

- DEER Conference 2009
- Dearborn, MI

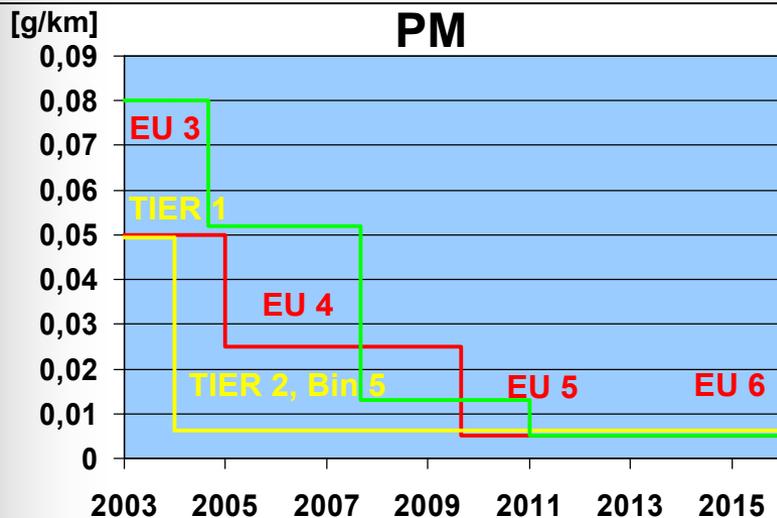


A View from the Bridge

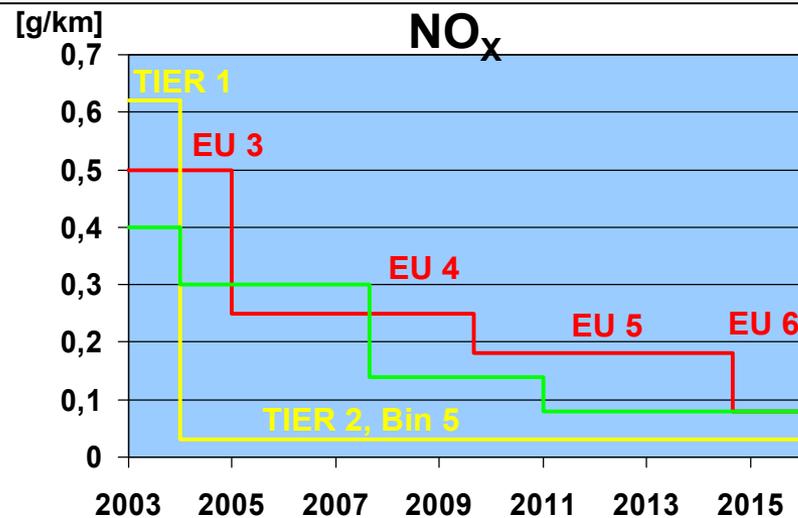
Gary W. Rogers
President and CEO, FEV Inc.
August 3, 2009

A View from the Bridge

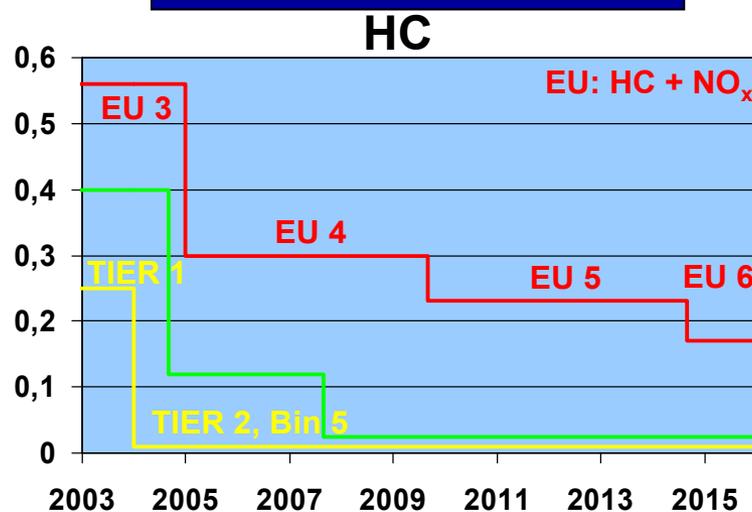
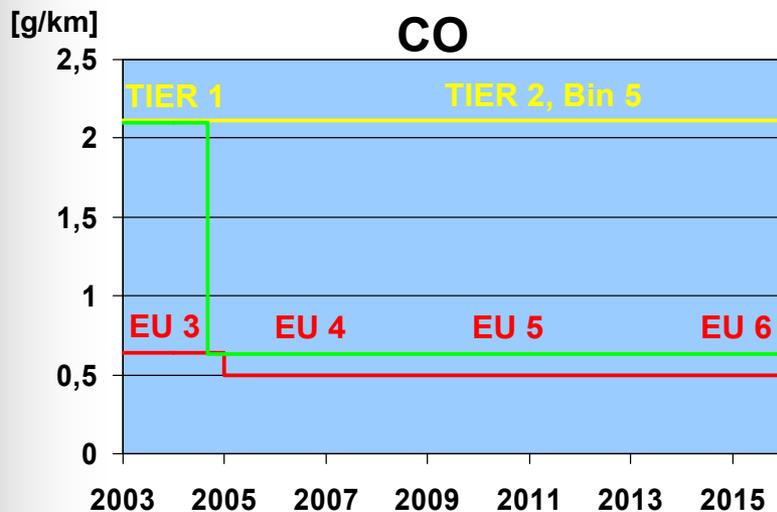
Light-Duty Emission Regulations History



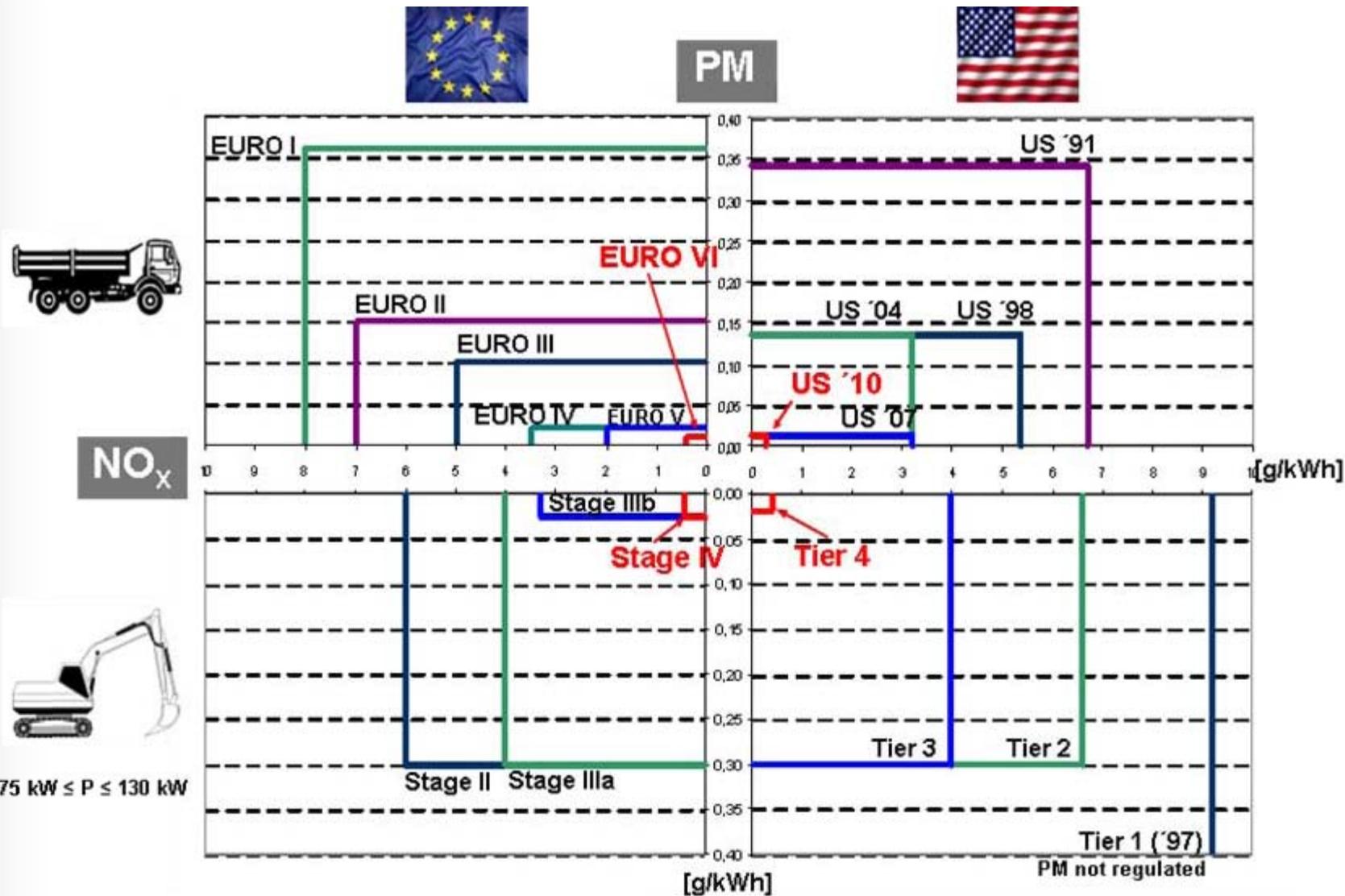
TIER 1 and TIER 2, Bin 5: 50.000 miles
Japan beyond Model Year 2011: proposed limits



— EU — USA — JAPAN

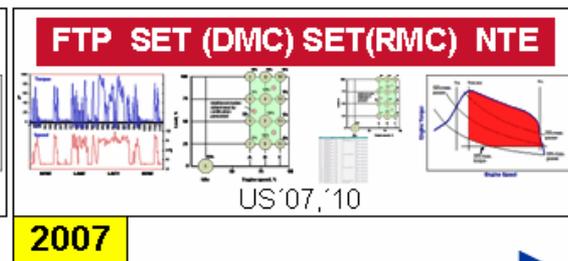
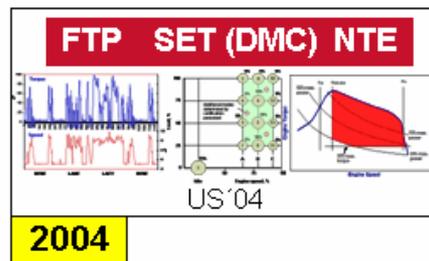
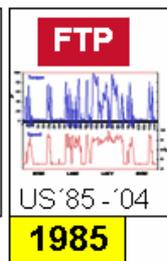
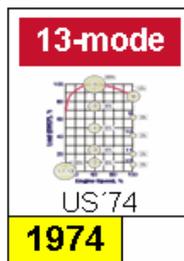
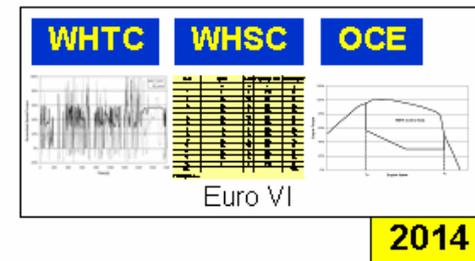
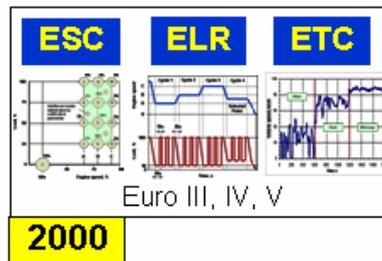


A View from the Bridge Heavy-Duty Emission Regulations History



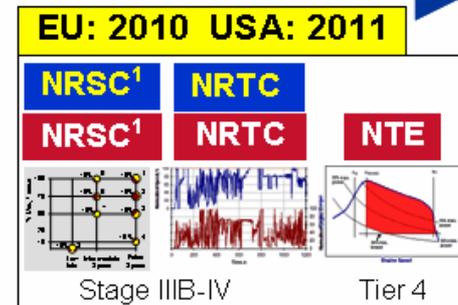
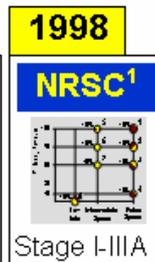
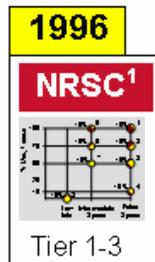
A View from the Bridge Heavy-Duty Test Cycle History

Heavy Duty-Engines



Evolution of Test Procedures for On- and Off-Road Engines

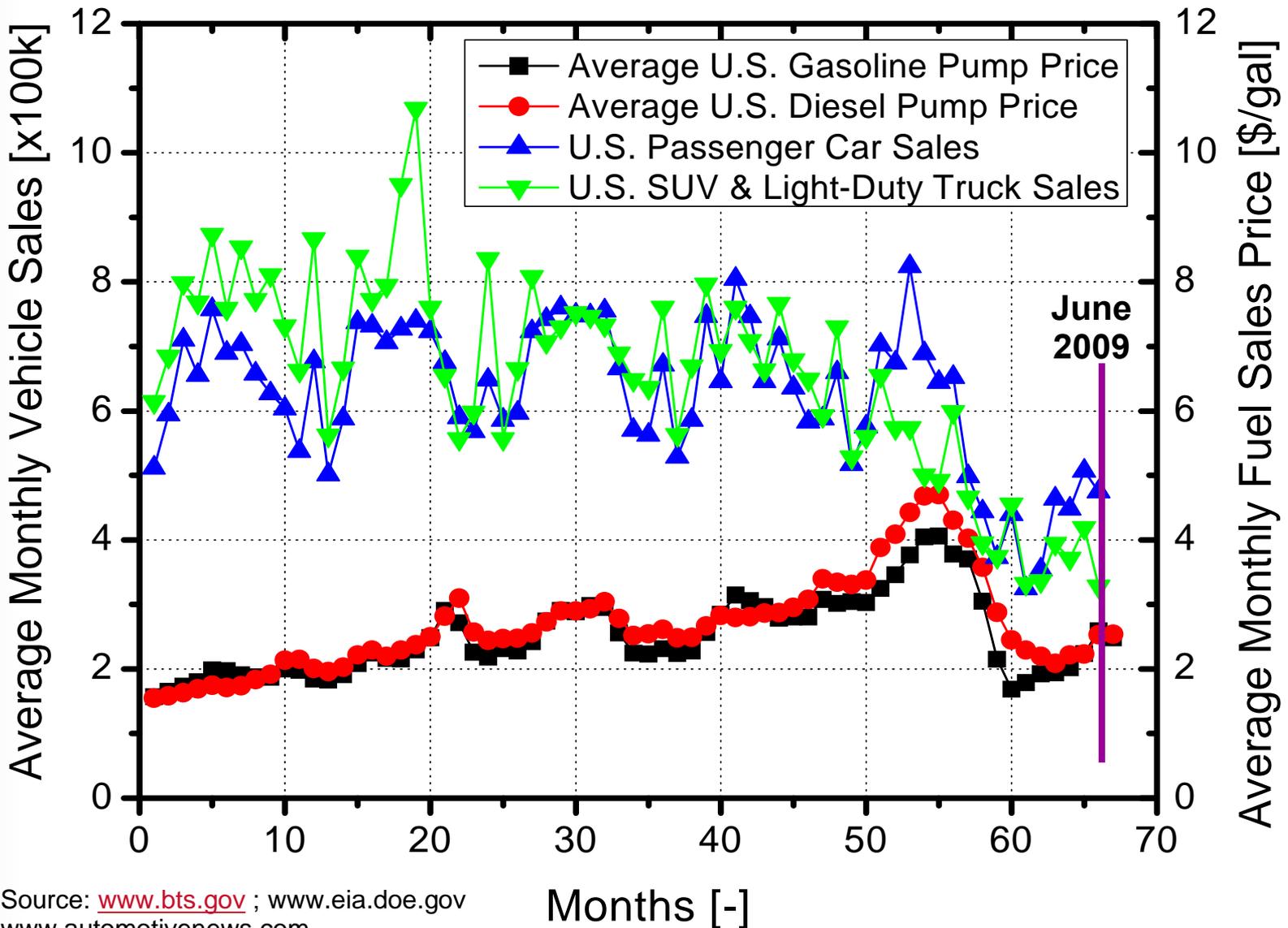
Off-Road-Engines



Europe USA 1) NRSC mostly ISO 8178 C1 test. Other ISO 8178 test cycles are allowed for selected applications.

A View from the Bridge

U.S. Vehicle Sales and Fuel Price Development



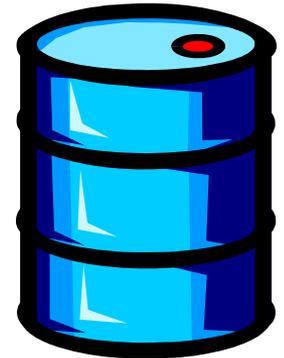
Source: www.bts.gov ; www.eia.doe.gov
www.automotivenews.com

A View from the Bridge

Factors that Influence Fuel Price

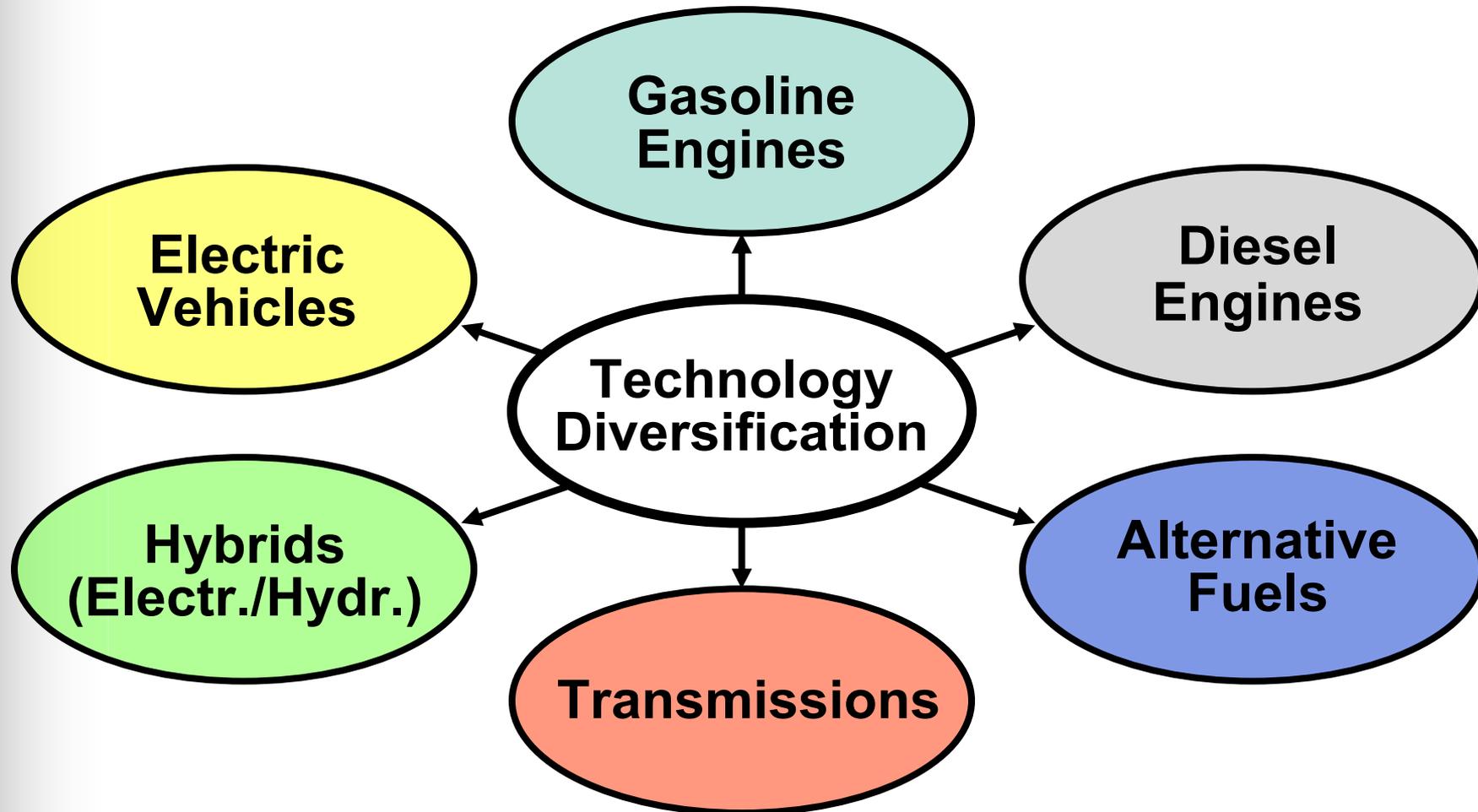
Fuel prices depend on a variety of factors:

- Supply and demand
 - General increase in demand
 - Emerging markets
- Political issues/instabilities
 - War
 - Embargos
 - Terrorist Attacks
- Natural disasters
- Investors and speculators
- Alternative Options
 - Hydrogen
 - Ethanol
 - Biodiesel & biomethane
 - CNG & LNG
 - Electricity



A View from the Bridge

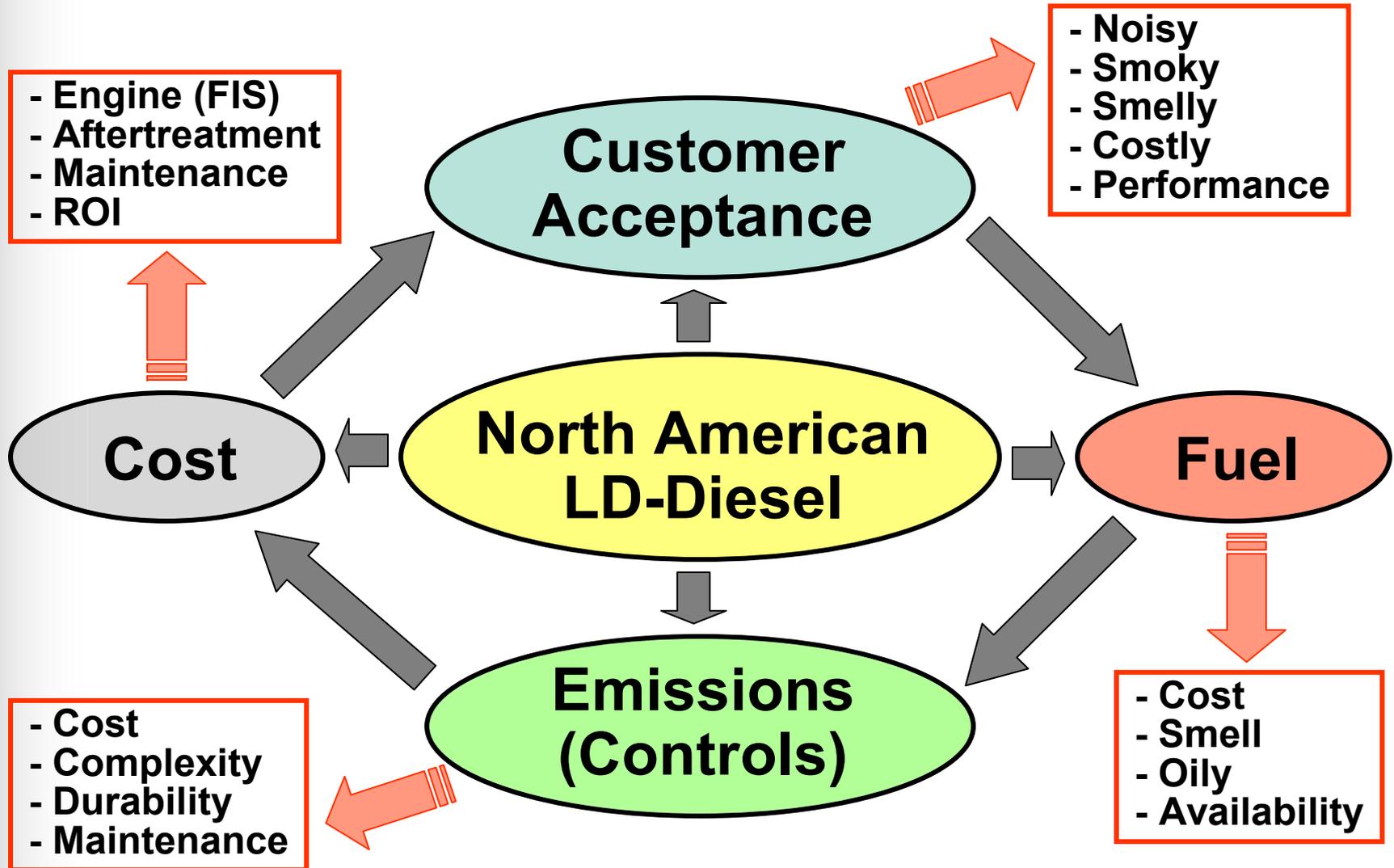
Light-Duty Powertrain Diversification



Optimization of individual systems and a combination of many technologies will be necessary to meet future requirements

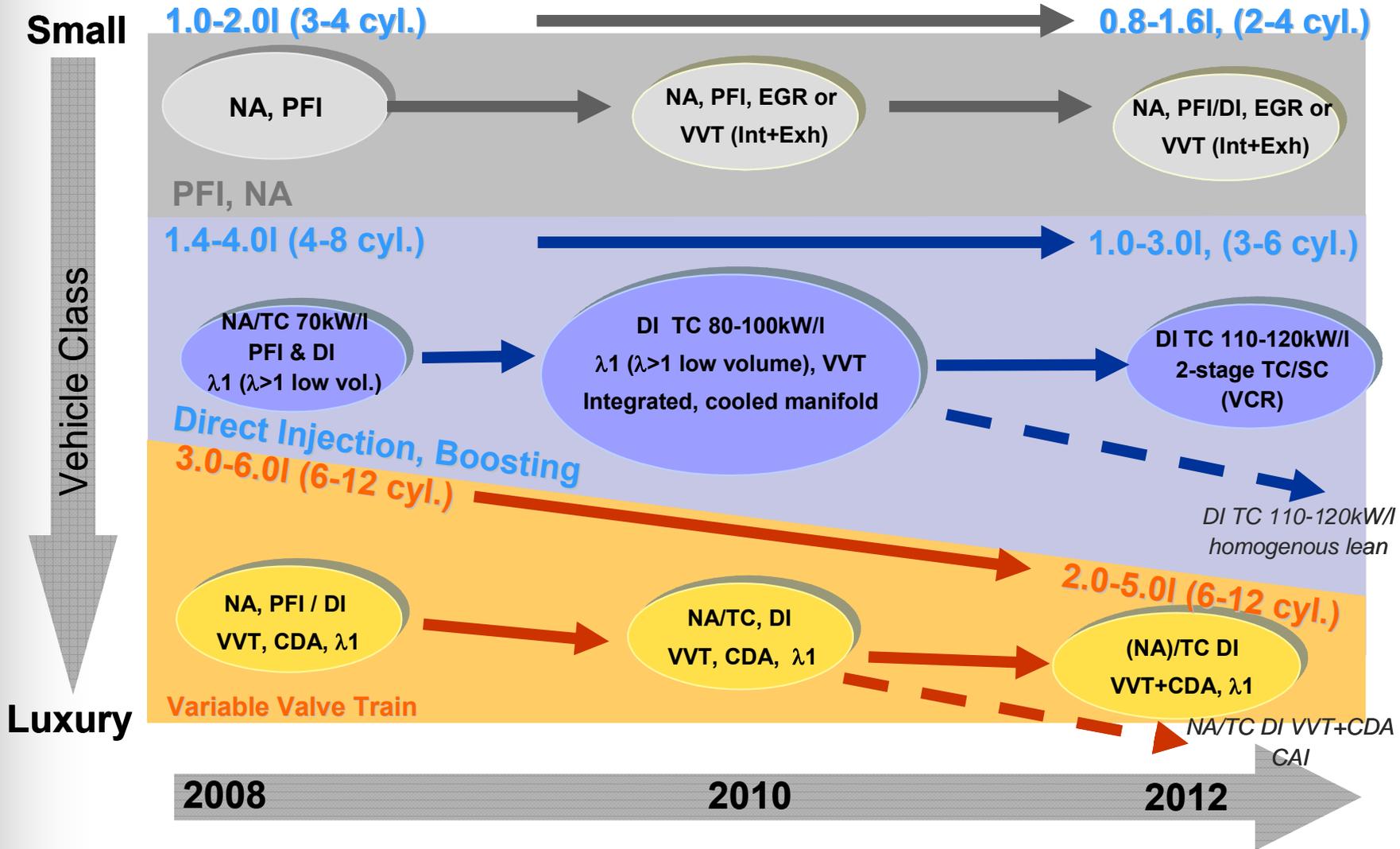
A View from the Bridge

U.S. Light-Duty Diesel Applications



A View from the Bridge

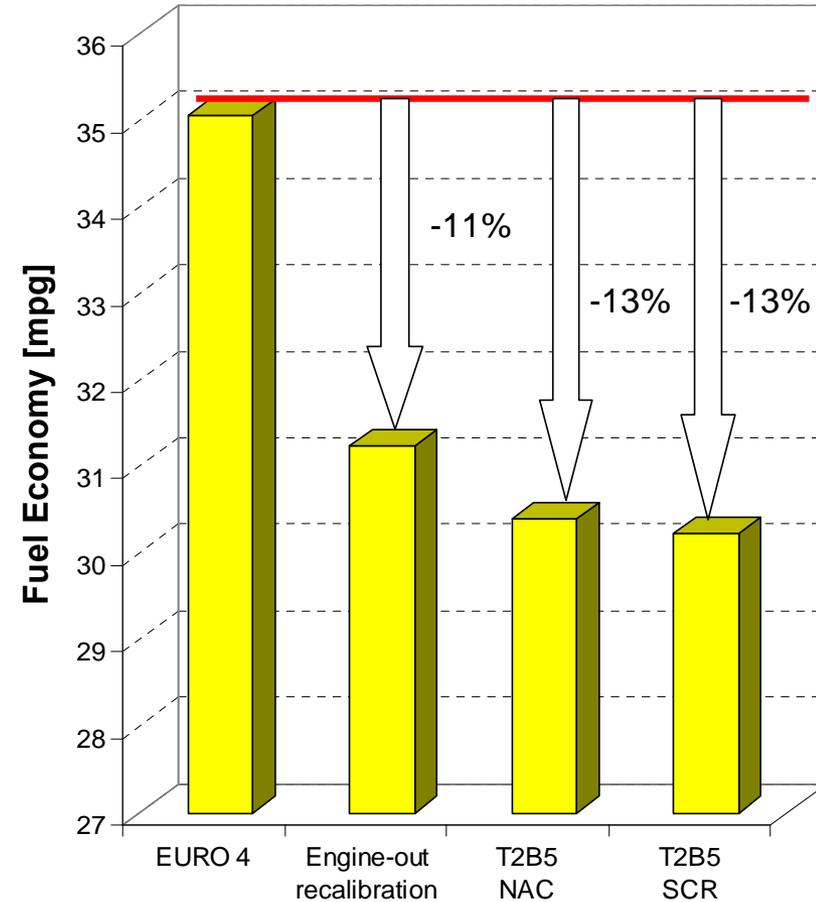
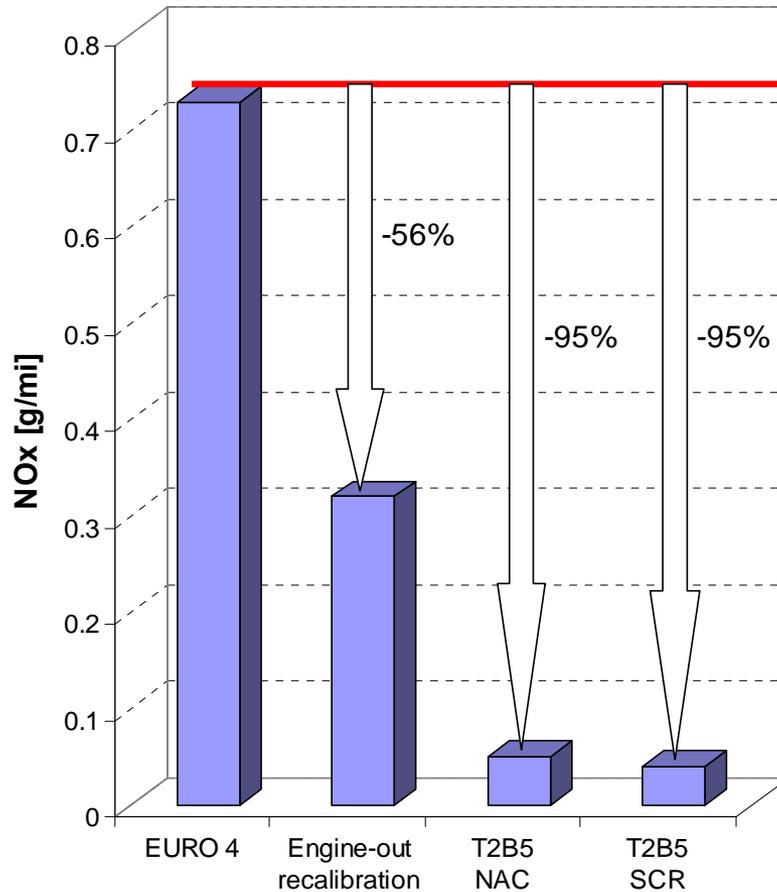
U.S. Light-Duty Gasoline Applications



A View from the Bridge

Emissions vs. Fuel Economy Trade-Off – FTP 75

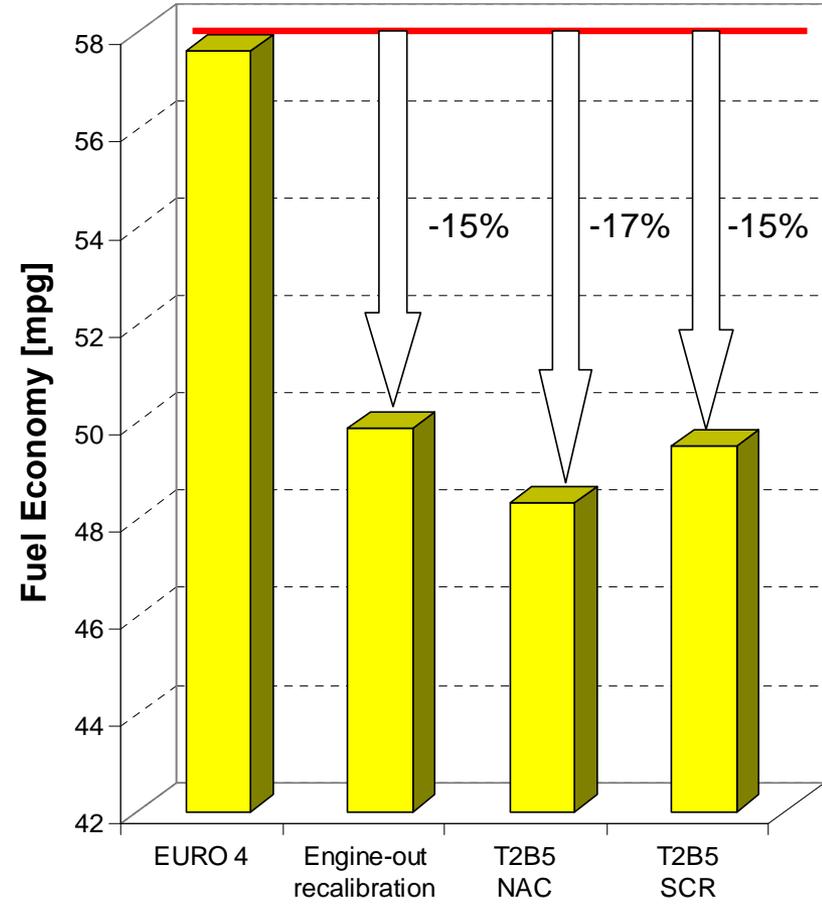
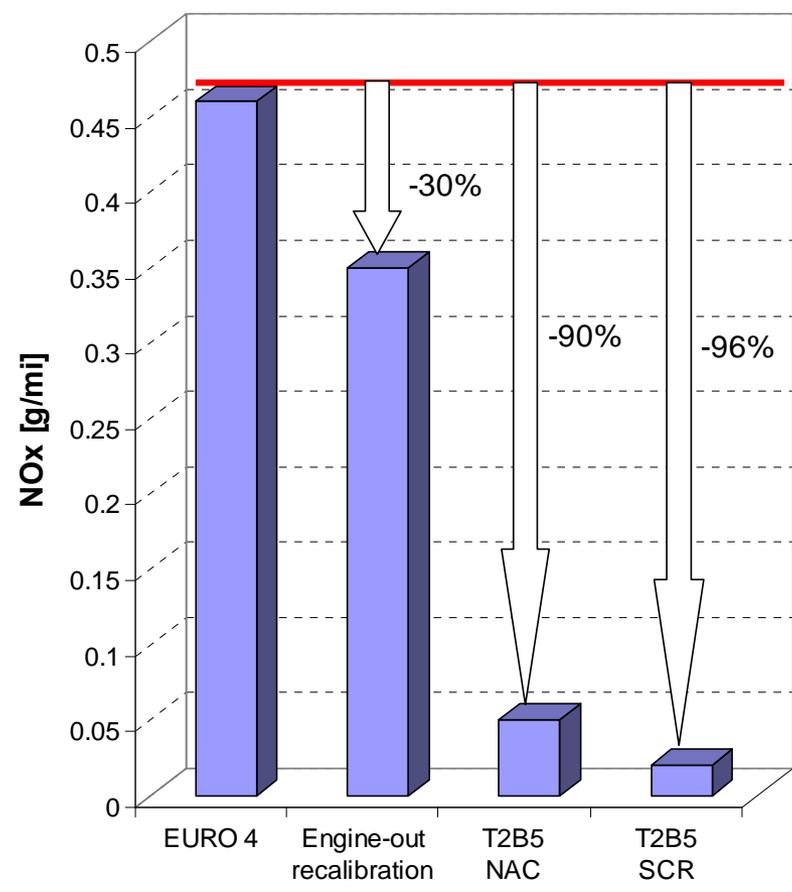
Diesel Passenger Car



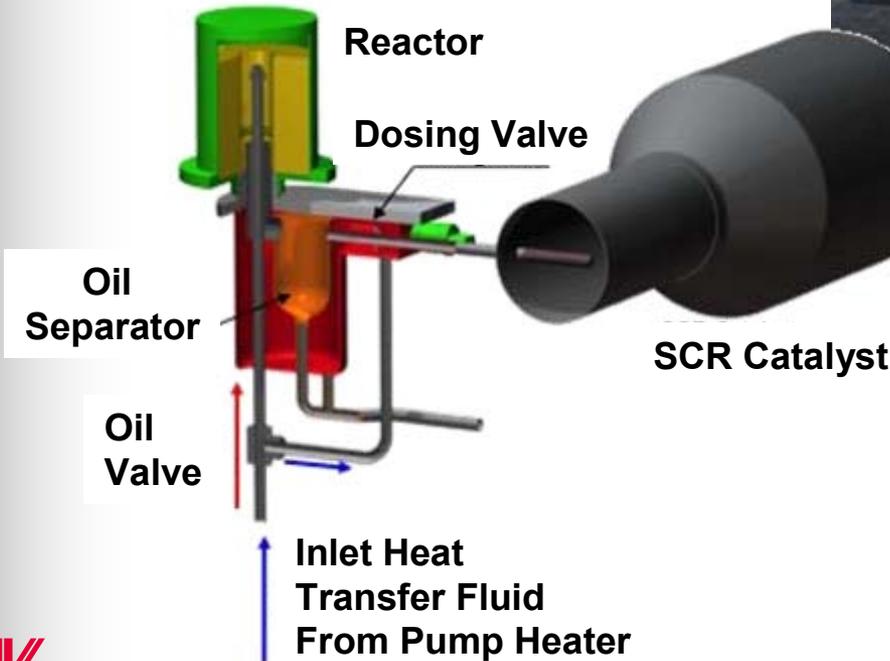
A View from the Bridge

Emissions vs. Fuel Economy Trade-Off - HWFET

Diesel Passenger Car



A View from the Bridge Alternative Aftertreatment Systems



A View from the Bridge Electronic Control Systems



Actuator Adaptation



Heat Management



Emission Management

Actuator Controls



Sensor Adaptation



Electronic Controls



Engine Controls



Sensor Controls



Fuel System Controls



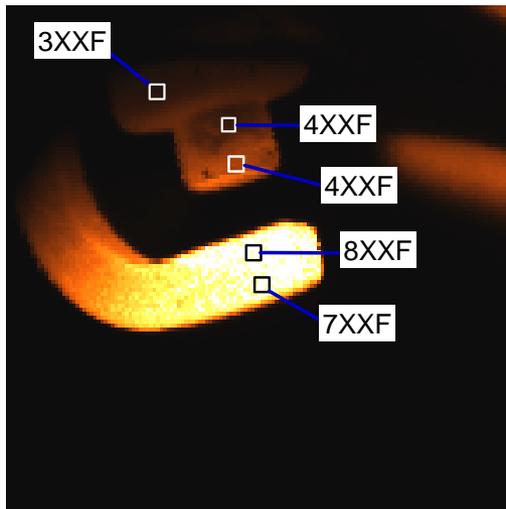
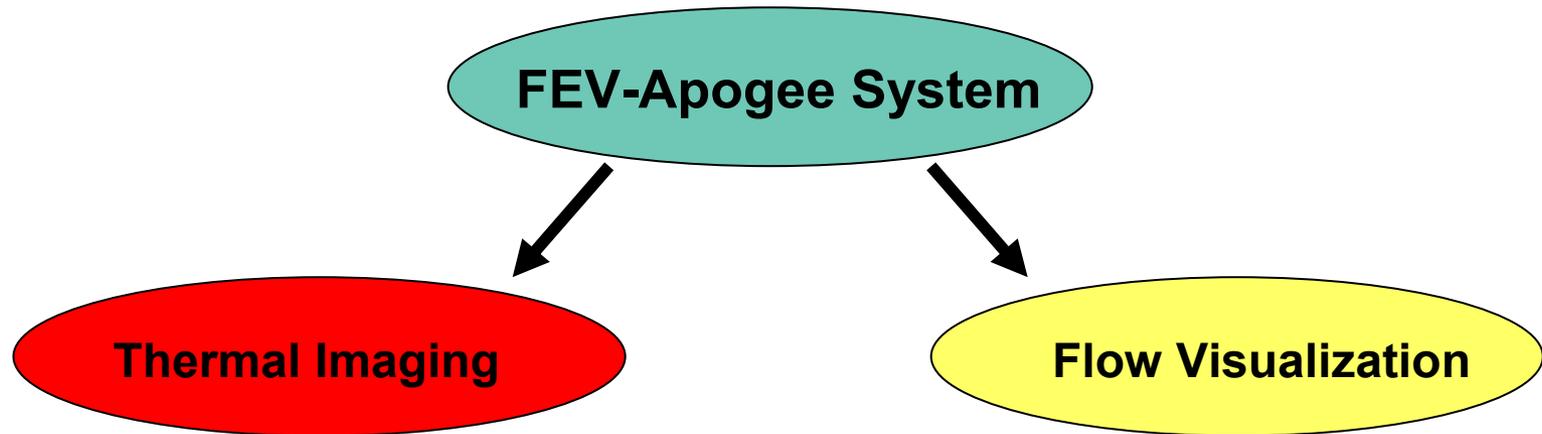
Air System Controls

Electric Motor Controls



A View from the Bridge Development Tools and Methodologies

System Capabilities



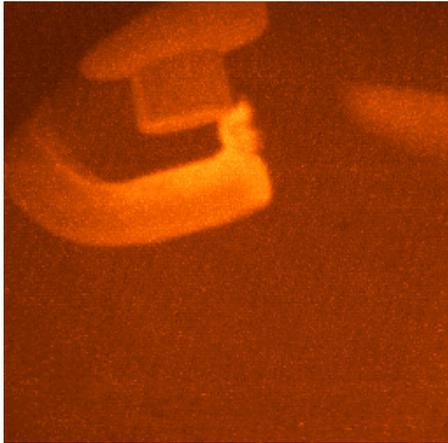
Spark Advance 5°



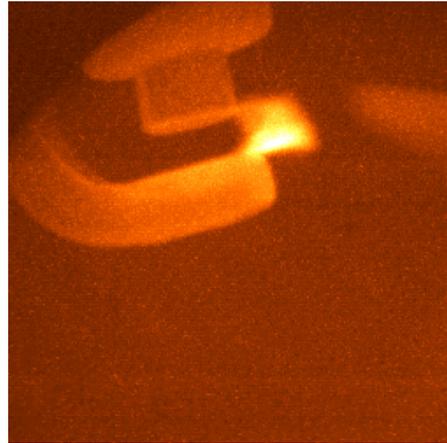
A View from the Bridge

Development Tools and Methodologies

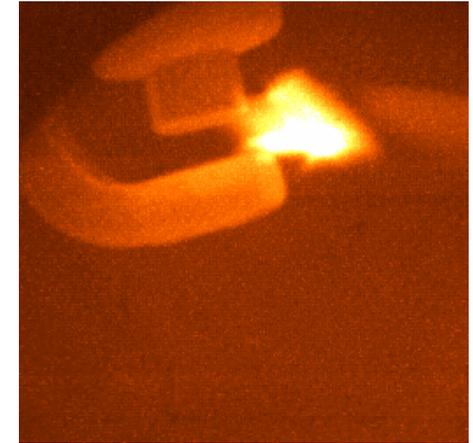
Fired Engine Test Results



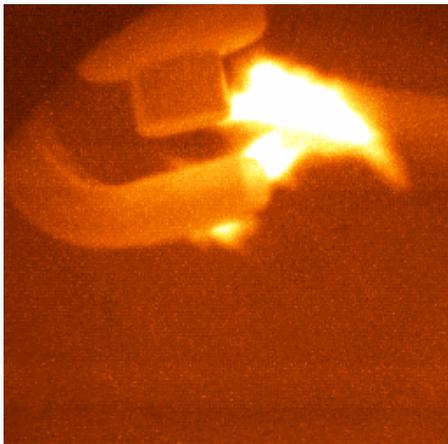
22°BTDC



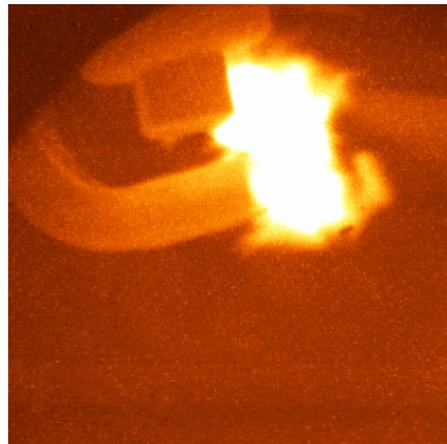
21°BTDC



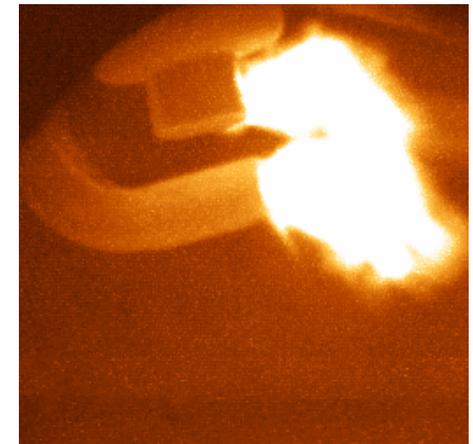
20°BTDC



19°BTDC



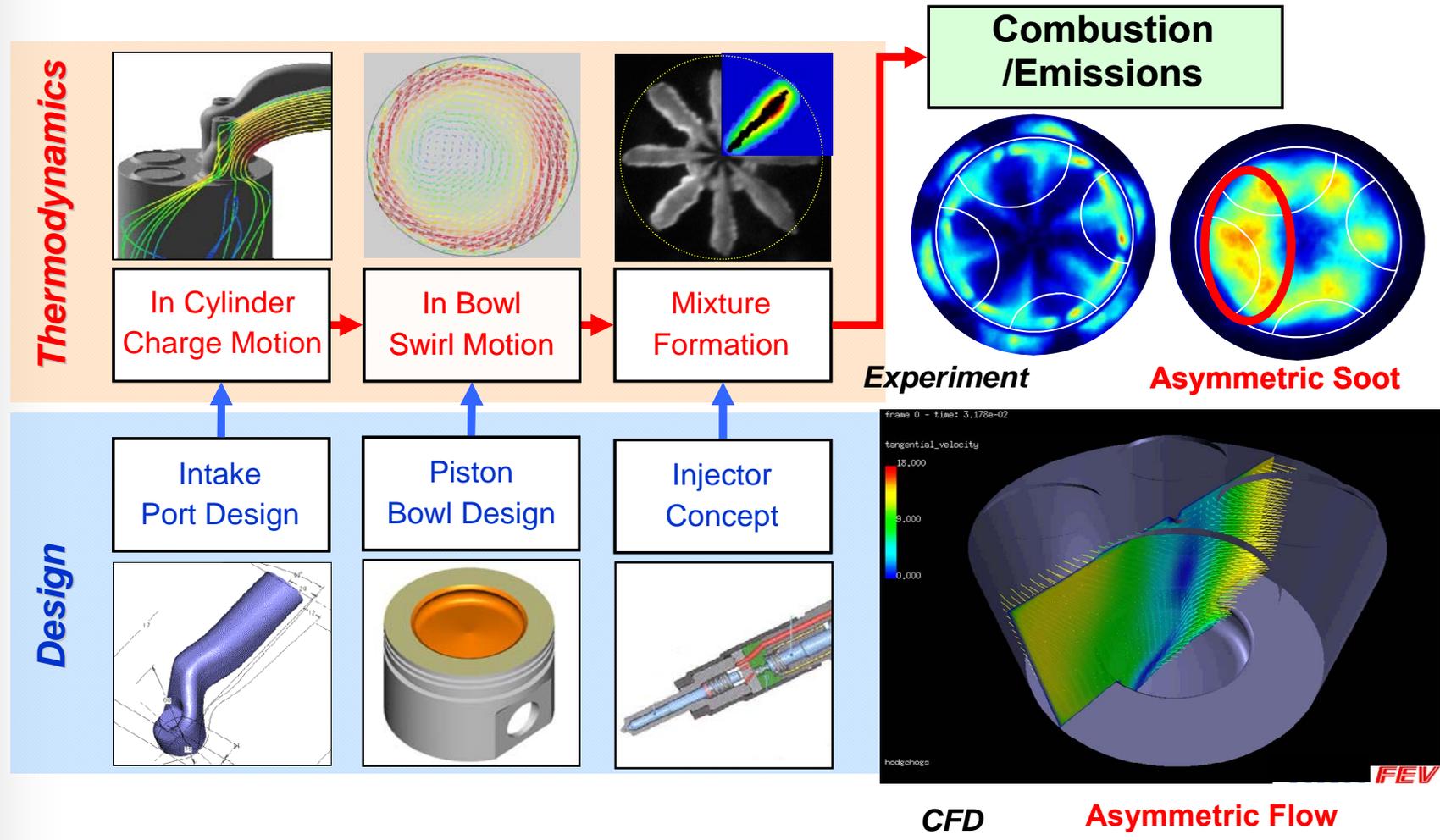
18°BTDC



17°BTDC

A View from the Bridge Development Tools and Methodologies

Combustion System Design and Optimization



A View from the Bridge

Conclusions

- On- and off-highway heavy-duty engine and emission-control technologies will tend to converge in the future
- Fuel prices will remain unpredictable, but increasing demand will lead to higher prices in the future
- Availability of alternative fuels, combined with CO2 legislation will significantly influence technology options
- Demand for larger trucks and SUVs will continue
- Shift towards lighter, more efficient passenger cars
- Expected technology mix will continue to increase
- Timely identification of optimal technology compromises is crucial to minimize cost