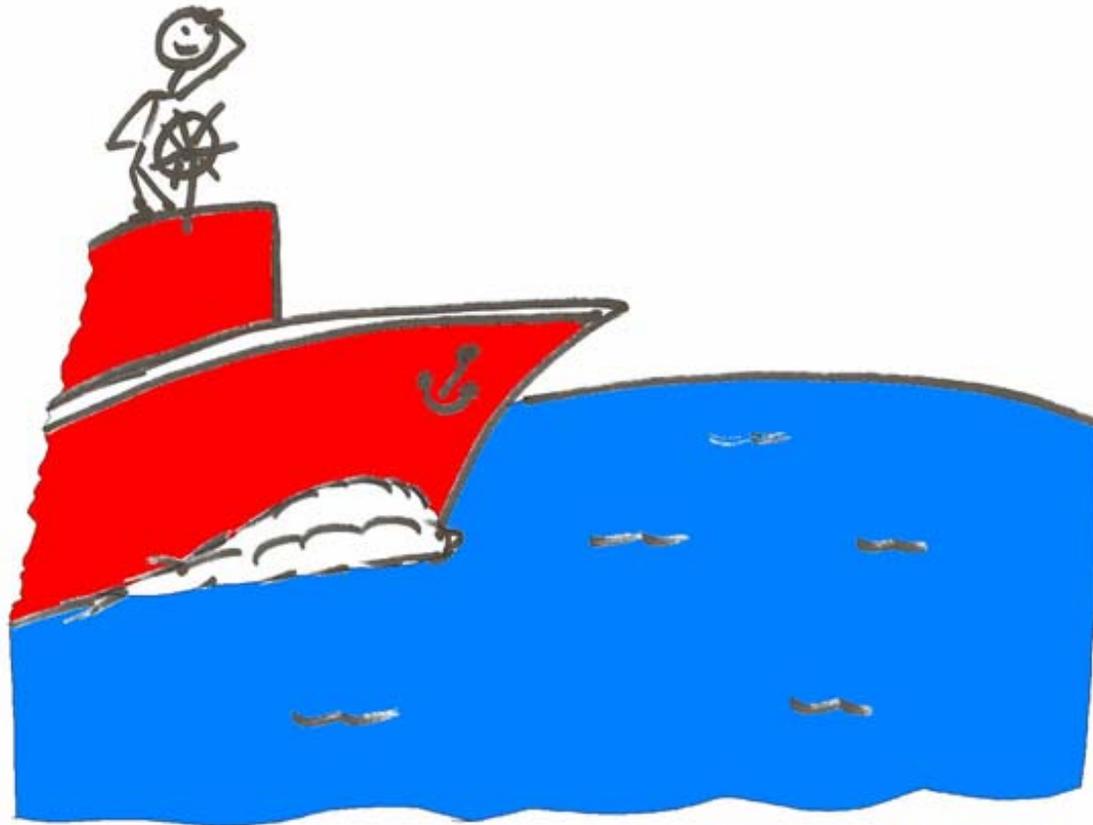


View from the Bridge:  
Technology Development for  
Energy Efficiency and Low Emissions

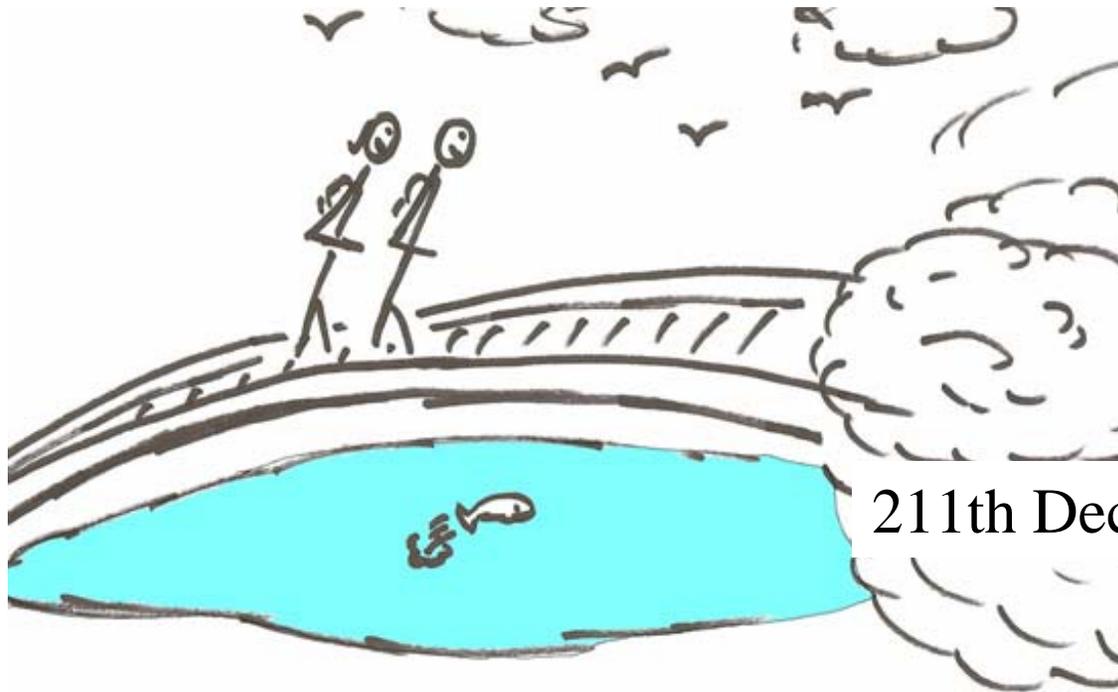
Dr. John Wall  
Vice President and  
Chief Technical Officer  
Cummins Inc.  
August 22, 2005



# "View from the Bridge"

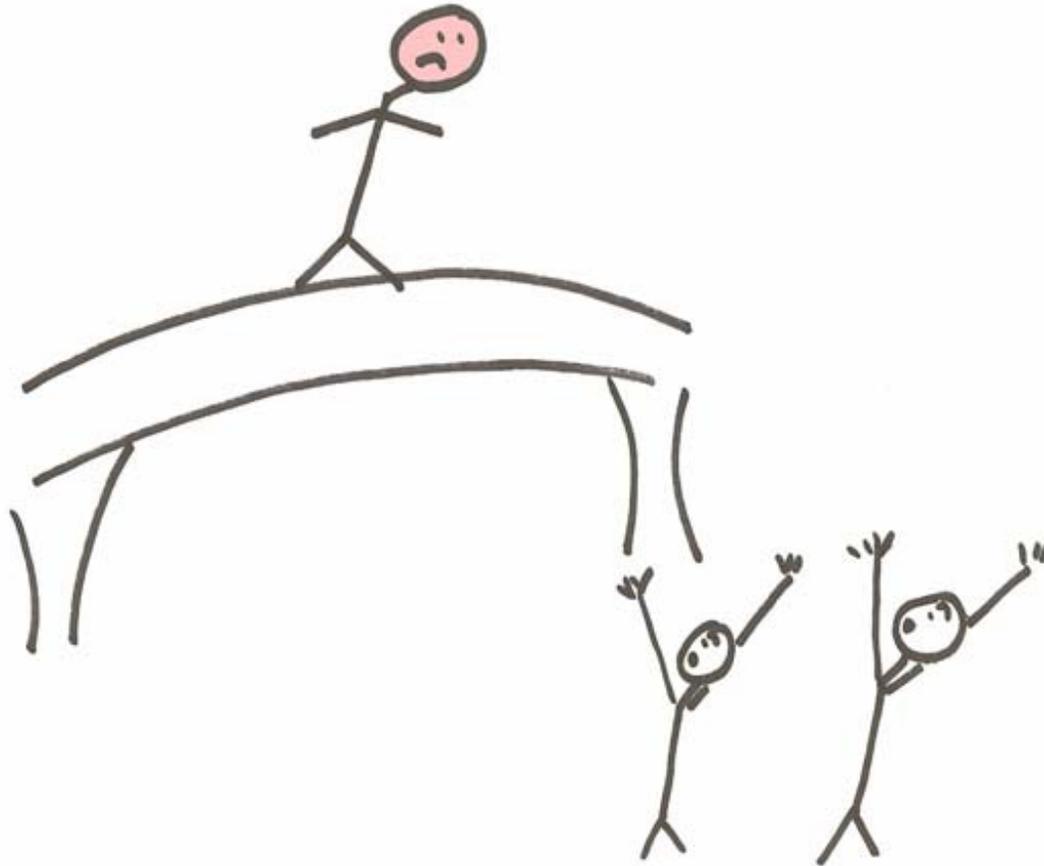


# "View from the Bridge"



211th Decade

# "View from the Bridge"



# The Technology Challenge

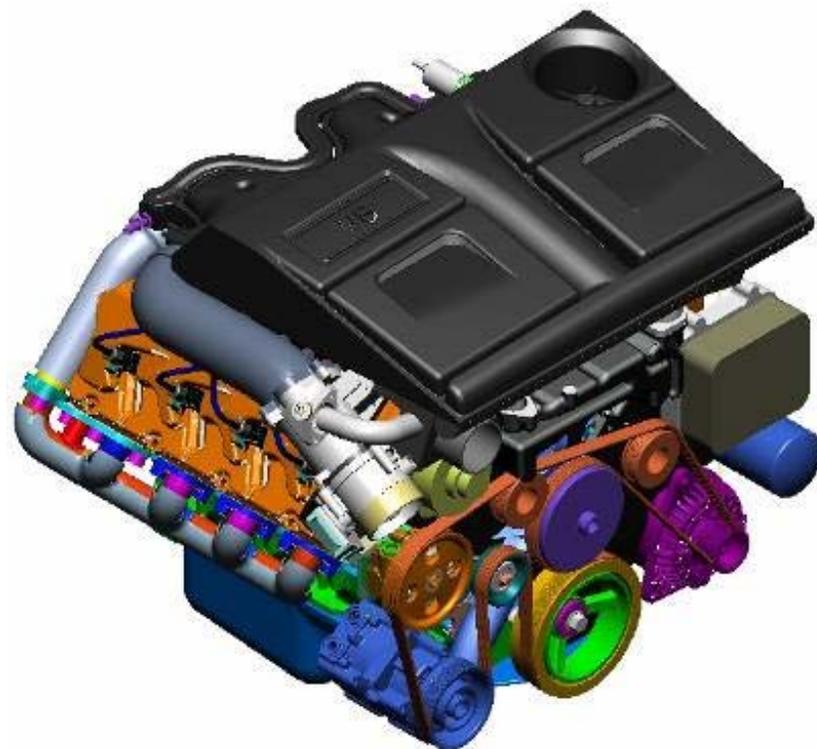
To continue to develop the diesel's outstanding

*fuel economy*

*performance*

*reliability*

*durability*



while meeting increasingly  
difficult future emission  
standards.

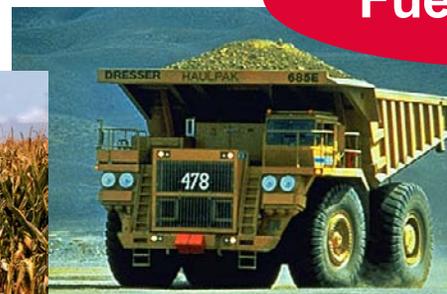


# Our Products Must Meet Customer Requirements

High Performance

Reliable and Durable

Fuel Efficient



Highly Sociable



Low Initial Cost



Low Maintenance

Electronic Integration

# Over a Wide Range of Vehicles & Applications



# Over a Wide Range of Engine Power

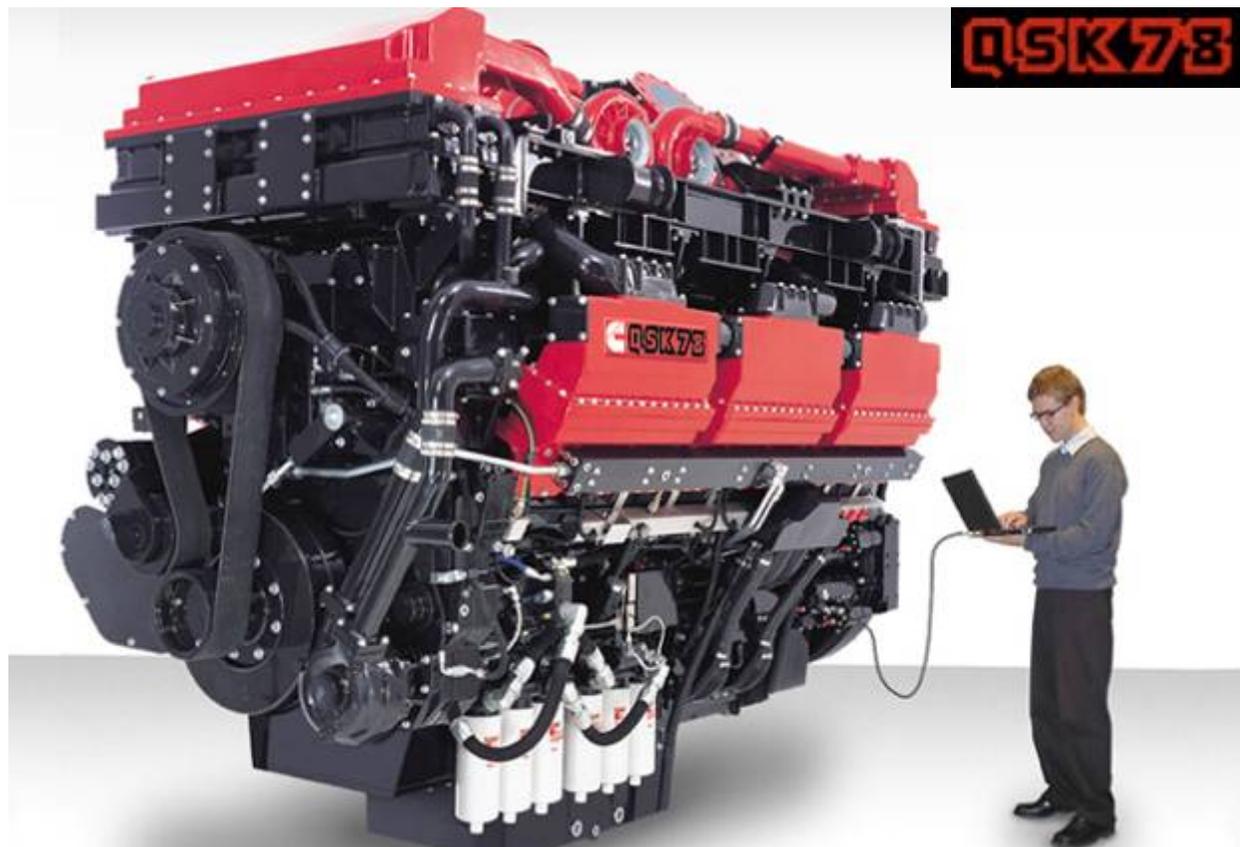
**3,500HP**



**31 HP**



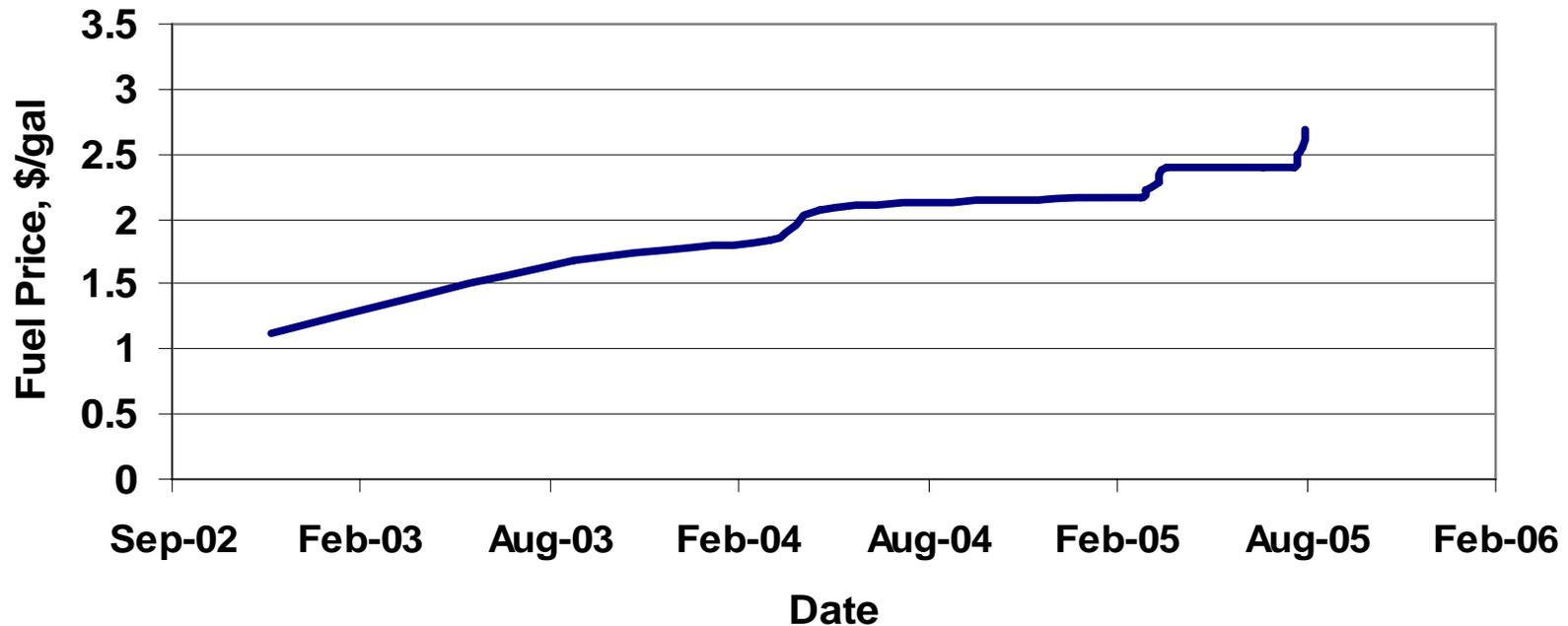
**A1400**



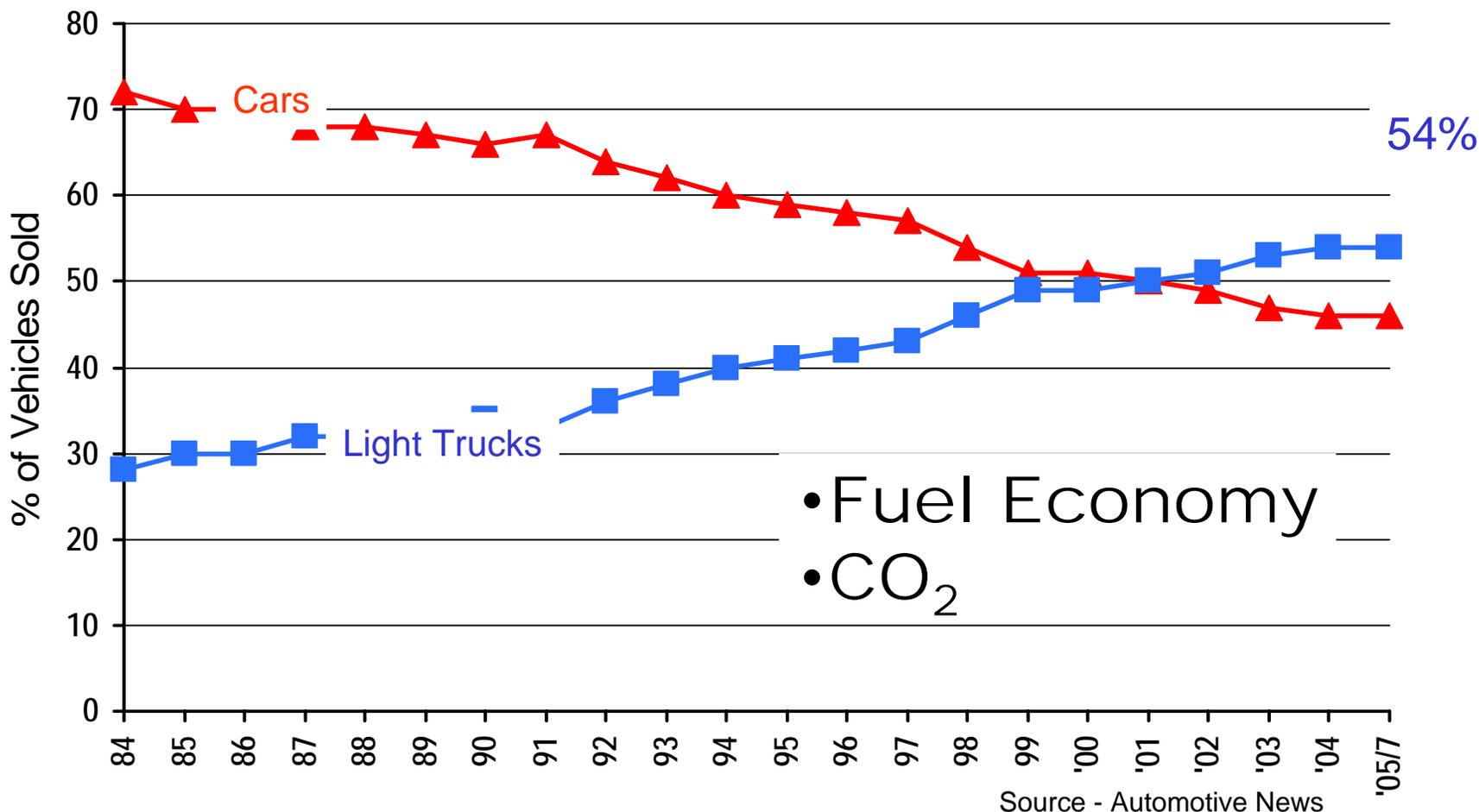
**QSK78**

# Customer Incentives are not Static

## Columbus, IN Fuel Price



# Customer *BASE* is Not Static: Clean Diesel is an Opportunity for New Customers *and* the Environment



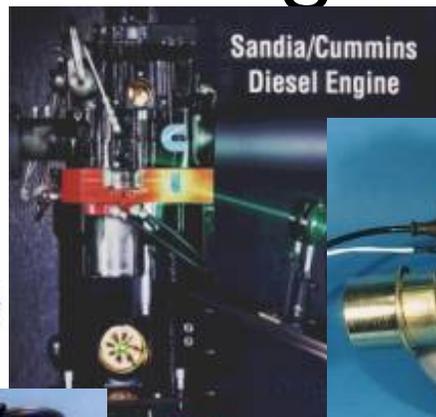
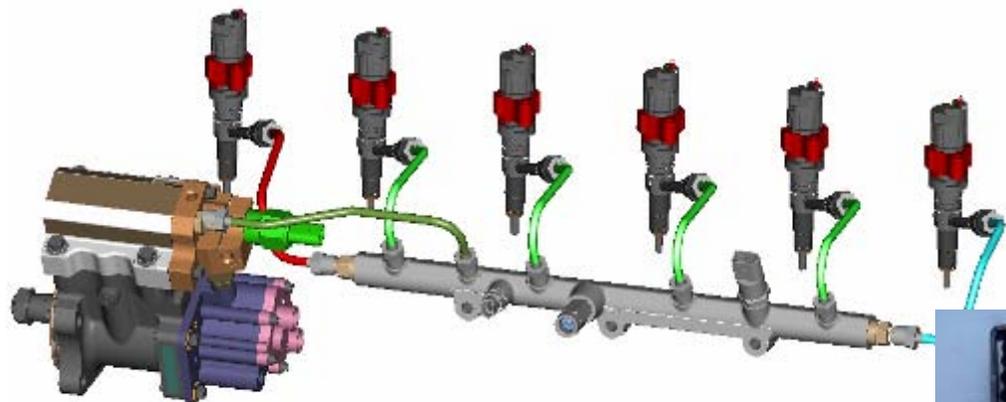


“The Right Technology Matters”

## *Architecture* for The Right Technology

- Develop broad range of modular technical building blocks
  - Analytical models
  - Product hardware and software
- Create integrated products tailored to meet customer needs
  - Low cost  $\leftarrow \rightarrow$  High feature content
  - On-highway  $\leftarrow \rightarrow$  Off-highway
  - North America  $\leftarrow \rightarrow$  India

# The Right Technology Matters ... in Diesel Subsystem Design



- Fuel systems
- Electronic controls



***... to deliver best customer  
value at low emissions***

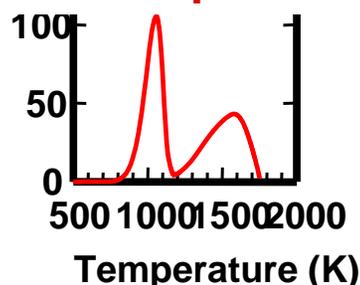
# Analysis-Led Design

- Use analytical tools and computer simulation to create and optimize designs
  - *Virtual Build*
  - Reduce expensive and time consuming prototype testing
  
- Arrive at the best solutions faster and at the lowest cost

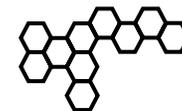
# Combustion Model

## Detailed Kinetics

1100+ equations



## Soot Model



Injector

Entrainment of air

Entrainment of hot products

Rich premixed reaction zone

Rapid conversion of precursors to soot

Soot growth region

Wall

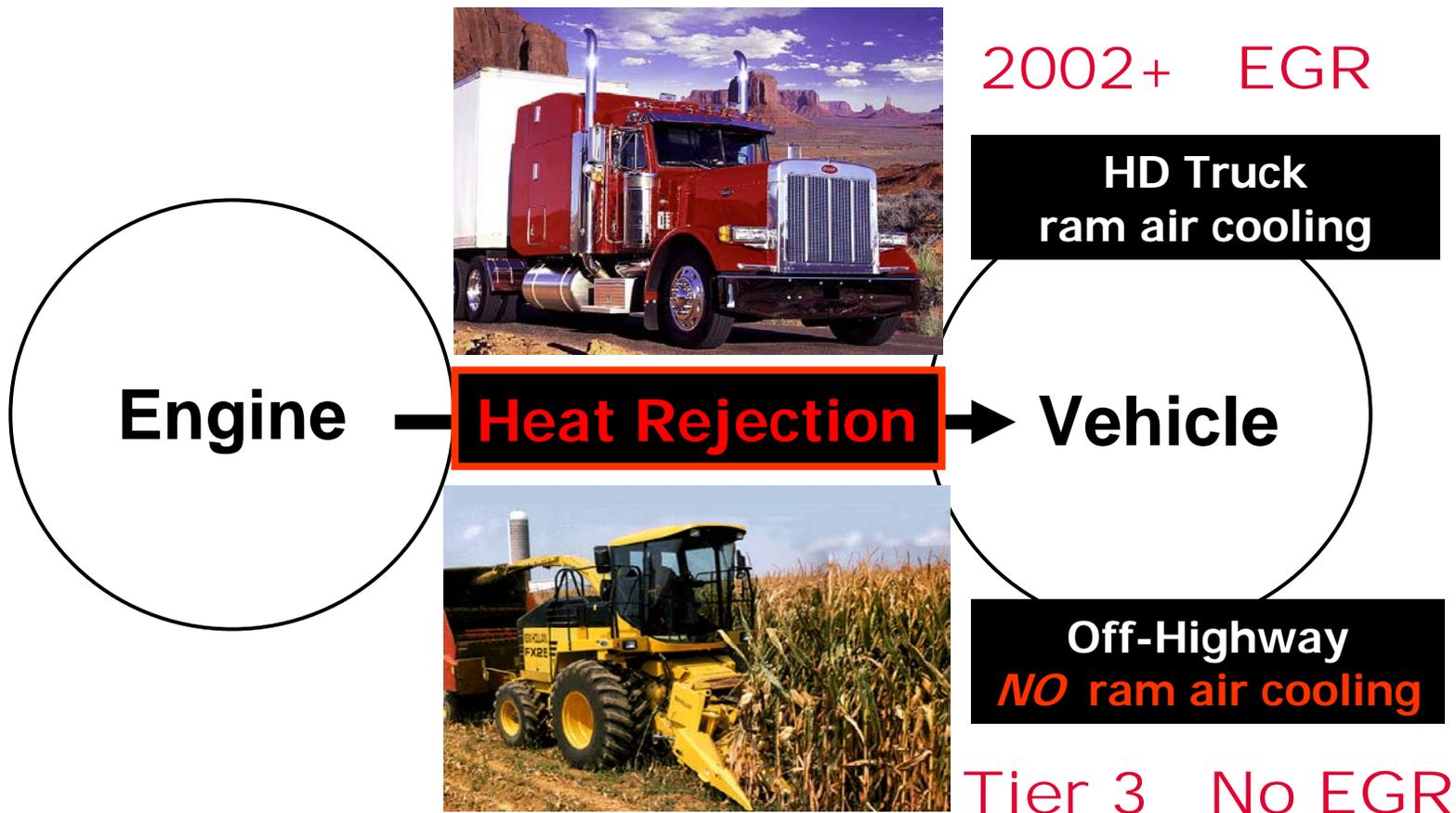
Diffusion flame between hot soot and air

## Flamelet Model

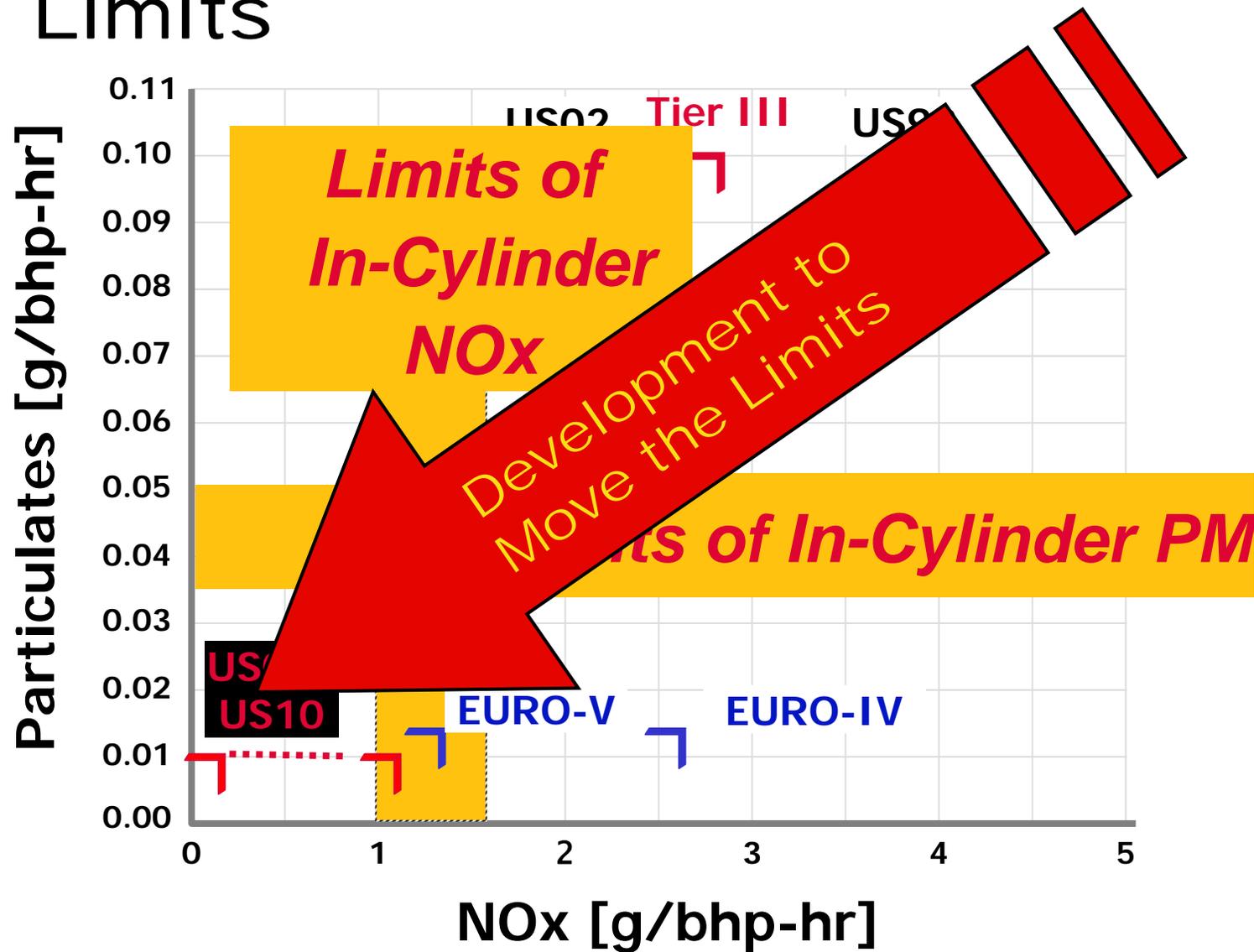
3-D CFD code with improved spray model

# Application Determines the Right Technology

*Heat Rejection makes a difference in vehicle applications*

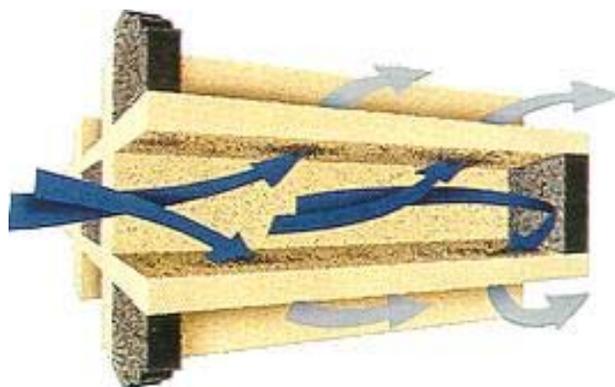


# HD Emission Technology Limits

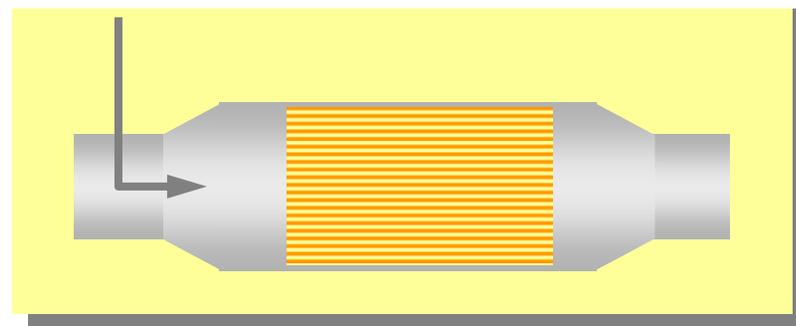


# Next Critical Subsystem: Exhaust Aftertreatment

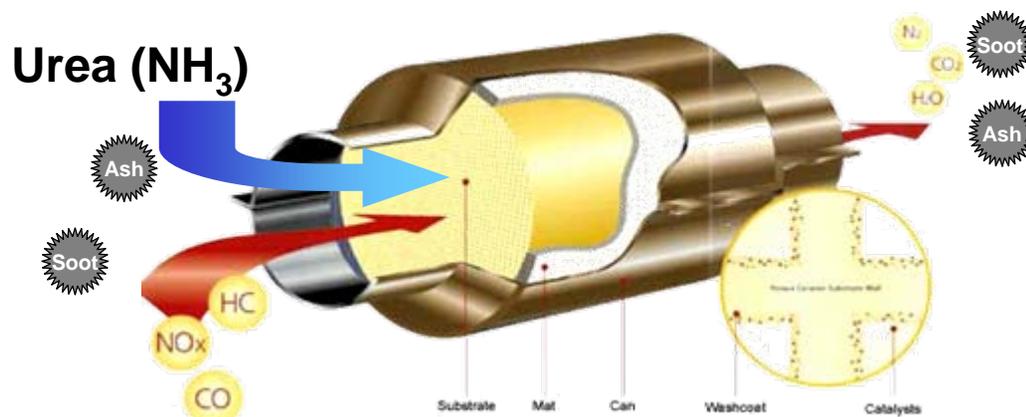
## Active Particulate Filter



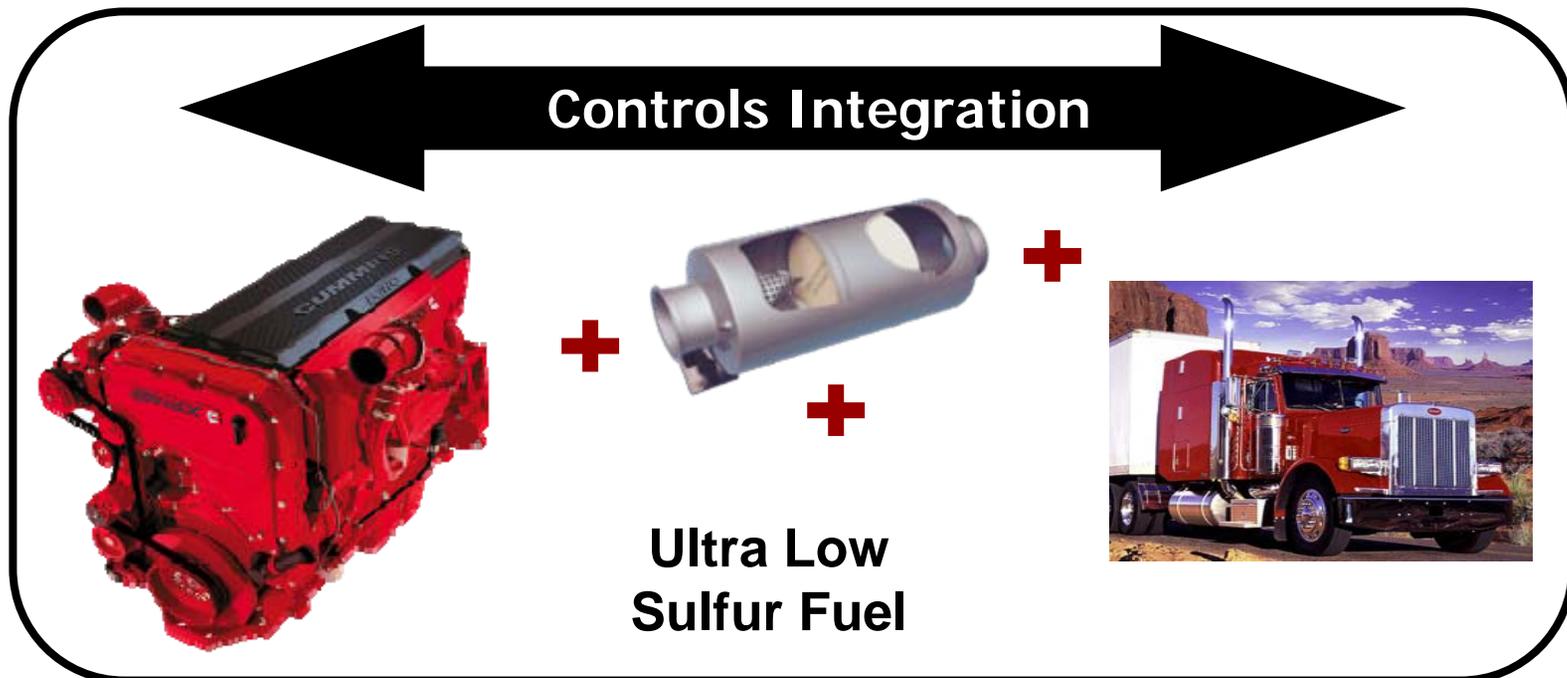
## NOx Adsorber



## NOx Control Using Urea SCR

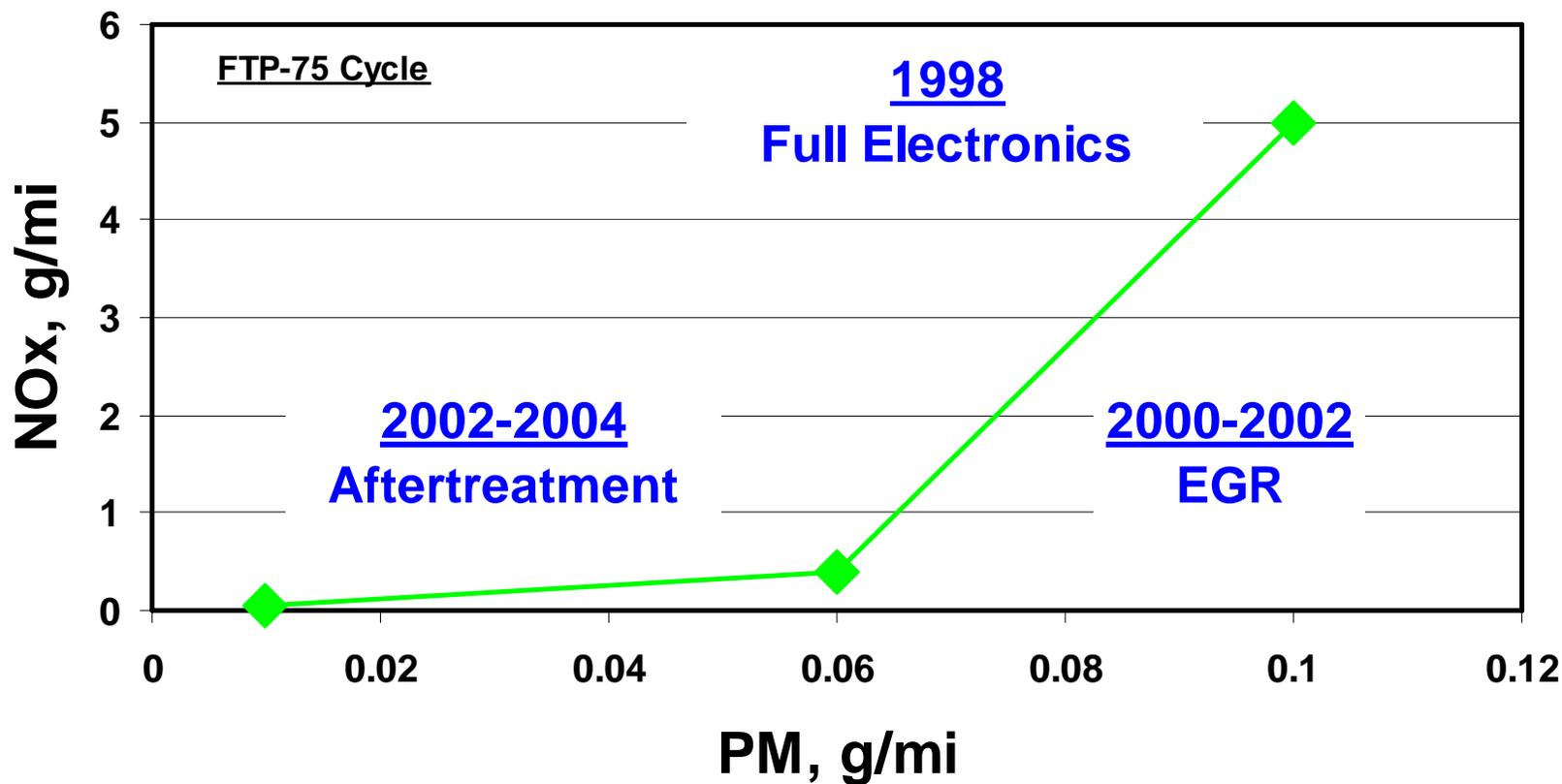


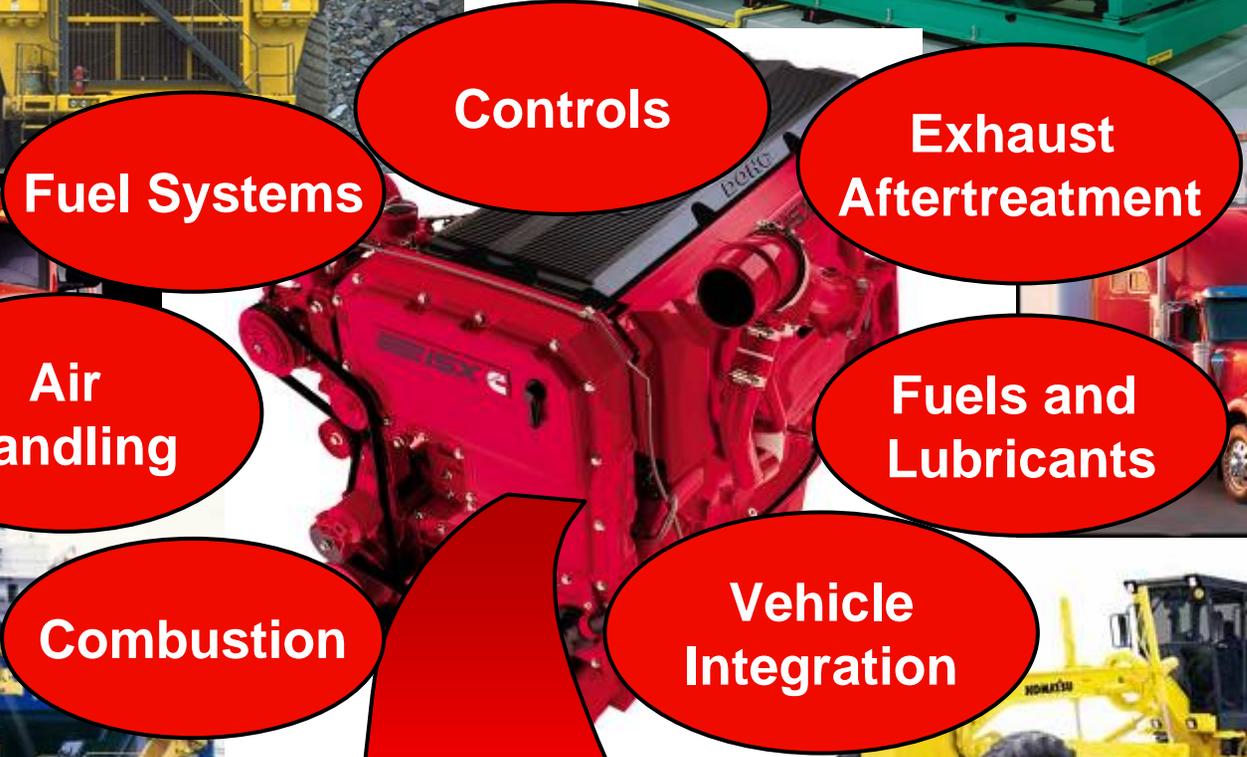
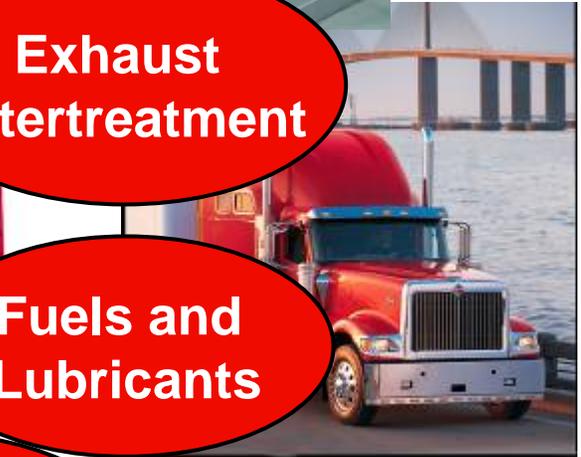
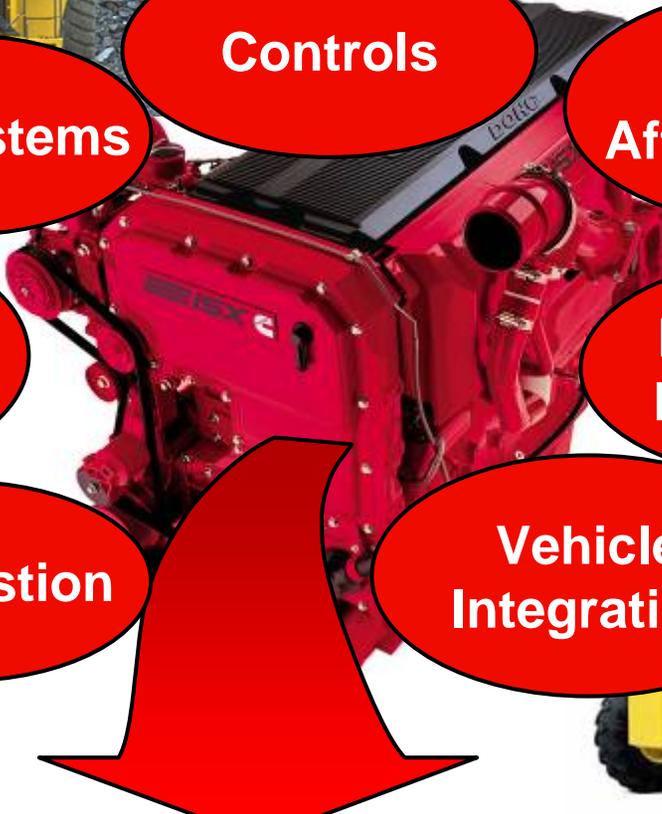
# System Integration is Critical



**Vehicle, engine, aftertreatment and fuel...  
*a single system designed to optimize  
fuel economy, performance,  
reliability, cost ... and emissions***

# Light Duty Emissions Progress





***Industry, universities and national laboratories must work together for our customers to deliver The Right Technology***

“The Right Technology Matters”

*... for Sustainable Development*

New technologies for developing countries

- Renewable fuels
- Robust design
- Low cost



**teri**

- Biomass gasifier



**IIT-B: Initial focus on  
straight vegetable oil  
biodiesel fuel**

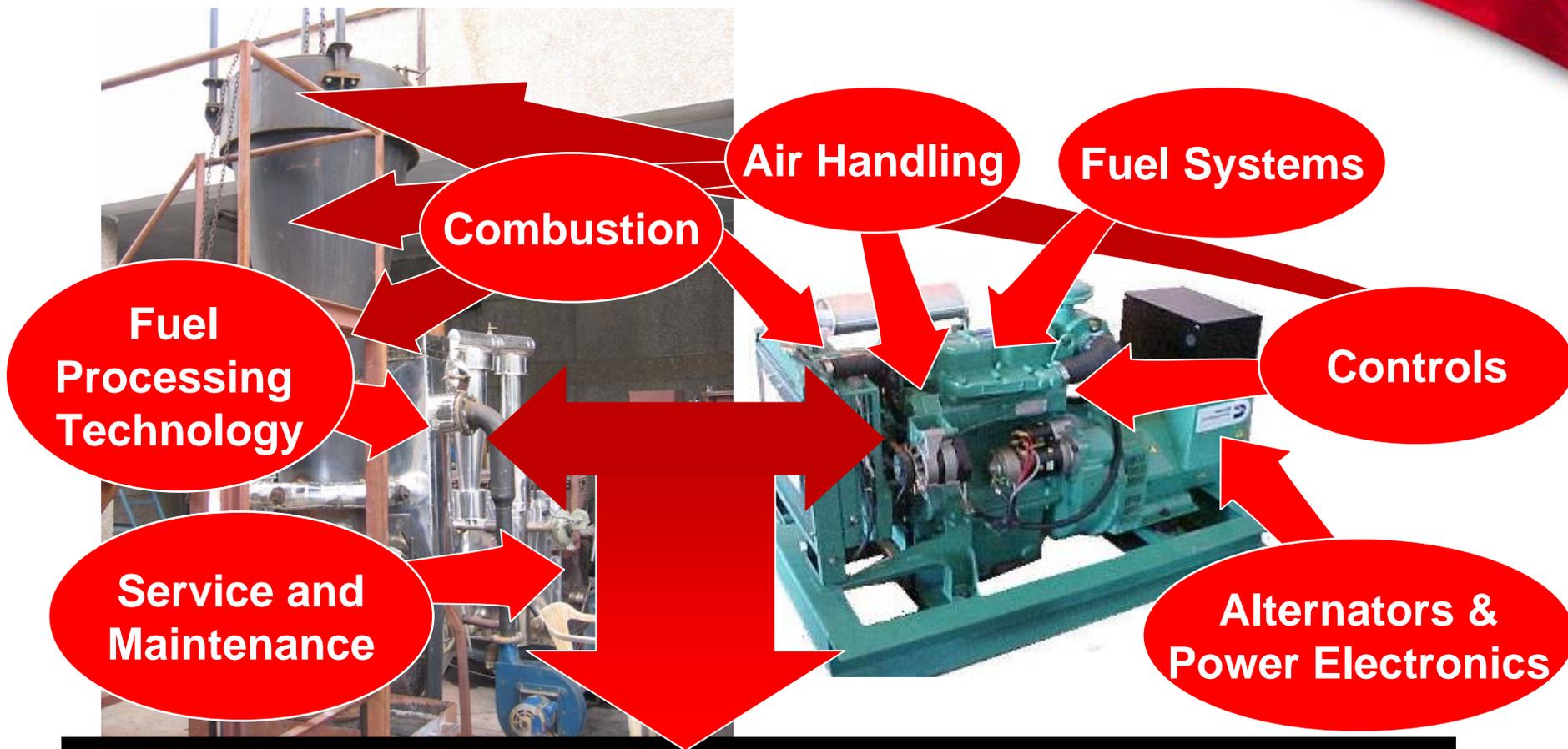
**Indian Institute of Technology Bombay**



भारतीय प्रौद्योगिकी संस्थान मुंबई

**Cummins Engine Research Facility**

# System Integration



***Rural applications in India will require significant changes in design paradigms at the system level.***

# “View from the Bridge”



US DOE Technology Programs are Critical  
for Development of Future-Sustaining Technology  
- for the US and for the World