FEMP Team Capabilities at ORNL in Buildings and Fleets

ORNL FEMP Team — Primary Technical Assistance Capabilities

- Geothermal (ground-source) heat pumps
- Combined heat and power (CHP, distributed energy, cogeneration)
- Benchmarking and strategic energy management
- Industrial energy efficiency
- Energy assessments
- Alternative financing
- Measurement & verification
- Commissioning, O&M
- Federal design/construction practices
- General technical/design assistance
  - LEED, Energy Star, life-cycle cost, modeling, etc.

Work-for-Others Customers

- DOE
- US Navy
- Marine Corps
- US Army
- Air Force
- Coast Guard
- Environmental Protection Agency
- Housing and Urban Development
- Fish and Wildlife Service
- Tennessee Valley Authority
- State of California
- New York State ERDA

Geothermal Heat Pumps — Retrofits or New Construction

- Feasibility studies
- Life-cycle-cost studies
- Review of technical and price proposals
- Review of system design
- Interpretation of thermal properties tests
- Review of bore field sizing
- Baseline and energy savings estimates/ calculations
- Review of pricing
- Development of building simulation models
- Development of measurement and verification plans

ORNL's independent design review and simulation modeling for residential GHP systems for Marine Corps Air Station Beaufort, South Carolina ("Fightertown") contributed to the success of the project.

Combined Heat and Power (CHP)

- FEMP's CHP Core Team at ORNL offers expertise in
  - Power generation technologies
  - Waste-heat-activated technologies
  - Feasibility issues
- Services
  - Initial feasibility screen using the Buildings CHP Screening Tool (developed by ORNL)
  - Detailed TRNSYS performance analysis of proposed systems
  - CHP system economic evaluations
  - Utility service rate evaluations

Cleaver-Brooks Super Boiler with efficiency of 93.8%

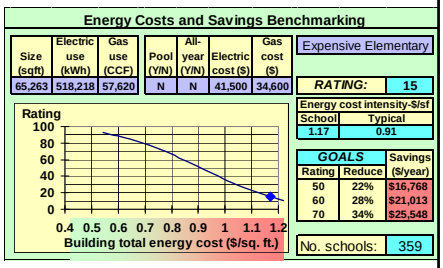
Industrial Facilities Expertise

ORNL supports FEMP's Industrial Facilities Initiative and the DOE Industrial Technologies' Best Practices Program

- Expertise in industrial technologies: steam, process heating, compressed air, motors, chilled water, pumping systems
- Industrial energy assessments – entire process or targeted systems
- In-plant technical assistance and training in identifying energy efficiency opportunities
- Specialized tools for assessing industrial facility performance
- Field testing to verify and validate the performance of new technologies

ORNL's State-of-the-Art Energy Benchmarking Tools for Strategic Energy Management

- Rating methodology for building-to-building energy performance comparison
  - Normalizes for floor area and energy-use drivers: operating hours, occupant and PC density, weather
- Installation- or campus-level energy benchmarking tool
  - Allows more realistic installation/regional energy use reduction goals
  - Army is using tool to improve targeting for audits/projects – instead of deploying resources to largest installations with highest energy costs (with no idea of performance)
- Meter Prioritization/Assessment tool (PAT)
  - Rapidly IDs buildings requiring meters per EPACT 2005
    - Prioritizes installs, minimizes over-installs, shows annual progress, allows instant scenario tests



State-of-the-Art Benchmarking of Commercial Building Energy Performance

ORNL develops the computational engines used to qualify buildings for EPA's Energy Star recognition

- *Office buildings*
- *Hotels/motels*
- *K-12 schools*
- *Hospitals*
- *Medical buildings*
- *Dormitories*

ORNL Helps Customers Achieve Energy Star Awards

VA/DOE/EPA Award Ceremony

- ***DOE Germantown HQ and Forrestal Building***
- ***GSA's R.B. Russell Federal Building***
- ***18 VA Medical Centers***
- ***VA Atlanta Regional Office***

Financed Energy Projects

— Energy Savings Performance Contracts
— Utility Energy Services Contracts

- Technology reviews
- Review of proposals: energy-conservation measures, pricing, financing, M&V plans and reports
- Benchmarks of all historical FEMP ESPC costs
- Training and best practices

Center for Transportation Analysis

Energy efficiency on the overall *transportation operations* can be gained through different combinations of the following strategies:

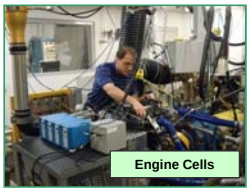
1. More energy efficient vehicle fleets
2. Drive fewer vehicle miles traveled (VMT)
3. Almost congestion-free mobility
4. More efficient logistics/supply chain planning
5. Increased access to alternative fuels
6. Sustainable workplace through smarter choices

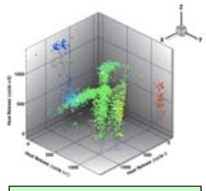
ORNL's Center for Transportation Analysis can support agencies in developing an integrated mission-specific transportation energy saving portfolio.

Fuels, Engines, & Emissions Research Center

.... a comprehensive laboratory for internal combustion engine technology

- A DOE National User Facility in the NTRC.
- Emphasis on unique or extraordinary diagnostic and analytical tools for engine/emission control R&D.
- R&D from bench-scale to vehicle
  - Analytical and chemical laboratories
  - 7 engine dynamometer cells (range 25 to 600 hp)
  - Flexible micro-processor based engine controls for unconstrained engine access
  - Emissions analysis with high resolution of time and species
  - Non-invasive optical and mass-spectroscopy diagnostics
  - Modeling & simulation





Additional Slides

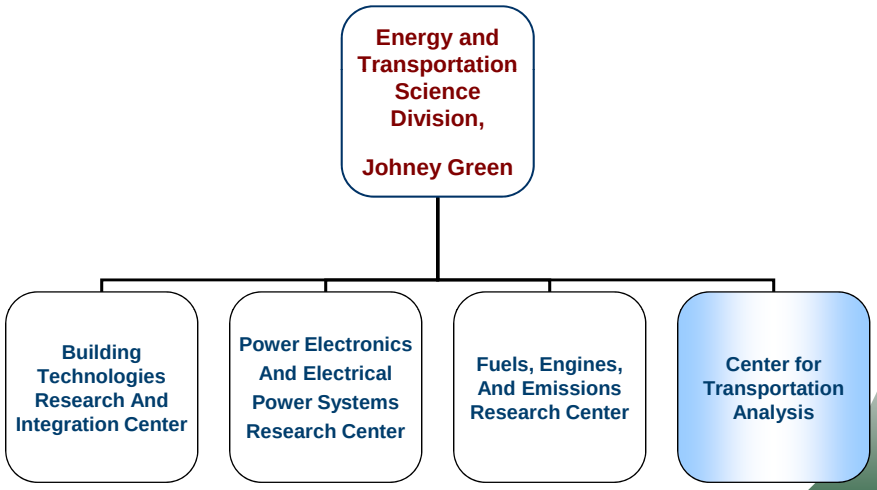
Tools to Identify
Agency-Specific Fuel Saving Opportunities —
ORNL Center for Transportation Analysis

Introduction to ORNL Fuels, Engines,
and Emissions Research Center

Tools to Identify Agency-Specific Fuel Saving Opportunities

Pat Hu
Director
Center for Transportation Analysis
Oak Ridge National Laboratory

Center for Transportation Analysis (CTA)

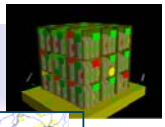


CTA Research Areas

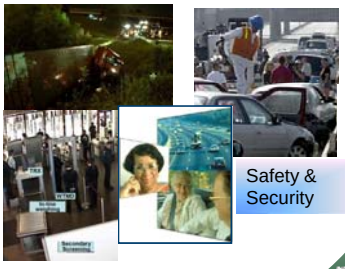
Transportation Planning & Operations

- Passengers
- Freight
- All modes

Energy & Environment



Asset Management & Logistics



Safety & Security

Governing Regulations

Under EISA Section 142, Federal agencies are required to achieve by 2015 at least a 20 percent reduction in annual petroleum consumption and a 10 percent increase in annual alternative fuel consumption.

Profile of Federal Fleets

- Federal agencies collectively operate about two thirds of a million vehicles – 28% of which are AFVs.
- Log in more than five billion miles
- Consume more than 366 million gasoline gallon equivalents (GGEs) – 4% of which are alternative fuels.
- The top five agencies account for 2/3 of total fuel consumption.
- AFV share of total Federal fleet has increased 11% per year since FY03 while alternative fuel consumption has increased 25% per year (though from a lower base)

Potential Fuel Saving Strategies

1. More fuel efficient vehicle fleets
   - Fuel saving technologies/equipment
   - Fleet composition – fewer gas guzzlers
2. Fewer vehicle miles traveled (VMT)
   - Route mapping
3. More efficient logistics/supply chain planning
   - Distribution network configuration
   - Forward and reverse logistics
   - Inventory levels and positioning
4. Increased access to alternative fuels
   - Locational analysis

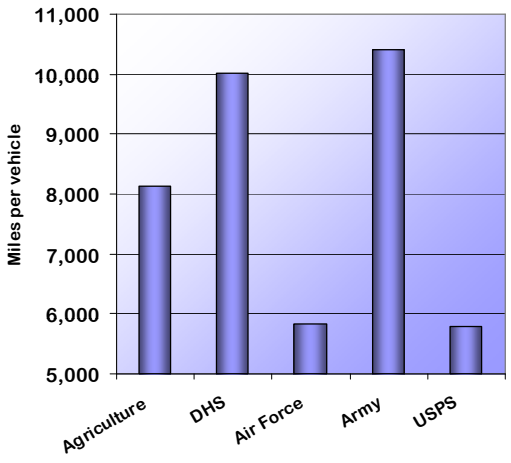
Challenge is

How to develop mission-specific fuel saving portfolio?

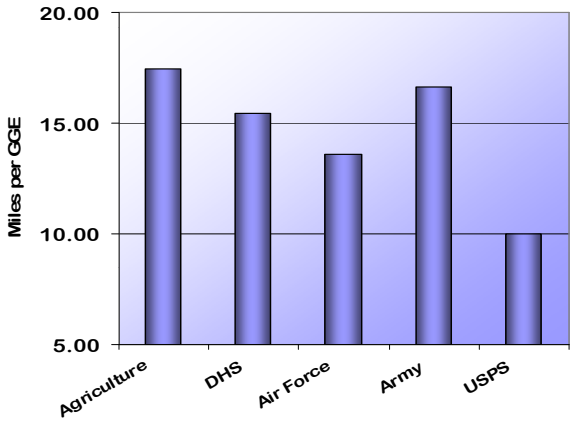
-- An agency-specific decision support tool

There is a lot of variability among agencies –

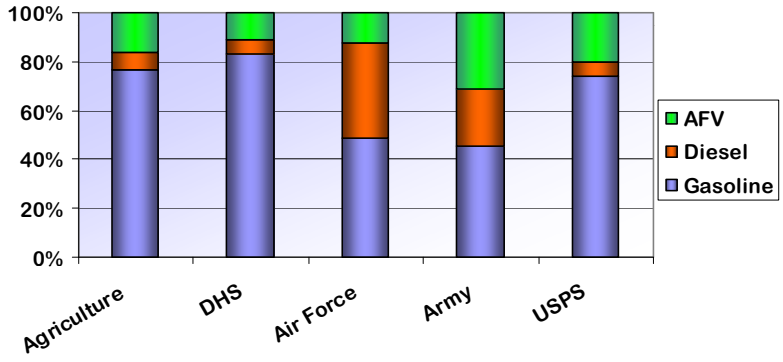
Vehicle usage ranges from < 6,000 miles to > 10,000 miles



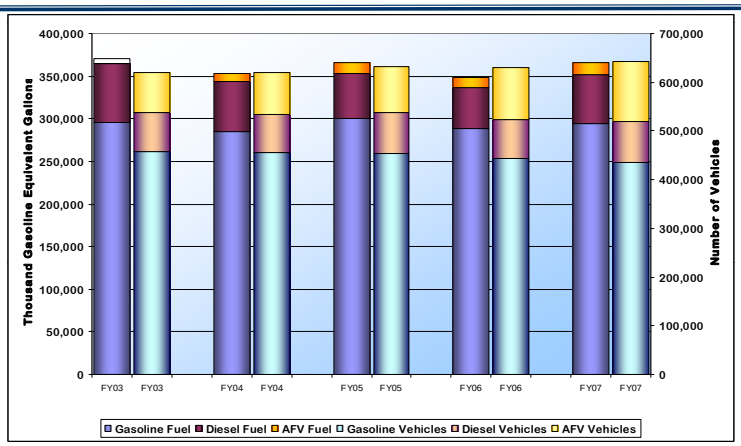
Fuel efficiency ranges from 17 miles per GGE in Army to 10 miles per GGE in U.S. Postal Service. Why?



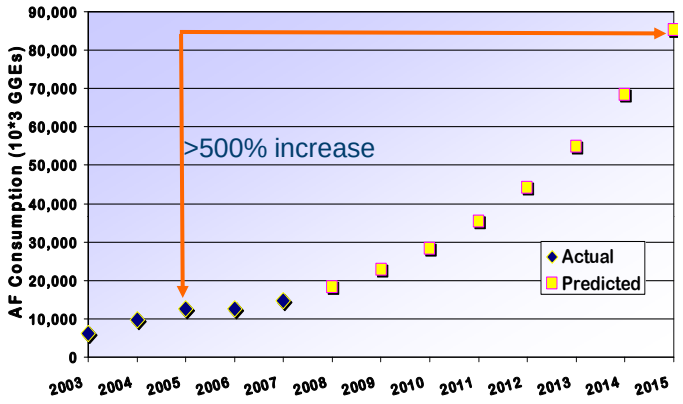
% AFV ranges from 31% in Army to 11% in DHS.



Although the percentage of alternative fuel vehicles increased from 18% in FY03 to 28% in FY07, alternative fuel use amounts to 1.6% of total fuel consumption in FY03 to 4% in FY07 – reflecting the inaccessibility to alternative fueling stations.



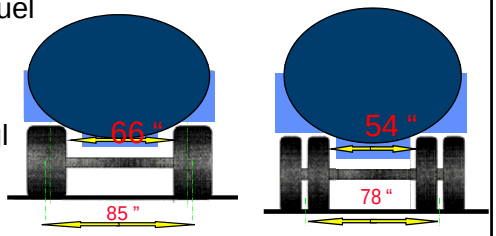
In 2007, an AFV used alternative fuels 21% of the time on average – Nonetheless, it's a significant increase of 12% per year from the 14% in 2003. If this growth rate were to continue, AF consumption in 2015 would be more than 500% greater than in 2005.



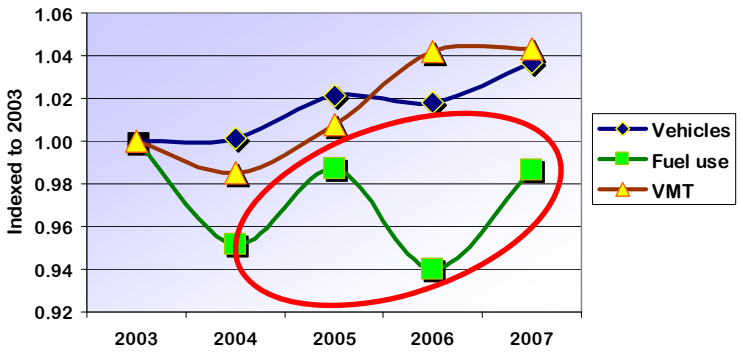
Fuel Efficiency of Single Wide Tires:

Test Results of DOE Heavy Truck Duty Cycle Project

- New single wide tires improve fuel efficiency over all-dual tires by 9.94%.
- As payload increases, new singl wide tires offer increased fuel efficiency -- approximately 9 to 10% over all-dual tires.
- Single wide tires are commercially available and widely accepted by the trucking industry



Need to Tackle Data and Data Quality Issues



…"simply reflect many agencies' continuing difficulties collecting and reporting accurate fuel consumption data."

Proposed Activities

- Identify lessons learns and best practices on fuel saving strategies
- Improve data collection and data quality
- Develop a decision support tool to help agencies identify mission-specific portfolio of fuel saving strategies, including but not limited to:
  - More fuel efficient vehicles
  - Fewer VMT
  - More fuel efficient logistics/supply chain management
  - Greater and more convenient accessibility to alternative fuels refueling centers
- Develop a *dash-board* for FEMP to monitor and assess agency progress on fuel conservation

Introduction to ORNL
Fuels, Engines, and Emissions Research Center

Presented by Ron Graves

Center Director

For Visit by Pat Davis

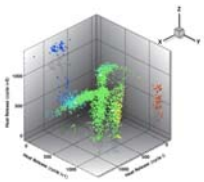
Vehicle Technologies Program Manager

March 2009

Fuels, Engines, & Emissions Research Center

…. a comprehensive laboratory for internal combustion engine technology

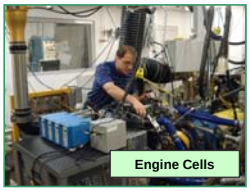
- **A DOE National User Facility in the NTRC.**
- **Emphasis on unique or extraordinary diagnostic and analytical tools for engine/emission control R&D.**
- **R&D from bench-scale to vehicle**
  - **Analytical and chemical laboratories**
  - **7 engine dynamometer cells (range 25 to 600 hp)**
  - **Flexible micro-processor based engine controls for unconstrained engine access**
  - **Emissions analysis with high resolution of time and species**
  - **Non-invasive optical and mass-spectroscopy diagnostics**
  - **Modeling & simulation**



Models and Controls

Off Site Sampling

Chassis Dyno Lab



Engine Cells

Analytical Labs

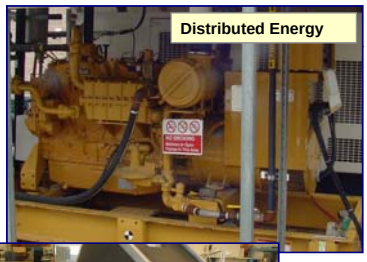
FEERC addresses most applications of combustion engines

Propulsion

21st Century Truck Partnership

FreedomCAR

Power

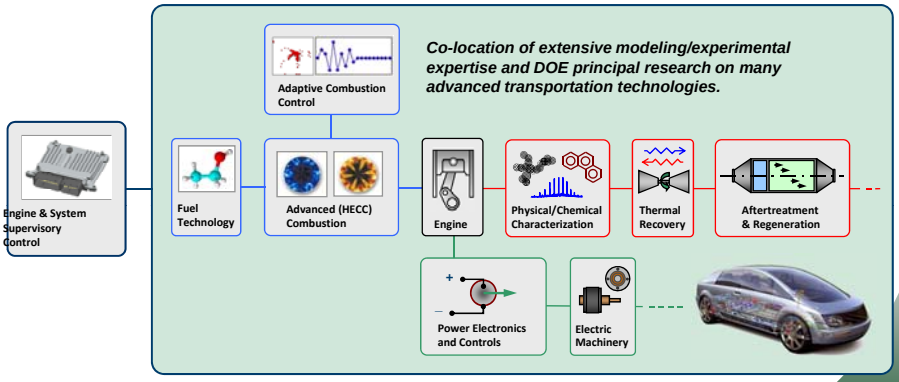


Distributed Energy

Portable Power

What we do…

- R&D to achieve key DOE milestones (Joule milestone)
- Solve barriers to deployment of efficient vehicles and alternative fuels
  - » Knowledge discovery
  - » Advanced diagnostic methods
  - » New technology
- Work with DOE and Industry Partners in assessing progress and defining future directions



Surface Spectroscopy
Catalyst Fundamentals

Laser Diagnostics
Remote Sampling

Fuel Cell R&D

Medium-Duty Diesel

Light-Duty Diesel
Advanced Combustion, Fuels, Efficiency

Heavy-Duty Diesel
Caterpillar CRADA

Spark Ignition Gasoline
Ethanol, Delphi CRADA

Chassis Laboratory
Ethanol, Controls

Single-Cylinder
HCCI, Fuels, Materials, Aftertreatment, Variable CR

Analytical Chemistry
Bench Core Reactor, Emissions & Particulate Characterization

Light-Duty Diesel
Emissions Control Integration

Heavy-Duty Diesel

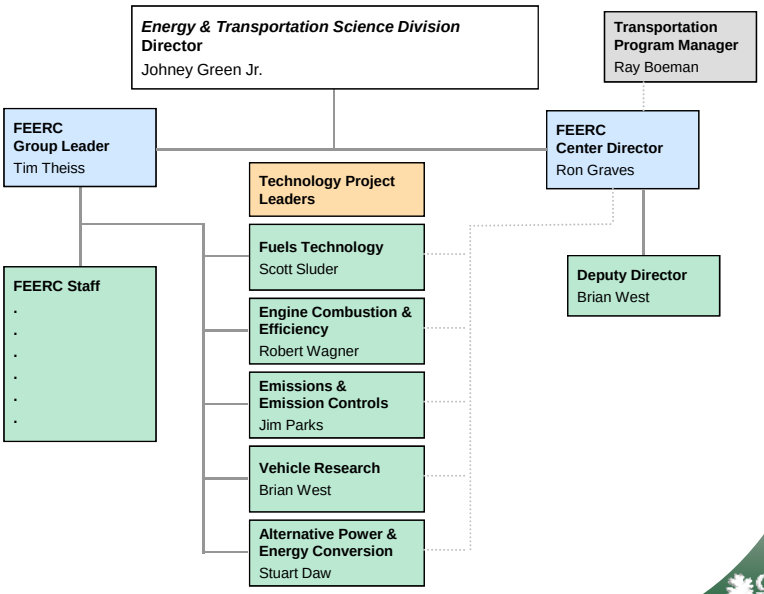
Medium-Duty Diesel
Variable Valve Actuation, Emissions Control

Staff includes many disciplines and specialties

- 40 technical staff, including post-graduate researchers
- 5+ student researchers
- Disciplines including engineering, materials, chemistry, physics, and fuel sciences.

- **Emissions characterization (gaseous and particle)**
- **Nonlinear dynamics and controls**
- **Combustion**
- **Fuel Cells**
- **Catalysis**
- **Fuels**
- **Emission control modeling and simulation**
- **Engine fundamentals and thermodynamics**

Center/Group Organization



Formal and Informal Partners/Collaborators

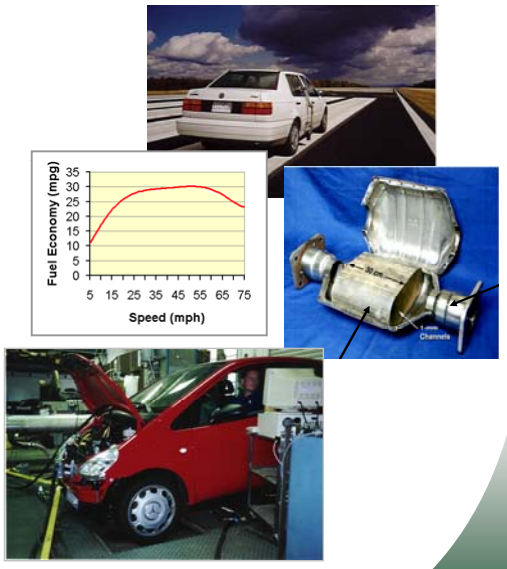
- Current CRADAs
  - Caterpillar
  - Cummins
  - Detroit Diesel Corporation
  - International Truck & Engine
  - Delphi Automotive Systems (2)
  - Reaction Design
- Informal Partners & Funds-In Customers (partial list)
  - Caterpillar
  - Waukesha Engine Division
  - BASF-Engelhard
  - Major energy company
  - Umicore
  - Ford Motor Company
  - General Motors
  - Dow Chemical Company
  - Woodward Industrial Controls
  - BorgWarner
  - Coordinating Research Council
  - And others through AEC Working Group
- **FEERC Advisory Panel**
  - **Delphi Automotive Systems**
  - **BP-Amoco**
  - **Ford Motor Company**
  - **Pennsylvania State University**
  - **Cummins Engine Company**
  - **Texas A&M University**
  - **Caterpillar**
  - **Umicore**
- **Universities & Labs**
  - **Pacific Northwest National Laboratory**
  - **Sandia National Laboratories**
  - **National Renewable Energy Laboratory**
  - **Lawrence Livermore National Laboratory**
  - **Argonne National Laboratory**
  - **Missouri University of Science & Technology**
  - **University of Wisconsin**
  - **University of Michigan**
  - **University of Tennessee**
  - **University of Kentucky**
  - **Pennsylvania State University**
  - **Texas A&M University**

What brings our industry sponsors and partners to FEERC?

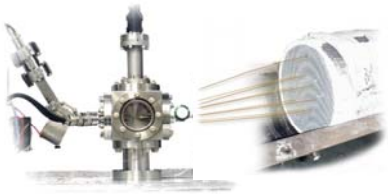
- Comprehensive, broad disciplines and equipment allow us to address a wide range of challenges.
- Rare or unique diagnostic instrumentation
  - Spatially resolved capillary inlet mass spectrometer (SpaciMS)
  - DRIFTS (catalyst surface diagnostics)
  - Phosphor thermography (non-contact temperature measurements)
  - EGR corrosion probe
  - Laser induced fluorescence oil diagnostic
- Flexible micro-processor based controls on most engines
- Know-how on integrating of engines and emission control systems
- Analytical chemistry laboratory is integral to FEERC and allows for detailed exhaust emissions and fuel analysis
- Application of non-linear dynamics and chaos theory to understtand and control engine processes
- Proximity to world class materials and power electronics research laboratories

A few notable accomplishments …

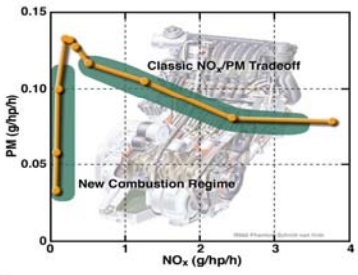
- Led field operational evaluation of DOE methanol fleet (1985-1990).
- First fuel economy and emissions maps suitable for DOT models (1992). Maps generated of fuel economy vs engine speed are still referenced today (1997).
- U.S. Vice-President PNGV Team Award for research on NOx control catalysts (1997).
- ORNL research cited in EPA rule making on low-sulfur diesel (2000).



Notable accomplishments continued …



ORNL Data from Mercedes 1.7 L Diesel



- Numerous CRADAs including *first ever* with International Truck & Engine and Deere, Inc.
- Development and use of spatially resolved capillary inlet mass spectrometer led to several *first ever* measurements in catalysts and engines (1999 to present).
- Co-development of CLEERS, a major government-industry modeling activity for emissions controls (2001 to present).
- Research and dissemination of details of low-temperature combustion in multi-cylinder engines (2001).
- Flame Doctor™ diagnostic for power plant furnaces (2002).
- Establishment of *FACE* (fuels for advanced combustion engines) with NREL (2005).

- Spatially resolved capillary inlet mass spectrometer (SpaciMS) cited in launch of new Cummins diesel engine (2007).
- SpaciMS instrument commercialized and awarded an R&D 100 Award (2008). Winner FLC Tech Transfer 2009.

"The SpaciMS changed the way we think about tuning engine combustion."

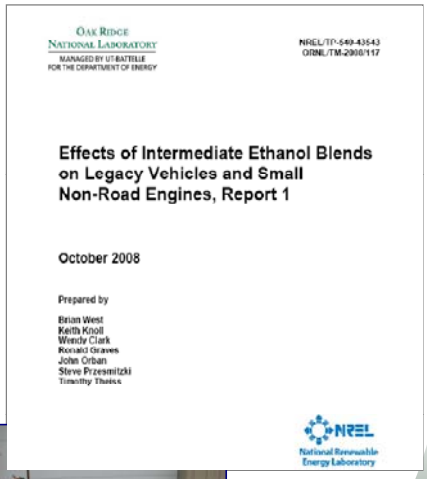
– Dr. John Wall, CTO, Cummins

Co-authored first report from DOE on intermediate ethanol blends (release October 7, 2008)

"In addition to the Biofuels Action Plan we are releasing today the first report on the potential impacts of intermediate ethanol blends on conventional vehicles and other gasoline engines….

.... Our report, published jointly by the Department of Energy's National Renewable Energy Laboratory and Oak Ridge National Laboratory, provides the results of tests using E15 and E20 on 13 popular late model vehicles and 28 small, non-road engines including lawn equipment and generators. The initial data indicates that regulated emissions and exhaust temperatures in cars running on E15 and E20 do not change substantially from those running on currently available fuels. And while additional studies are needed on a wider range of vehicles and engines, this data is encouraging."

Secretary of Energy Bodman
October 7, 2008


Oak Ridge National Laboratory
Managed by UT-Battelle for the Department of Energy

NREL/TP-540-43543
ORNL/TM-2008/117

Effects of Intermediate Ethanol Blends on Legacy Vehicles and Small Non-Road Engines, Report 1

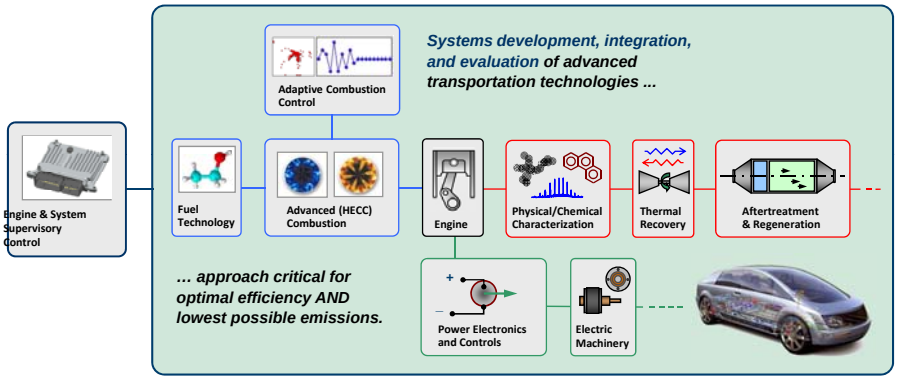
October 2008

Prepared by

Brian West
Keith Knoll
Wendy Clark
Ronald Graves
John Orban
Steve Przesmitzki
Timothy Theiss

NREL
National Renewable Energy Laboratory

Future directions…



- **Resolve the vehicle/engine issues with bio-derived fuels**
- **Stretch engine efficiency for cars and trucks, with efficient emission compliance and non-petroleum capability**
- **Bring emphasis to the system level for synergies between combustion and electric devices and the vehicle**

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