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DaimlerChrysler Powersystems

**State-of-the-art and emerging truck engine
technologies**

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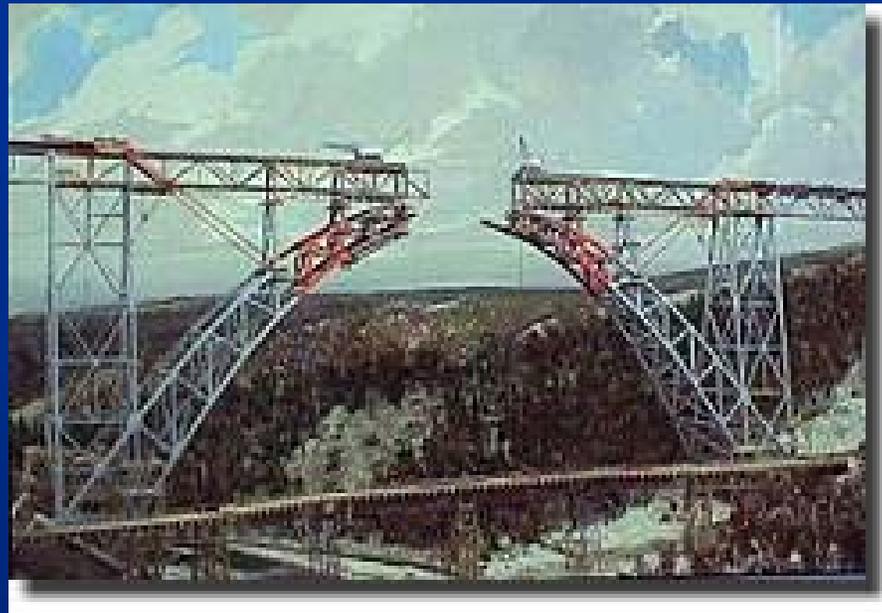
State-of-the-art and emerging truck engine technologies for optimized performance, emissions and life-cycle-costs

- The challenge for commercial vehicles engine R&D
- Engine technology development until today
- Aftertreatment systems as emerging technologies also for commercial vehicle Diesel engines
- What will be the right technology for US MY07?
- Prerequisites to be established

Engine R&D efforts have to focus on bridging ecological and economical requirements of all stakeholders

Ecology

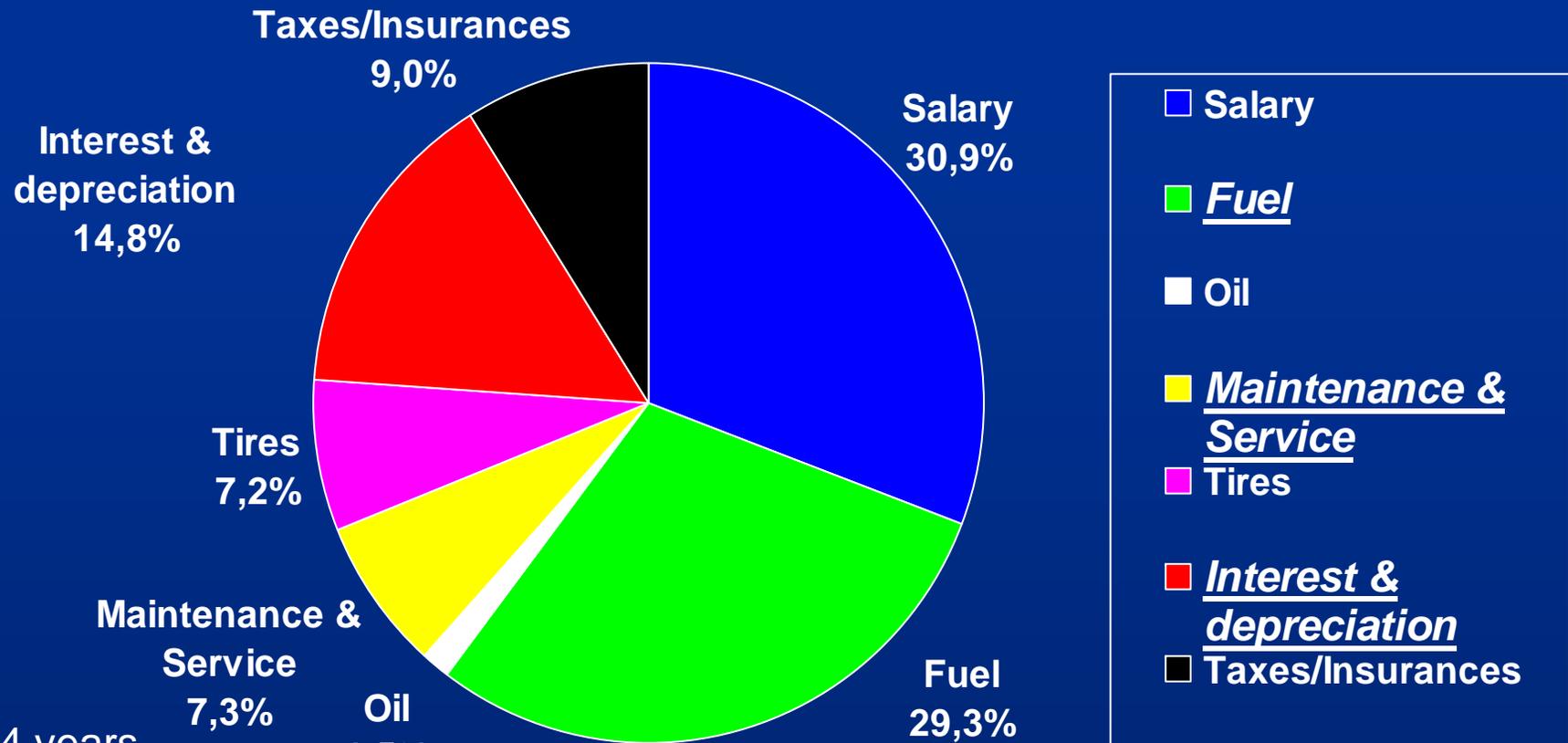
- **Society**
 - Gaseous and PM Emissions
 - CO₂-Emissions
 - Noise



Economy

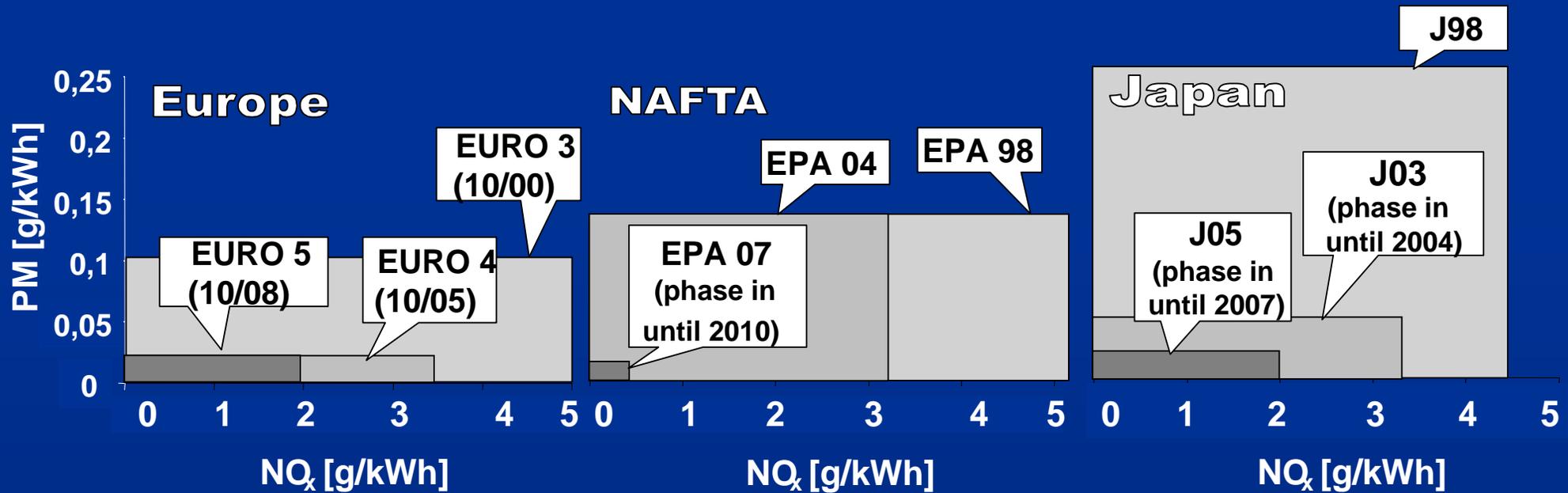
- **Truck Operator**
 - Life-Cycle Costs
- **OEM**
 - Profitability
- **Nation**
 - Haulage Costs

Costs for fuel, purchase and maintenance/service are highly influenced by engine design.



time of use: 4 years,
mileage/year: 95,000 mls (app. 150.000 km),
fuel consumption: 7,35 mpg (32,5 l/100 km)

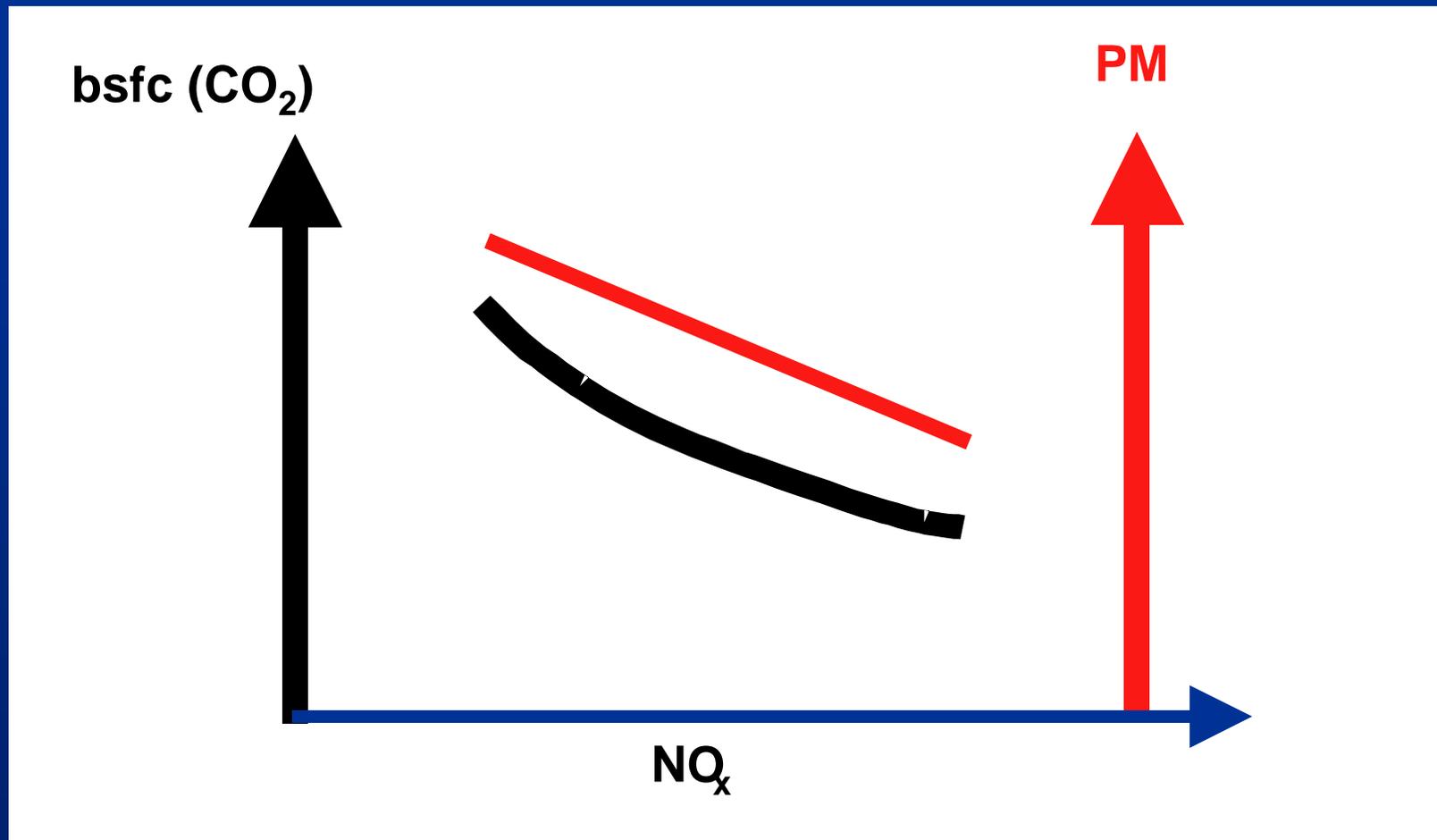
Worldwide emission standards and respective test cycles



	Test cycles
Euro4/5	European Steady Cycle (ESC) + European Transient Cycle (ETC)
EPA 04/07	Federal Test Procedure (FTP) + European Transient Cycle (ETC)
Japan 05	Transient (hot start test)

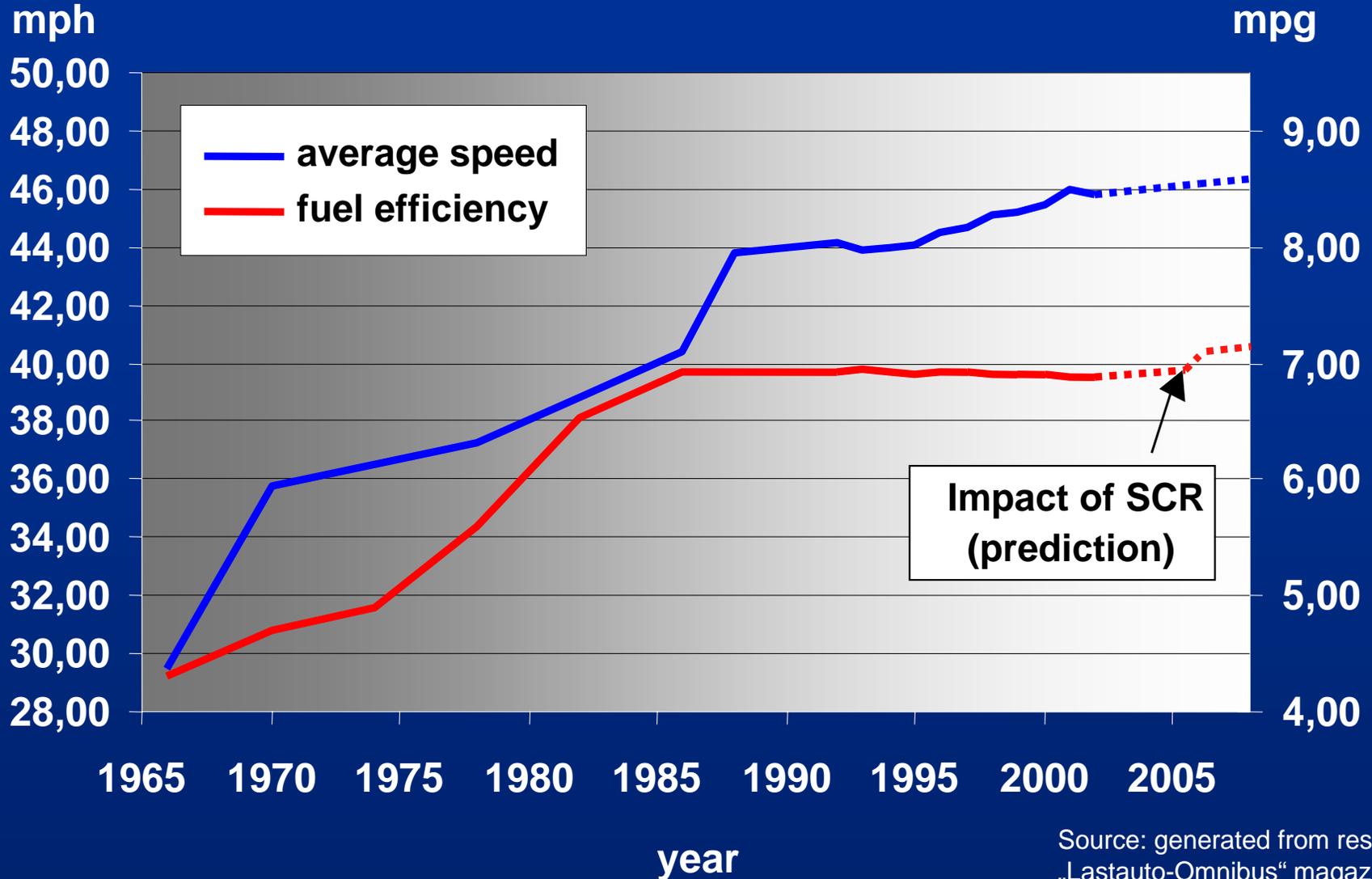
For Europe, NAFTA and Japan different test cycles are mandatory with different weightings regarding engine speed and load

Traditional measures aiming at lower peak combustion temperature reduce fuel efficiency and increase PM- and CO_2 -emission

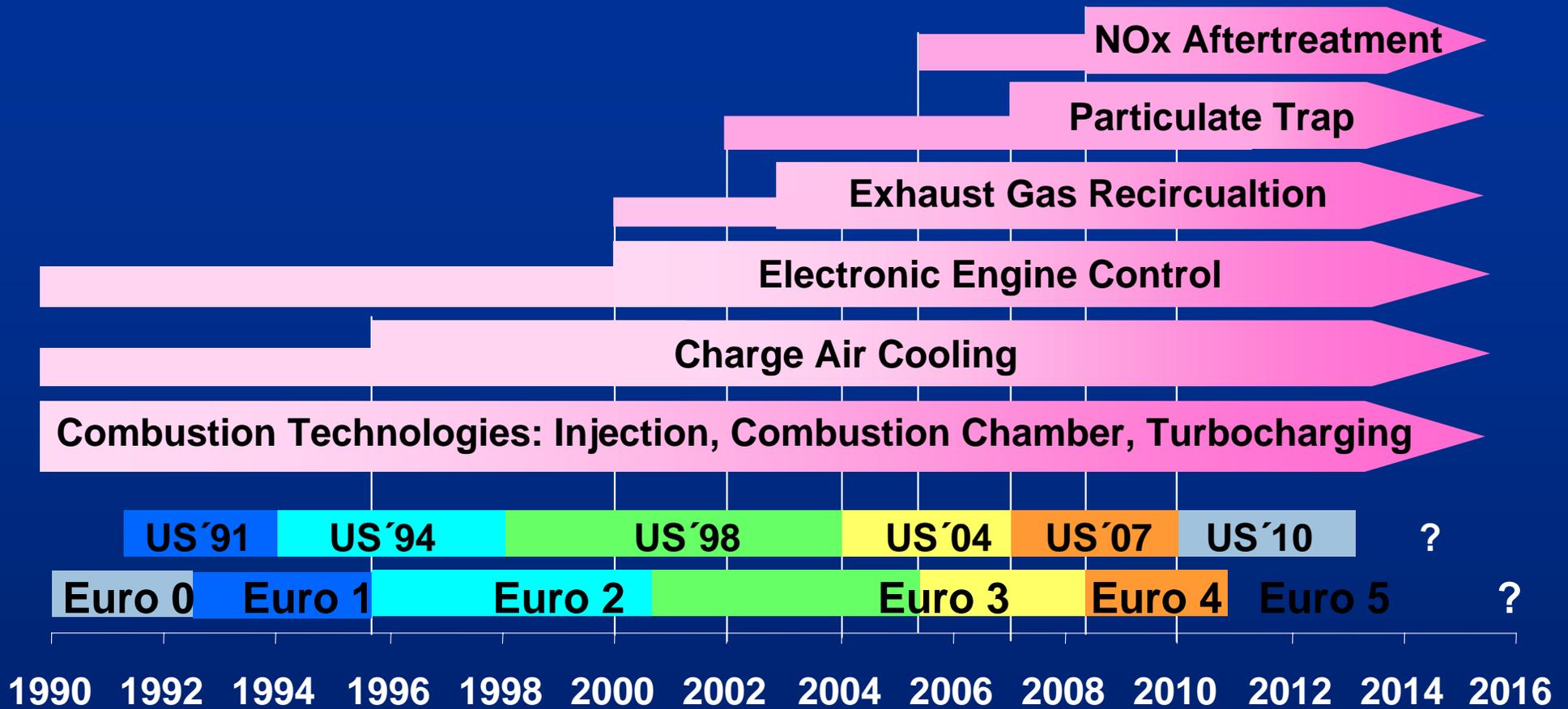


Average fuel efficiency and speed of a 40t tractor-trailer combination

European OEMs have been able to increase transport efficiency in spite of more stringent emissions regulations



Source: generated from results of „Lastauto-Omnibus“ magazine



NOx aftertreatment

- Adsorber catalyst
- Selective Catalytic Reduction (SCR)

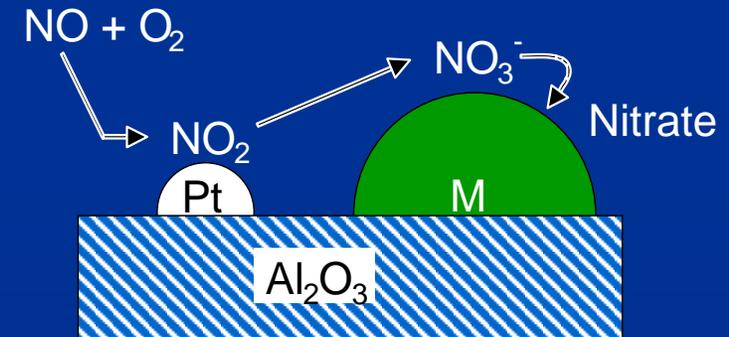
PM aftertreatment

- Continuously Regenerating Diesel Particle Filter (CDPF)

PHASE 1: Regular operating conditions

AFR > 1

- Air-To-Fuel Ratio (AFR) > 1
- storage of NOx on catalyst surface:
 - Oxidation from NO to NO₂
 - Production of nitrate (out of NO₂)
 - storage of produced nitrate

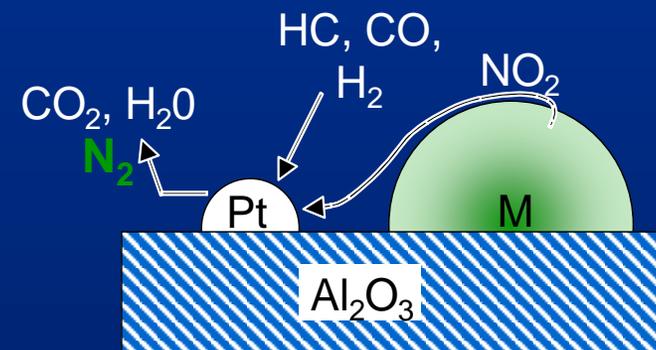


Nitrate-storage

PHASE 2: Brief enrichment (ECU controlled)

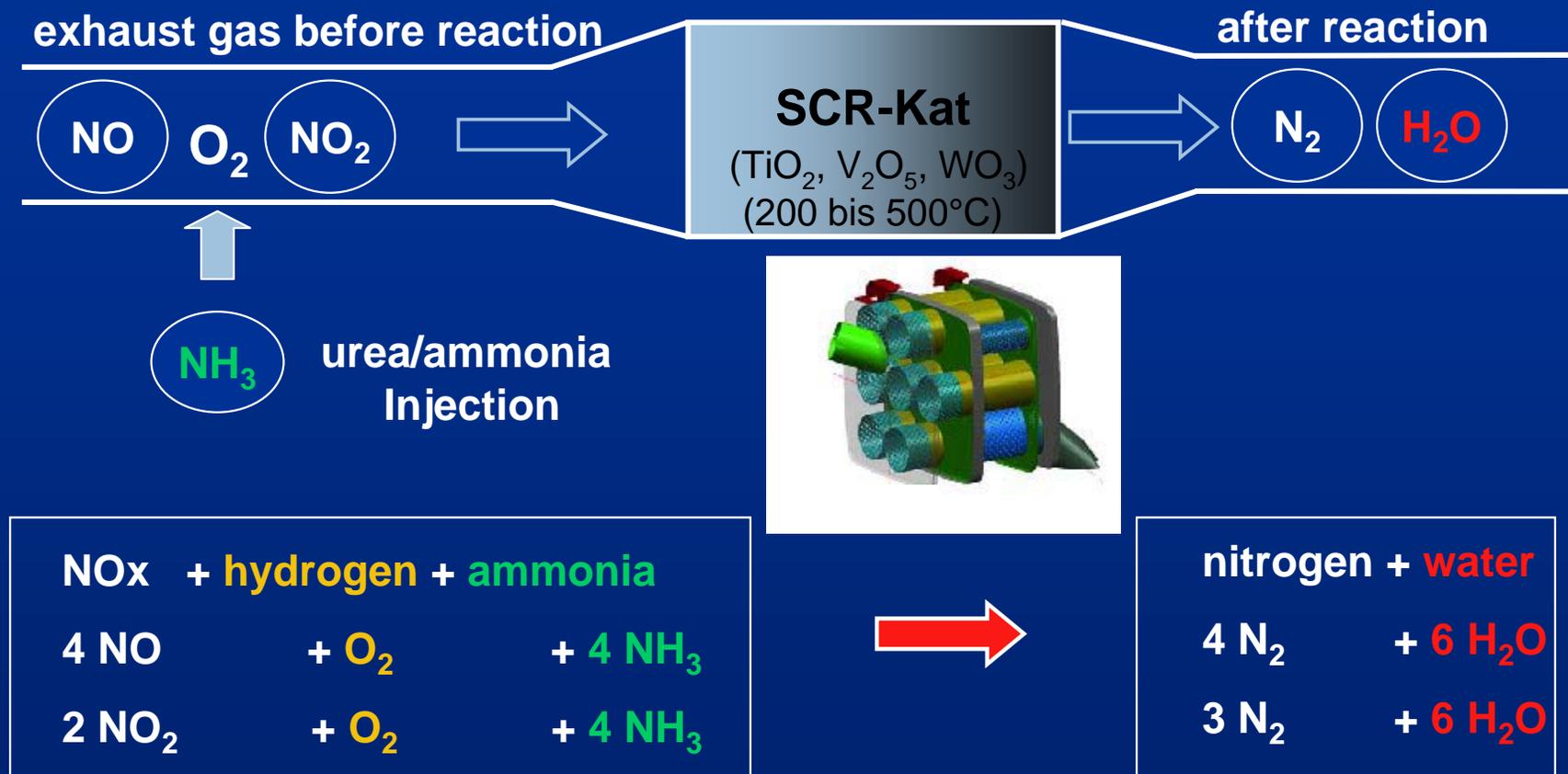
AFR < 1

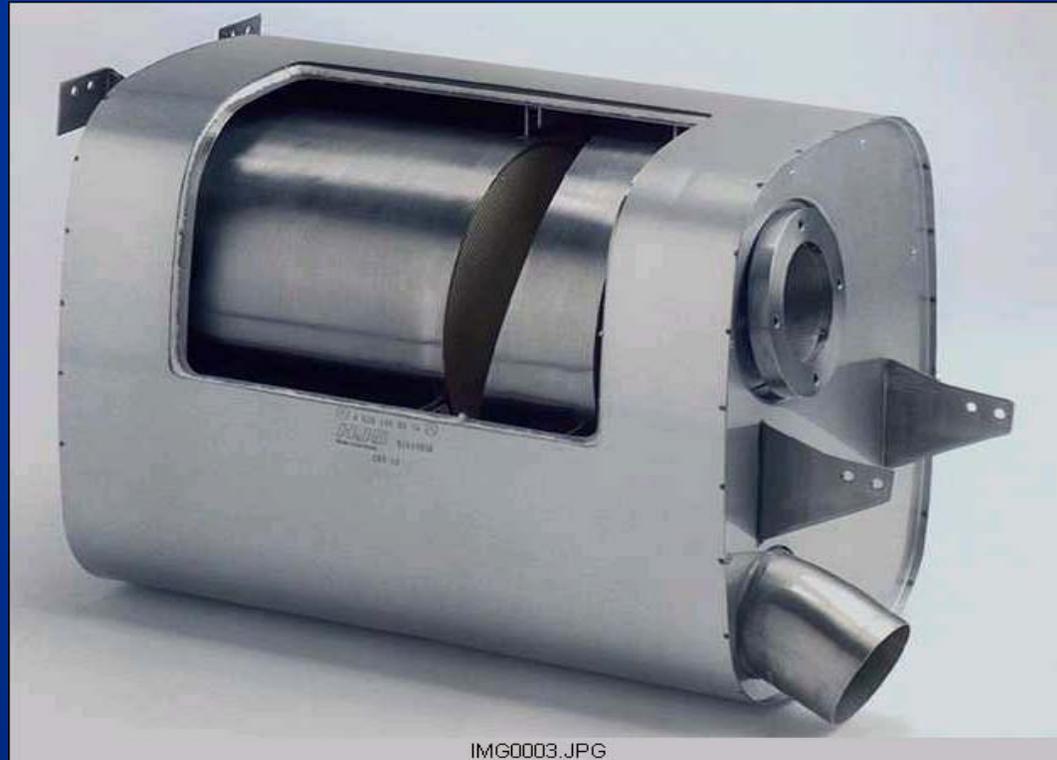
- AFR < 1
- Reduction of stored nitric oxides:
 - back-formation of nitrate to NO
 - Reaction of NO with CO and H₂
 - (2NO + 2CO → 2CO₂ + N₂)
 - (2NO + 2H₂ → 2H₂O + N₂)



Reduction to nitrogen

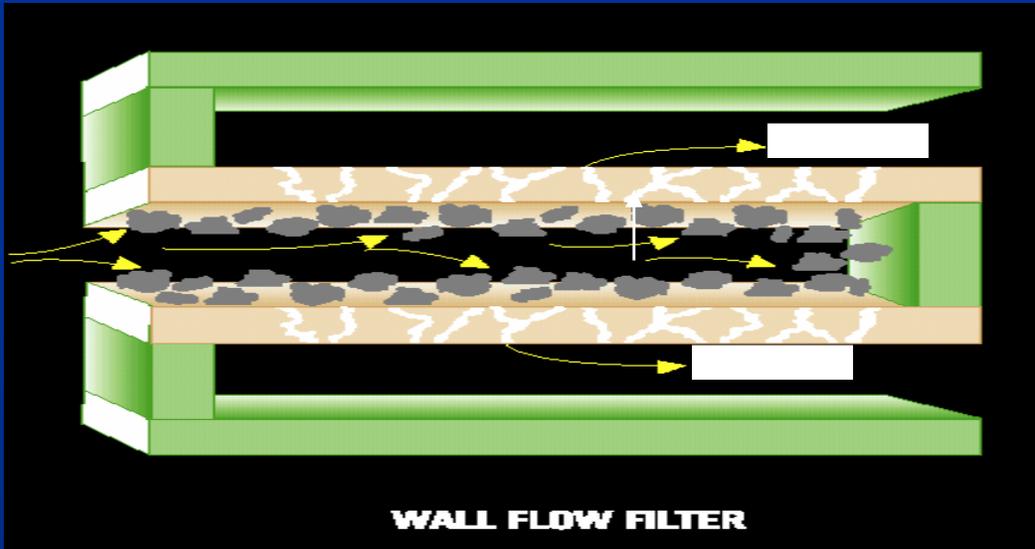
The SCR technology uses urea, respectively ammonia (which forms after decomposition of urea at temperatures $>200^{\circ}\text{C}$) to convert nitric oxides (NO , NO_2) into harmless molecular nitrogen N_2 and water.





Combination of oxidation catalytic converter and soot trap



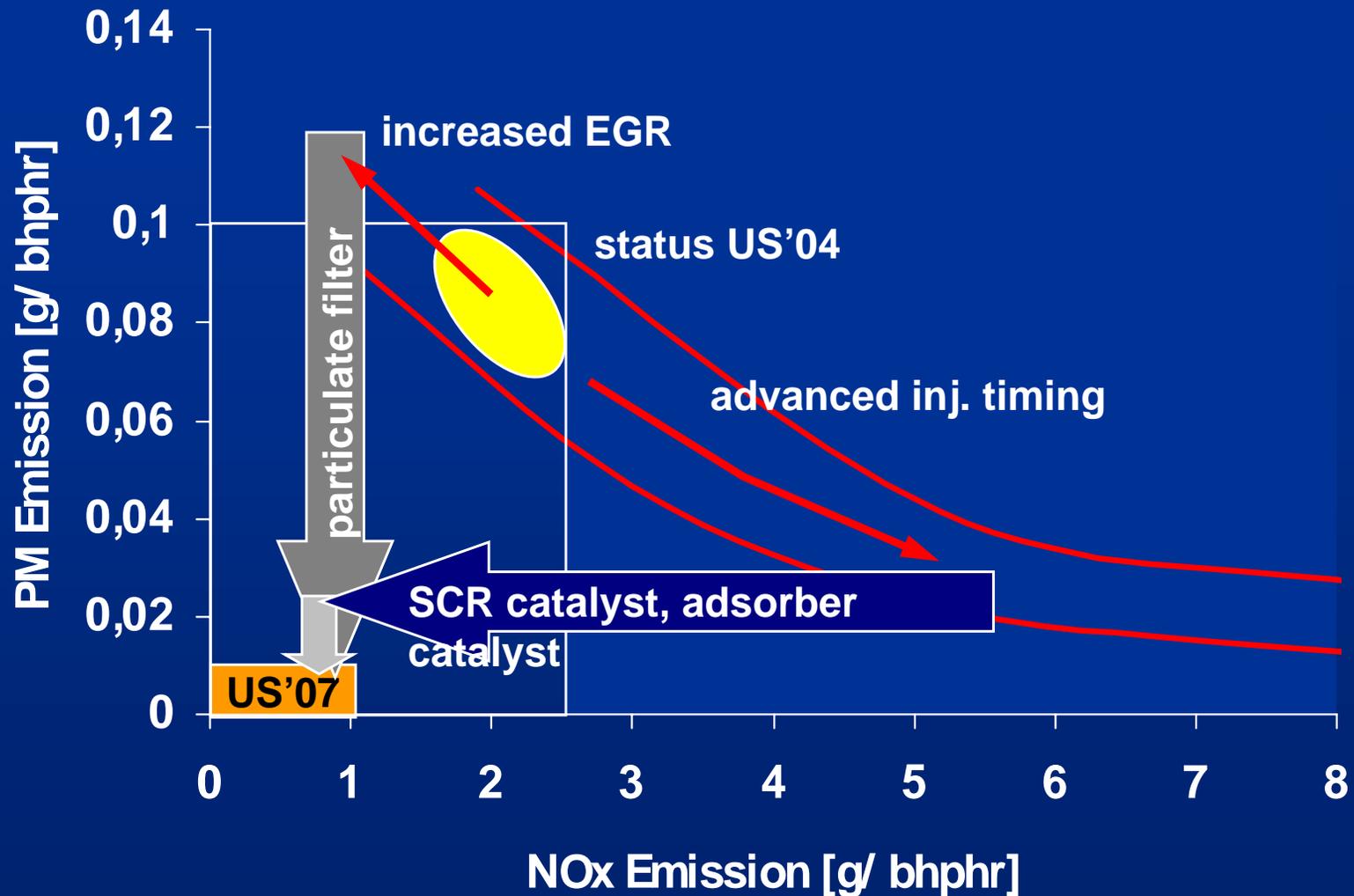


Courtesy Johnson Matthey

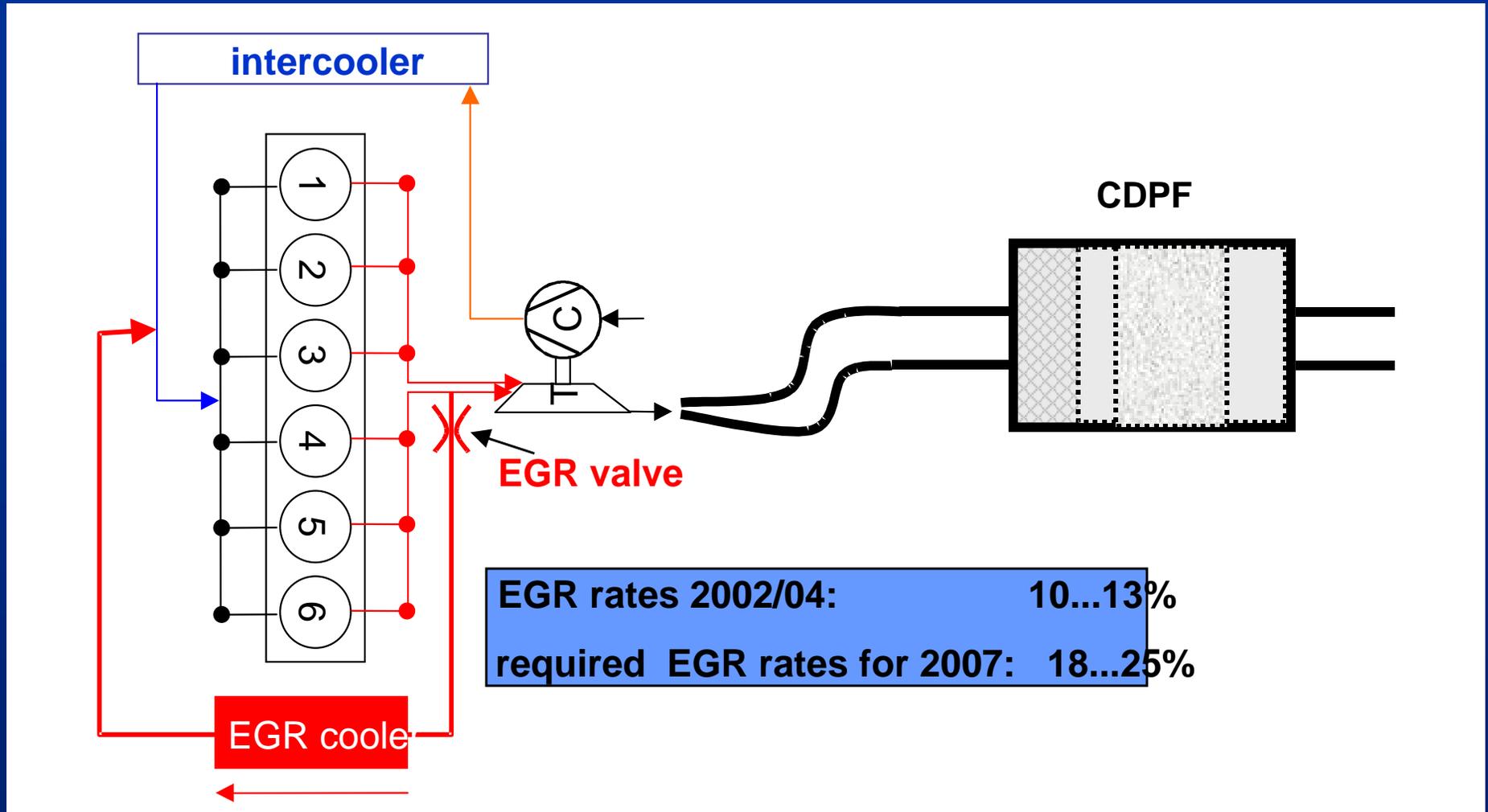
Monolith with a high number of filter channels

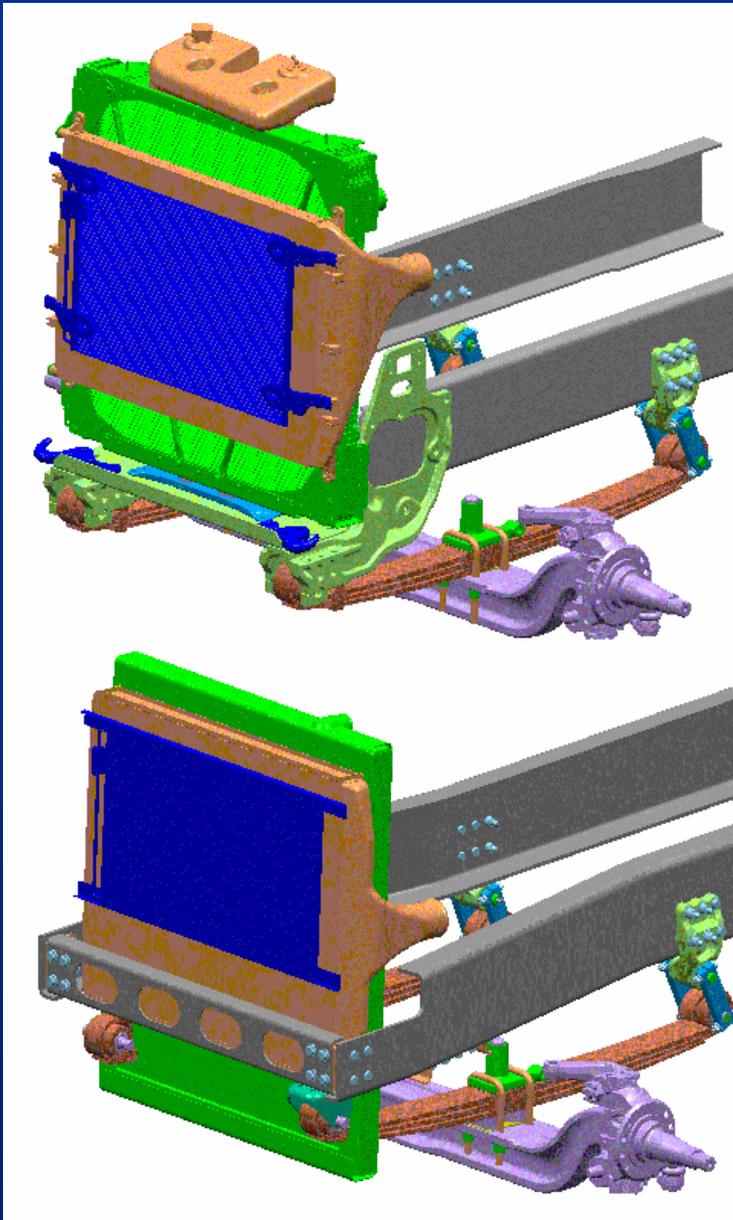
Sintered metal filter with a low number of filter plates





The EGR system for US'07 features approximately twice the EGR rates of US'04

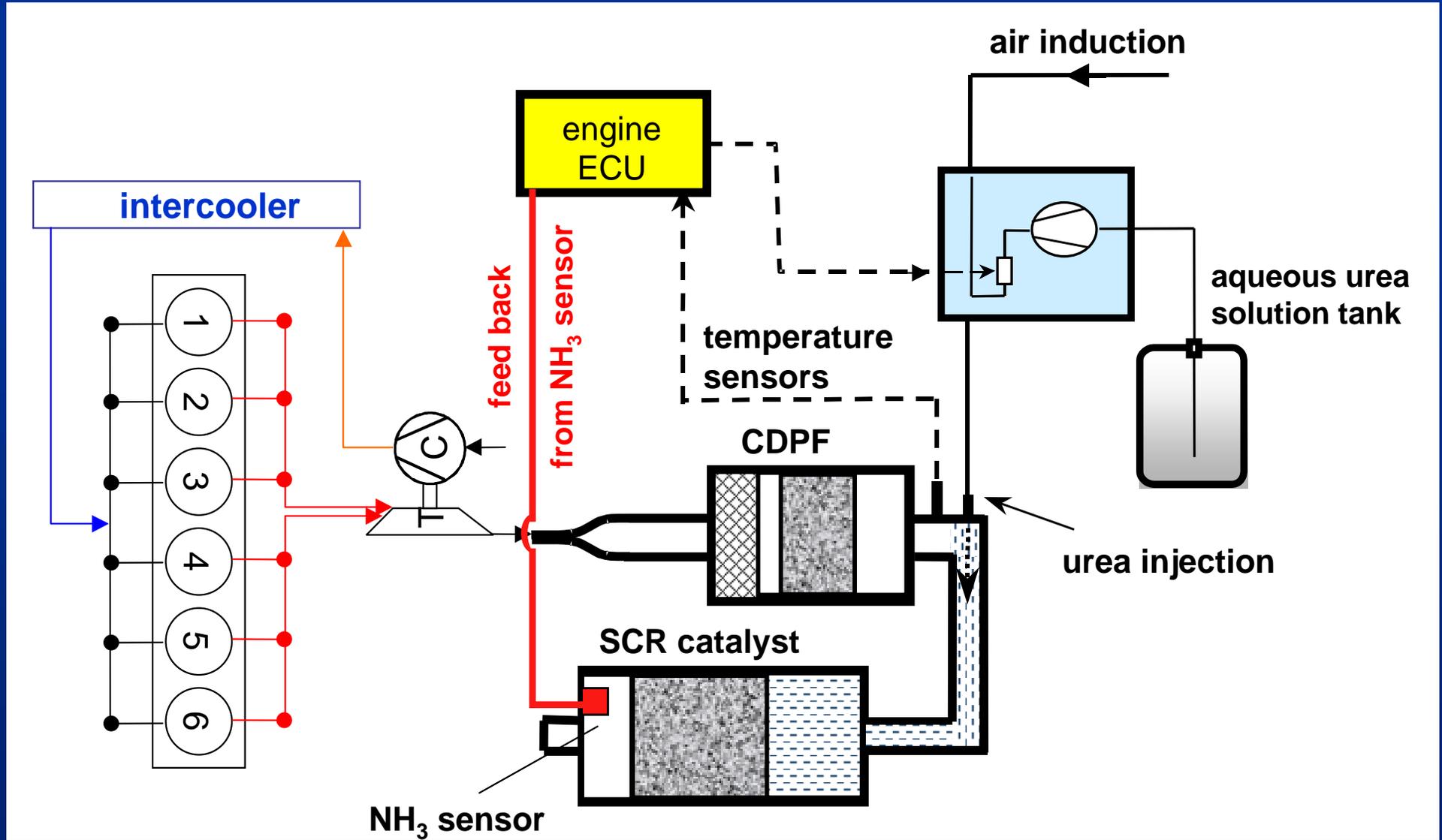


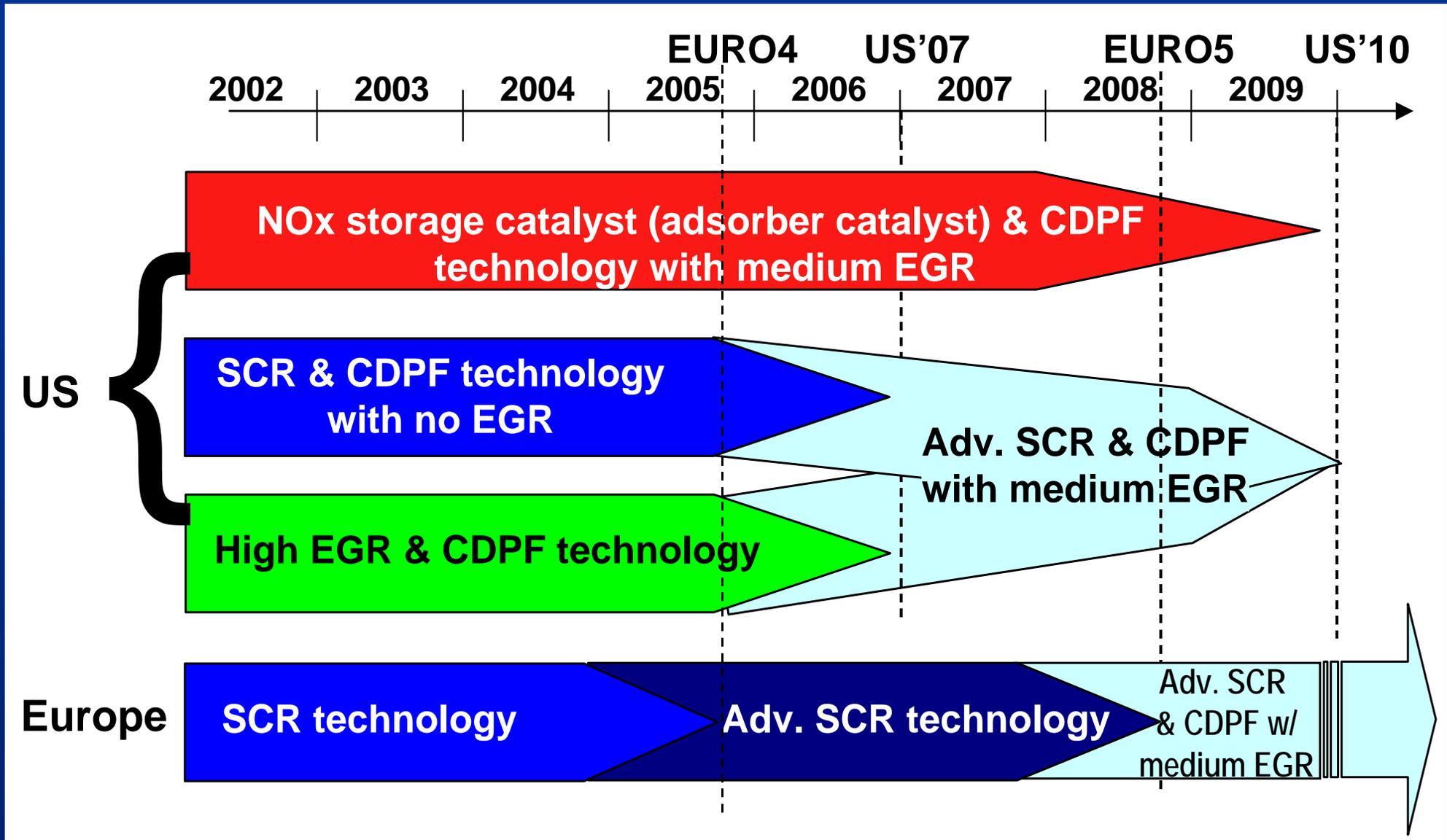


**2002/2004 design
crossflow radiator**

**2007 design
downflow radiator**

**splayed frame
interference w/ axle forward springs**



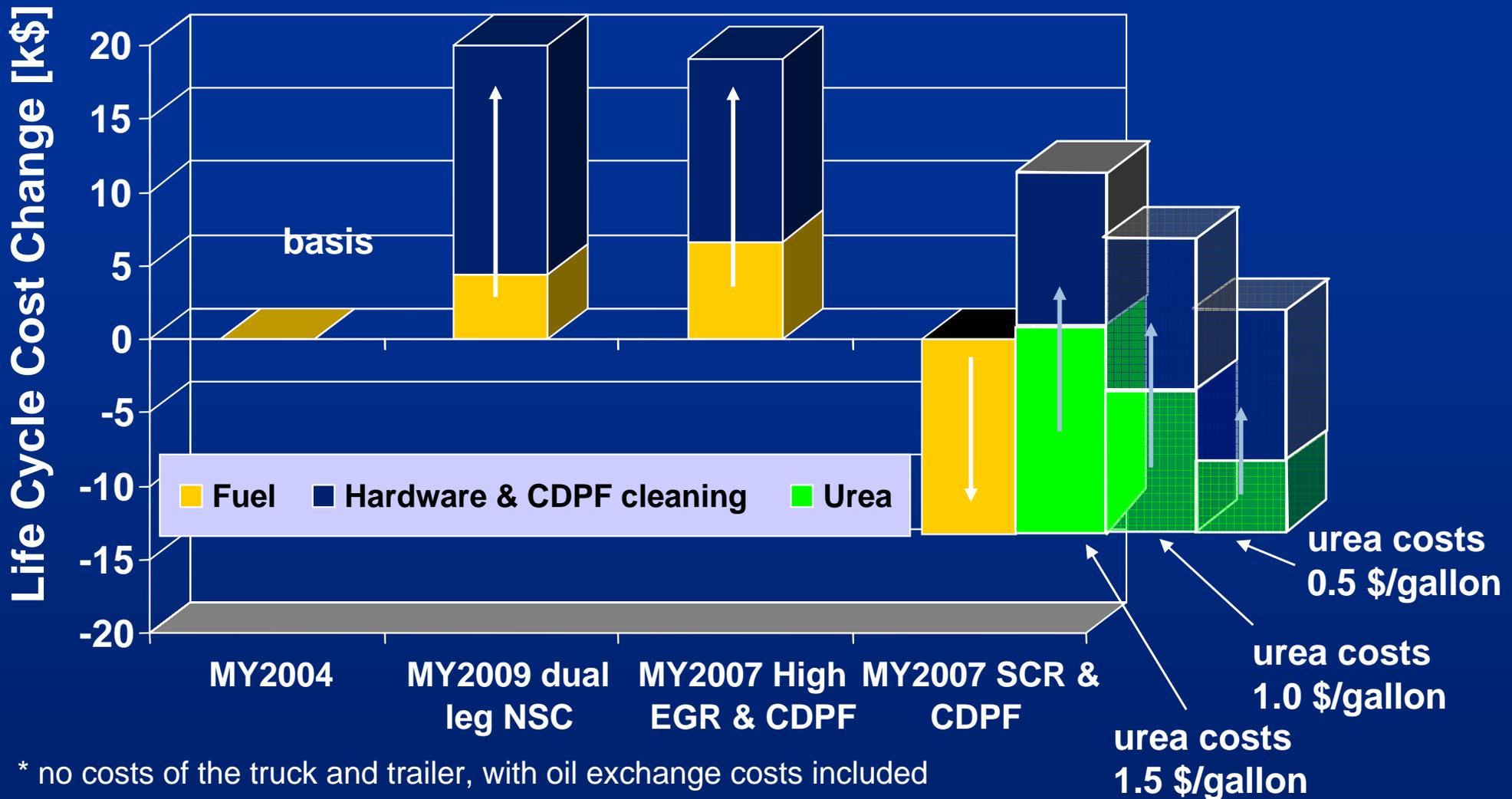




Life-Cycle-Cost comparison for a long haul truck

(only costs are considered, no prices that include profit and overhead)

The SCR & CDPF technology reduces fuel consumption and life cycle costs; the cost advantage depends on the urea costs



* no costs of the truck and trailer, with oil exchange costs included

Installation of SCR & CDPF technology in a demonstrator truck



SCR catalyst

urea tank

urea doser

Two issues need to be resolved in order to enable the introduction of SCR:

- **urea supply infrastructure**
- **securing that system is tamper-proof and working correctly**

Urea is

- colorless
- non-toxic
- used in food, agricultural fertilizers, cosmetics pharmaceuticals etc.
- available at required quantity; installed production capacity allows CV supply w/o additional investments

AdBlue is

- the European trade name for 32.5% aqueous urea solution

How does Europe approach the installation of a supply infrastructure for urea solution

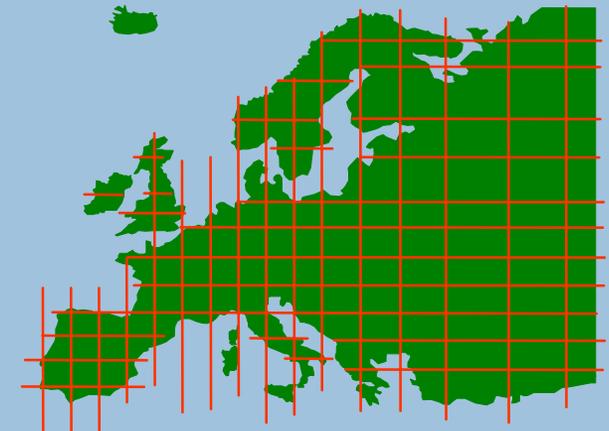
- The urea supply industry has a major interest to establish a urea infrastructure.
- 80% of the entire heavy duty truck diesel fuel is being distributed by local fuel stations which are operated by the fleets themselves.
- Fleet owners will install urea filling stations at their places. Financial support through urea manufacturing companies is in discussion.
- Large highway truck-stops will be equipped with urea filling stations. Other fuel filling stations will install urea supply gradually.



supply of the most important intersections



supply along the most important routes



areawide supply with minimal distances



AdBlue

small filling station



AdBlue

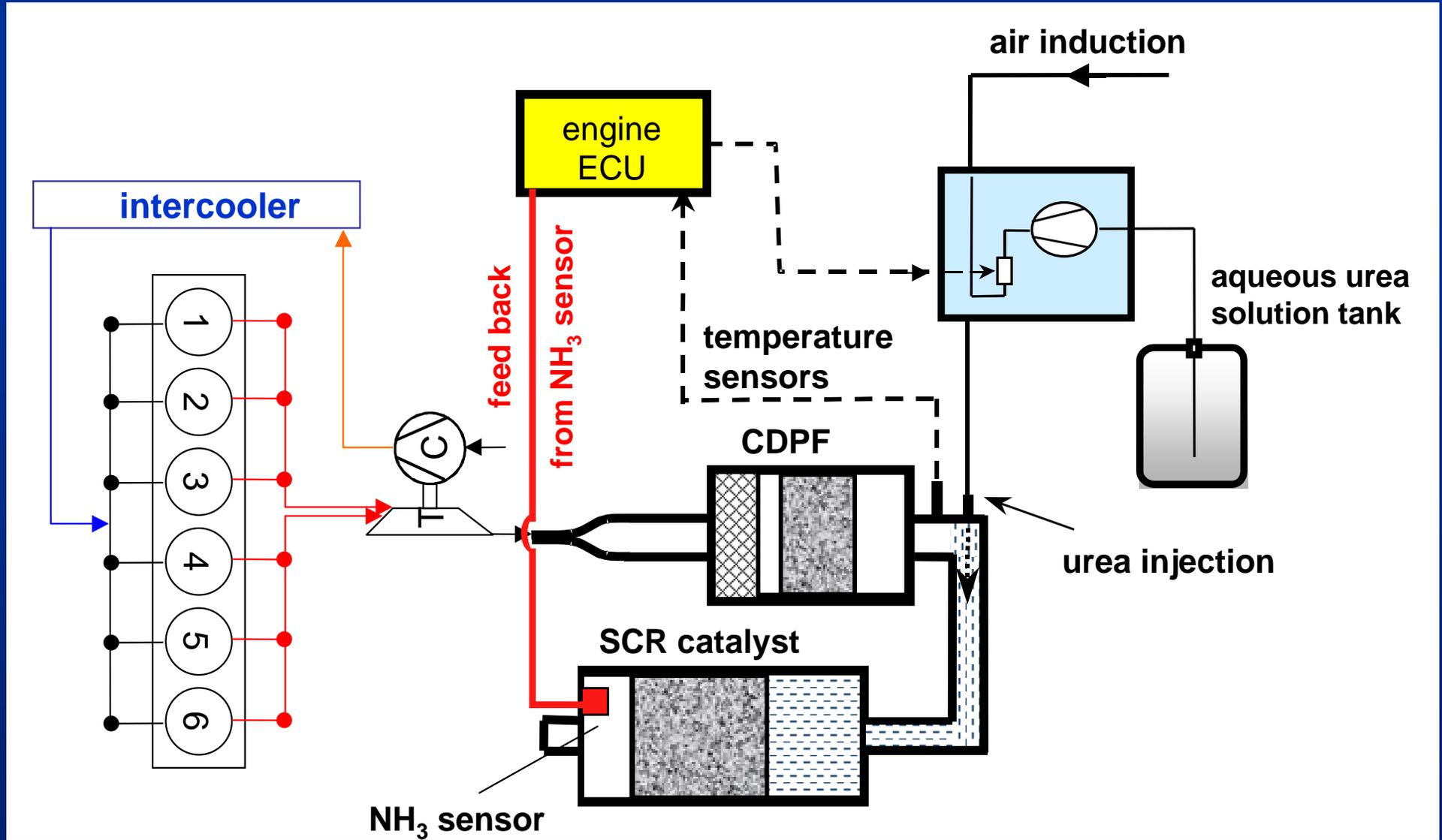
**supply unit: 265 gals
(1000 l)**

Excerpt from TIAX-Report:

- “Economics favor the SCR/urea technology over the NOx adsorber technology for most applications of long-haul and vocational trucks in the long-term.”
- “Economics also generally favor the SCR/urea technology over the NOx adsorber technology in the near-term if early NOx adsorbers have a high fuel penalty ($\approx 5\%$) and a higher initial incremental cost.”
- The study furthermore states that provision of Urea is both possible and economically reasonable if “strong signals regarding manufacturers intentions to provide SCR-equipped trucks” are sent to truck operators and other stakeholders starting 3rd quarter 2003 and no later than mid-2004

Remark: TIAX is a consulting firm which formed from Arthur D. Little’s Technology and Innovation business

source: TIAX-report



Emission technology comparison

preliminary estimates as of June 2003

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	High EGR	SCR	NOx Adsorber
Fuel Economy	-3%	+6% (app. 6% urea usage)	-3%
Cooling Requirements	up to 55%	-20%	0%
Power Density	-5%	+6%	0%
Weight	+50 lbs.	-400 lbs.	+200 lbs.
Oil Exchange Intervals	1X	2X	1X
Urea Infrastructure	No	Yes	No
Driver's Responsibility	None	Urea Refill	None