

A close-up photograph of a car's front end, focusing on the headlight and grille area. The headlight is red and white, and the grille is silver. Below the grille, a badge reads "V10 TDI".

**10<sup>th</sup> Diesel Engine Emissions Reduction Conference**  
**Coronado, CA (USA)**  
**August 29<sup>th</sup> – September 2, 2004**

**The Diesel Engine Powering  
Light Duty Vehicles –  
Today and Tomorrow**

**K.-P. Schindler**

**Volkswagen AG, Wolfsburg, Germany**

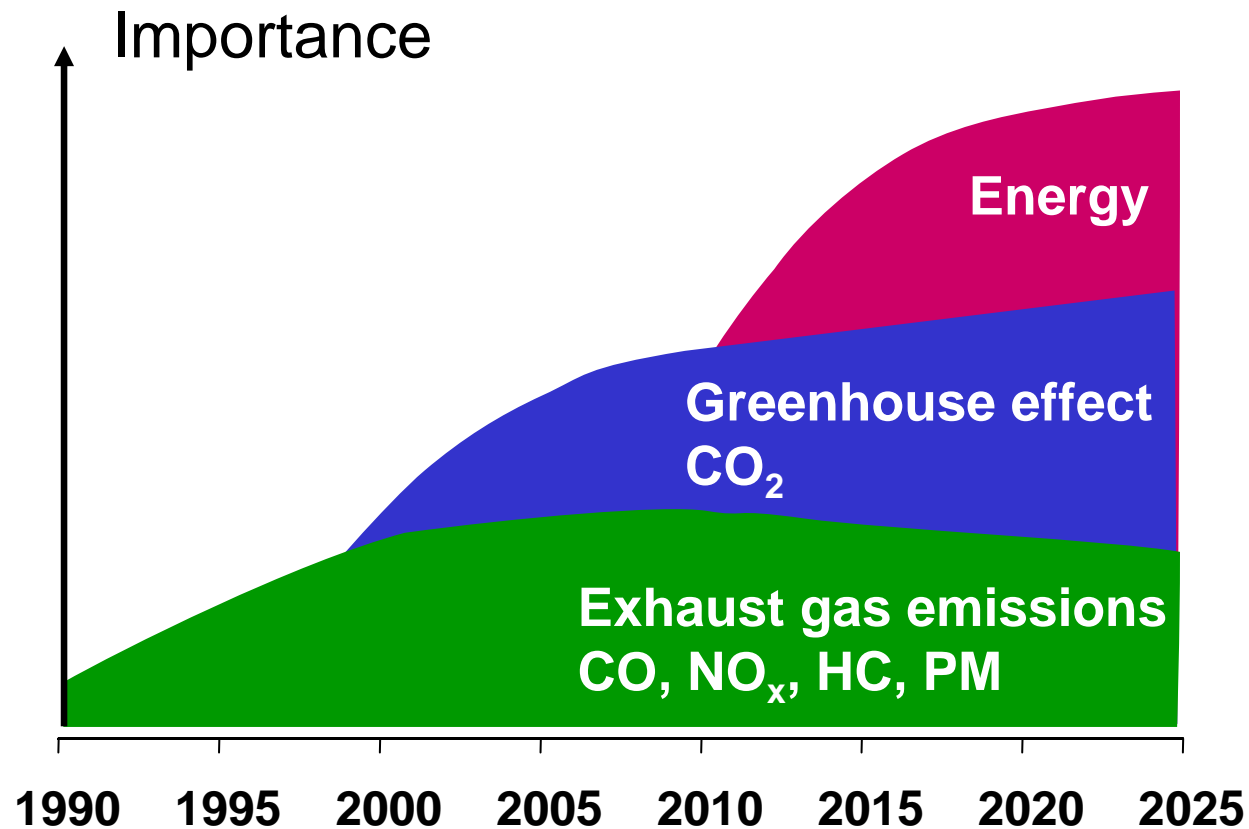


# Outline

- ❖ Introduction: Why do we need the diesel?
- ❖ Diesel technology: Examples
- ❖ Legislation
- ❖ Future solutions
- ❖ Future fuel strategy
- ❖ Conclusion



# Environmental driving forces of vehicle development



Modern diesel-powered light-duty vehicles



# Why do we need Diesel engines?

- ❖ **The modern TDI engine is ....**
  - **powerful**
  - **economical**
  - **ecological**
  - **future-oriented**



**Modern diesel-powered light-duty vehicles**



# The modern TDI engine is ...

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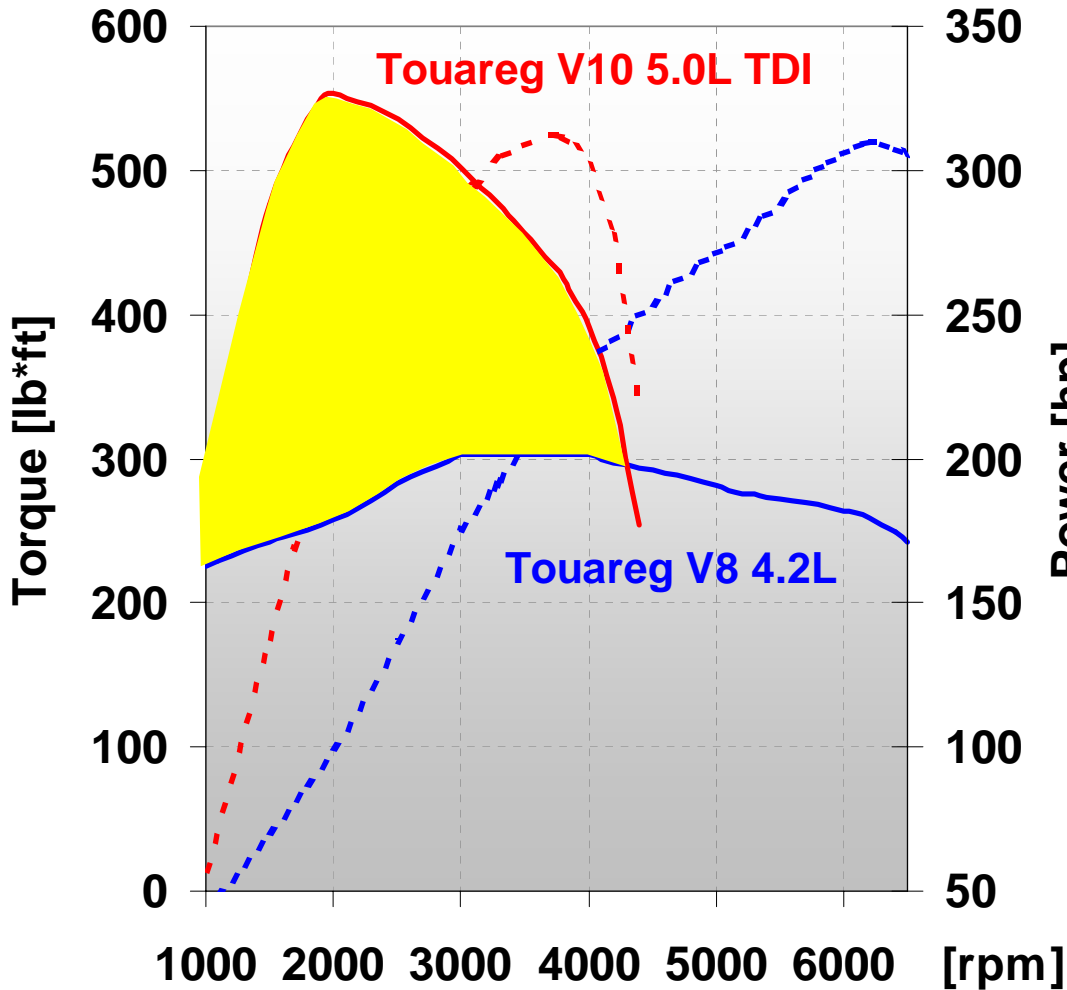
## powerful

- ❖ because it is a mature high-tech product with
  - high traction power
  - high elasticity
- ❖ and impressing with its
- ❖ speed
  - acceleration
  - handling
  - comfort



# The TDI is powerful ...

Touareg

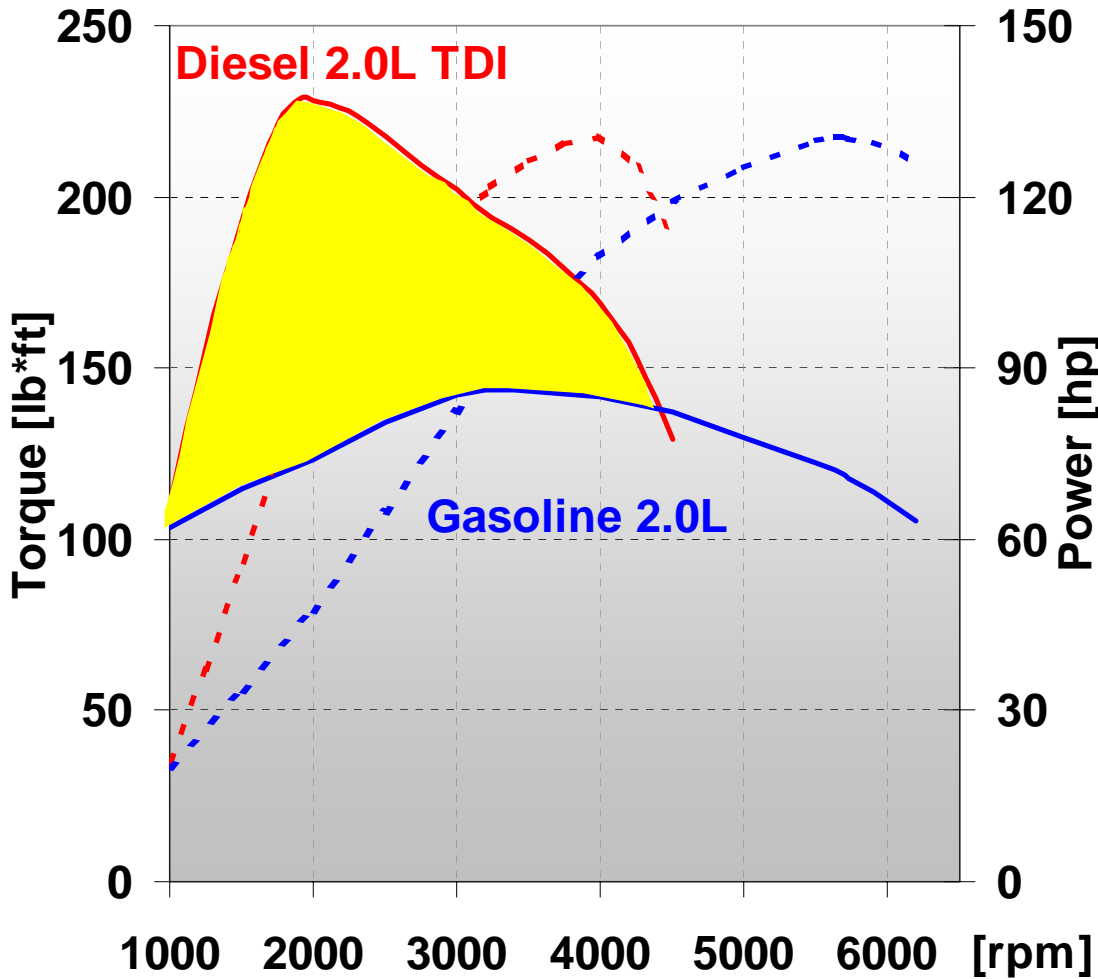


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# The TDI is powerful ...

Passat



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# The TDI is powerful ...

	<b>Gasoline 2.0L</b>	<b>Diesel 2.0L TDI</b>
<b>Max. Power</b>	<b>130 hp (96 kW) @ 5700 rpm</b>	<b>130 hp (96 kW) @ 4000rpm</b>
<b>Max. Torque</b>	<b>144 lb*ft (195 Nm) @ 3300 rpm</b>	<b>228 lb*ft (310 Nm) @ 1900rpm</b>
<b>Max. Speed</b>	<b>131 mph (210 km/h)</b>	<b>130 mph (208 km/h)</b>
<b>Acceleration 0-62 mph</b>	<b>9.9 s</b>	<b>9.9 s</b>
<b>Elasticity 50-75 mph</b>	<b>13.5 s</b>	<b>11.5 s</b>
<b>Mileage</b>	<b>30 mpg</b>	<b>42 mpg</b>

**Passat**



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# The modern TDI engine is ...

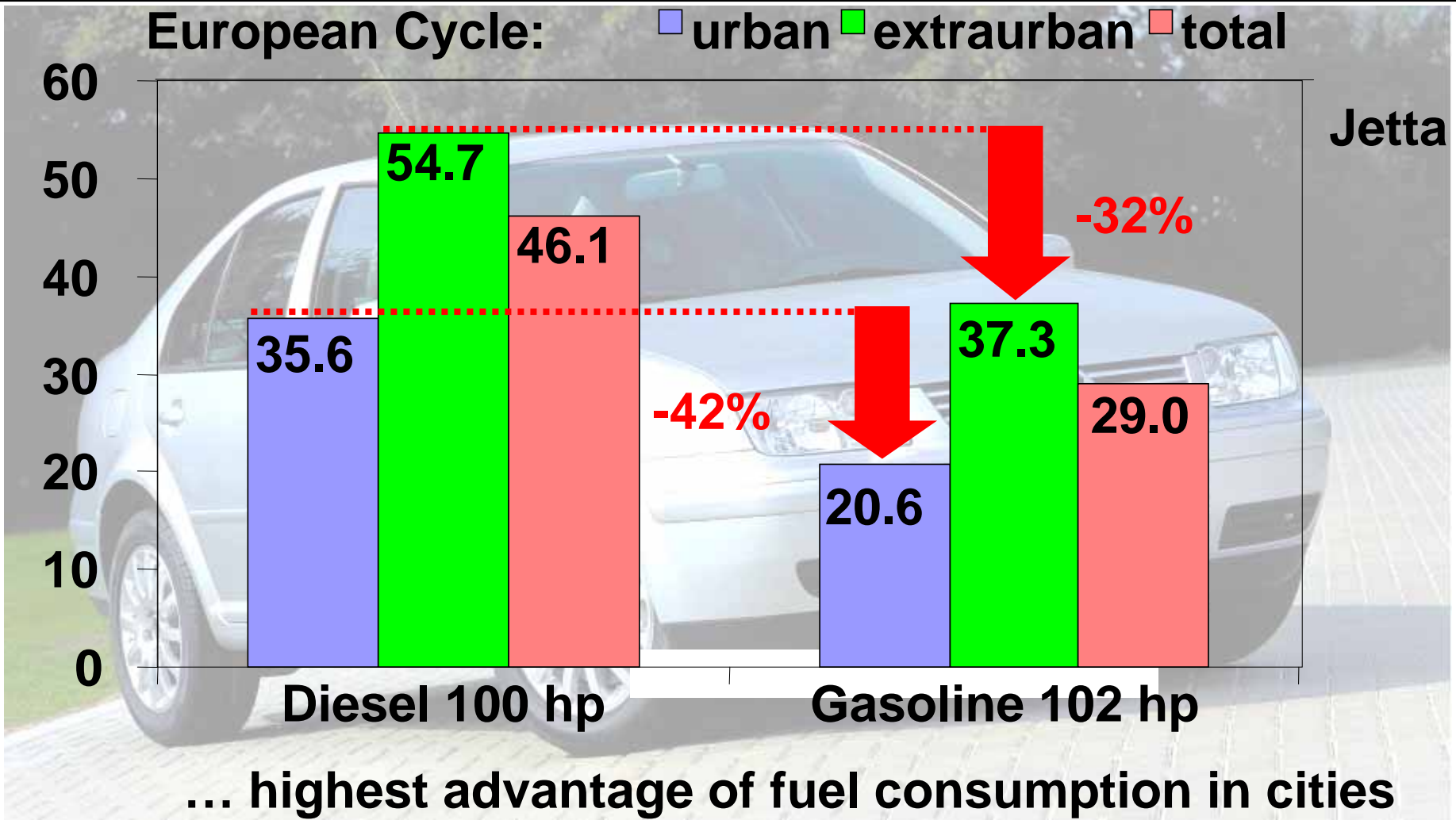
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## economical

- ❖ **because of**
  - low fuel consumption
  - extreme durability



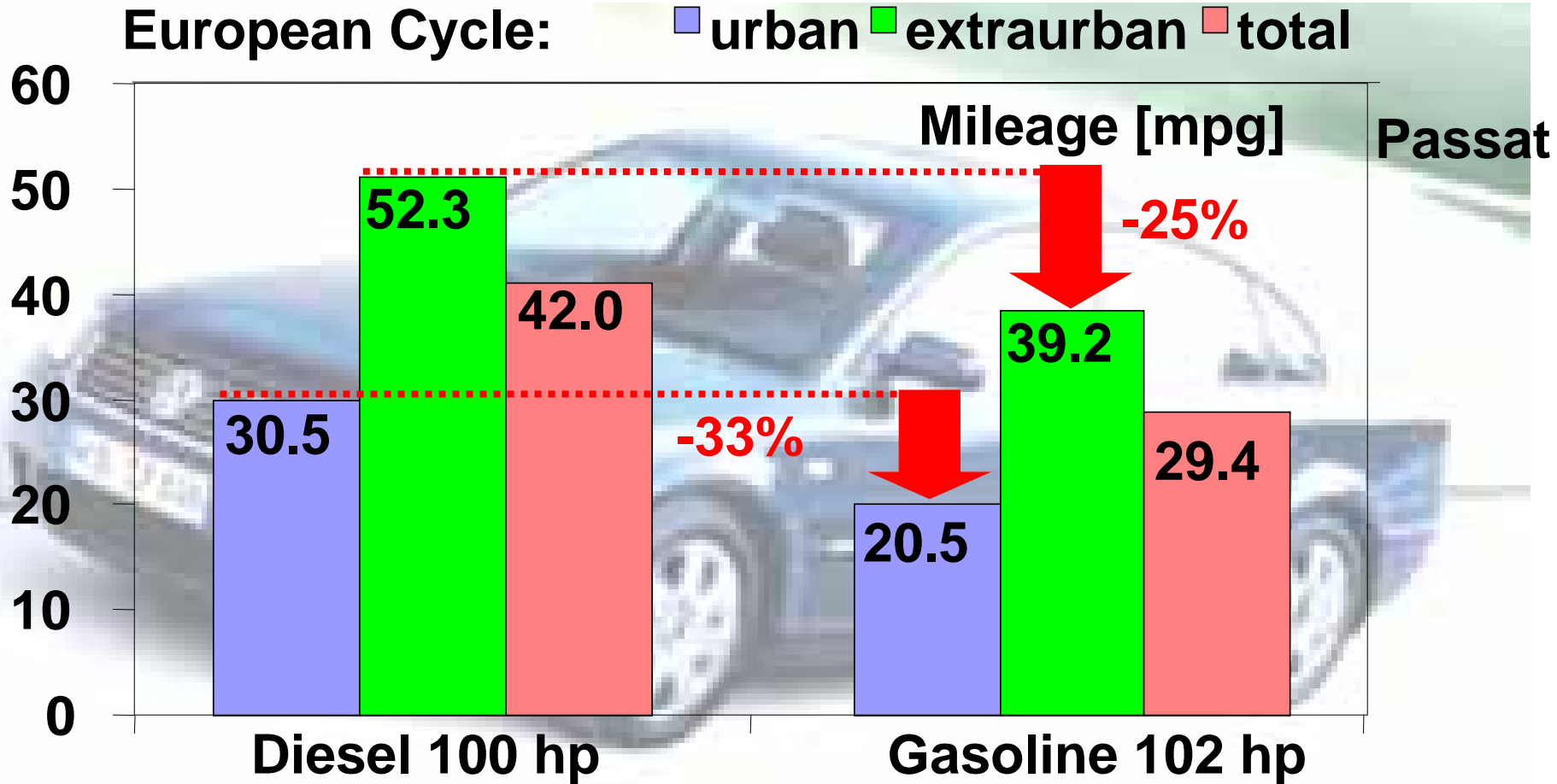
# The TDI is economical ...



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# The TDI is economical ...



... highest advantage of fuel consumption in cities

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# The modern TDI engine is ...

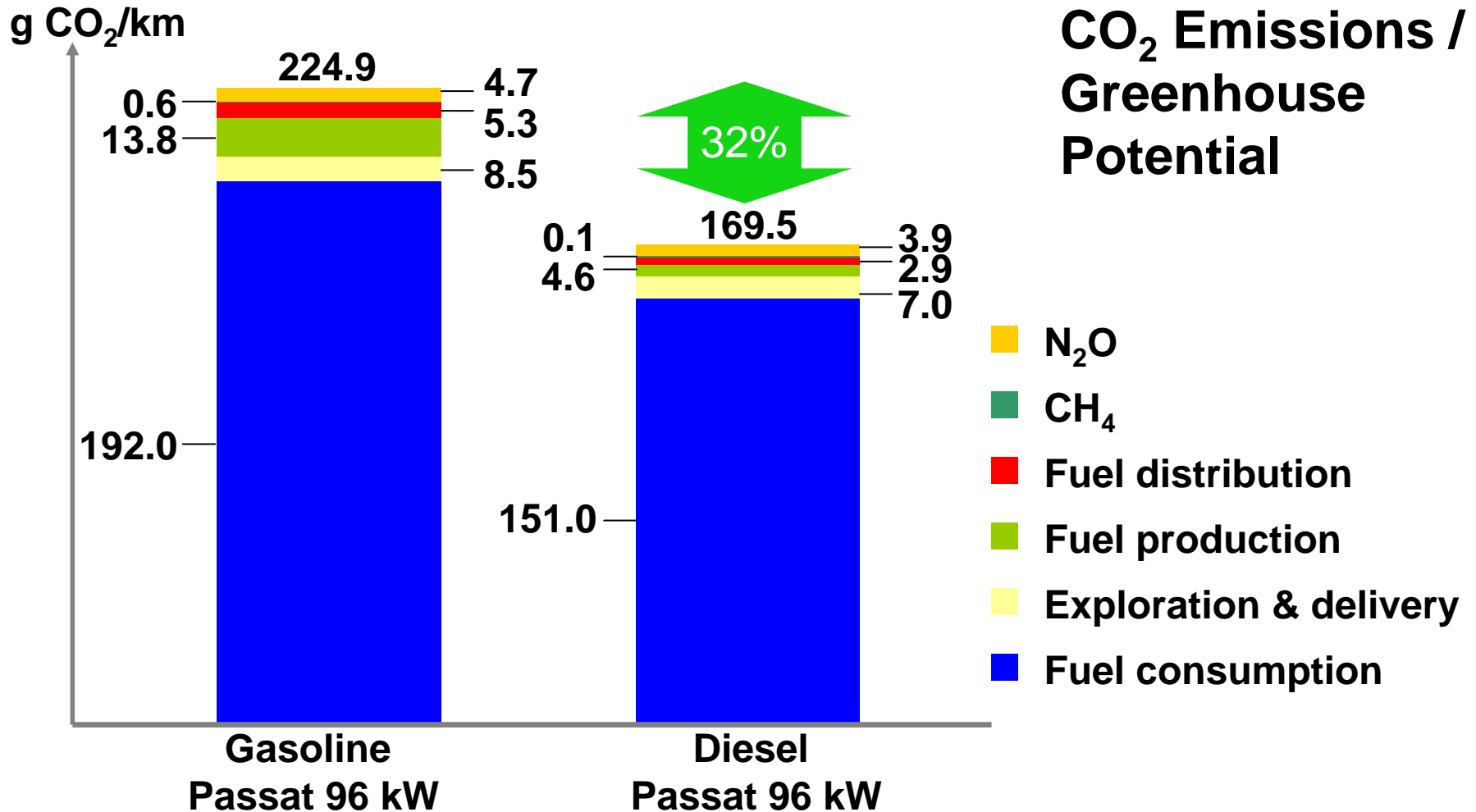
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## Ecological

- ❖ **because**
  - **it saves the resources worldwide due to its outstanding fuel economy**
  - **it enables low environmental pollution**
  - **it contributes very little to greenhouse relevant gases**
  - **the particulate emissions have been reduced by over 90% since 1988**



# The TDI is ecological ...



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# Why do customers in Europe purchase Diesel engine vehicles?

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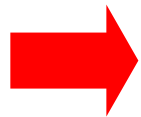
- ❖ TDI technology closed the gap to the gasoline engine on
  - Performance
  - Noise
  - Emissions
- ❖ TDI has increased fuel economy/reduced CO2 emissions dramatically
- ❖ TDI provides lower operating costs



# Conclusion

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- ❖ Modern TDI Diesel technology has come a long way since the old diesel engines of the past
- ❖ The modern TDI Diesel engine is not only powerful but also very economical
- ❖ In Europe a major progress in lowering the exhaust gas emissions has taken place



**We are convinced that the TDI is a solution for future powertrains for light duty vehicles**



# Outline



- ❖ Introduction: Why do we need the diesel?
- ❖ Diesel technology: Examples

V10 TDI

Modern diesel-powered light-duty vehicles





# First Diesel Engine for the Golf I 1976 and latest Diesel Engine for the Golf V 2003

<b>Cylinder number:</b>	<b>4</b>	<b>4</b>
<b>Displacement:</b>	<b>1.5L</b>	<b>2.0L</b>
<b>Power:</b>	<b>50 HP</b>	<b>140 HP</b>
<b>Rotational speed:</b>	<b>5000 rpm</b>	<b>4200 rpm</b>
<b>Maximum torque:</b>	<b>62 lb*ft (84 Nm)</b>	<b>236 lb*ft (320 Nm)</b>
<b>Maximum speed:</b>	<b>87 mph</b>	<b>126 mph</b>
<b>0-100 km/h:</b>	<b>18 sec</b>	<b>9.3 sec</b>
<b>Consumption:</b>	<b>36.2 mpg</b>	<b>42.8 mpg</b>
<b>Car weight:</b>	<b>780 kg</b>	<b>1400 kg</b>



**Modern diesel-powered light-duty vehicles**



# The first "3 l" vehicle in production (1999)

VW Lupo **3L TDI**

the first **3 liter/100km = 78 mpg** car in production

- ❖ 1.2 L TDI engine  
with unit injector
- ❖ 61 hp (45 kW)
- ❖ 78 mpg (2.99  
L/100km)
- ❖ Euro 4 (2005)  
emission standard



# The first " 1 l" Car Demonstration of Feasibility (2001)



- 0.3 l SDI 1cyl.
- 6,3 kW (8,6 hp)
- 0,99 l/100 km  
(235 mpg)
- Euro 4 limits



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# V10 TDI: Strongest Diesel in Production

**230 kW**

**750 Nm**



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# VW Phaeton V10 TDI

## Strongest Diesel in Production



- **5.0 l TDI 10 cyl.**
- **230 kW (313 hp)**
- **11,4 l / 100 km (20,6 mpg)**

**Modern diesel-powered light-duty vehicles**



# Outline



- ❖ Introduction: Why do we need the diesel?
- ❖ Diesel technology: Examples
- ❖ Legislation

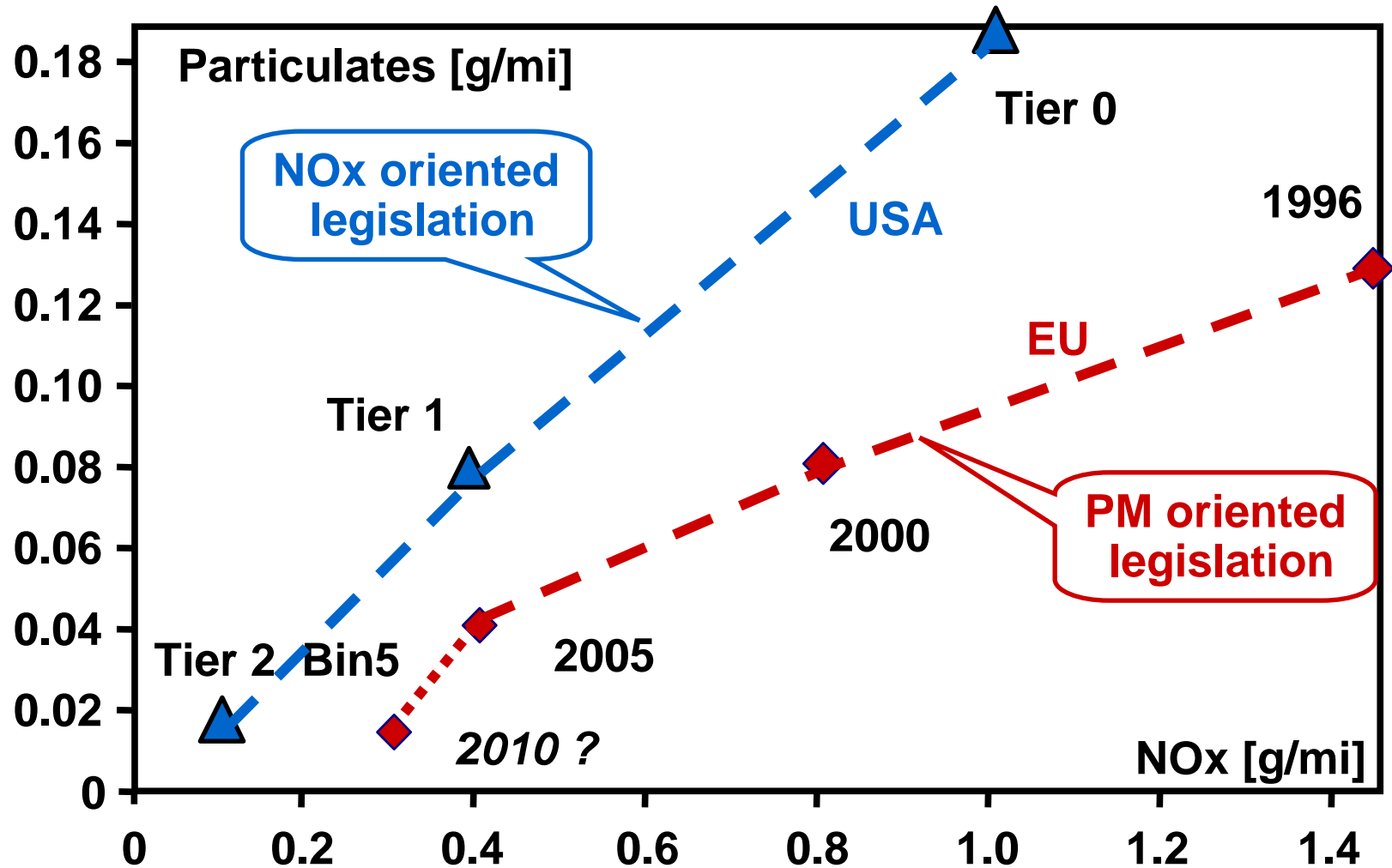
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# Legislation requirements in EU and US

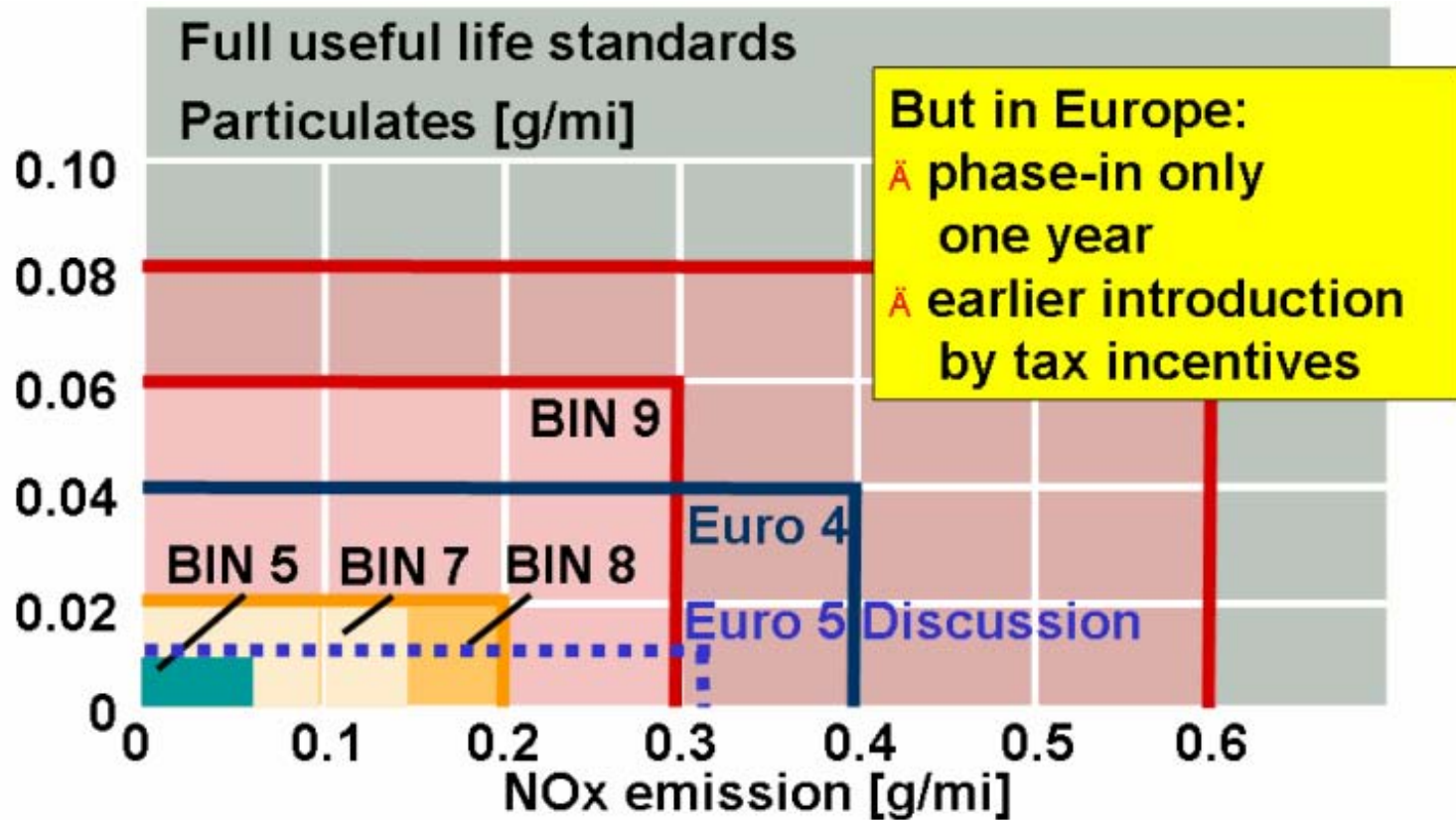
## Passenger cars



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# TIER 2/LEV 2 emission standard for passenger cars



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# Outline



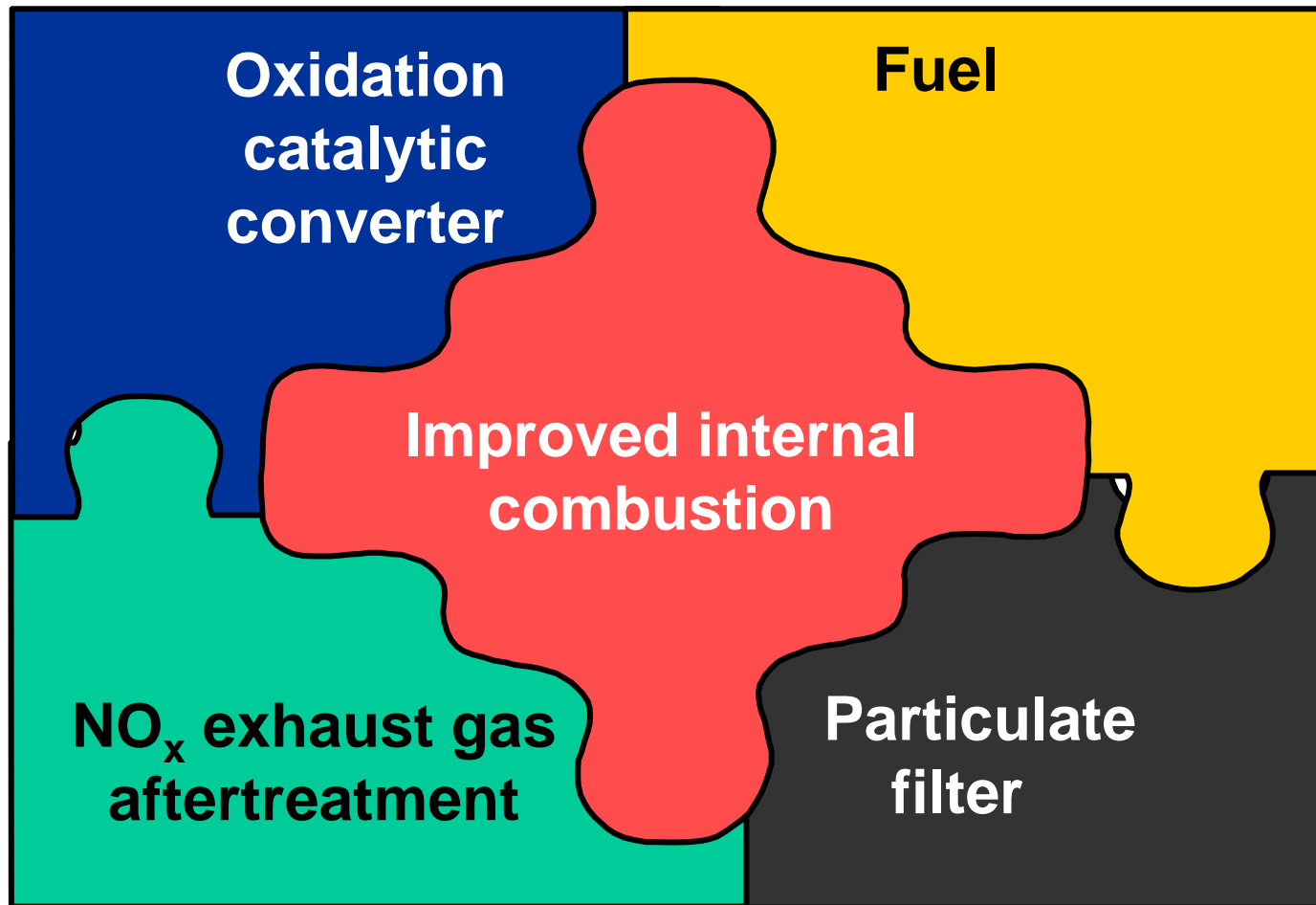
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# Building blocks of diesel development



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# Unit injector in two-valve cylinder head

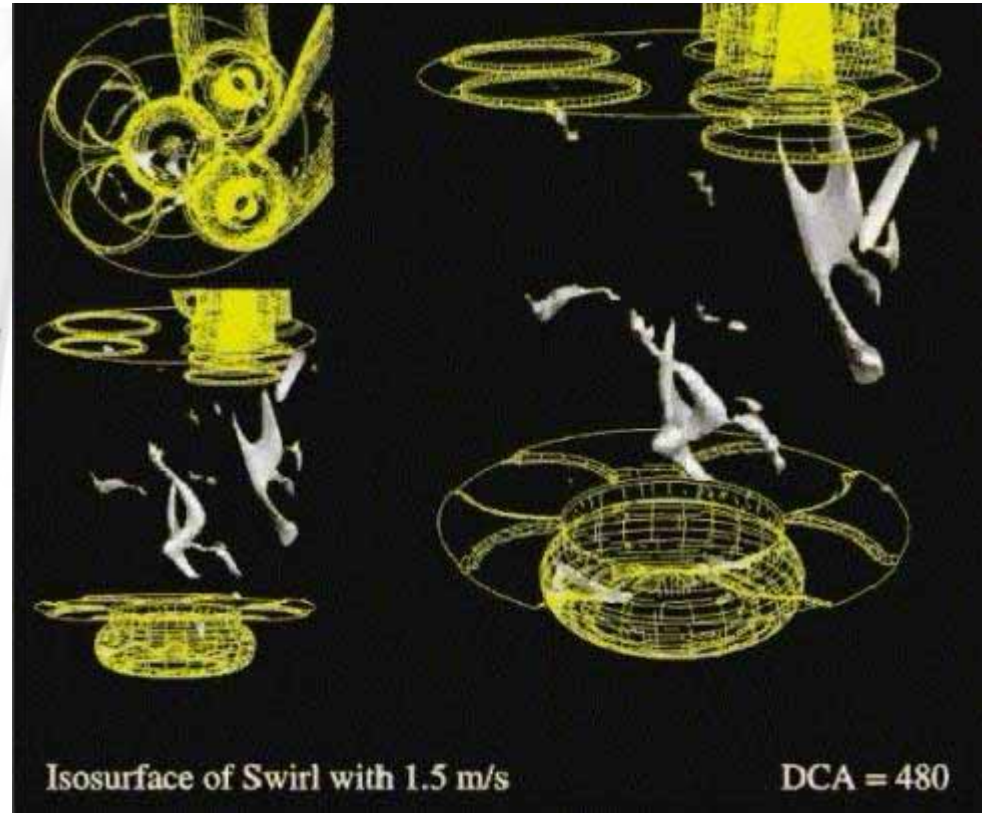
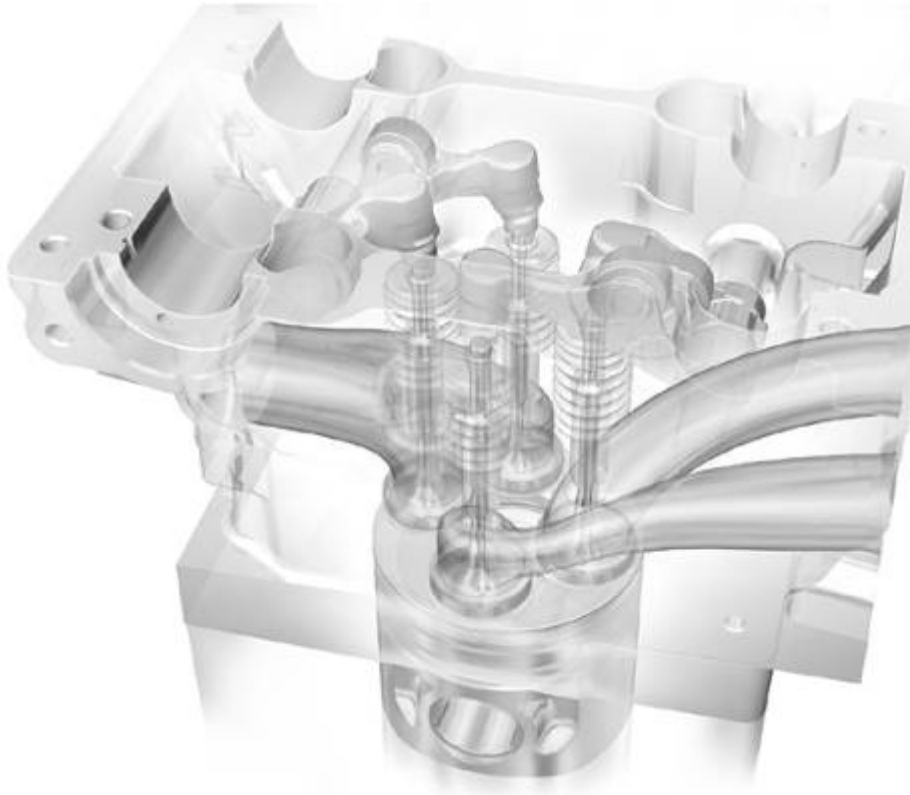


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# Four-valve cylinder head

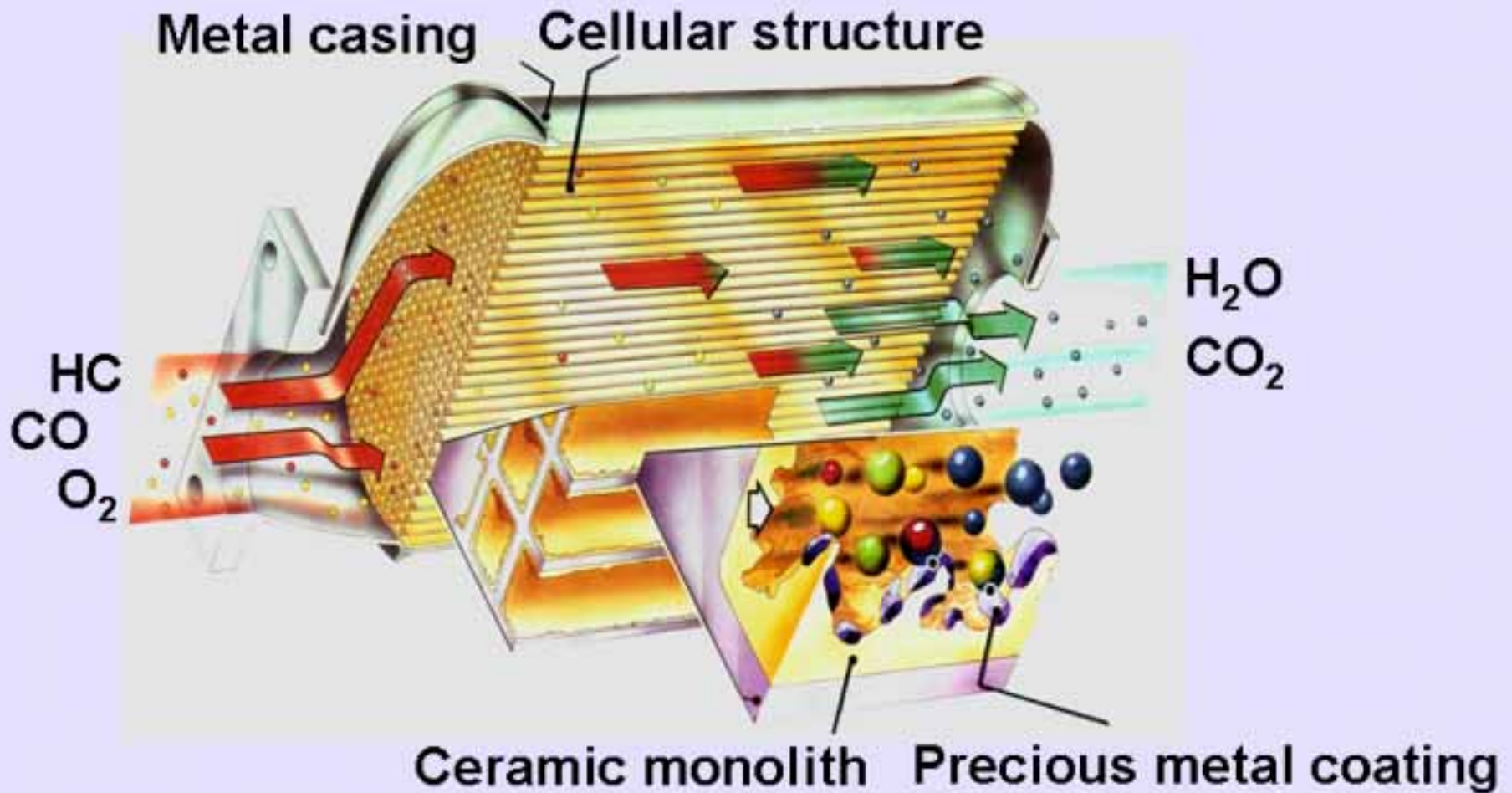
## Simulation of intake flow, swirl axis



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# Oxidating catalytic converter principle



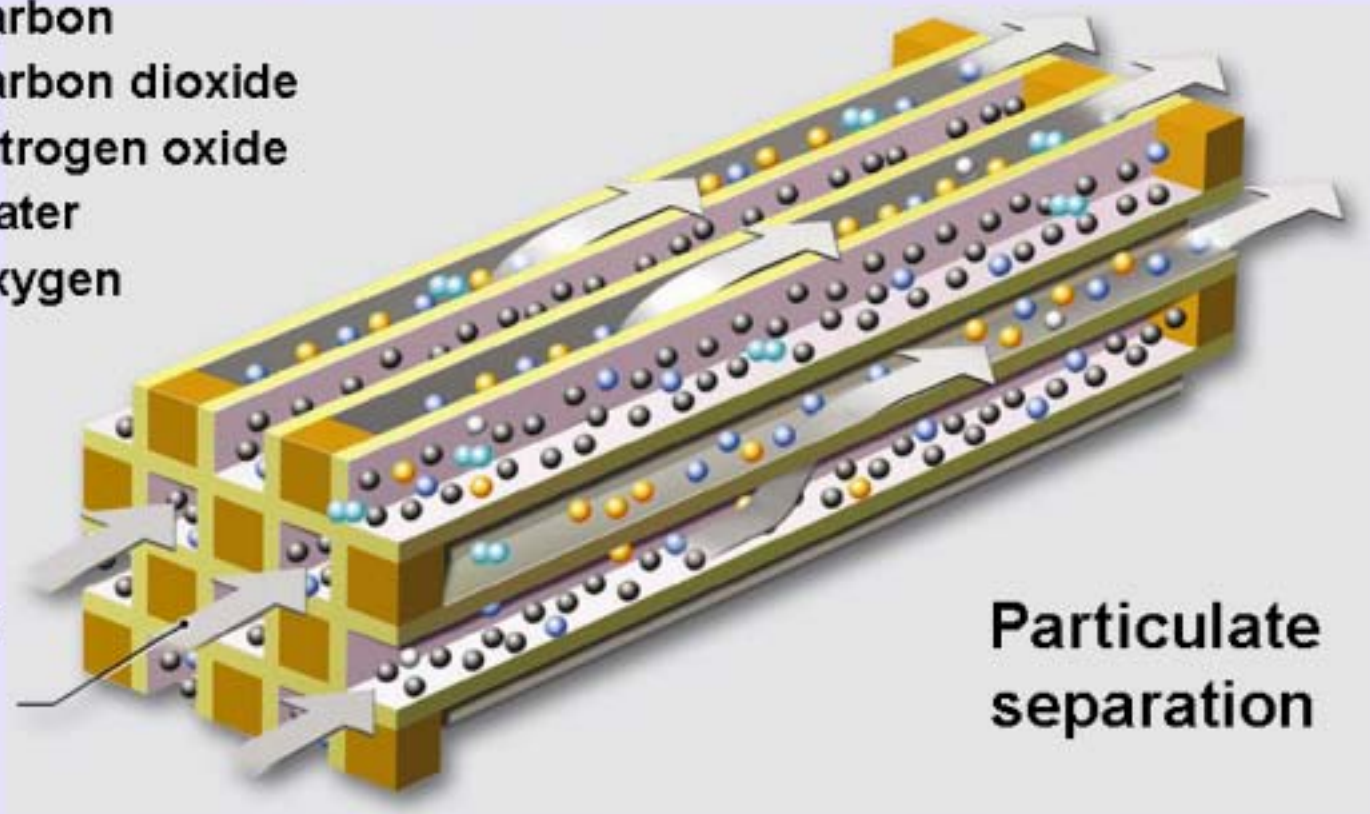
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# Diesel Particulate Filter - Function

- CO - carbon monoxide
- HC - hydrocarbons
- C - carbon
- CO<sub>2</sub> - carbon dioxide
- NO<sub>x</sub> - nitrogen oxide
- H<sub>2</sub>O - water
- O<sub>2</sub> - oxygen

Pre-treated  
exhaust gas  
with  
particulates



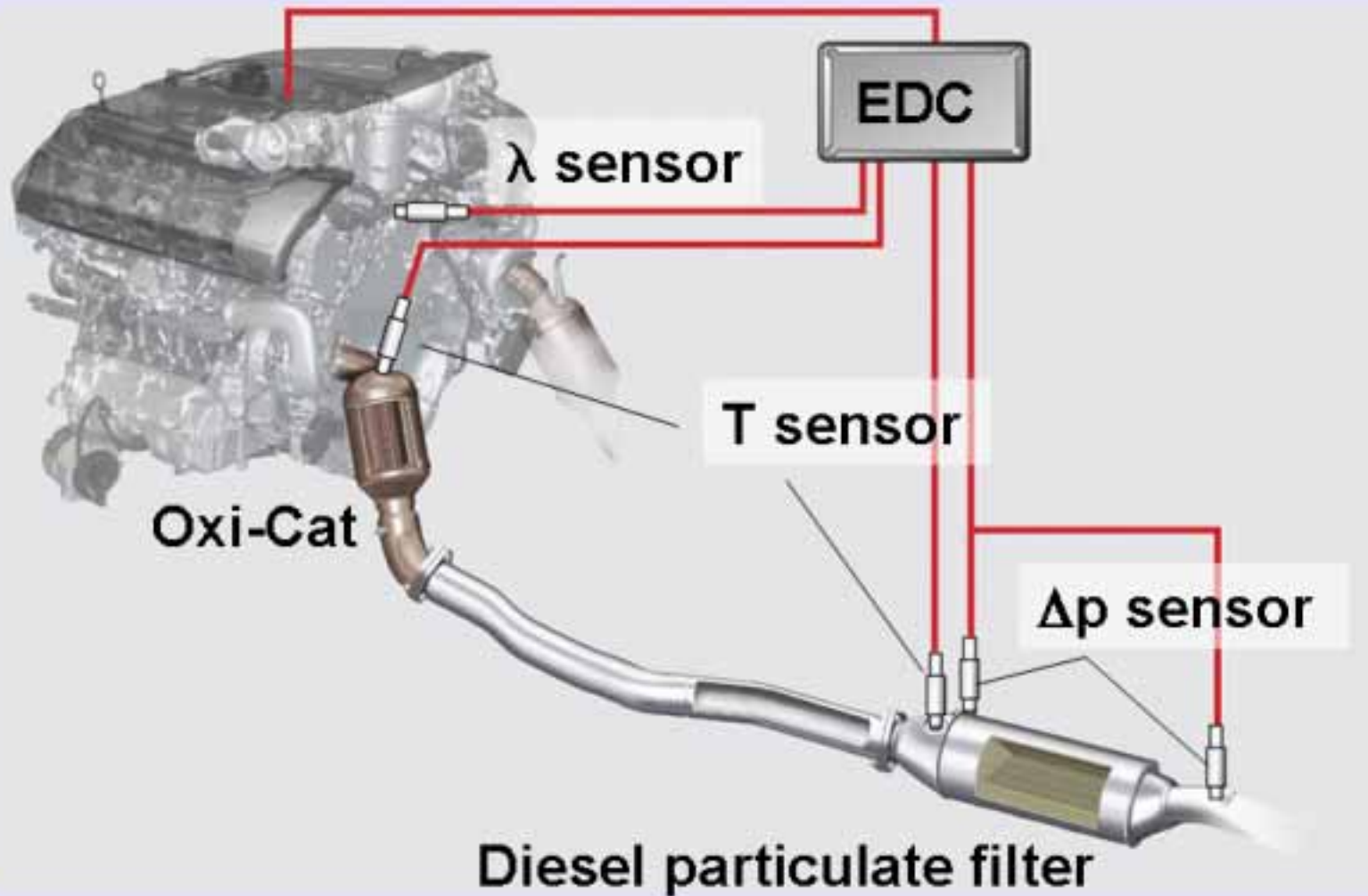
Treated exhaust gas  
without particulates

Particulate  
separation

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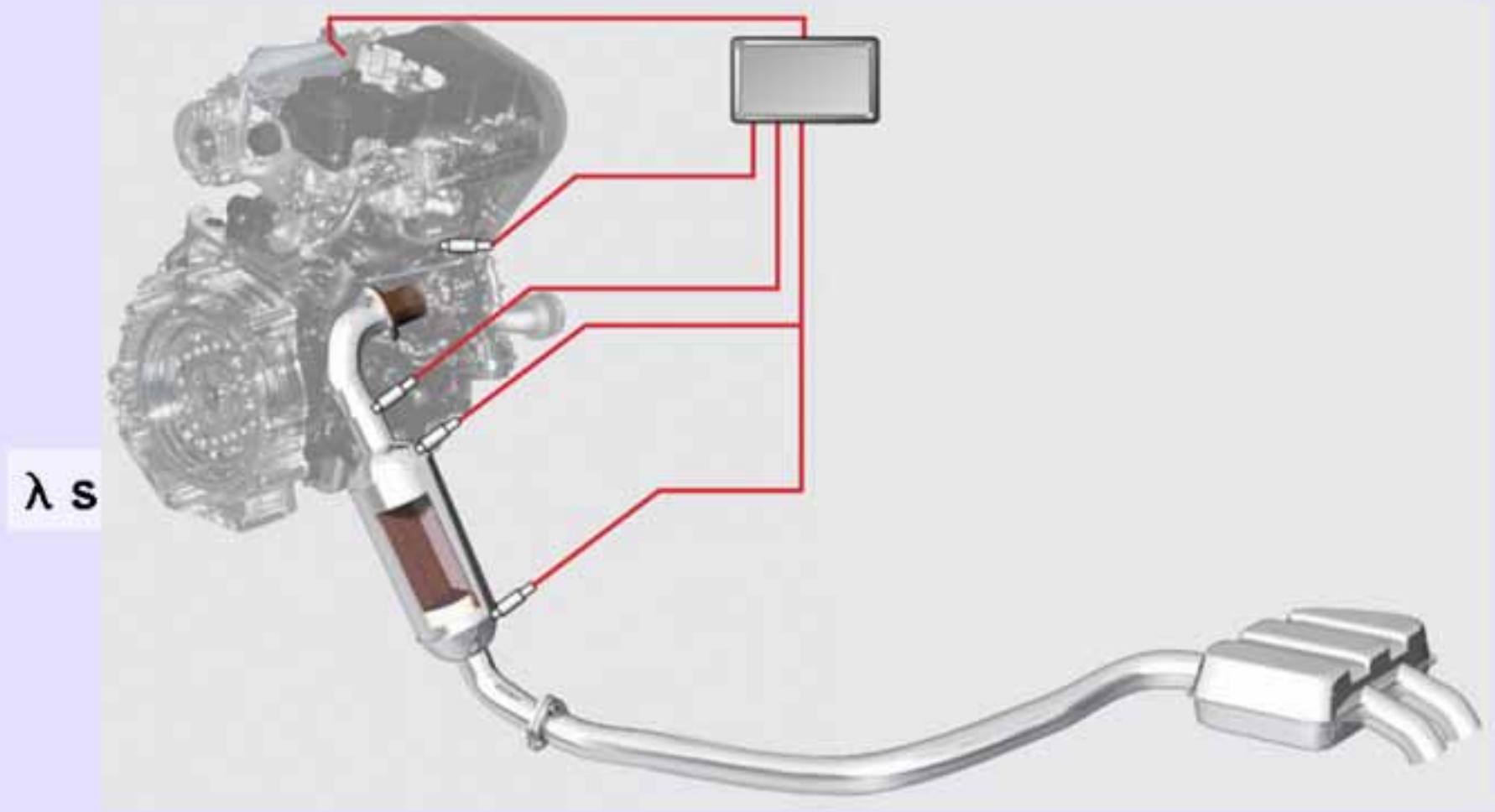
# VW exhaust aftertreatment systems



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# VW exhaust aftertreatment systems

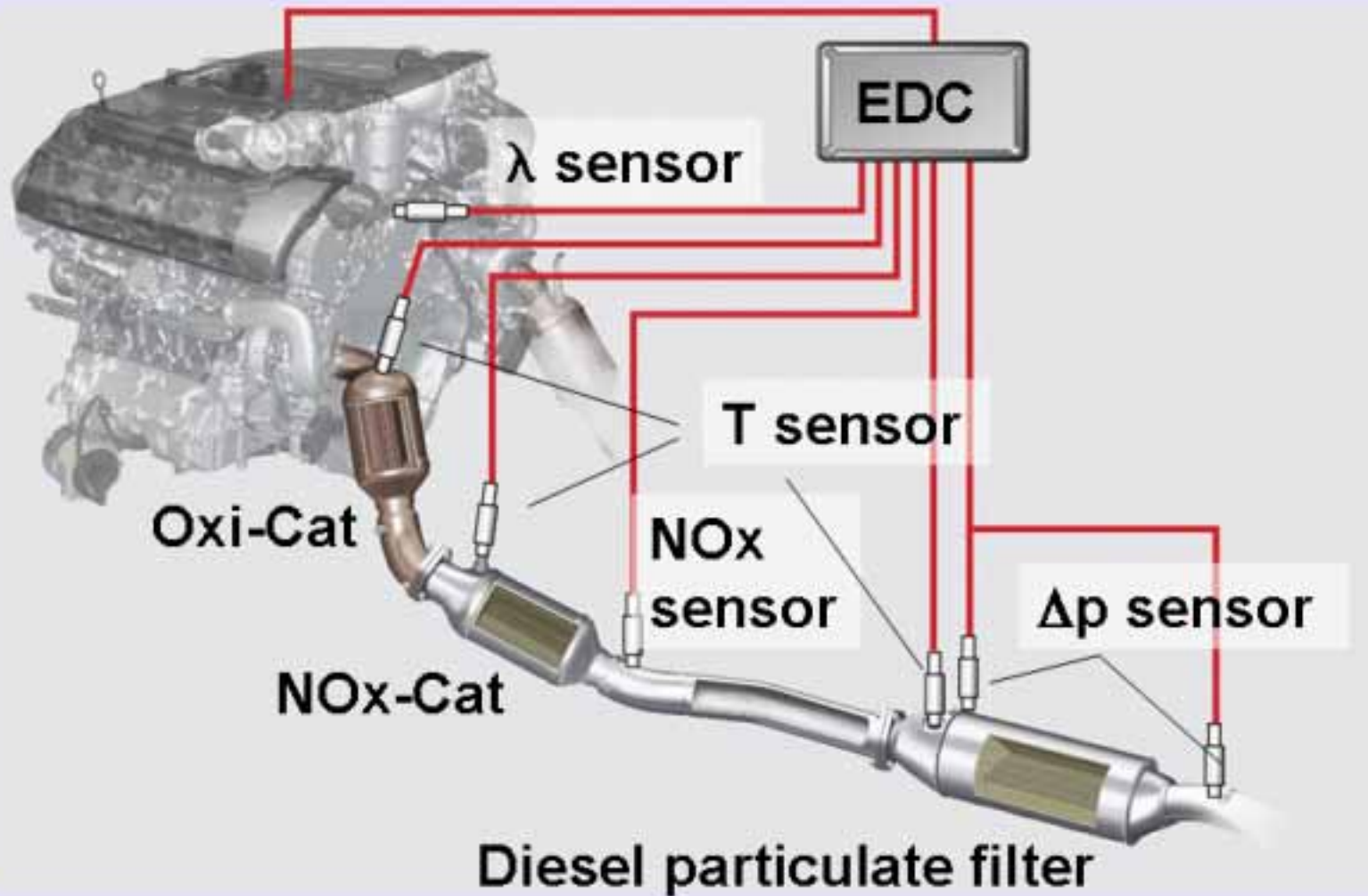


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# VW exhaust aftertreatment systems



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- ❖ Future solutions
- ❖ **Future fuel strategy**

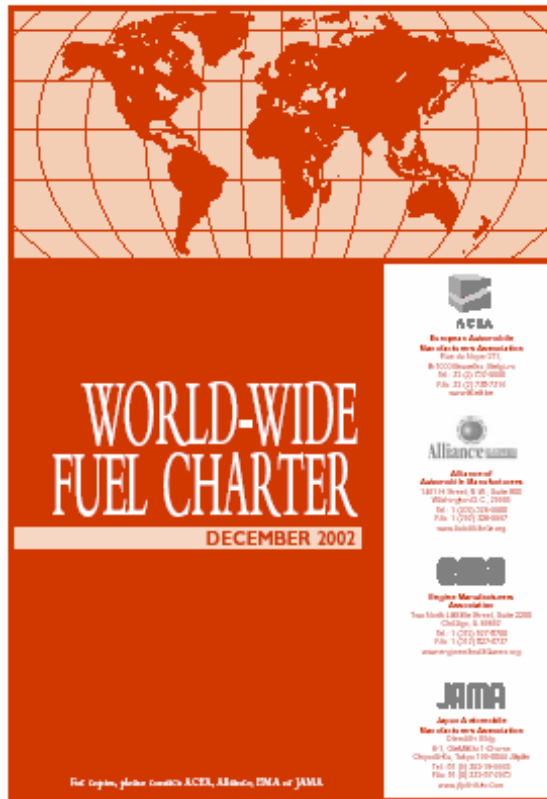
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# Need for better fuel quality

... to reduce fuel consumption and exhaust gas emissions:



- ❖ optimized combustion processes
- ❖ efficient oxidation catalytic converter
- ❖ particulate matter aftertreatment
- ❖ nitrogen oxide aftertreatment

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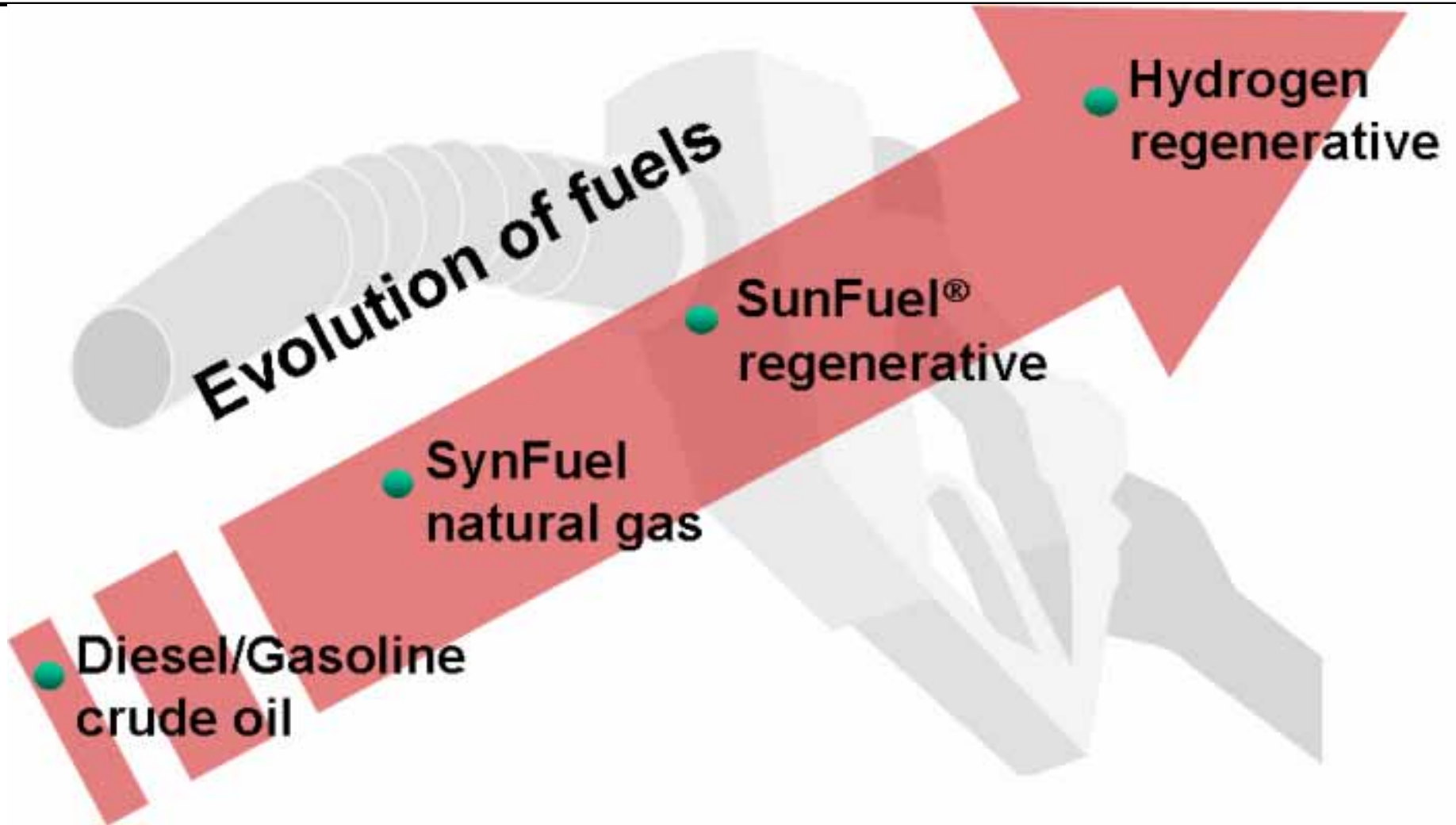


# Improvement of fuel quality

	Future	EU 2003	US 2003	US 2006
● Sulphur content [ppm ]	< 10	10	350	< 15
● Polyaromatics content (Tri+) [mass percent ]	< 0.5	1.0	3.0	3.0
● Cetane number [ - ]	> 55	53	46	< 50



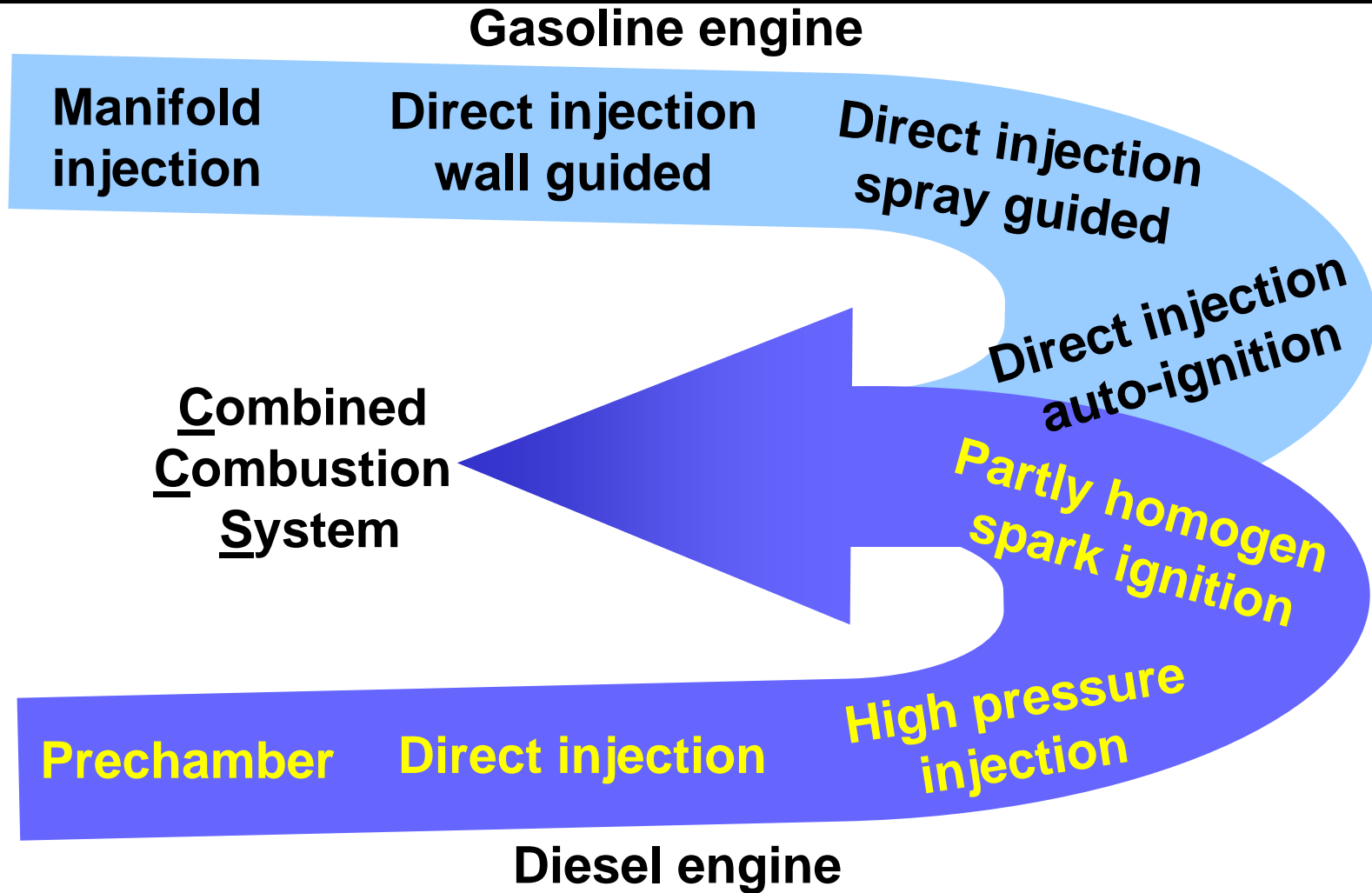
# Volkswagen's fuel strategy



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# Further development of ICE



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- ❖ **Conclusion**

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# Conclusion

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- ❖ For the development of diesel engines we have to use leading edge technology
- ❖ Main focus of the diesel engine development is an optimised internal combustion system to achieve the emission standards
- ❖ For the LEV 2/BIN 5 limits we need:
  - a new combustion process
  - an optimised aftertreatment system
  - a high standard of fuel quality

