Fuel Cell Vehicle Systems Analysis

Fuel Cells for Transportation Program Review
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Outline

- Objective
- Approach
- Timeline of Milestones
- Accomplishments
- Addressing Reviewer Comments
- Industry Interactions
- Future Plans
- Summary

Objectives

- Provide DOE and industry with early design insights and modeling tools that lead to introduction and application of advanced technology

- Quantify benefits and impacts of Fuel Cells for Transportation program technology development efforts at the vehicle level

Approach

- Collaborate with industry to populate the model database
- Develop and link to existing component and vehicle models to enhance systems analysis capabilities
- Apply optimization tools to automate analysis process
- Study benefits of fuel cell vehicle design scenarios

Highlights/Milestones

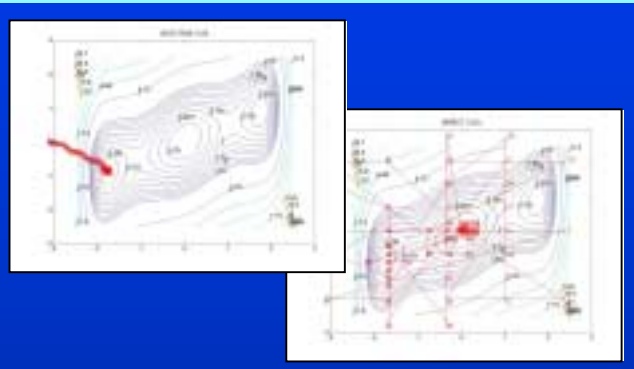
10/01	M	Presented drive cycle impacts study at EVS-18
11/01	M	Presented optimization methods for fuel cell hybrid vehicles at ASME IMECE Conference
2/02		Testing of initial fuel cell thermal systems model from Virginia Tech
4/02		Participated in SAE Fuel Cell Standards Committee
4/02		Initiated data collection effort with web seminar
5/02	M	Incorporation of fuel cell component data into vehicle systems models
6/02		Present fuel cell system characteristics study at FutureCar Congress
7/02	M	Analysis of vehicles using DOE fuel cell technology
8/02	M	Evaluation of technical target based vehicle

M - Completed Milestones

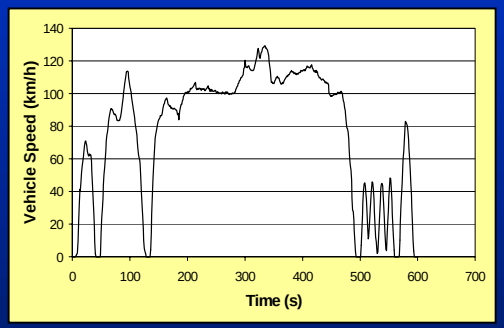
M - Planned Milestones

Accomplishments
Fuel Cell Vehicle Design Optimization

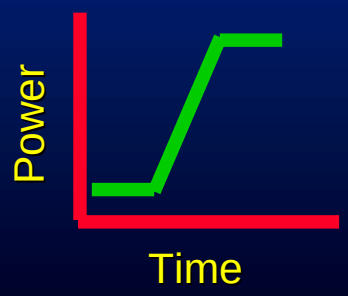
- Optimization Algorithms
  - efficiency of gradient and derivative-free algorithms



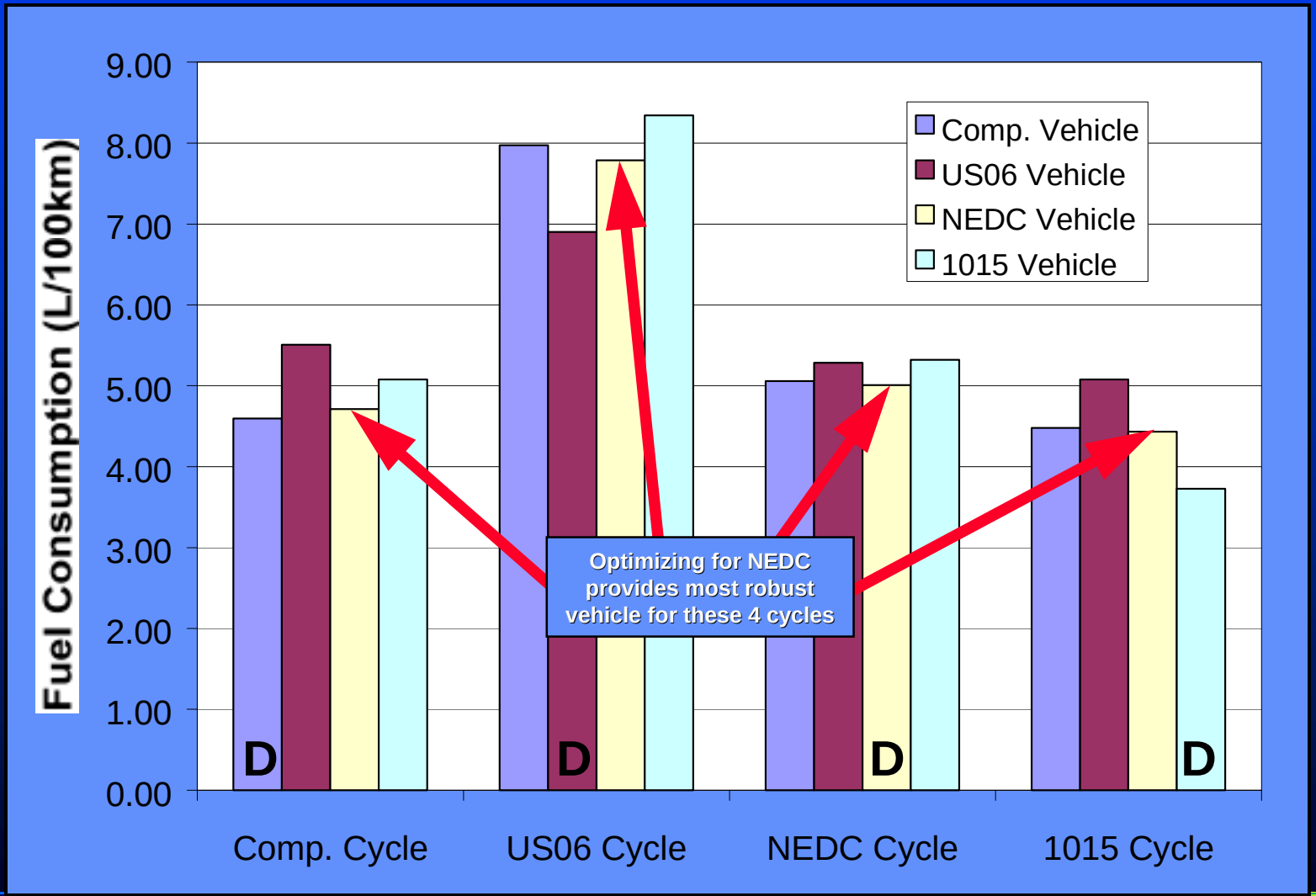
- Drive Cycle Impacts
  - Vehicle optimization for a drive cycle
  - Assessment of robustness of vehicle design



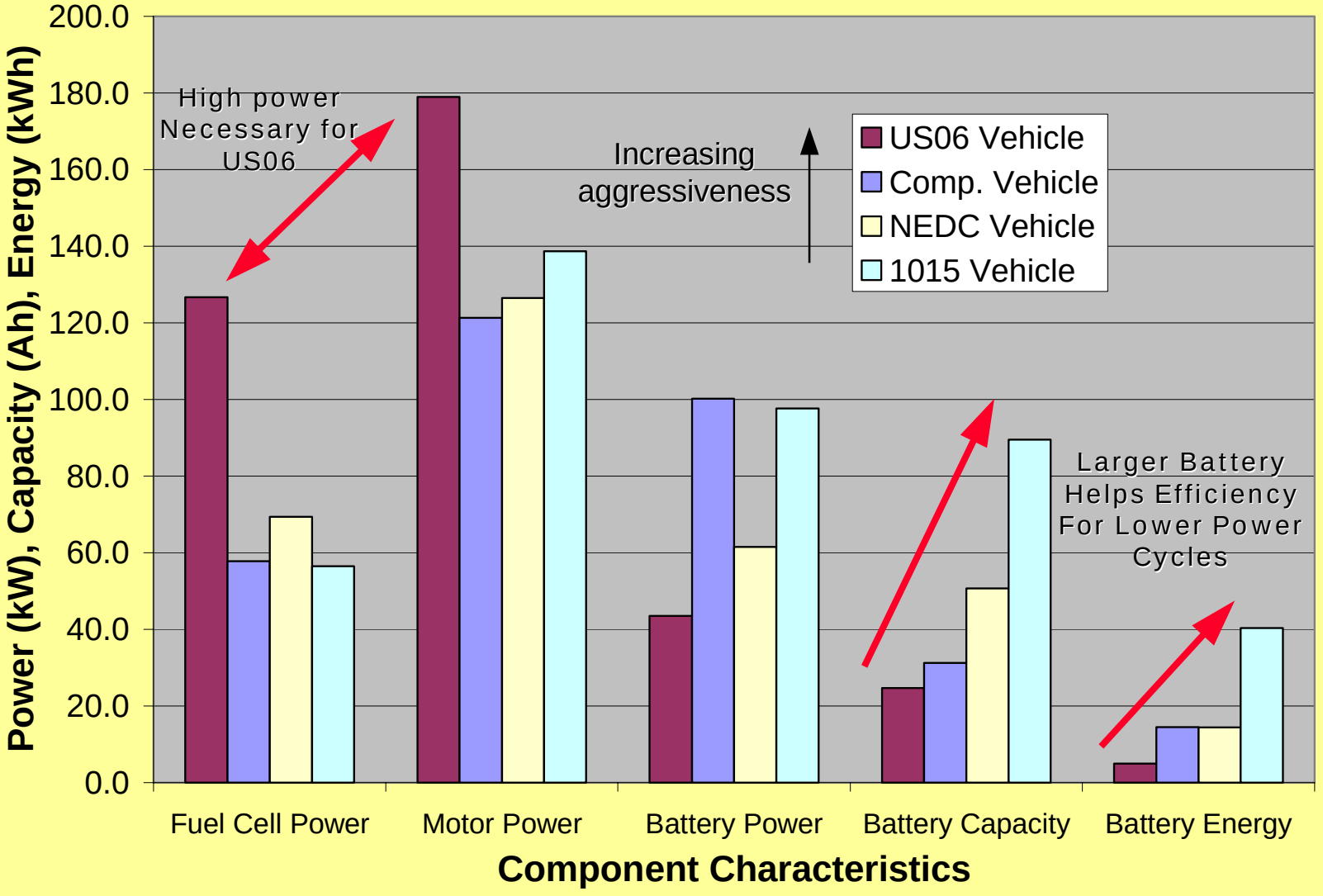
- Fuel Cell Systems Characteristics Impacts
  - Component characteristics drive system design



Results: Drive Cycle Investigation (D = vehicle designed for this cycle)

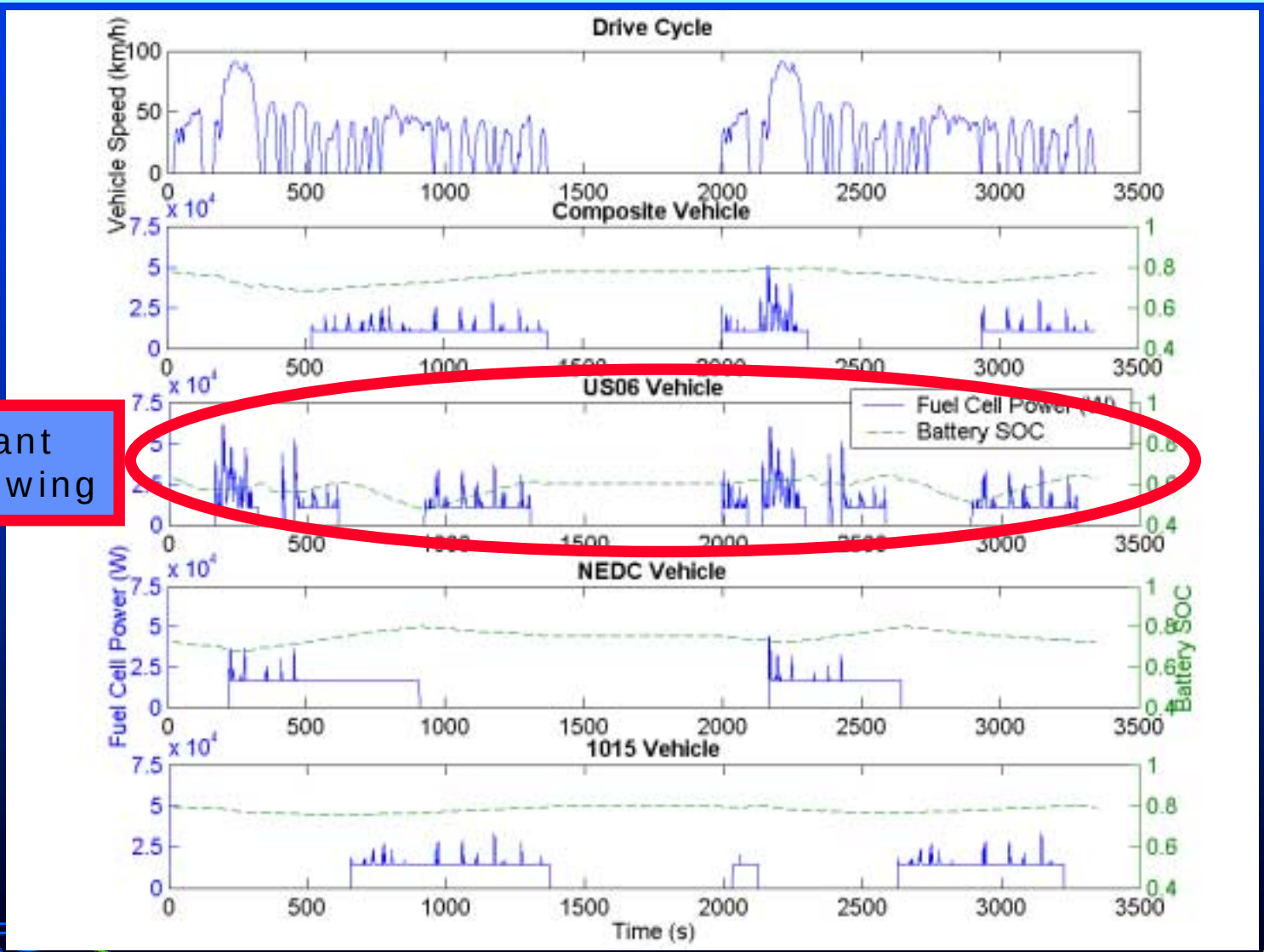


Characteristics of Components for Optimized Vehicles

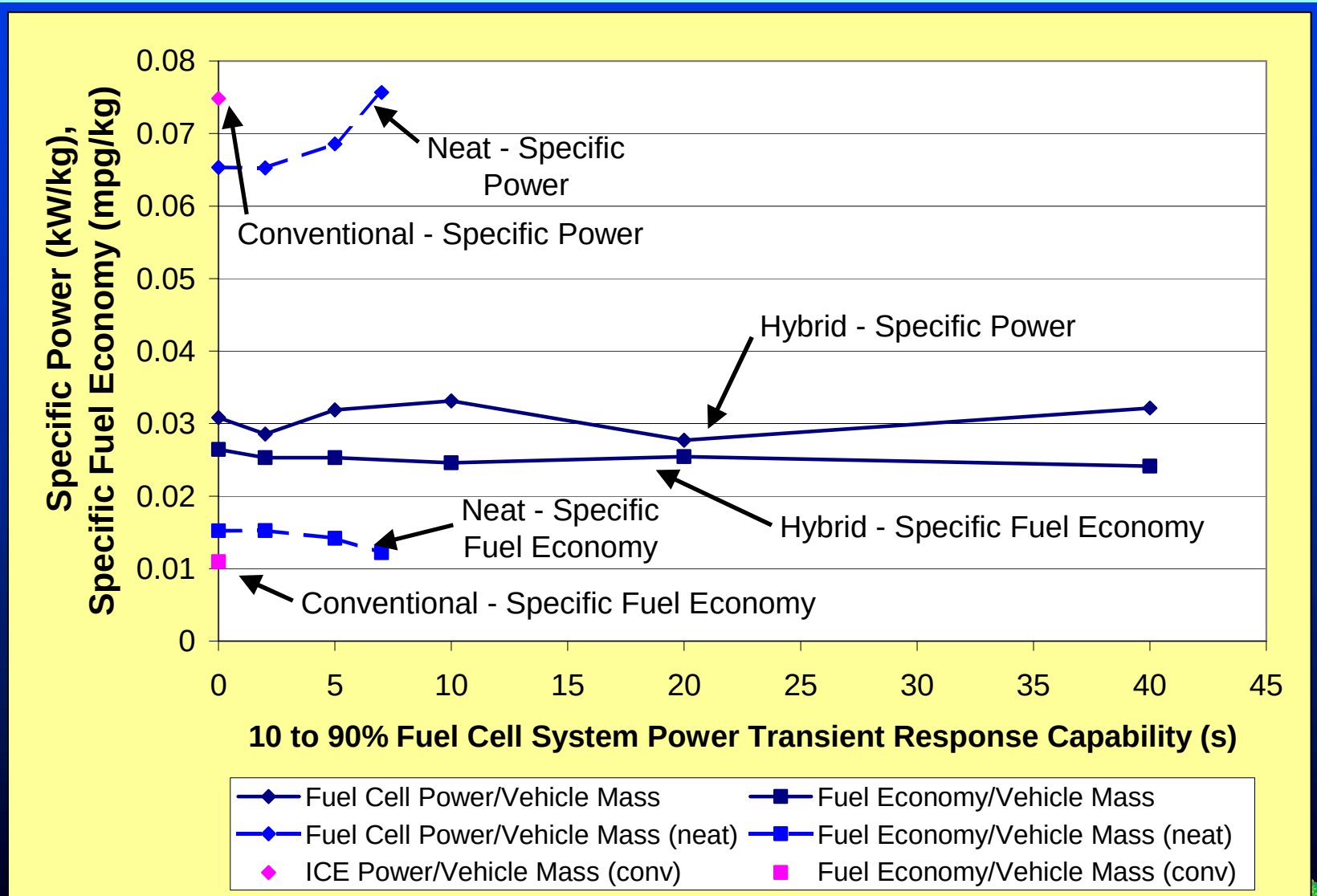


Cycle Operating Characteristics on the 4 Cycles

Significant Load Following



Comparison of Hybrid, Neat, and Conventional Vehicles



Optimization of Fuel Cell Vehicle Design Provides Insight into System Trade-offs

- Determined that derivative-free optimization algorithms necessary for complex design space of HEVs
- Drive cycle influences optimal degree of hybridization and control parameters
  - NEDC provides robust design
- Fuel cell transient response capability critical for neat fuel cell vehicle
- An optimized hybrid design can nullify the effects of fuel cell transient response

Progress on Data Collection
Key Industry Partners Involved

porvair fuel cell technology

UTC Fuel Cells
A United Technologies Company

Arthur D Little

AIR PRODUCTS

3M

GRUPPO DE NORA

Honeywell

gti

McDERMOTT

McDermott Technology, Inc.

NUVERA FUEL CELLS

Collaboration will help identify applicability and systems issues early in the R&D process.

Draw Upon All Available Sources to Gather Data and and New Models

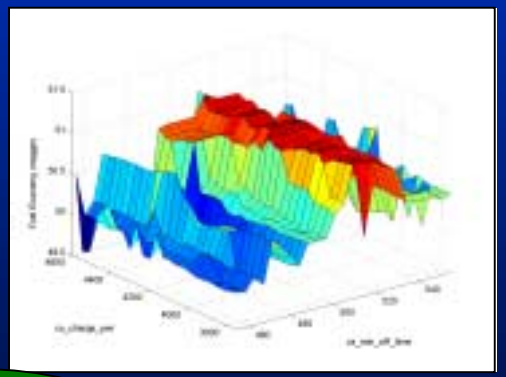
Test Data

Processing

Modeling

National Labs -- Vehicle Manufacturer's -- Component Suppliers

***** Result *****
Finding solutions to technical barriers!



ADVISOR 3.2
Advanced Vehicle Simulator

+ Optimization

Addressing Reviewer Comments

- Focus on fuel cell system model improvement with lab and industry input for experimental verification of assumptions, conclusions, and results
  - developing partnerships with program contractors that can provide data and feedback on modeling assumptions
- Model validation with experimental data
  - initiated data collection effort to help with model validation and enhancement
- Apply models to analysis questions and disseminate results in peer reviewed setting
  - published three key papers this year discussing fuel cell hybrid vehicle systems analysis

Recent Interactions with Industry

- Creating partnerships with key fuel cell component developers to address technical barriers
- Corresponding with more than 30 entities under contract to DOE to collect data for model validation and systems analysis
- Initiated discussions with Vairex and Opcon Autorotor on air compression systems
- Contributing to development of SAE Code & Standards for fuel cell vehicle testing

Plans and Future Milestones

- Fuel cell hybrid vehicle system optimization
  - Using ultra-capacitors, and other storage technologies
  - Investigating fuel cell idle rather than shut-down
  - Technology application to multiple platforms
- Data collection and systems modeling
- Evaluate options for fuel cell system performance enhancement and cost reduction in a vehicle application
- Completion of enhanced fuel cell system thermal model under development at Virginia Tech

Summary

- Vehicle systems tools coupled with optimization are being applied to provide design insights
- Progress has been made to collect data for populating models and validating model results
- Many fuel cell vehicle systems design scenarios yet to be evaluated
- Developing partnerships with industry to provide modeling assumptions review