DOE Emission Control R&D

Kenneth C. Howden
Director, 21st Century Truck Partnership
Vehicle Technologies Program
Energy Efficiency and Renewable Energy
U.S. Department of Energy

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The Federal Role

- Undertake High-Risk Mid- to Long-Term Research
- Utilize Unique National Lab Expertise and Facilities
- Help Create a National Consensus
- Work Cooperatively with Industry

DOE Advanced Combustion and Emission Control R&D

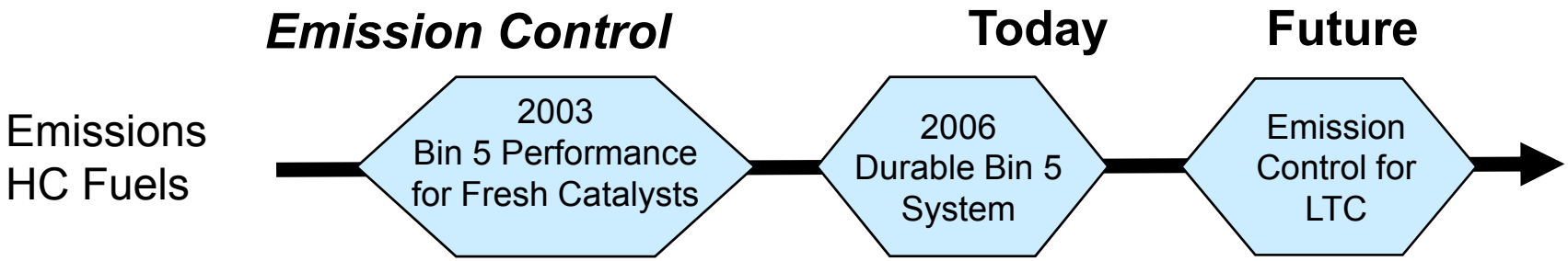
Goal: Reduce petroleum dependence by removing critical technical barriers to mass commercialization of high-efficiency, emissions-compliant internal combustion engine (ICE) powertrains

Primary directions ICE efficiency improvements for light- and heavy-duty vehicles through advanced combustion and minimization of thermal and parasitic losses

- Emission Control development integrated with combustion strategies for emissions compliance and minimization of efficiency penalty
- Coordination with fuels R&D to enable clean, high-efficiency engines using hydrocarbon-based (petroleum and non-petroleum) fuels

Goals	**2010 (light-duty)**	**2013 (heavy-duty)**
-Engine brake thermal efficiency	45%	55%
-Powertrain cost	< $30/kW	
-NOx & PM emissions	Tier 2, Bin5	EPA 2010

Emission Control for Hydrocarbon Fuels



- Bin 5 emissions demonstrated for fresh catalysts for cars and light-duty trucks using NOx adsorber and urea SCR systems
  - Extended testing (120k miles equivalent) of urea SCR system completed
- Focus on improving understanding of emission control systems
  - Mechanisms of catalyst deactivation at high temperature and by sulfur
  - Computer models to predict aftertreatment performance
  - Control strategies to optimize efficiency
  - Discovery of new, lower cost catalyst materials
- Technology areas:
  - Urea and HC SCR
  - NOx adsorbers
  - Particulate filters

Emission Control Research Approach

Advanced Combustion Engine R&D → Industry

Fundamental Research → Applied Research → Technology Maturation & Deployment

Fundamental R&D

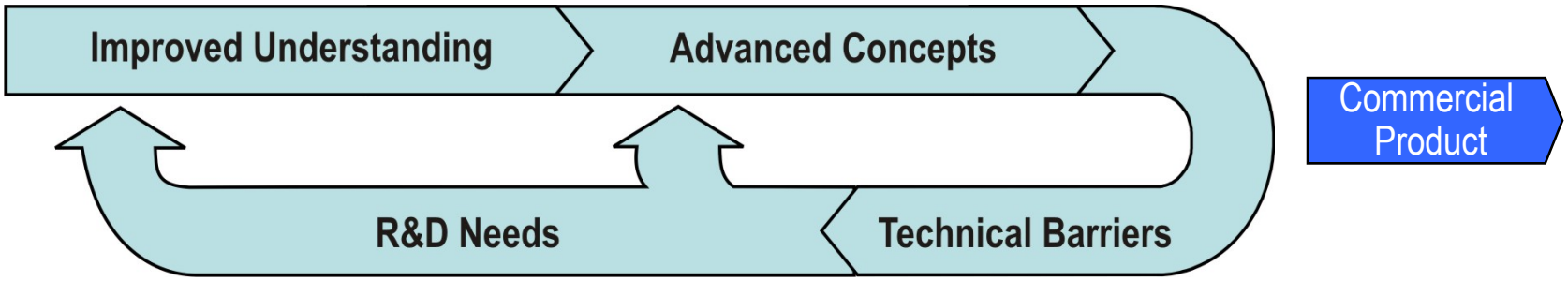
- SNL – Advanced Combustion Engine-Out Emissions
- PNNL – Catalyst and DPF Fundamentals
- ANL – Heavy Duty DPF CRADA
- LLNL – Chemical kinetics models (LTC and emissions)
- Universities – Kentucky, Houston

Fundamental to Applied Bridging R&D

- ORNL – Experiments and simulation of emission control systems (bench-scale to fully integrated systems)

Competitively Awarded Cost-shared Industry R&D

- Vehicle and engine companies – engine/emission control systems
- Suppliers – enabling technologies (Catalysts, Substrates, NOx/PM control devices, sensors)

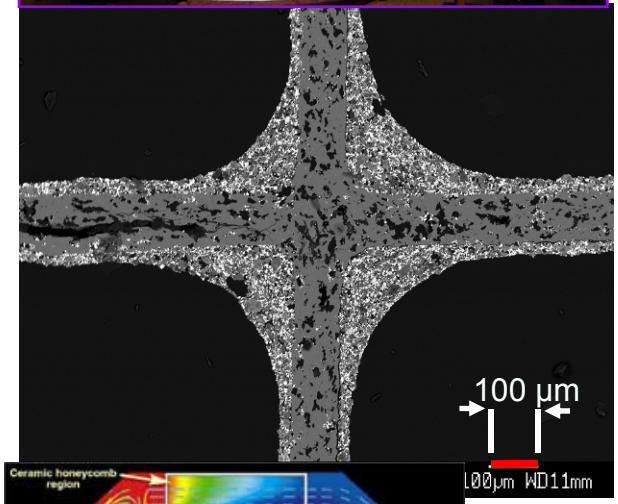


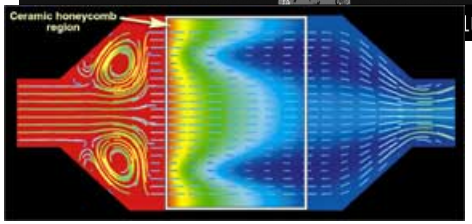
Collaboration in Emission Control R&D

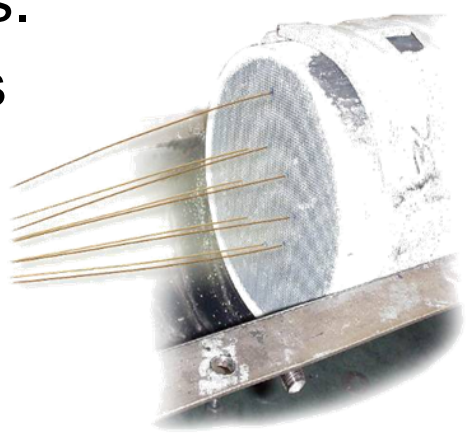
- CLEERS* started in 2001, encompasses DPF, LNT, SCR. Govt.-industry research coordination (www.cleers.org)
- Thousands of NOx catalyst formulations studied
- Emphasis on minimizing "fuel penalty" while achieving emissions levels
- Integration of advanced combustion regimes with emission control
- Creation of "kinetics maps."
- Reduce need for precious metals

*Crosscut Lean Exhaust Emissions Reduction Simulation

8th CLEERS workshop at U Michigan, Dearborn

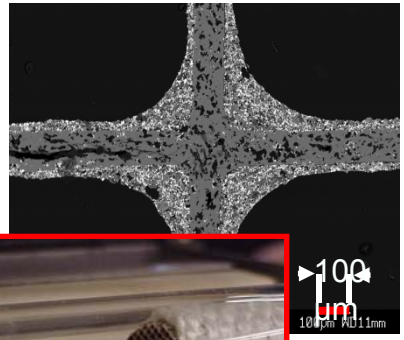


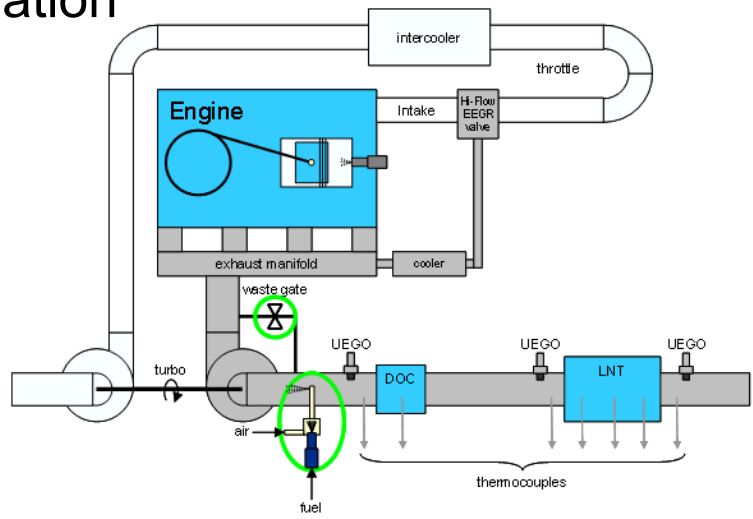




Emission Control Technical Barriers

- Deficiencies in fundamental understanding and modeling capabilities
- Degradation from sulfur in fuels (even at 15 ppm) and lubricants and thermal processes
- High platinum group metal content, high cost
- Need high effectiveness over broader temperature range
- Inefficient engine management for regeneration and desulfation (LNT) and poor reductant utilization (LNC)
- Inadequate sensors for process control or diagnostics;
- Inadequate methods for rapid-aging
- Cost/Packaging constraints on the vehicle





Health Impacts Activity

Goals

- To provide a sound scientific basis underlying any unanticipated potential health hazards associated with the use of new power train technologies, fuels and lubricants in transportation vehicles; and
- To ensure that vehicle technologies being developed by VT for commercialization by industry will not have adverse impacts on human health through exposure to toxic particles, gases, and other compounds generated by these new technologies.

Projects

- Advanced Collaborative Emissions Study (ACES)
- Real-World Studies of Ozone Formation as a Function of NOx Reductions
- Measurement and Characterization of Unregulated Emissions from Advanced Technologies

Advanced Combustion Engine R&D Budget by Activities

Major Activities	FY 2007 Appropriation	FY 2008 Appropriation	FY 2009 Appropriation
Advanced Combustion Engine R&D	**$48,346K**	**$44,591K**	**$40,800K**
Combustion and Emission Control *	26,778	38,815	35,089
*Heavy Truck Engine***	*14,495*	*0*	*0*
Solid State Energy Conversion***	4,579	4,527	4,568
*Health Impacts***	*2,494*	*0*	*0*
SBIR/STTR		1,248	1,143

Changes in FY 2008 Request

*Expanded to include Heavy Truck Engine and Health Impacts.
**Incorporated within expanded Combustion and Emission Control R&D.
***Formerly Waste Heat Recovery

Advanced Combustion Engine Research Program

- The mission is to provide the science-base on combustion and emission formation processes needed to develop more efficient, cleaner engines for transportation.
- Supports FreedomCAR mid-term program goals
  - light-duty - peak efficiency of 45%, emissions compliant, by 2010
- Supports 21st Century Truck Partnership goal
  - heavy-duty - peak efficiency of 55%, emissions compliant, by 2013
- Key customers: the U.S. auto and engine industries.
- Strong interactions and collaborations between industry, universities, and national labs.