



# Sustainable

TRANSPORTATION

U.S. DEPARTMENT OF  
**ENERGY**

Energy Efficiency &  
Renewable Energy

## Overview of the DOE High Efficiency Engine Technologies R&D

Roland Gravel

Advanced Combustion Engine R&D Program  
Vehicle Technologies Office

*2013 Annual Merit Review and Peer Evaluation Meeting  
DOE Vehicle Technologies Office*

Washington, DC

May 16, 2013

ACE00C

# The Federal Role

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- ❑ Facilitate development of **precompetitive technical** knowledge base through investments in fundamental and applied R&D
- ❑ Undertake **high-risk** mid- to long-term research
- ❑ Utilize unique **national lab** expertise and facilities
- ❑ Help create a national consensus
- ❑ Enable **public-private** partnerships to integrate R&D into industrially useful design tools

# Advanced Combustion Engine R&D

**Strategic Goal:** Reduce **petroleum dependence** by removing critical technical **barriers** to mass commercialization of **high-efficiency**, emissions-compliant internal combustion engine (ICE) powertrains in passenger and commercial vehicles

## Primary Directions

- **Improve ICE efficiency** for cars, light- and heavy-duty trucks through advanced combustion and minimization of thermal and parasitic losses
- Develop aftertreatment technologies **integrated** with combustion strategies for emissions compliance and minimization of efficiency penalty
- Explore **waste energy recovery** with mechanical and advanced thermoelectric devices
- **Coordinate with fuels R&D** to enable clean, high-efficiency engines using hydrocarbon-based (petroleum and non-petroleum) fuels



# Overall R&D Approach



## Fundamental R&D

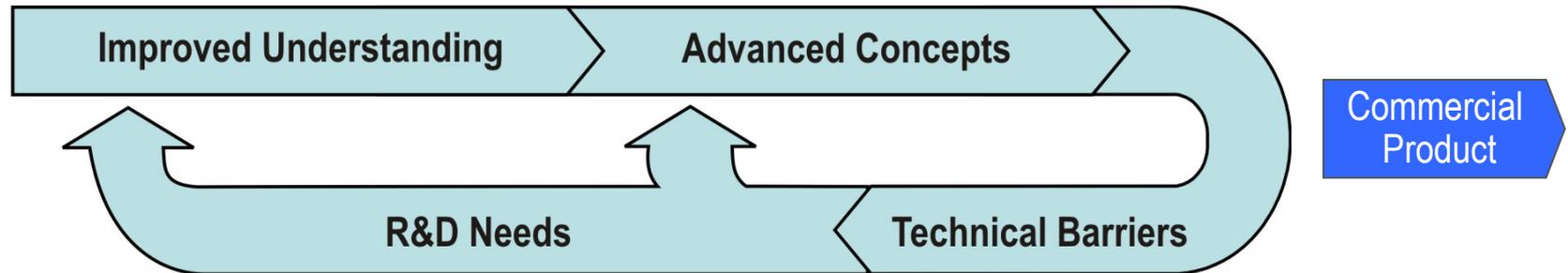
- SNL – Advanced Combustion Strategies (lean-burn, LTC, advanced DI)
- PNNL – Catalyst Characterization (NO<sub>x</sub> and PM Control)
- ANL – X-ray fuel spray characterization
- LLNL – Chemical kinetics models (LTC and emissions)
- LANL – CFD modeling of combustion
- Universities – Complementary research

## Fundamental to Applied Bridging R&D

- ORNL – Experiments and simulation of engines and emission control systems (bench-scale to fully integrated systems)
- ANL – H<sub>2</sub>-fueled ICE; fuel injector design

## Competitively Awarded Cost-shared Industry R&D

- Automotive and engine companies, – engine systems
- Suppliers – enabling technologies (sensors, VVA, WHR)



# Advanced Combustion Engine R&D

## Key Subprograms

### ❑ Combustion and Emission Control R&D

- Combustion Research
- Emission Control R&D
- **High Efficiency Engine Technologies**
  - Heavy Truck Engine and Enabling Technologies
  - Advanced Technology Powertrains for Light-Duty Vehicles

### ❑ Solid State Energy Conversion

# Light-Duty Vehicle Goals

- By 2015, improve the fuel economy of light-duty gasoline vehicles by 25% and light-duty diesel vehicles by 40% compared to the baseline 2010 gasoline vehicle
- By 2030, improve the fuel economy of gasoline and diesel vehicles by 35% and 50%, respectively, compared to the baseline 2010 gasoline vehicle

## Performance Targets

	Light-Duty Vehicles	
	2015	2020
Fuel economy improvement* (gasoline vehicles)	25%	35%
Fuel economy improvement* (diesel vehicles)	40%	50%
NOx & PM emissions	Tier 2, Bin2	Tier 2, Bin2
Durability	5,000 hrs	5,000 hrs
Thermal efficiency penalty due to emission control	<1%	<1%

\*over 2010 baseline gasoline vehicle



# DOE Heavy Truck Engine Goals Support the *SuperTruck* Effort

- By 2015, improve heavy truck fuel economy (engine thermal efficiency) by 20 percent with demonstration in commercial vehicle platforms
- By 2020, improve heavy truck fuel economy by 30 percent compared to 2009 baseline



## Performance Targets

	Heavy-Duty Vehicles	
	2015	2020
Engine brake thermal efficiency	50%	55%
Fuel economy improvement	20%	30%
NOx emissions, g/bhp-hr	<0.20	<0.20
PM emissions, g/bhp-hr	<0.01	<0.01
Stage of development	Prototype	Prototype

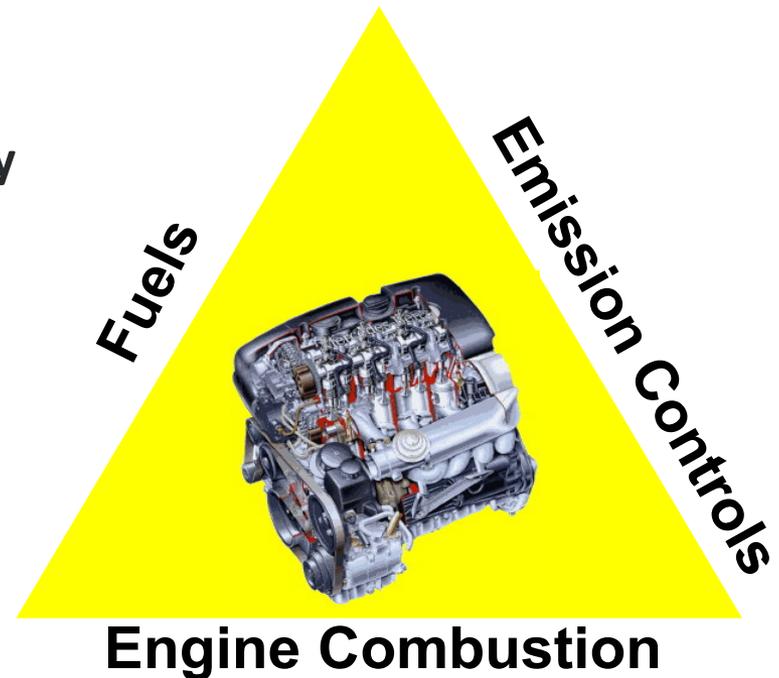
# Challenges

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- ❑ Increasing Fuel Economy
- ❑ Reducing Emissions
- ❑ Ensuring Durability
- ❑ Maintaining or Reducing Cost

# Systems Approach to Dramatically Improve Engine Efficiency and Reduce Emissions

- ❑ Partnerships with auto/truck manufacturing industry, suppliers, energy companies, and national labs
- ❑ Improve fundamental understanding
- ❑ Use Integrated systems approach
- ❑ Progress being made in all 3 areas



**Auto** ↔ **Light Truck** ↔ **Heavy Truck**

# R&D Coordinated with the U.S.DRIVE Partnership



## Focus R&D in Key Technology Areas

- Advanced Combustion Engines**
- Electric Propulsion Systems
- Energy Storage
- Hydrogen-fueled ICEs
- Materials Technologies



CHRYSLER



DTE Energy



EPR2

ELECTRIC POWER RESEARCH INSTITUTE

ExxonMobil

bp



ChevronTexaco

ConocoPhillips

# R&D Coordinated with 21<sup>st</sup> Century Truck Partnership



## Research, Development, and Demonstration in Key Technology Areas

- Engine Systems*
- Heavy-Duty Hybrid
- Parasitic Losses
- Idle Reduction
- Safety

## INDUSTRY PARTNERS

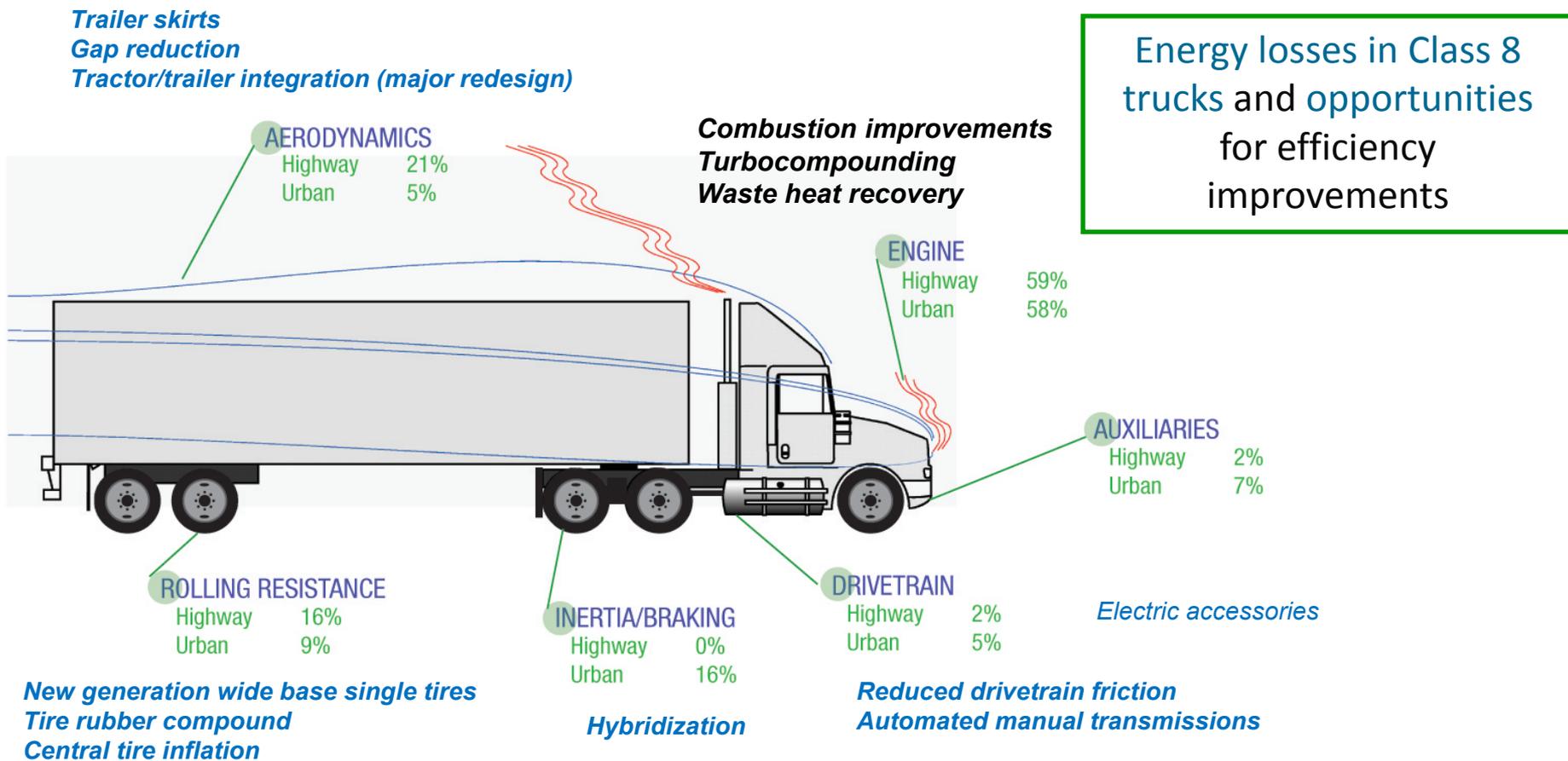


## GOVERNMENT PARTNERS



# SuperTruck Project

Demonstrate a **50% improvement** in freight efficiency by 2015



Heavy-duty trucks use 20% of the fuel consumed in the United States.  
 Fuel economy improvements in these trucks directly and quickly reduces petroleum consumption

# SuperTruck and ATP-LD Awardees

## Systems Level Technology Development, Integration, and Demonstration for Efficient Class 8 Trucks (SuperTruck)

Awardees
Cummins, Inc.
Daimler Trucks North America
Navistar, Inc.
Volvo

## Advanced Technology Powertrains For Light-Duty Vehicles (ATP-LD)

Awardees
Chrysler Group
Cummins Inc.
Delphi Automotive Systems, LLC
Ford Motor Company
General Motors Corporation
Robert Bosch LLC

## Enabling Technologies for Engine and Powertrain System

Awardees
General Motors LLC
MAHLE Powertrain LLC
Filter Sensing Technologies, Inc.
Eaton Corporation
Robert Bosch LLC
Los Alamos National Laboratory
Envera LLC

# Advanced Combustion Engine R&D Program: Budget by Subprogram

Major Activities	FY 2012* Enacted	FY 2013** Full Year CR	FY 2014*** Request
<b>Advanced Combustion Engine R&amp;D</b>	<b>\$58,027K</b>	<b>\$56,725K</b>	<b>\$59,500K</b>
Combustion and Emission Control	49,320	48,216	54,500
Solid State Energy Conversion	8,707	8,509	5,000

\* FY 2012 SBIR/STTR removed.  
 \*\* FY 2013 full year CR inclusive of SBIR/STTR.  
 \*\*\* FY 2014 budget request inclusive of SBIR/STTR.

# Questions?

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**Thank You!**

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<http://www.eere.energy.gov/vehiclesandfuels>