Overview of the DOE Heavy Vehicle Technologies R&D Program

Dr. James J. Eberhardt, Director
Office of Heavy Vehicle Technologies
U.S. Department of Energy

Presented at the
Meeting at the Construction Industry
Manufacturers Association
Milwaukee, WI
May 2, 2001

OHVT Mission
To conduct, in collaboration with our heavy vehicle industry partners and their suppliers, a customer-focused national program to research and develop technologies that will enable trucks and other heavy vehicles to be more energy efficient and able to use alternative fuels while simultaneously reducing emissions.
DOE Office of Energy Efficiency and Renewable Energy

Office of Energy Efficiency and Renewable Energy

Assistant Secretary

Principal Deputy

Office of Utility Technologies

Office of Industrial Technologies

Office of Transportation Technologies
  - Office of Heavy Vehicle Technologies
  - Office of Advanced Automotive Technologies
  - Office of Fuels Development
  - Office of Technology Utilization

Office of Building Technologies
DOE/EE/OTT Organization

U.S. Department of Energy
Office of Transportation Technologies

Thomas Gross, DAS 202-586-8027
Richard Moorer, ADAS 202-586-9315

Fuels Development
John Ferrell 202-586-6745

Advanced Automotive Technologies
Dr. Robert Kirk 202-586-8055

Heavy Vehicle Technologies
Dr. James Eberhardt 202-586-9837

Technology Utilization
David Rodgers 202-586-7182
Office of Heavy Vehicle Technologies

- The U.S. Department of Energy - Secretary
- Efficiency and Renewables - Deputy Assistant Secretary, Transportation Technologies

**Office of Heavy Vehicle Technologies**

- Created in the DOE/Office of Transportation Technologies restructuring (March 1996)
- Focuses research and development on critical areas identified with heavy vehicle customers

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Office of Heavy Vehicle Technologies
Program Coordination Structure

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**Office of Heavy Vehicle Technologies**

*Dr. James J. Eberhardt, Director*

Constance Lorenz, Communications Specialist
Patricia Williams, Administrative Program Support

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**Engine Technologies**

*Gurpreet Singh*
Team Leader

- Diesel Engine Technologies R&D
- Combustion and Emissions Control
- Propulsion System Materials + HTML

*John Fairbanks, Dr. Sidney Diamond*

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**Vehicle System Technologies**

*Dr. Sidney Diamond*
Team Leader

- Vehicle Aerodynamics and Tire Rolling Technology
- High Strength Weight Reduction Materials
- Heavy Truck Auxiliary and Safety Systems
- Heavy Hybrid Systems

*Richard Wares, Esther Ku, Susan Rogers*

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**Fuels and Lubrication Technologies**

*Stephen Goguen*
Team Leader

- Advanced Petroleum Based Fuels R&D
- Alternative Fuels R&D
- Environment, Safety, and Health

*Dr. Michael Gurevich, Gurpreet Singh, Richard Wares, Kevin Stork*
1 Quad of energy is equivalent to 340,000 tank cars of crude oil stretched from Miami to Seattle (3,300 miles).
## Targets of Opportunity for Heavy Vehicles

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<th>Heavy Vehicle Category</th>
<th>1995&lt;sup&gt;a&lt;/sup&gt;</th>
<th>2000&lt;sup&gt;b&lt;/sup&gt;</th>
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<tr>
<td>(GVW≤10,000 lbs)</td>
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<tr>
<td>(10,000 &lt; GVW &lt; 26,500 lbs)</td>
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<td>Class 7-8 trucks</td>
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<td>(GVW &gt; 26,500 lbs)</td>
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<sup>a</sup>The 1995 values are from S.C. Davis, *Transportation Energy Data Book, 17<sup>th</sup> Ed.*, ORNL 6919, Oak Ridge National Laboratory, August 1997.

<sup>b</sup>Projections are from Tables 45 and 46 in the U.S. DOE Energy Information Administration, *Annual Energy Outlook 1999*, DOE EIA-0383 (98), July 1998.
Rationale for a Heavy Vehicle Technologies R&D Program

Since the 1973 Oil Embargo All of the Increase in U.S. Surface Transportation Fuel Consumption has been due to Heavy Vehicles

Energy Use - Million Barrels per Day

Transportation Energy Data Book: Edition 20, DOE/ORNL-6959, October 2000
A Healthy National Economy Depends Upon Efficient Heavy Vehicle Freight Transportation

Gross Domestic Product (1992$)

Ton Miles of Travel

Year

GDP or TMT (billions)
Workshops and Meetings
Soliciting Customer Input

- DOE/OHVT Customer Focus Workshop, May 1996
- SAE Truck and Bus Council Meeting, June 1996
- DOE/OHVT Workshop on Applications of Carbon Products, September 1996
- DOE Automotive Technology Development Customers’ Coordination Meeting, October/November 1996
- Workshop on Future Fuels Technologies for Heavy Vehicles, November 1996
- Natural Gas Program Planning Workshop, January 1997
- Workshop on Improving Heavy Vehicles Aerodynamics, January 1997
- OHVT Executive Steering Committee Meeting, February 1997
- Fuels and Engines Workshop: Policy Issues and Technology Directions, April 1997
- Windsor Workshop on Transportation Fuel, June 1997
- 1997 Diesel Engine Emissions Reduction Workshop, July 1997
- DOE Automotive Technology Development Customers’ Coordination Meeting, October 1997
- Symposium on Air Pollution Health Impacts, November 1997
- National Conference of State Legislators Energy Institute on Alternative Fuel Use in Heavy Vehicles, December 1997
Workshops and Meetings
Soliciting Customer Input (continued)

- Workshop on Diesel Fuels and Engine Technology, January 1998
- Workshop on Performance and Emissions of New Diesel Fuels, January 1998
- OHVT Peer Review, February 1998
- Review of Multi-Year Program Plan on Aerodynamic Drag, February 1998
- DOE/EMA Meeting on New Fuel Options for Diesel Engines, March 1998
- OHVT/EFI “Fuels, Lubricants, Engines, and Emissions” Meeting, January 1999
- DOE-OHVT Workshop on Emissions Control Strategies for ICEs, January 1999
- Workshop on Research Needs for Reducing Friction and Wear, March 1999
- HTML User Forum, August 1999
- DOE/ORNl Running Resistance and Braking Systems Workshop, August 1999
- Heavy Vehicle Propulsion Materials Workshop, August 1999
- Thermal Management Workshop, October 1999
OHVT Plans Focus on Critical R&D Areas for All Truck Classes

Office of Heavy Vehicle Technologies (OHVT)
Office of Transportation Technologies

October 1997


Revised OHVT Technology Roadmap


August 1998

U.S. Department of Energy
Energy Efficiency and Renewable Energy
Office of Transportation Technologies

**OHVT Technology Roadmap Development**

*Industry stakeholders provide input to Technology Roadmap*

- Initial draft developed by DOE and the National Laboratories as recommended by industry stakeholders attending the initial OHVT customer-focus workshop.

- **OHVT Executive Steering Committee Meeting**
  - held in conjunction with SAE Truck and Bus Show (October 1996).
  - Draft **OHVT Technology Roadmap** presented to industry stakeholders for review.

- Additional **targeted workshops** and **one-on-one meetings** with industry stakeholders provided feedback and comments.

- Final version released (October 1997).

- Technology Roadmap updated/revised by OHVT Team (May 1999).

- Revised OHVT Technology Roadmap presented to industry stakeholders at the 1999 SAE International Truck and Bus Meeting and Exposition (November 1999).

- Final revised OHVT Technology Roadmap (February 2000).
OHVT Technology Roadmap

Roadmap Development Approach

- Formulate goals consistent with DOE Strategic Plan required by the Government Performance and Results Act (GPRA).
- Assess the status of the technology.
- Identify technical targets.
- Identify barriers to achieving the technical targets.
- Develop R&D solutions to overcoming the barriers.
- Develop schedules and milestones.
### R&D Needs of Three Groups of Trucks are Addressed

#### Heavy (Class 7-8) Trucks

To develop by 2004, the enabling technologies needed to achieve a fuel efficiency of at least **10 miles per gallon** *(at 65 miles per hour)* and meet emissions standards prevailing in 2004, using petroleum-based diesel fuel.

#### Medium (Class 3-6) Trucks

By 2004, to develop and demonstrate commercially viable vehicles that achieve, on an urban driving cycle, at least **double the fuel economy** of comparable current (1999) vehicles, and as a *research goal*, reduce criteria pollutant emissions to at least **30 percent below** EPA standards prevailing in 2004.

#### Light (Class 1-2) Trucks

To develop by 2004 the enabling technologies for clean diesel engines to be competitive with and **at least 35-percent more fuel efficient** than equivalent gasoline engines for light trucks, while meeting Federal and state emissions standards prevailing in 2004.
High-efficiency clean diesel-cycle engines utilizing compression ignitable clean fuels/blends derived from diverse feedstocks

**Multiple Alternative Feedstocks**
- Coal
- Biomass
- Natural Gas
- Petroleum

**Clean Diesel Fuels/Blends**
- Common Diesel Fuel Specification
- Uses Existing Infrastructure

**Advanced High-Efficiency Clean Diesel Engine Technologies**

**Efficient Low Emission Heavy Vehicles**
- Heavy Truck
- Construction/Farming Vehicles
- Locomotive

**Strategy**
EPA Emissions Standards

- February 10, 2000 EPA adopted Tier 2 Emissions Standards which became effective April 10, 2000. (Includes reducing sulfur levels in gasoline to 30 ppm.)
- January 18, 2001 EPA issued rule requiring 80 percent of all on-road diesel fuel to have less than 15 ppm sulfur starting in 2006.
EPA Emissions Standards

- **Tier 2 Regulations for Light-Duty Vehicles (LDVs):**
  - 0.07 g/mi NOx and 0.01 g/mi PM; represents 77 to 95% reduction from Tier 1 levels
  - Includes all LDVs under 10,000 lbs
  - Phased in 2004-2008

- **Heavy-Duty Diesel Engine Regulations:**
  - 0.2 g/bhp-hr NOx and 0.01 g/bhp-hr PM; represents about 90% reduction from 2004 regs
  - Phased in 2007-2010

- **Heavy-duty regulations include ultra-low sulfur diesel fuel**
What Do We Have to Offer?

- National Laboratory scientific expertise
  - Unique research facilities (neutron residual stress measurement capabilities, engine combustion research facility, synchrotron, x-ray sources)

- Catalyze formation of unique teams
  - Example: Industry team on casting of large vehicle components (Alcoa, CMI)
DOE/Office of Heavy Vehicle Technologies

Gateway to Partnering on Heavy Vehicle Technologies R&D

Department of Energy

Office of Heavy Vehicle Technologies

Oak Ridge National Laboratory

National Renewable Energy Laboratory

Sandia National Laboratory

Argonne National Laboratory

Lawrence Livermore National Laboratory

Lawrence Berkeley Laboratory

Brookhaven National Laboratory

Idaho National Engineering Laboratory

Los Alamos National Laboratory

Pacific Northwest Laboratory
Advanced Laser-Imaging Diagnostics have Changed our Understanding of Diesel Combustion.

Numerous advanced diagnostics have been applied over the past decade.

Liquid spray  Mixture & Temp.  Soot: LII and Mie  OH PLIF  NO PLIF

Old Description  New Conceptual Model

Dec et al., SAE papers 950456, 970873, & 980147
Objective: To provide the fundamental understanding needed to help manufacturers reduce emissions and improve performance.

Approach: Investigate the processes in the cylinder of an operating diesel engine using advanced optical diagnostics.

Modified heavy-duty truck engine provides good optical access while maintaining the basic combustion characteristics of a production engine.

Data from multiple advanced laser diagnostics have substantially improved our understanding of diesel combustion and emissions formation.
Recommendation 3

The Office of Heavy Vehicle Technologies (OHVT) should reevaluate its priorities and increase its support for projects focused on overcoming the most critical barriers to success. For example, meeting emissions standards will be critical to OHVT’s program on advanced combustion engines. Therefore, emissions should be a major focus of this program.

Bolding and italicizing provided for emphasis.

The Office of Heavy Vehicle Technologies should place a *high priority on integrated emissions-control technology (engine combustion and after-treatment technologies)* to meet future emission requirements.


Bolding and italicizing provided for emphasis.
## OHVT Budget by Activities

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*Potential for R&D related to off-highway heavy vehicles
Industry/Government R&D Partnerships

Summary

- Legislation and policy are in place to encourage and enable industry/government R&D partnerships.

- A variety of mechanisms are available for the U.S. heavy vehicle (including the off-highway) industry to partner with DOE and its national laboratories.

- A workshop was recently conducted to develop an industry/government (DOE) R&D partnership on off-highway vehicle technologies.

- Partnership with the construction industry manufacturers on engine and vehicle technologies could fit under the purview of an industry/government off-highway vehicle technologies R&D partnership.
Truck Classification (by Gross Vehicle Weight)

CLASS 1
6,000 lbs. & Less

CLASS 2
6,001-10,000 lbs.

CLASS 3
10,001-14,000 lbs.

CLASS 4
14,001-16,000 lbs.

CLASS 5
16,001-19,500 lbs.

CLASS 6
19,501-26,000 lbs.

CLASS 7
26,001-33,000 lbs.

CLASS 8
33,001 lbs. & Over
Advanced Laser-Imaging Diagnostics have Changed our Understanding of Diesel Combustion.

Numerous advanced diagnostics have been applied over the past decade.

Liquid spray  Mixture & Temp.  Soot: LII and Mie  OH PLIF  NO PLIF

Old Description  New Conceptual Model

Dec et al., SAE papers 950456, 970873, & 980147