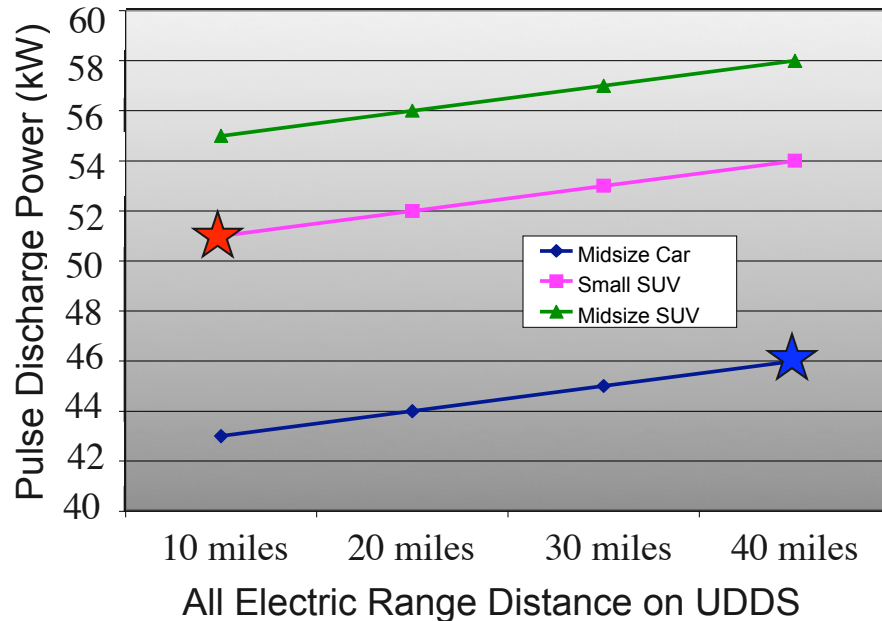
Randy Yost - GM Engineering

PHEVs Component Requirements Process

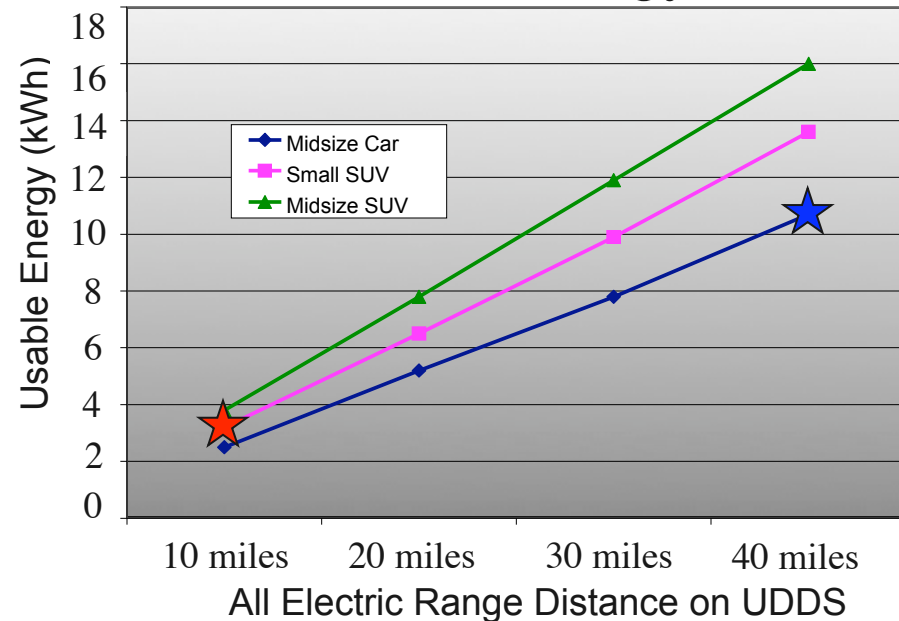


Optimum Battery Power and Energy Defined for Several Vehicle Platforms and AER

Power



Usable Energy



Final values selected by the ESS Tech Team

- Short term 10 miles AER (3.4 kWh, 50 kW) ★
- Long term 40 miles AER (11.6 kWh, 46 kW) ★

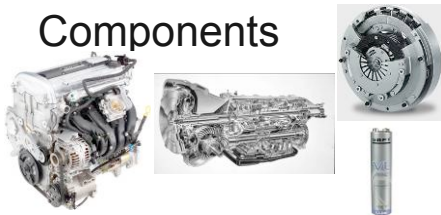
Component Requirements Uncertainties Currently Evaluated

Vehicle
Technology

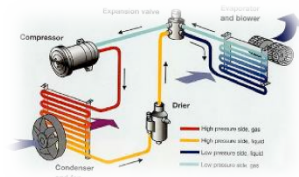
Glider
Mass



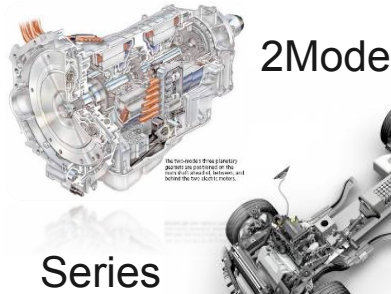
Components



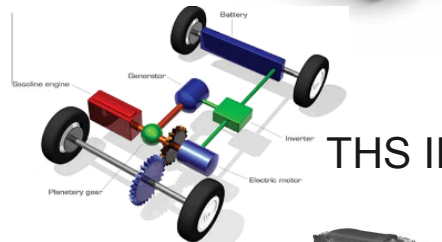
Air Conditioning



Powertrain
Configuration



Series



THS II

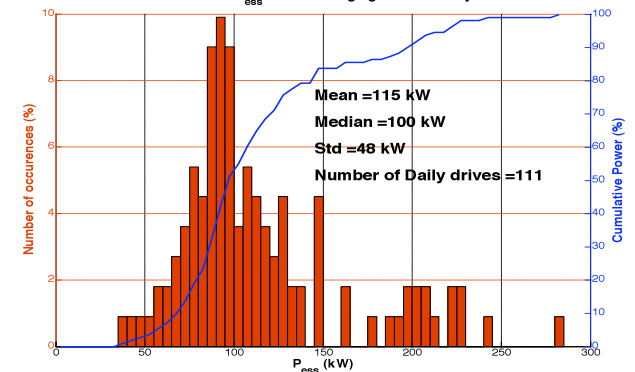
Parallel



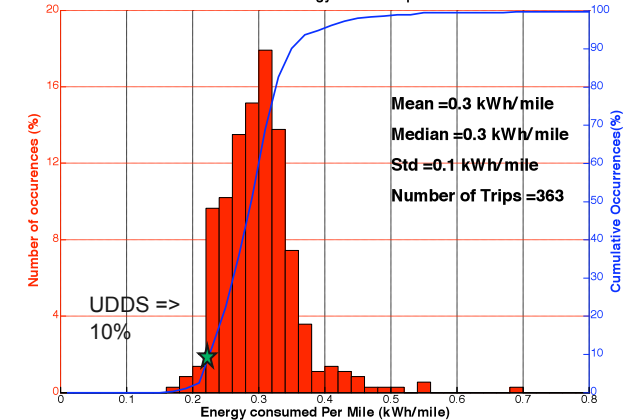
Real World
Drive Cycles



Distribution of P_{ess} max discharging for each Daily drive

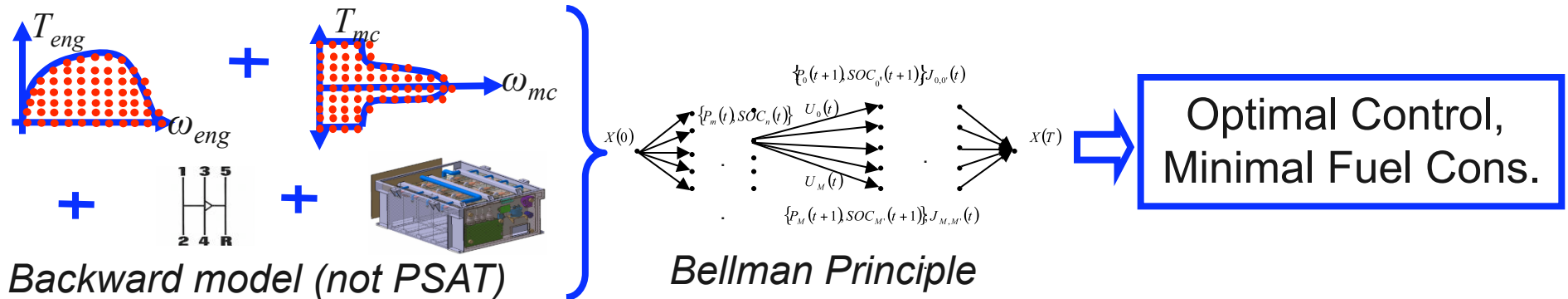


Distribution of energy consumed per mile

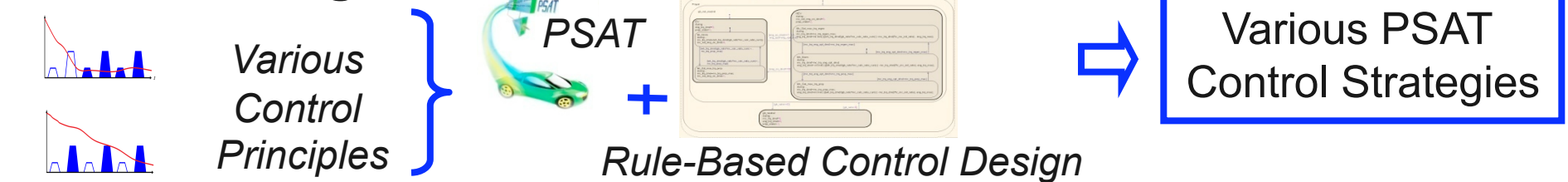


3-Way Approach to Control Optimization

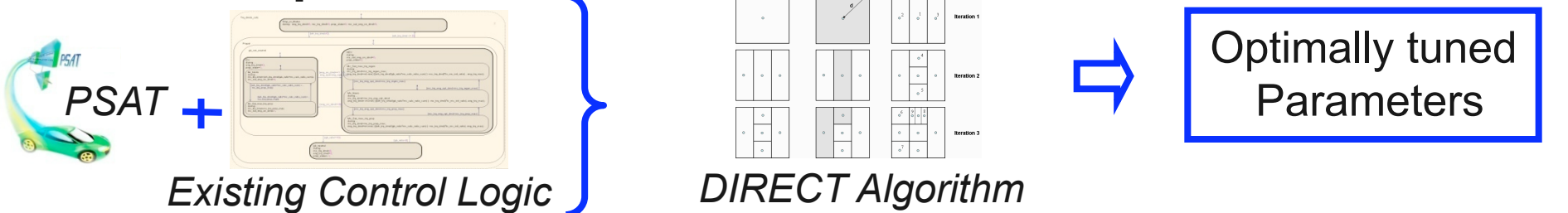
Global Optimization



Control Design

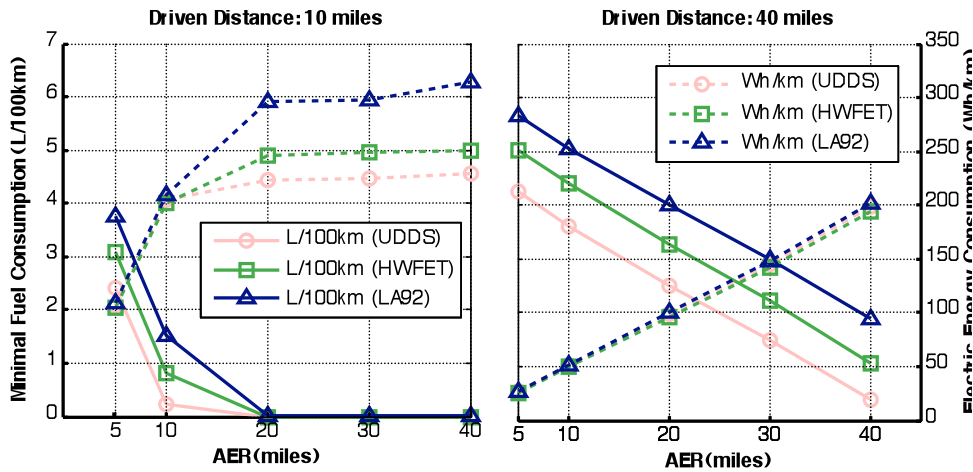


Heuristic Optimization

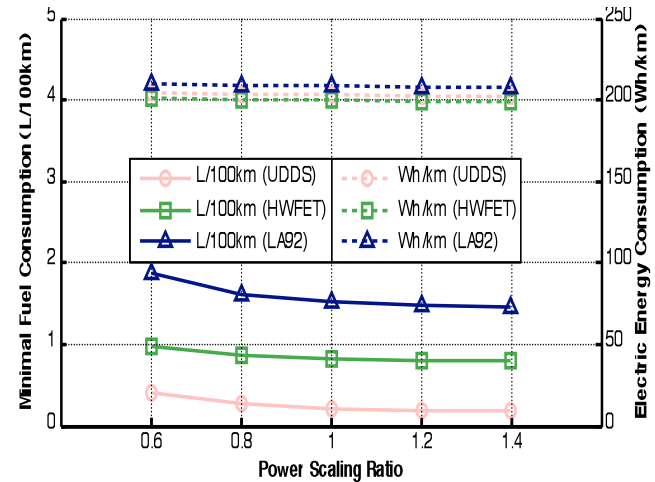


Influence of Component Characteristics Impact

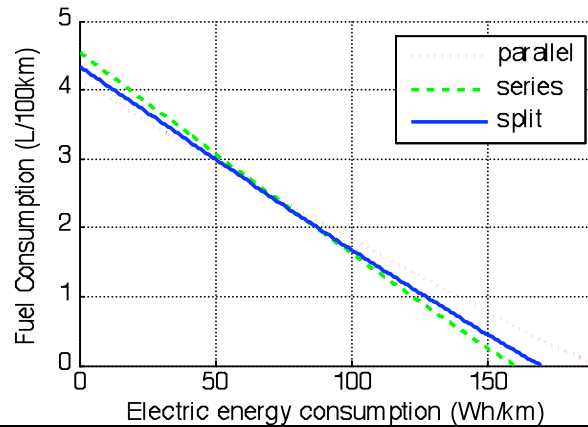
Battery Energy



Battery Power

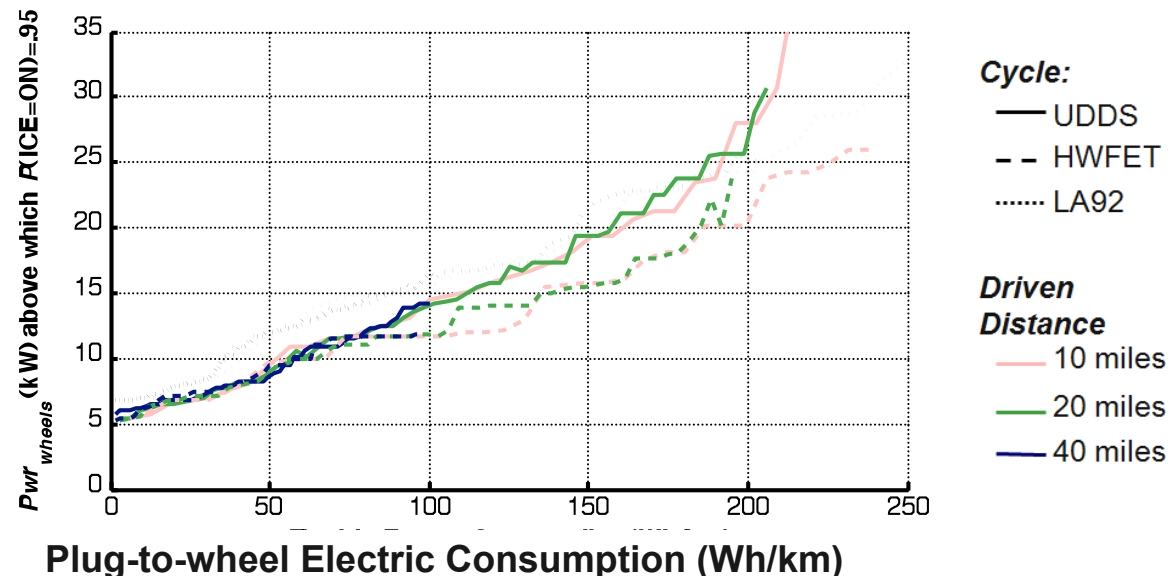


Powertrain Configuration



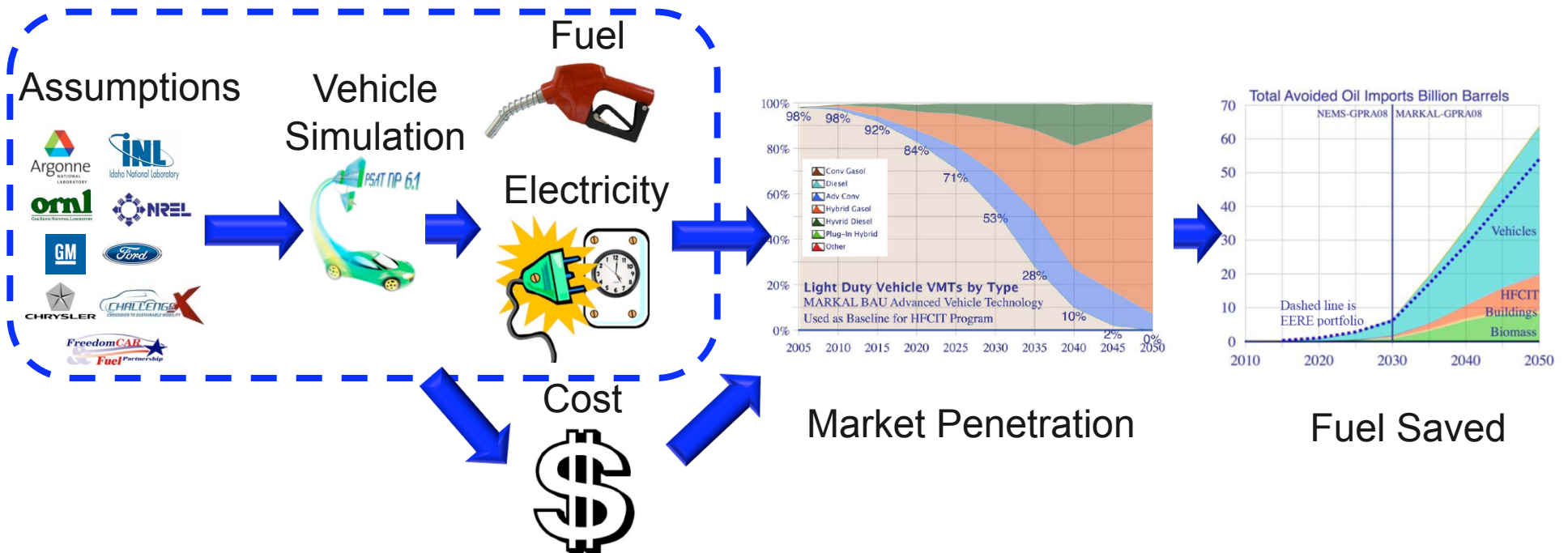
Definition of Rules for Real Time Control

- When the trip distance is greater than the All Electric Range, using the engine throughout the trip (blended control) is preferable to depleting the battery as fast as possible
- Optimum control depends on the distance
- Engine On/Off is linked to wheel power demand and available electrical energy
- When used, engine should be operated at high efficiency

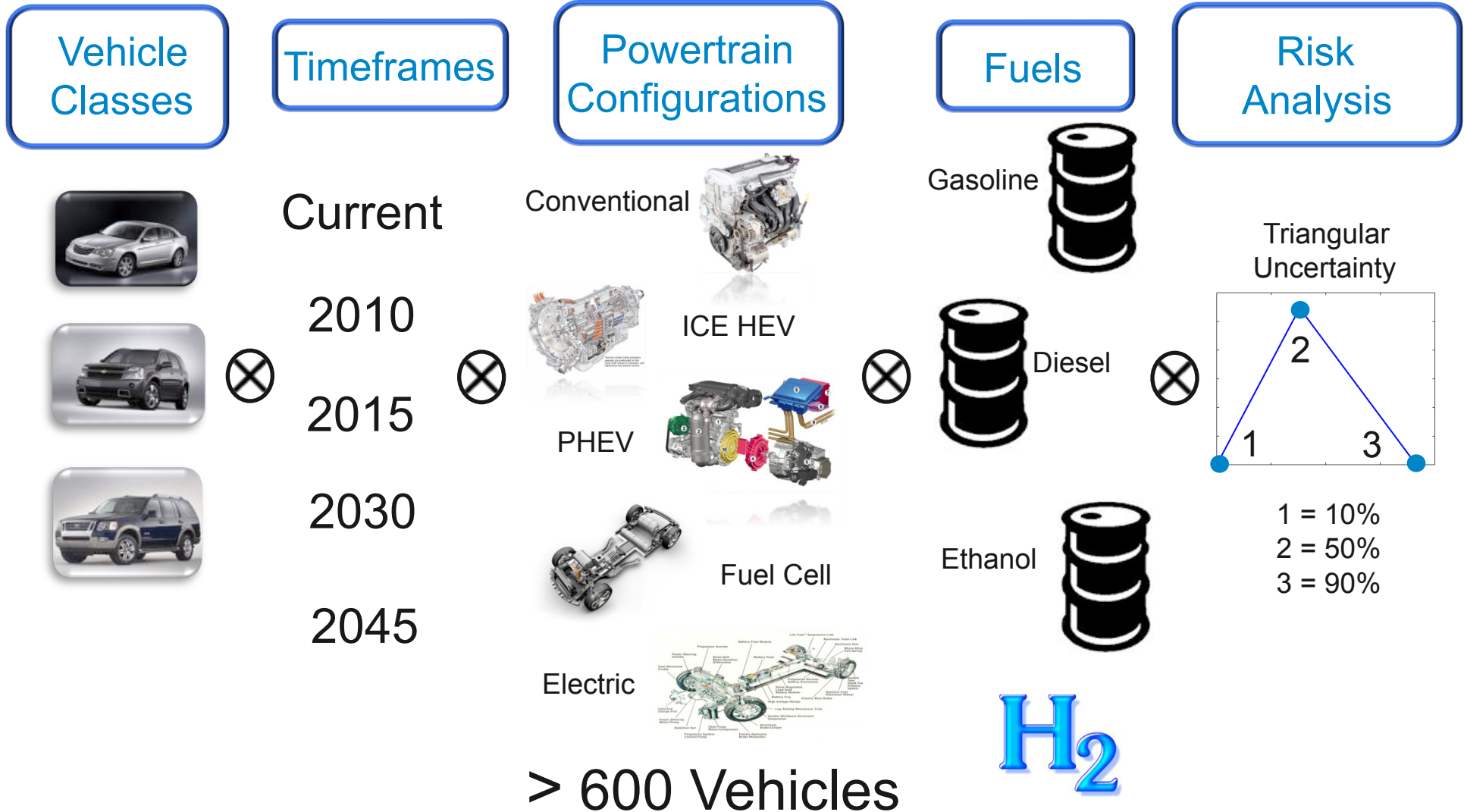


Evaluate Vehicle Fuel Economy of Advanced Technologies

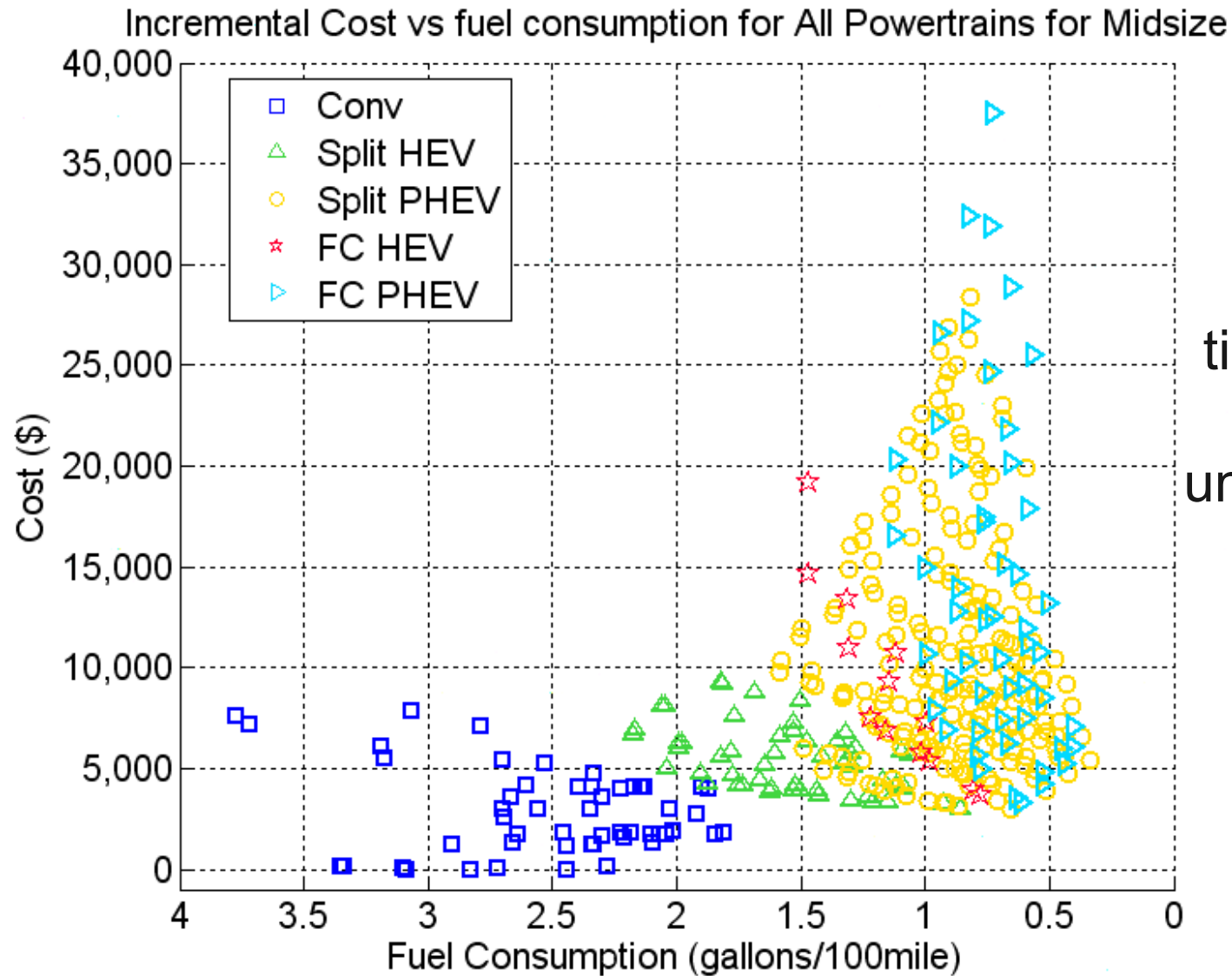
- Developed as an input to the Government Performance and Results Act (GPRA) evaluates the amount of fuel saved due to the introduction of new technologies.
- Used to evaluate cost/benefit of DOE sponsored projects



Large Number of Vehicles



Example of Cost Benefit Analysis



All timeframes and uncertainties included

Current & Future Activities

- Assess influence of component and vehicle assumptions on PHEV requirements and fuel efficiency
- Evaluate benefits of PHEVs using real world drive cycles based on component, powertrain configuration, control strategies...
- Assess different high level vehicle control strategy benefits for PHEVs