The Premier Global Eco-Innovation Technology Firm

Clean Diesels, an Economy or Performance Option?

DEER Conference - August 13, 2007

Dean Harlow

President - Ricardo, Inc.

$3.4 Million in DOE R&D Awards

Thank You DOE

"Ricardo *is* Fuel Economy"

Engine Downsizing - Cooled EGR

- Goal: 15% Fuel Economy Improvement
- Partner: GM

Advanced Flex-Fuel Technologies

- Goal: Gas-like Fuel Economy with E85
- Partners: Bosch & University of Michigan

R&D - Technologies for fuel economy, emissions & vehicle electrification

Technology Portfolio

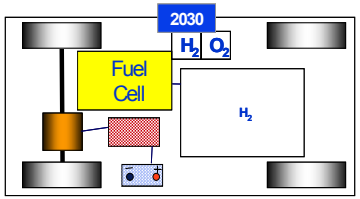
- Hybrids & Fuel Cells
- Advanced Gasoline Engines
- Clean Diesels
- Efficient Transmissions
- Controls and Electronics
- Alternative Fuels

Example Ricardo Solutions

Pass Car T2B2 Diesel Adv Tech Demo Vehicle

2-Stroke/ 4-Stroke Engine

Torque Vectoring - Active Steer with Safety Critical Software



Hydrogen-Powered Vehicle Concept

Down Sizing & Boosting "DI Boost"

"Efficient-C" Diesel Hybrid -- world's most efficient powertrain

Hybrid Transmission Design

Vehicle-to-Vehicle or Infrastructure Communication

Advanced Electronic Controllers

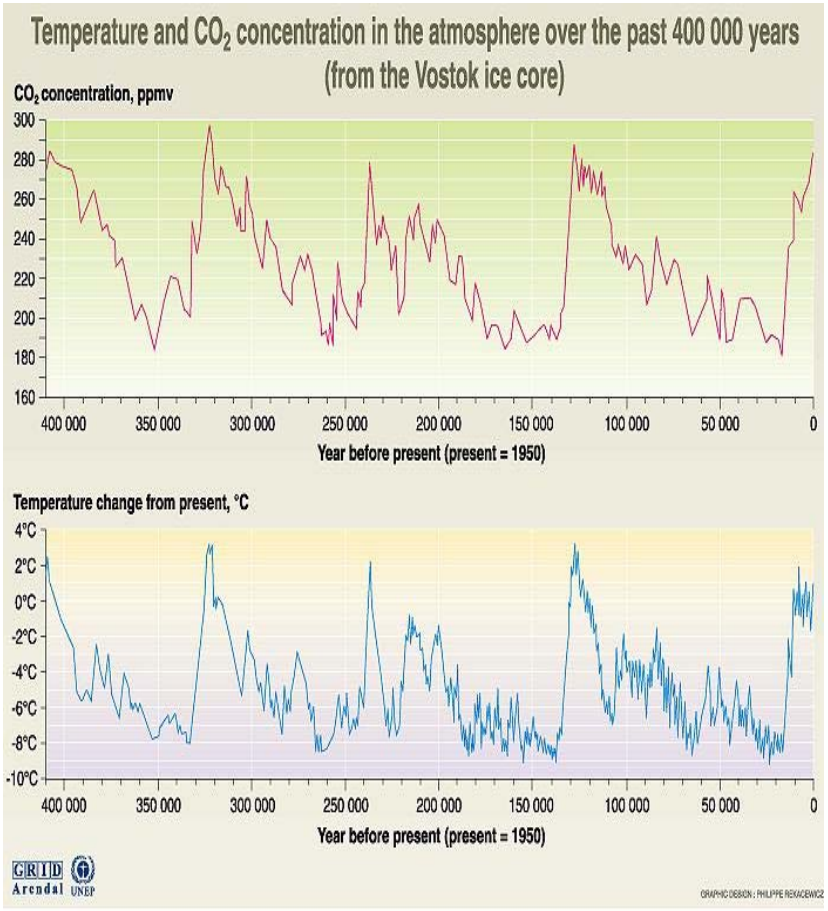
WAVE-RT for Full Model Based Control in ECU

Key Messages / Agenda

- **A systems approach is required to meet the Fuel Economy and CO_2 challenge**
- **Ricardo is applying a systems approach to optimizing powertrain efficiency and *Total Vehicle Fuel Economy***
- **Diesels have a bright future in the US and Ricardo is helping to deliver the technology that is leading the way**
  - World's Most Efficient Powertrain – Ricardo "Efficient-C" Diesel Hybrid
  - Tier2Bin2 Breakthrough
  - DIESELMAX – land speed record

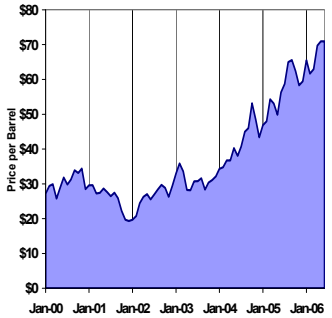
Energy Security, Fuel Availability and Low Carbon Fuel Efficient Vehicle Technologies are driving industry investments

Evidence links increased use of fossil fuels with global warming



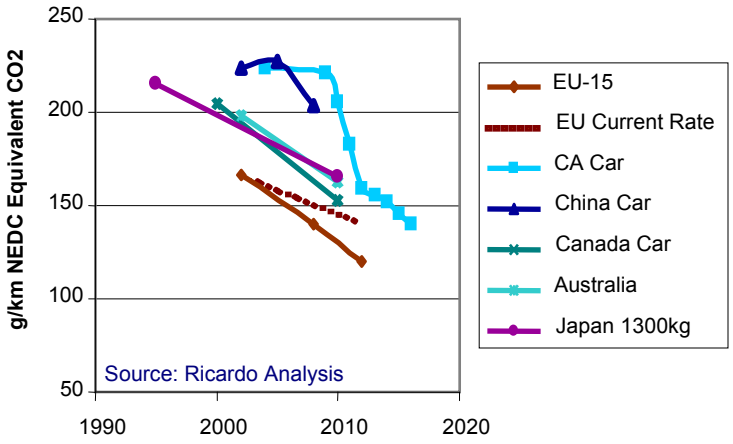
Source: J.R. Petit, J. Jouzel, et al. Climate and atmospheric history of the past 420 000 years from the Vostok ice core in Antarctica, Nature 399 (3JUne), pp 429-436, 1999.

Oil Pricing up sharply, increasing global demand will increase prices further



World-wide adoption of low carbon targets

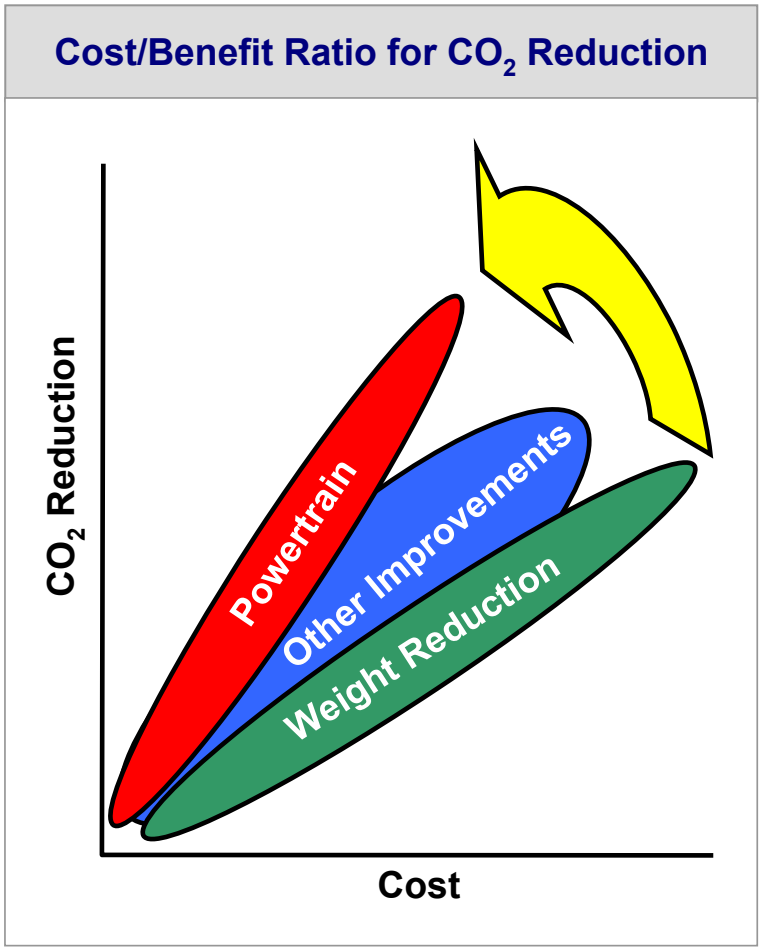
NEDC-Equivalent CO2 comparison



In the near term, powertrain improvements will remain the most cost effective solution to the FE & CO_2 challenge

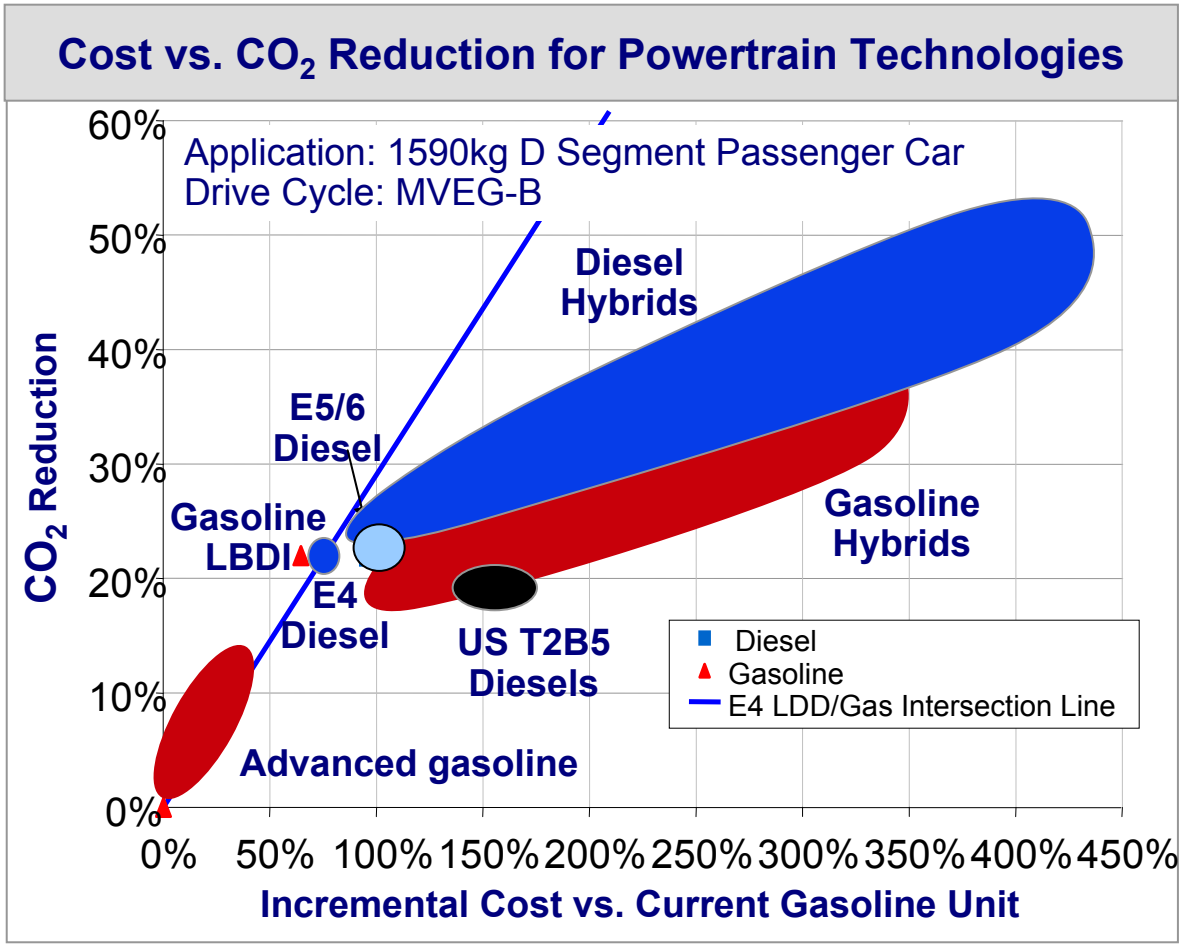
- Vehicle Down-sizing
- Restricting Vehicle Use
- Improved vehicle Weight, Aerodynamics and Friction
- Alternative Fuels and Energy
- Improved Powertrain Efficiency

- Each solution has its own merits, and all have a role to play
- However, improved powertrain efficiency will be a main-stay of short / medium term fuel consumption & CO_2 reduction



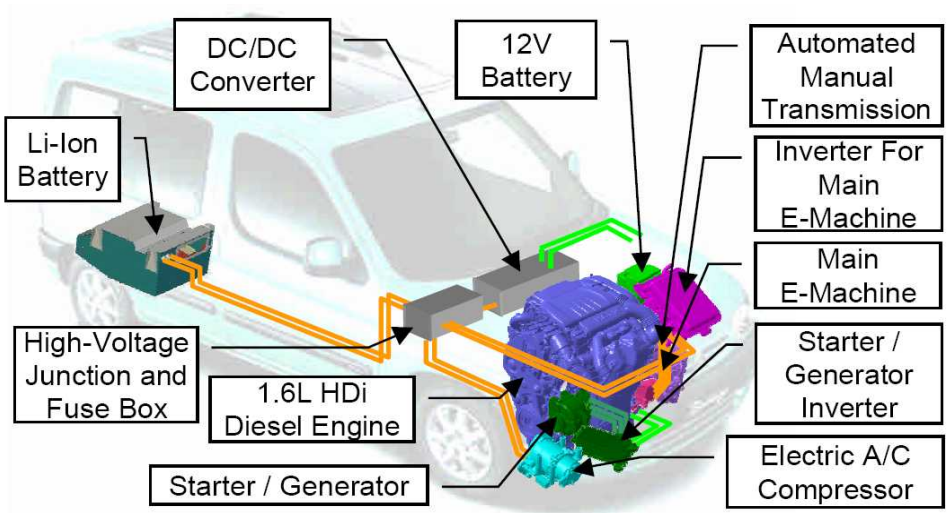
Source: Ricardo Internal data

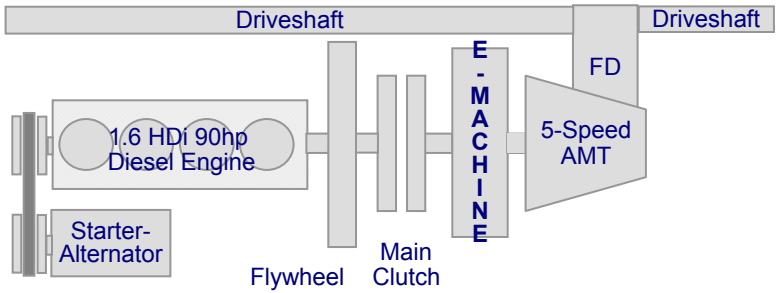
Advanced Gasoline technologies will close the gap with Diesel with Hybrid solutions remaining expensive



Source: Ricardo Internal data

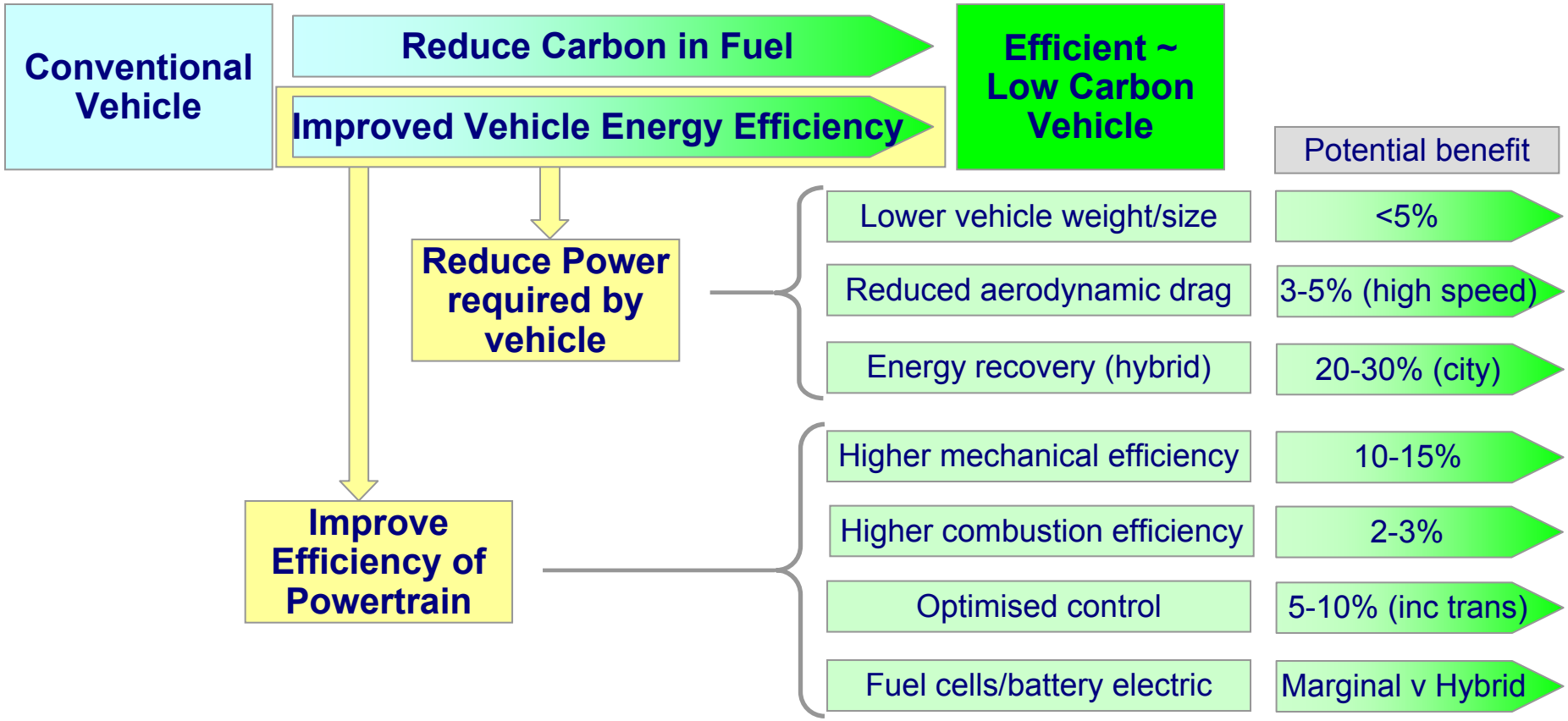
Ricardo "Efficient–C" Diesel Hybrid Demonstrator features the world's most efficient powertrain, achieving >60 mpg





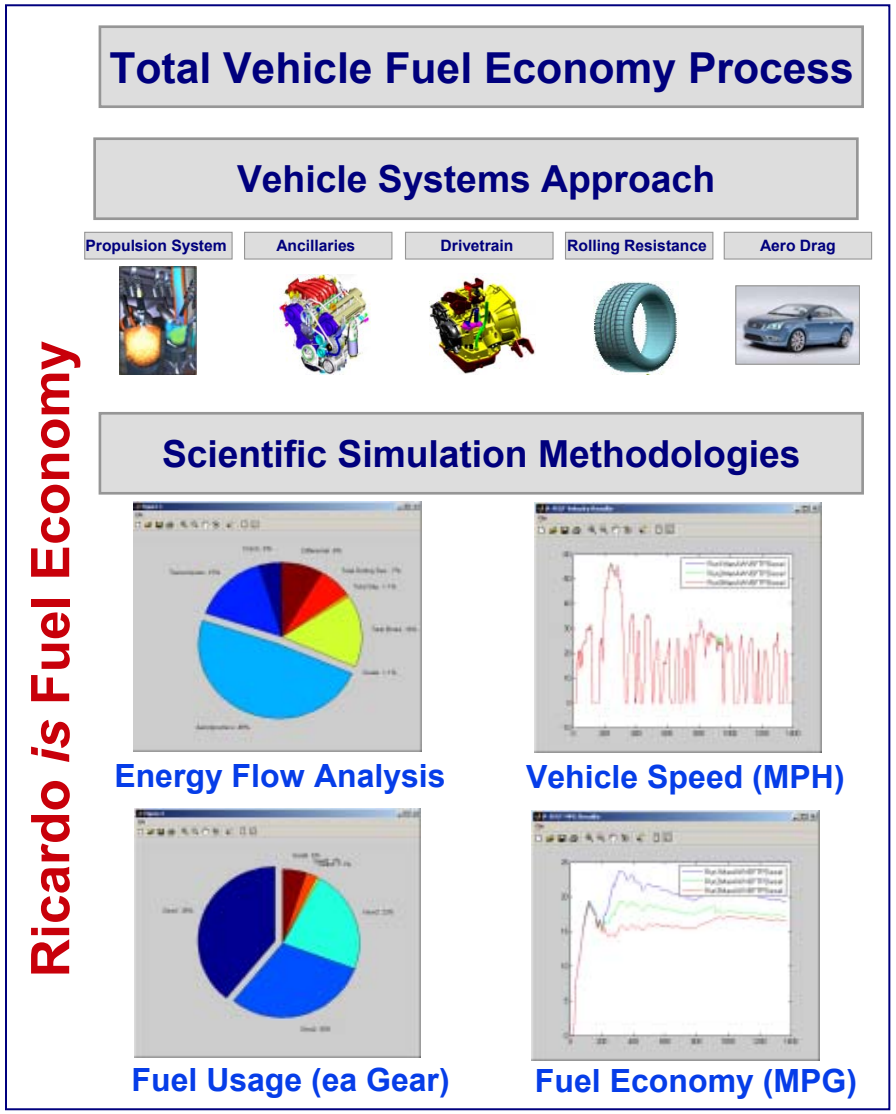
- Powertrain efficiency optimization program
- 35% improvement in cycle fuel consumption compared with 2.0l base vehicle
- 0-60 mph less than 13 seconds
- 5 km to 10 km electric only range

Further gains will be achieved by combining powertrain efficiency improvement with vehicle systems optimization

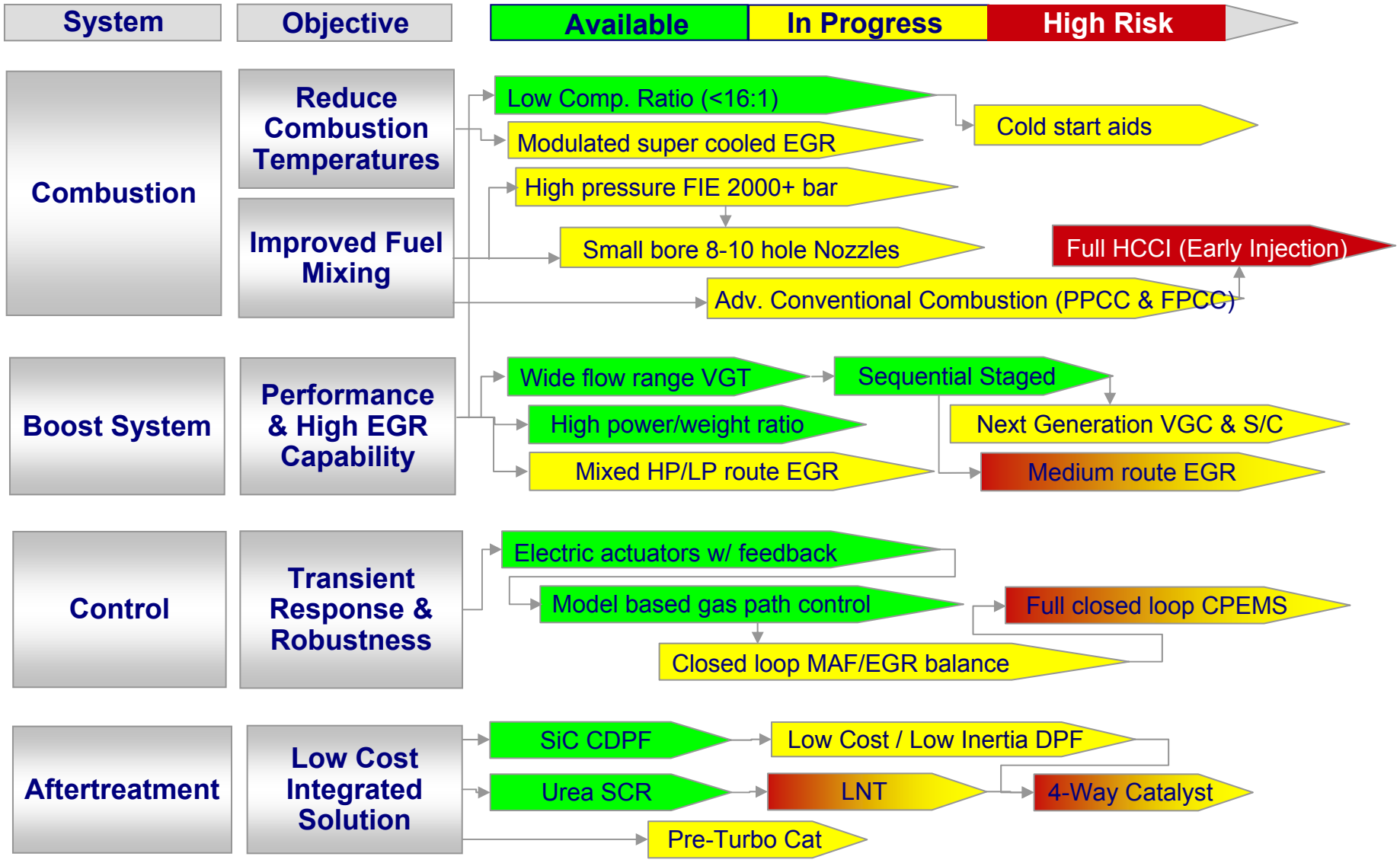


Ricardo is uniquely contributing to the systems approach

- Offering OEMs…
  - "No Compromises" *Total Vehicle Fuel Economy* improvement process
  - Independent, unbiased assessment of most cost effective strategies to meet increased fuel economy standards across their product portfolios
- Assisting EPA with objective approach to reasonable and achievable future CAFE standards
- Providing Governments strategic insights on balancing CO_2 reduction strategies with regulations and industry/ societal impact

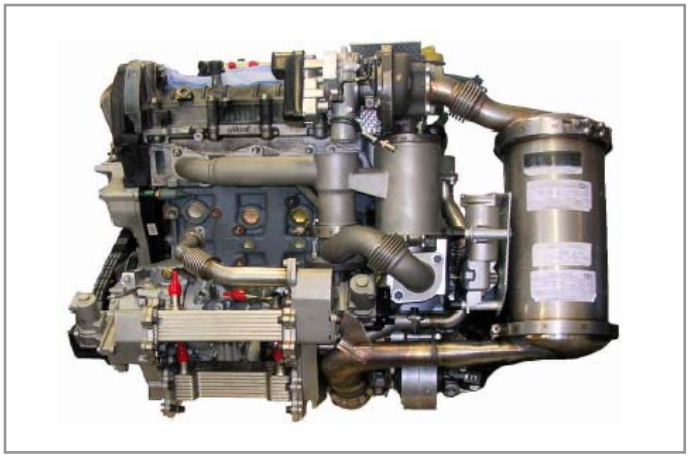


T2B2 emission requirements dictate a comprehensive and integrated systems approach to Diesel engine optimization



Ricardo's "Tier 2 Bin 2" Diesel Technology Breakthrough

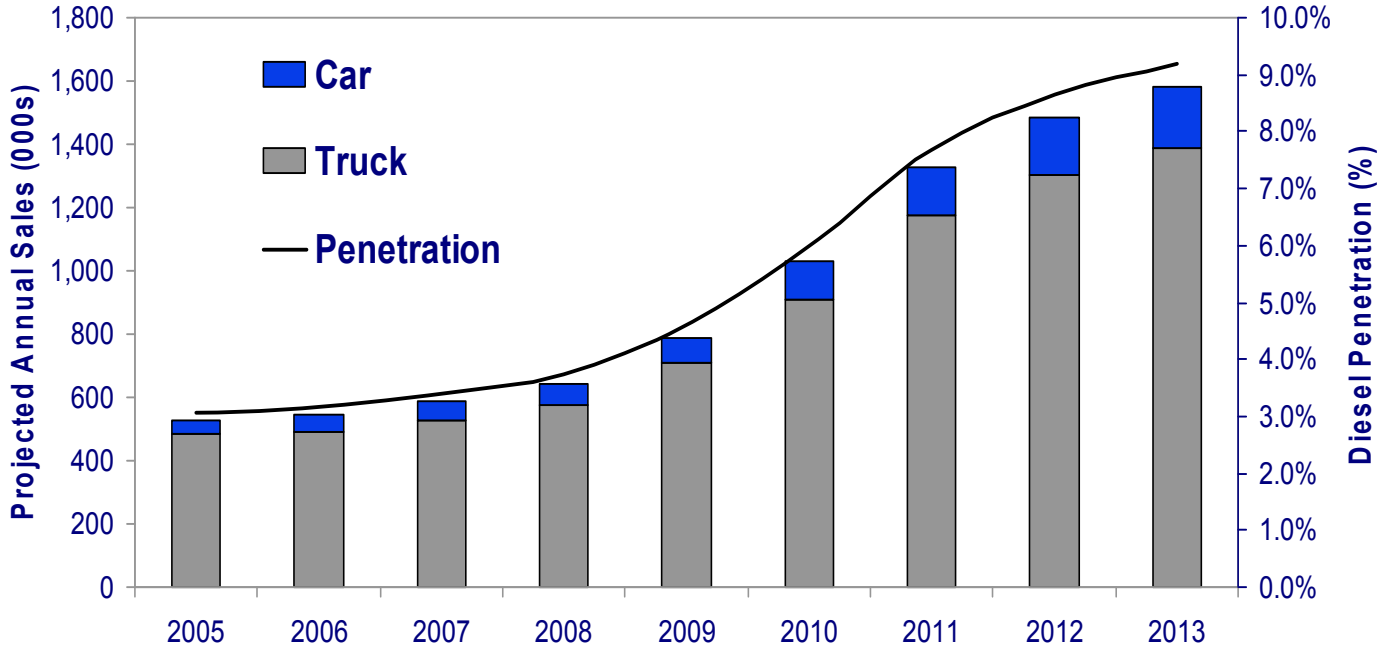
- **Research Program with Production Intent**
- **Goals - Demonstrate on D-class Pass Car:**
  - **Tier 2 Bin 5 without NOx aftertreatment**
    - Bin 5 "Engine-Out" emissions
    - August 2007 Demo
  - **SULEV with simplified LNT NOx aftertreatment**
    - Bin 2 "Tailpipe" emissions
    - December 2007 Demo
- **Results:**
  - **Achieved Bin 5 "Engine-Out" emissions**
  - **Targets demonstrated with acceptable smoke and fuel economy**
  - **Further refinement continues**



Details at 2:20 pm Today
Mark Kuhn - Ricardo

Diesels are an important part of the solution – penetration will nearly triple to 9% by 2013

Projected US Diesel Passenger Vehicle Sales and Market Penetration



Other forecasters are even more optimistic:

- Bosch forecasts 6% Diesel penetration in the U.S.A by 2010 and 15% by 2015 (over 2.5 mm)
- J.D.Power forecast a rise to 10-15+% penetration in North America by 2015 (up to 2.5 mm)
- Martec Group forecast 10-12% in North America by 2013 depending on Diesel price vs. Gasoline

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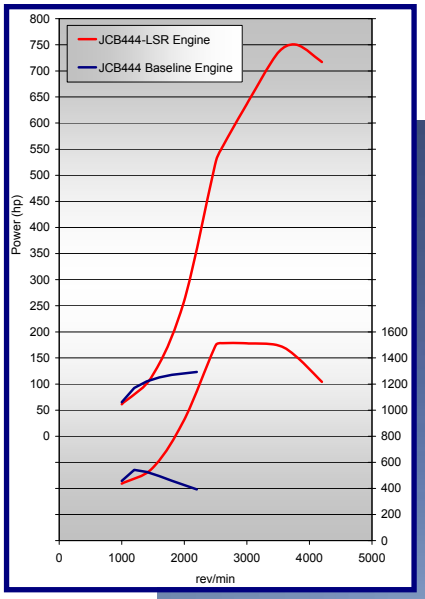
www.ricardo.com

DIESELMAX - 350.092 mph FIA Land Speed Record – high performance while fuel efficient!



DIESELMAX
• 4.5 mpg @ 350 mph

Bugatti Veyron
• 2.8 mpg @ 250 mph

Mini Cooper S
• 5 mpg @ 120 mph