DOE Goals and Perspectives on Lean-Burn Emissions Controls

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Engine Technologies R&D
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Presented at the
DOE Crosscut Workshop on Lean Emissions Reduction Simulation
Knoxville, TN
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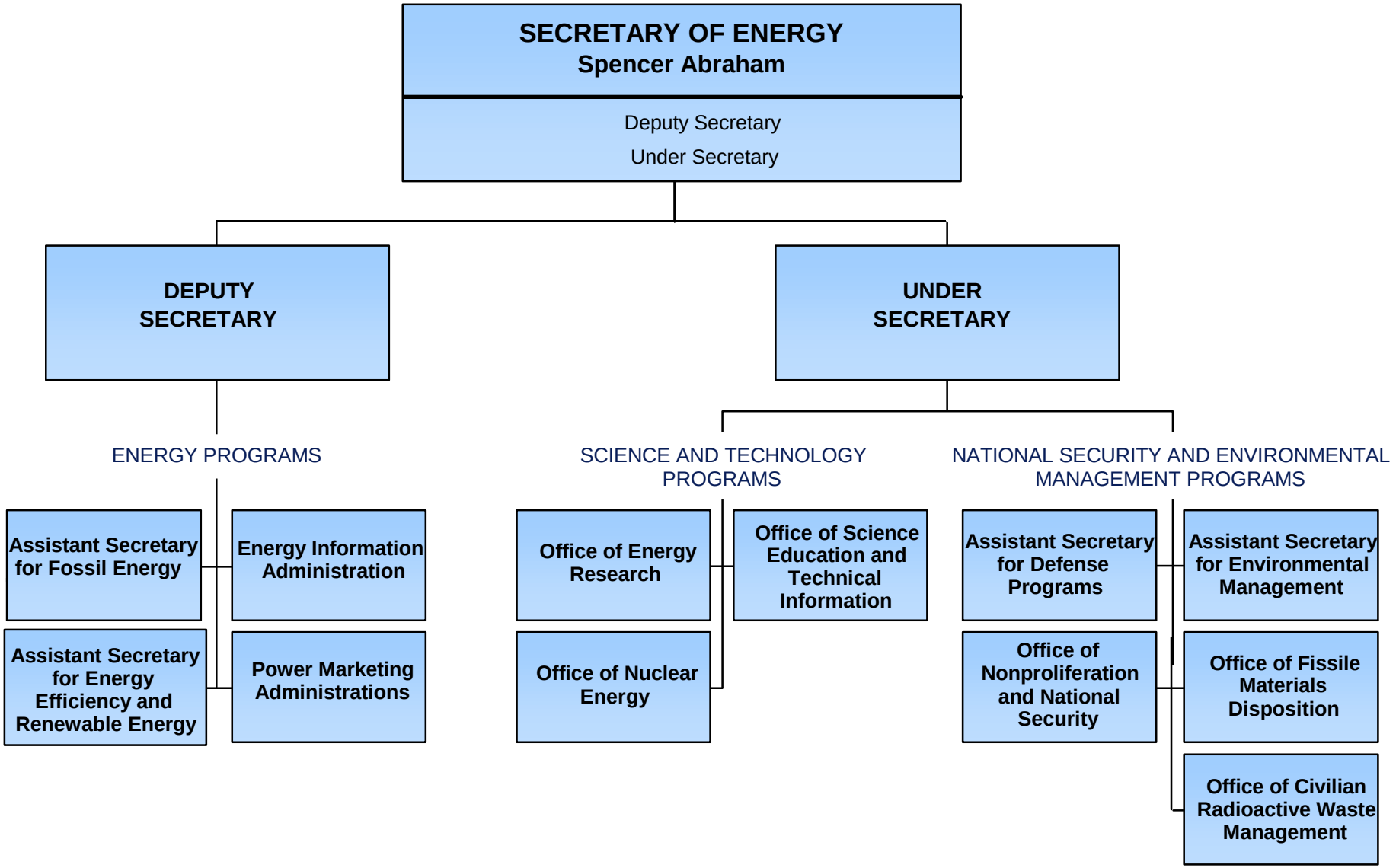
OHVT Mission

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.

Department of Energy Organization

Office of Heavy Vehicle Technologies



DOE Office of Energy Efficiency and Renewable Energy

Office of Heavy Vehicle Technologies

Office of Energy Efficiency and Renewable Energy

Assistant Secretary

Principal Deputy

- Office of Power Technologies
- Office of Industrial Technologies
- **Office of Transportation Technologies**
  Thomas Gross
  Deputy Assistant Secretary
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Advanced Automotive Technologies
Robert Kirk
202-586-8055

Heavy Vehicle Technologies
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Technology Utilization
David Rodgers
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Rationale for a Heavy Vehicle Technologies R&D Program

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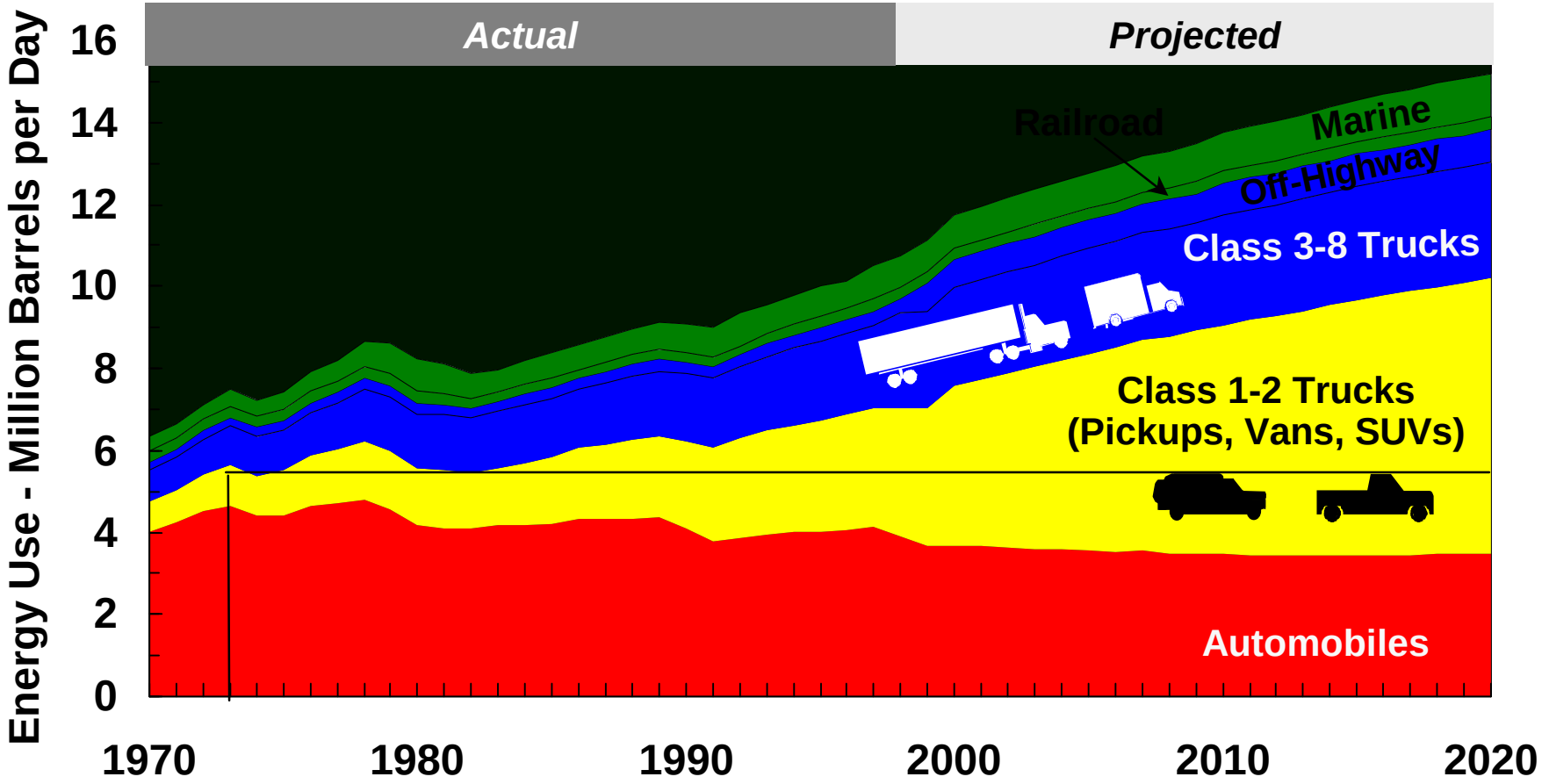
Since the 1973 Oil Embargo All of the Increase in U.S. Surface Transportation Fuel Consumption has been due to Heavy Vehicles



Sources: *EIA Annual Energy Outlook 2000*, DOE/EIA-0383(2000), December 1999
Transportation Energy Data Book: Edition 20, DOE/ORNL-6959, October 2000

DOE Office of Heavy Vehicle Technologies

Office of Heavy Vehicle Technologies

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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 capable of using alternative fuels while simultaneously reducing emissions.

Office of Heavy Vehicle Technologies
Program Coordination Structure

Office of Heavy Vehicle Technologies

Office of Heavy Vehicle Technologies

Dr. James J. Eberhardt, *Director*

Constance Lorenz, Communications Specialist
Patricia Williams, Administrative Program Support

Engine Technologies

Gurpreet Singh
Team Leader

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

John Fairbanks
Dr. Sidney Diamond

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

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

Strategy

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High-efficiency clean diesel-cycle engines utilizing compression ignitable clean fuels/blends derived from diverse feedstocks

Multiple Alternative Feedstocks

- Coal
- Biomass
- Natural Gas
- Petroleum

Synthesis gas route to:

Liquid Fuels

Conventional petroleum refining

Clean Diesel Fuels/Blends

- Common Diesel Fuel Specification
- Uses Existing Infrastructure

Advanced High-Efficiency Clean Diesel Engine Technologies

Fuel Quality

Exhaust Treatment

Diesel Engine

In-cylinder Processes

Efficient Low Emission Heavy Vehicles

Heavy Truck

Construction/ Farming Vehicles

Locomotive

OHVT Advanced Combustion Engine R&D Program

Office of Heavy Vehicle Technologies

OHVT Advanced Combustion Engine R&D
Gurpreet Singh
John Fairbanks
DOE Headquarters

Combustion and Emission Controls
- SNL
- LLNL
- LANL
- ORNL
- ANL
- PNNL

Light Truck Engine R&D
- Cummins/ DaimlerChrysler
- Detroit Diesel/ DaimlerChrysler
- Caterpillar/GM-Izusu

Heavy Truck Engine R&D
- Caterpillar
- Cummins
- Detroit Diesel

Engine Boosting R&D
- Honeywell/ International
- Caterpillar

Component Improvement R&D
- NOxTech/ Deere/Mack
- HiZ/Kenworth

Progress in lean emission control clearly evident… but much left to do

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- NOx and PM reduction on order of 90% seen under certain operating regimes today, not so 5 years ago.
- *Integrated* engine+fuel+aftertreatment system is critical
- See 21st Century Truck Roadmap for key technical challenges

Emission Control R&D Deficiencies (from 21st Century Truck Roadmap)

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- Immature systems integration (optimization of NOx, PM hindered by inadequate device simulation capability)
- New catalyst performance prediction /screening limited by inadequate tools, test methodologies
- Inadequate methodologies for rapid aging assessment of new technologies
- Non-optimal collaboration among engine companies, emission control suppliers, government labs on precompetitive issues

DOE-Supported Emission Control Aftertreatment R&D

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Conducted by engine OEMs, suppliers, laboratories

- Vertical teams led by engine OEMs, sponsored via DOE coop agreements
  - Heavy truck engine R&D program
  - Light-truck clean diesel program
- CRADAs between labs, engine OEMs and suppliers
- Informal partnerships between labs, suppliers, and engine OEMs

Companion programs in DOE provide major contributions

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- Advanced Petroleum-Based Fuels Program
  - Effects of fuel sulfur and lubricants on emission control systems
  - Unregulated emissions
  - Other fuel parameters that impact emissions
- CIDI R&D Program
  - Emission controls and aftertreatment for light duty applications
- Propulsion Materials Program
  - Catalyst materials development and characterization
  - Sensor materials

The DOE Diesel Cross-Cut Team

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- Includes representatives from U.S. diesel engine manufacturers, automotive companies, DOE, TACOM, and EPA
- Coordinates development of advanced, low-emission, high-efficiency diesel engines
- Identifies and prioritizes specific R&D projects appropriate for government funding
- Interfaces between the automotive and diesel engine manufacturers, the PNGV CIDI Team, and the Diesel Engine Development Team
- Provides mechanism for efficient interactions among industry, government, and national labs in addressing strategic energy and emissions control issues

Diesel Cross-Cut Lean Exhaust Emissions Reduction Simulation (CLEERS)

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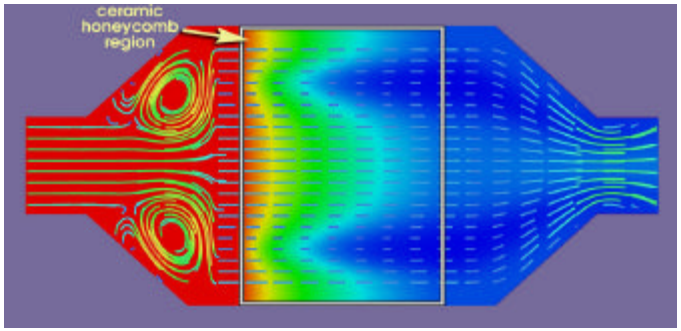
Objectives:

- Accelerate introduction of new powerplants meeting emission standards by providing new simulation capability for integrated engine + aftertreatment
- Improve tools for aftertreatment development



Approach:

- Promote computational tools for simulating realistic full-system performance (engine to tailpipe)
- Support OEM's, DOE labs, universities in developing aftertreatment component performance models
- Define consistent framework for sharing information and comparing new emissions control technologies

Status:

- Established coordinating subcommittee (reporting to Diesel Crosscut Team)
- Establishing a simulation test bed and data base at ORNL
- Sponsoring technical workshops (today's is the first)

CLEERS is coordinated by a subcommittee appointed by the Diesel Cross-Cut Team

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CLEERS subcommittee:

- **R. Blint, General Motors**
- **N. Hakim, Detroit Diesel**
- **G. Singh, U.S.-DOE/HQ**
- **S. Daw, Oak Ridge National Lab**
- **C. Rutland, Wisconsin**
- **H. Kung, Northwestern**

Website:

- General information about emissions control simulation
- Technical information and benchmark data base
- Data and model exchange forum

Simulation Testbed

Workshops:

- Focused 2-day meetings on emissions control topics
- Invited and contributed technical presentations on specific topics
- Overview presentations and panel discussions

Workshop Objectives

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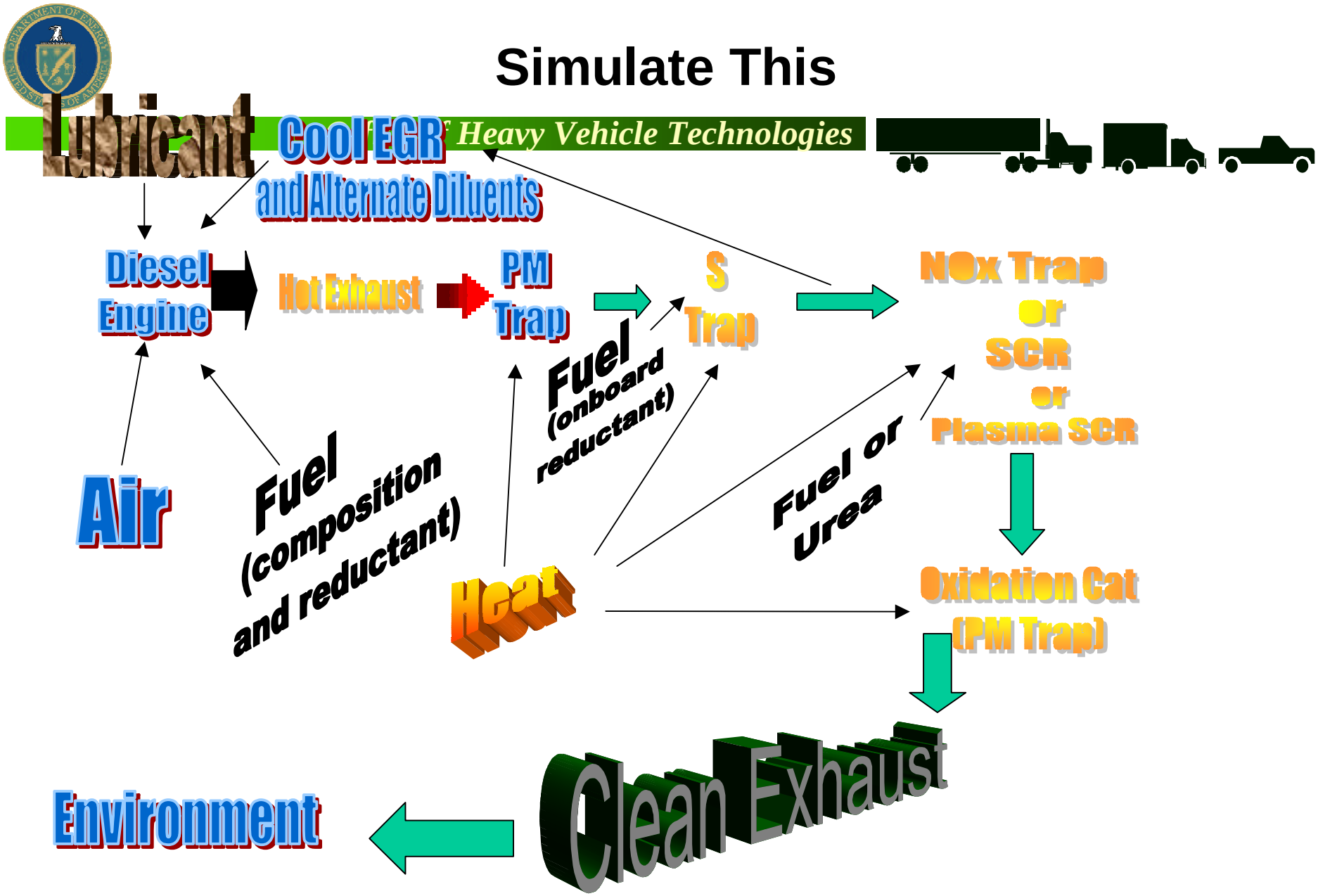
- **Focus:** "Addressing the Full-System Context (Engine to Tailpipe) for Lean Exhaust Emissions Control."
- Solicit input from stakeholders in government, universities, and industry on the state-of-the-art for simulating lean exhaust emissions control.
- Document workshop discussions, **especially the all-participant discussion at the end**, for DOE-OTT to consider in improving R&D priorities and technical focus in DOE-supported programs.

Simulate This



Requires: 90+% NOx and PM reduction
Less than 10% energy penalty
Duty cycle flexibility, incl off-road

Closed loop control, OBD
No slip, unregulated emissions