





FPT POWERTRAIN TECHNOLOGIES

Ingenieurskunst kontra Gesetzgebung: Sind die Emissionsvorgaben Innovationstreiber oder lähmendes Korsett?

FIAT INDUSTRIAL

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Overview

- **Technological development from Euro 0 to Euro VI**
- **Innovations**
- **What have we achieved with Euro VI, is there a need for further steps in reducing criteria pollutants?**
- **Paradigm change to focus on fuel efficiency and CO2**
- **Summary and Conclusions**

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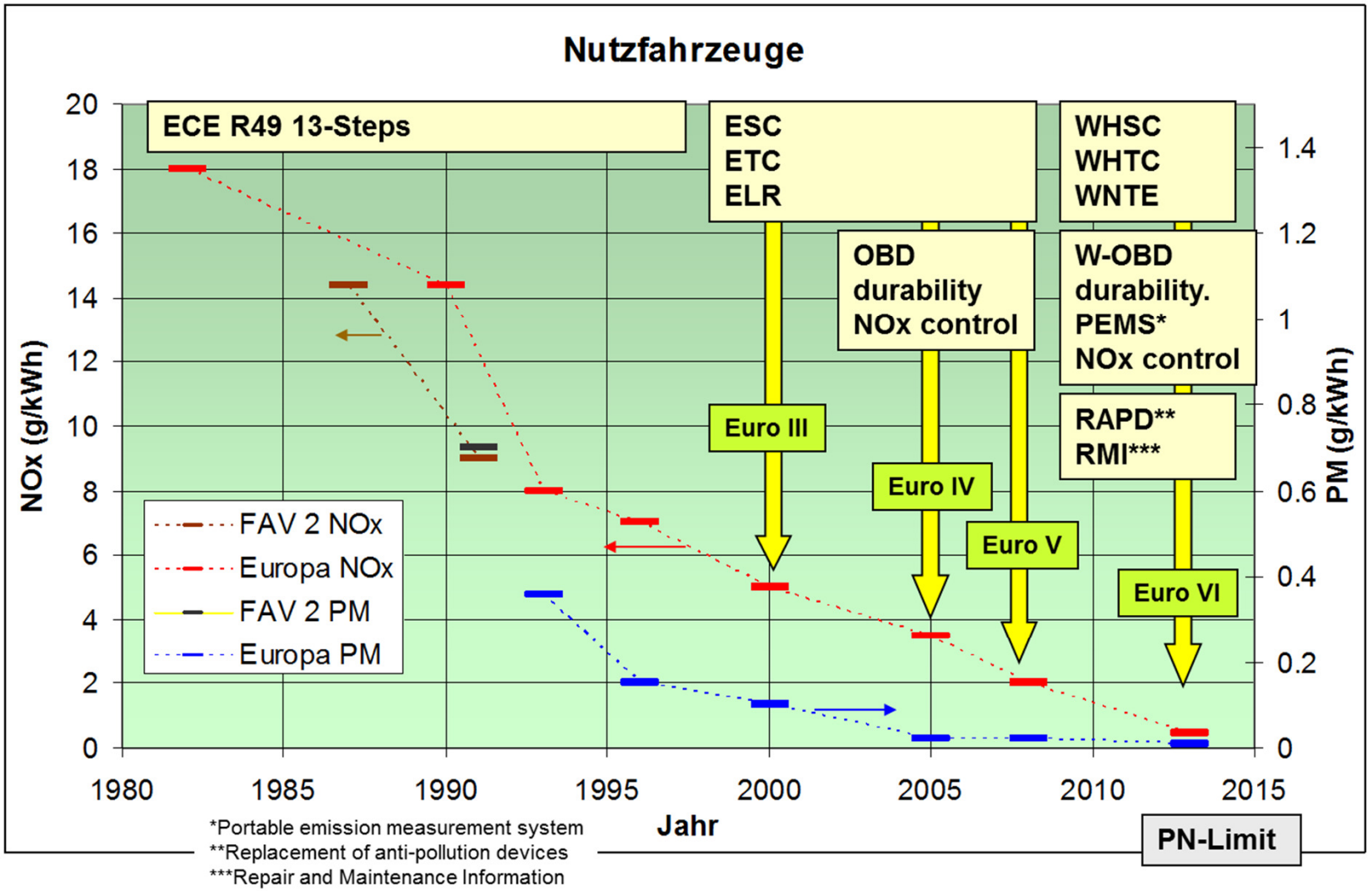
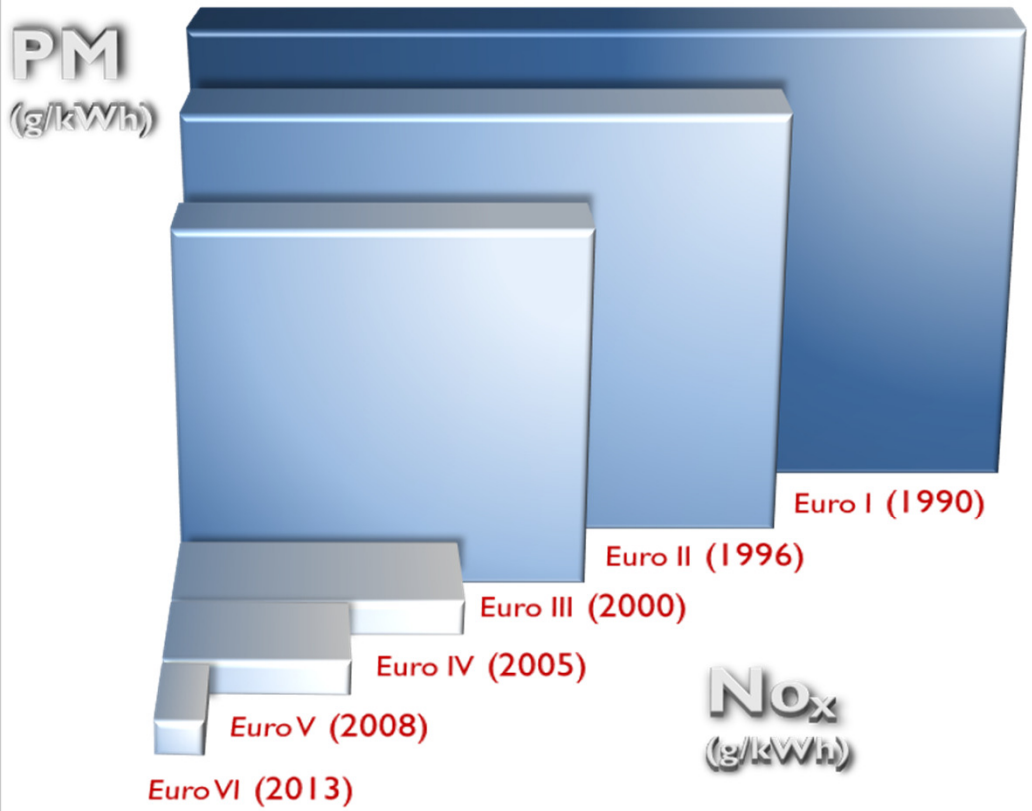
Emission Regulation in Europe



A challenge for the industry, a benefit for the environment



Euro VI
emissions decrease compared to 1990

CO	-66%
HC	-88%
PM	-98%
NO_x	-98%

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Main innovation breakthroughs

1980 — First Direct Injection engine on LCVs

1985

1989 — First EGR on Diesel engines for LCVs

1992

1999 — First Common Rail engine on LCVs

2002 — First Common Rail engine on medium duty trucks

2005 — Introduction of SCR technology for Euro IV - V

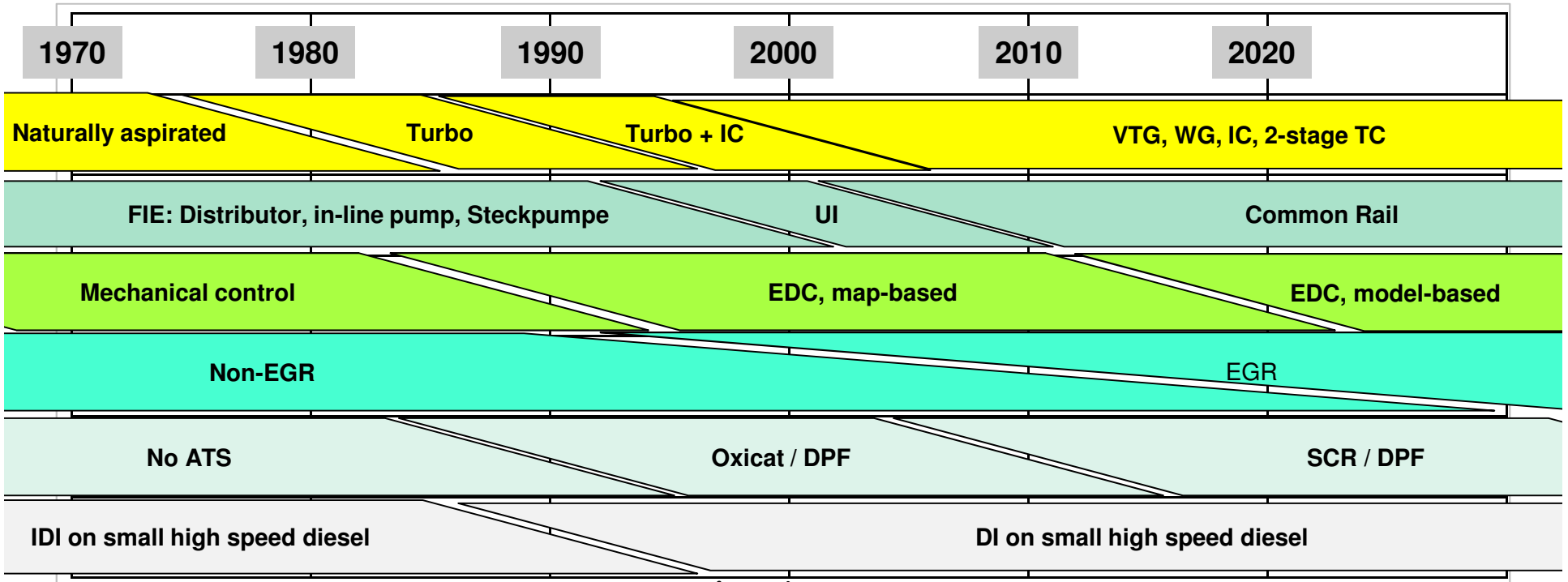
2009 — Launch of Multijet technology

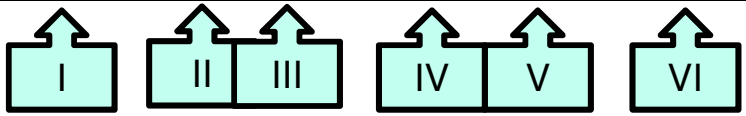
Multijet

2012 — HI-eSCR on IVECO Euro VI heavy range

HI-eSCR

Truck Diesel Engine technology development





Power density hp/liter					
20	26	37	43	45-50	?
3’000	20’000	50’000	150’000	150’000	?
Oil drain interval km					

Technology roadmap Euro 0 to Euro VI

- The ‘battle’ between SCR and EGR is only a part of the technological development from Euro 0 to Euro VI, but lead to new and innovative solutions

Selective Catalytic Reduction

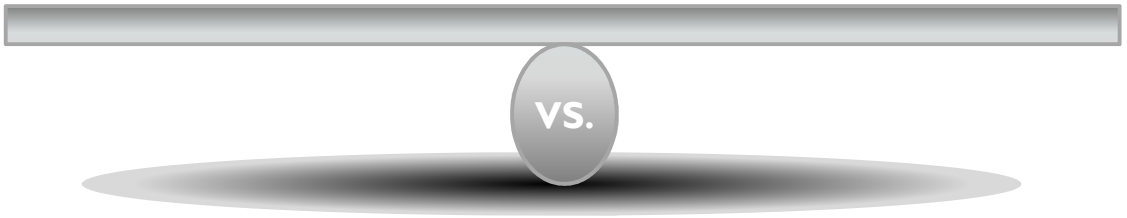
is a simple system that treats exhaust gases with Urea to eliminate pollutants and allows to maximise engine power

SCR

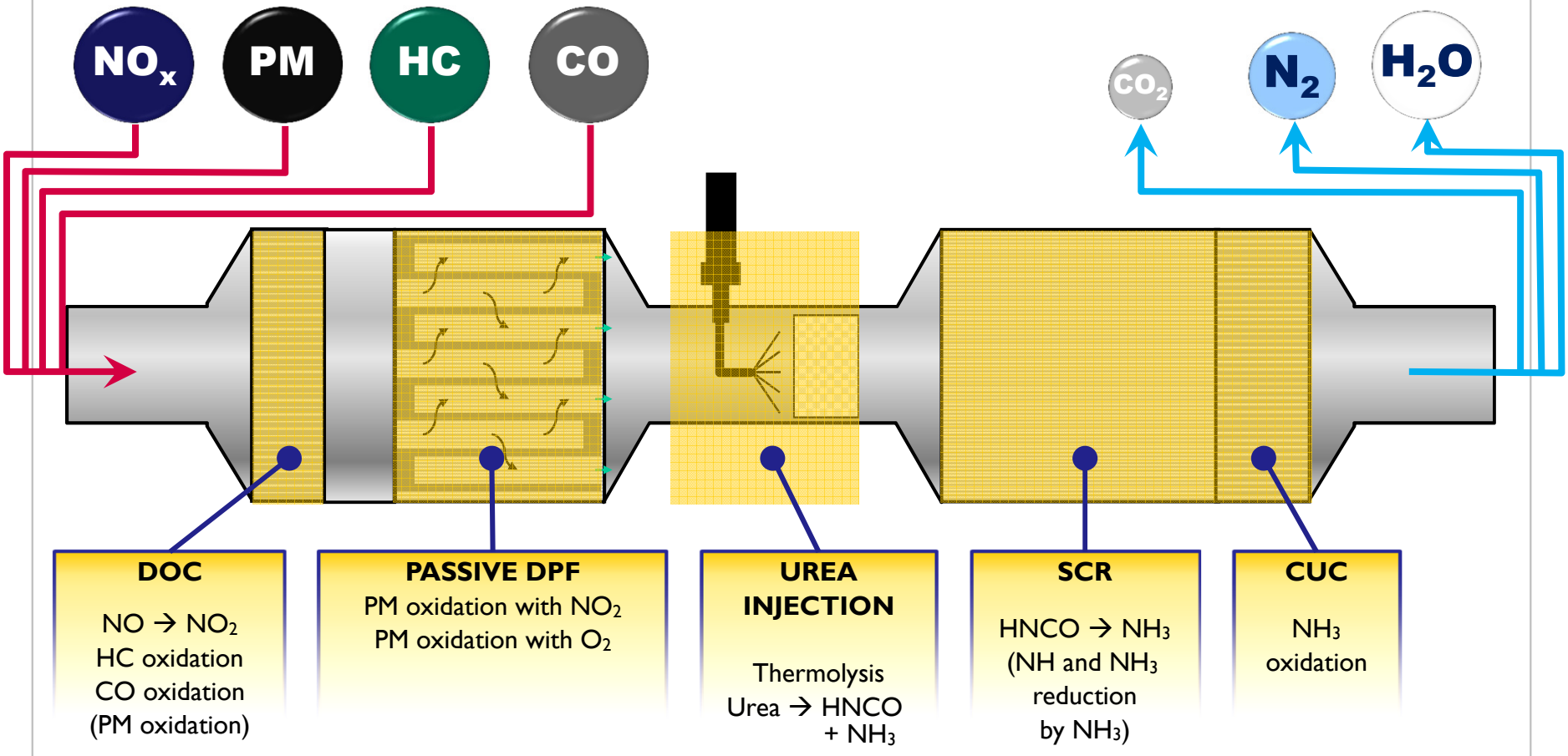
Exhaust Gas Recirculation

recirculates exhaust back into the engine to reduce combustion peak temperature and NO_x, but limits engine performance

EGR

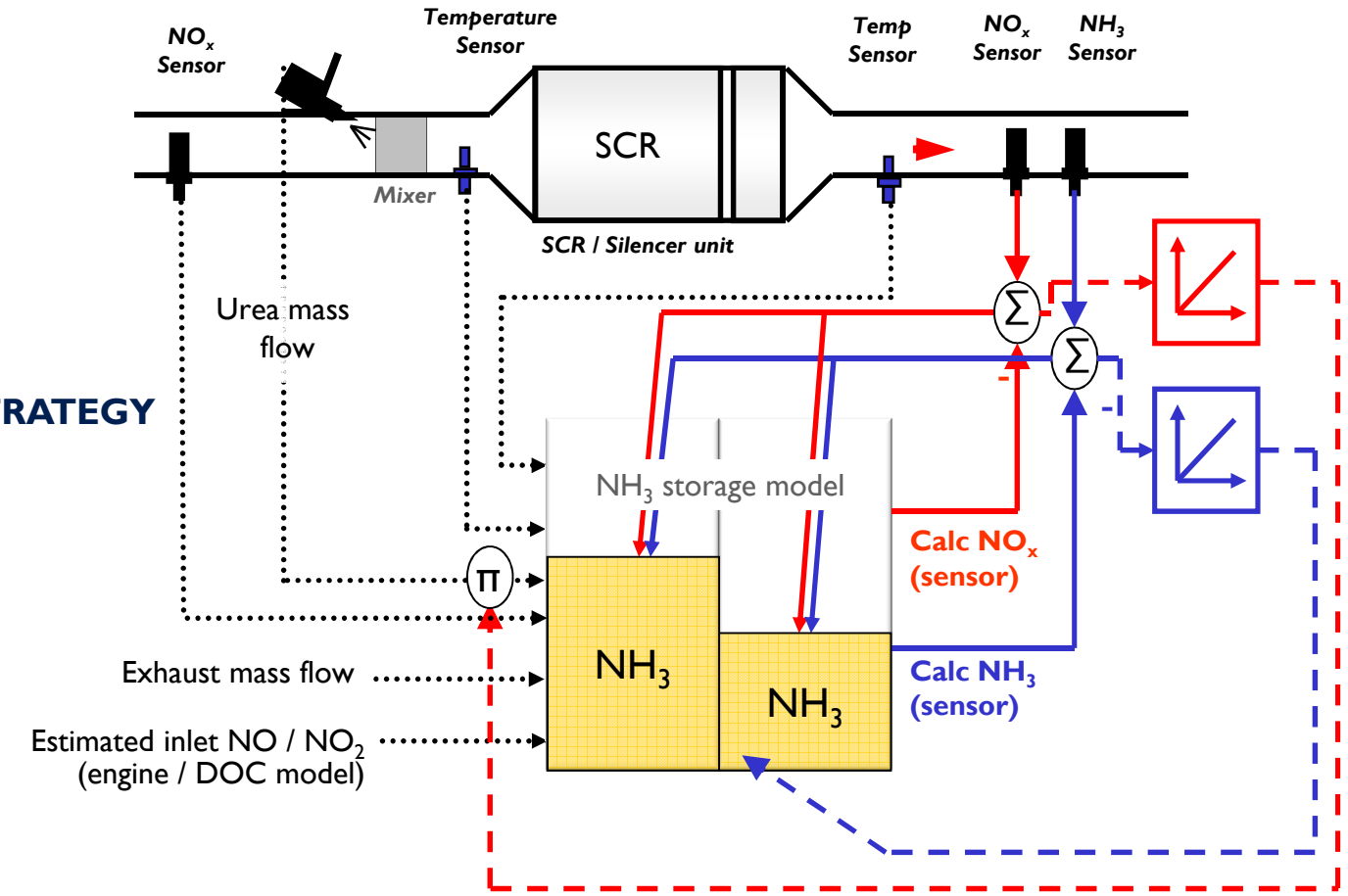


Hi-eSCR….SCR only



Hi-eSCR model-based control

MODEL-BASED UREA DOSING STRATEGY



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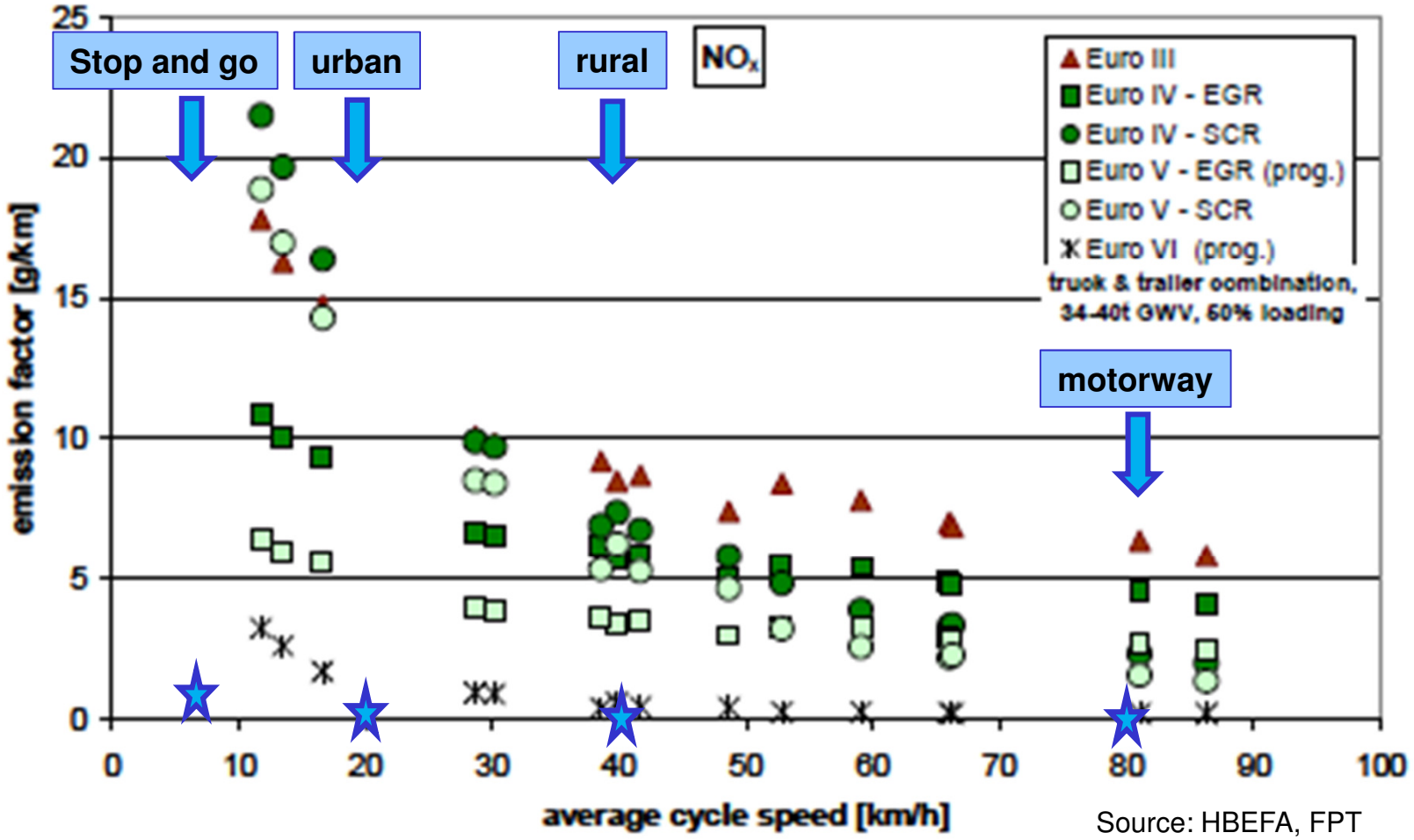
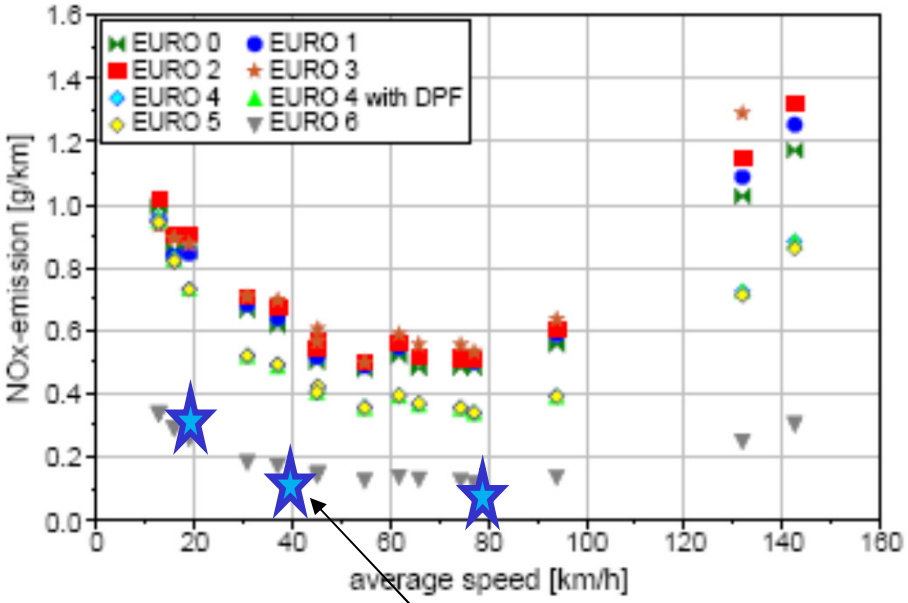
Euro VI NOx in use



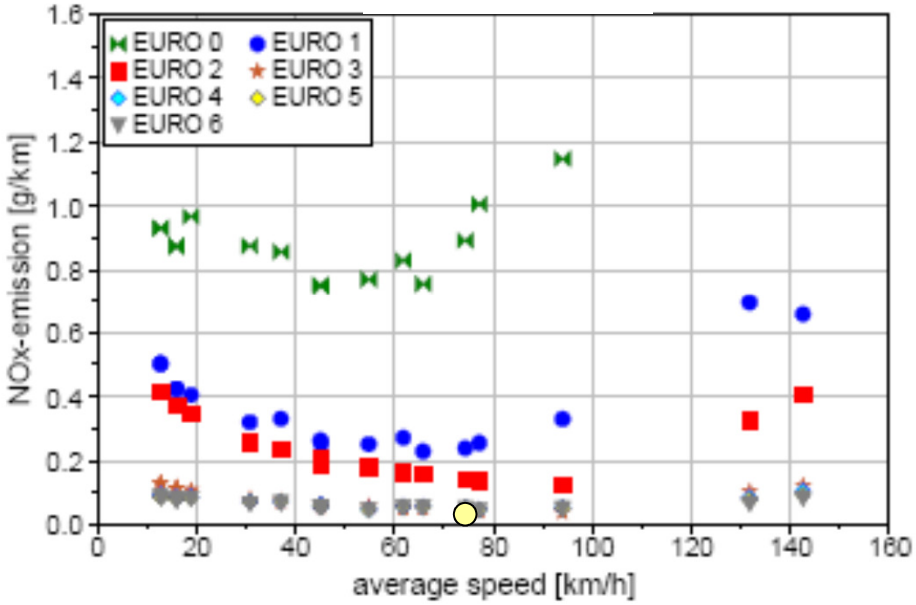
Source: HBEFA, FPT

Euro VI NOx in use, compared to pass car

Pkw Diesel



Pkw Benzin



Euro VI Truck 40t

- One Euro VI 40t truck-trailer has same NOx emissions as an average Euro 5/6 passenger car (g/km)

Quelle: TU Graz, HBEFA 3.1, EBT

Euro VI in use emission summary

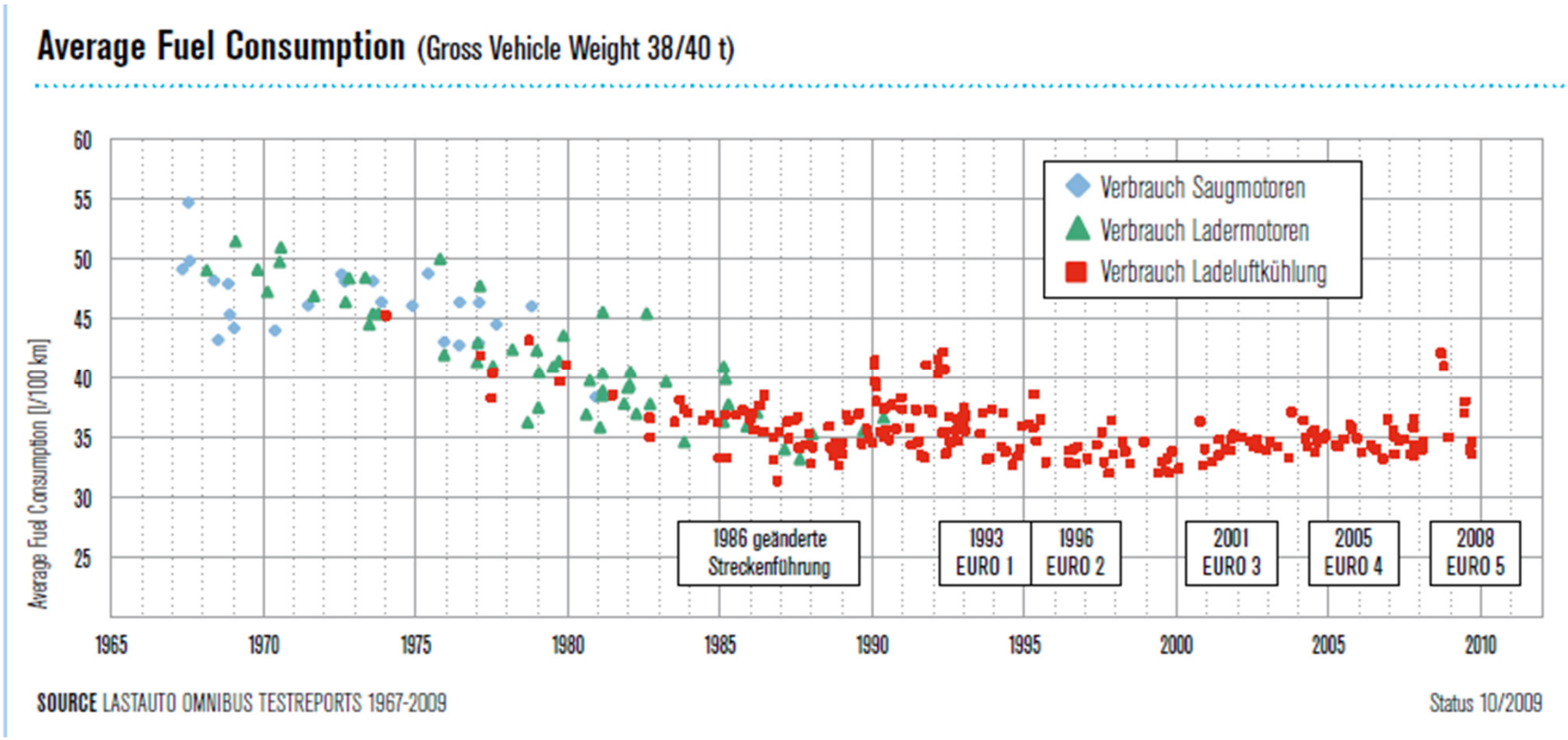
- On-road emissions of Euro VI heavy duty trucks (fully loaded) are on the level of a single passenger car. (in g/km)
- Criteria Pollutants in the exhaust are within max workplace conentration limits (ppm)

- The PEMS requirements will guarantee that emissions remain within the limits over the useful life of the vehicle

- There is no need for further reduction of criteria pollutatns

- Euro VI = near zero emission truck

Fuel consumption development



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Industrial diesel technology main drivers

IN RECENT YEARS

Innovation driven by
emissions legislation
NO_x / PM

Maintaining or improving
fuel consumption / CO_2
and operating cost

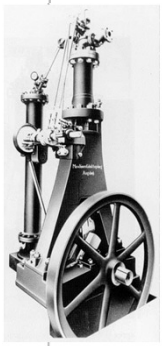
Improving
cost, reliability
and weight

Industrial diesel technology main drivers

PARADIGM CHANGE

Innovation driven by emissions legislation NO_x / PM	Innovation driven by fuel consumption / CO_2 and operating cost
Maintaining or improving fuel consumption / CO_2 and operating cost	Maintaining low NO_x / PM emission level
Improving cost, reliability and weight	Improving total cost of ownership, reliability and weight

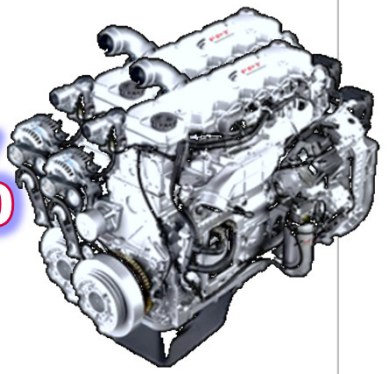
Diesel engine efficiency in the past



26% 39% 42%

THERMAL EFFICIENCY

>45%



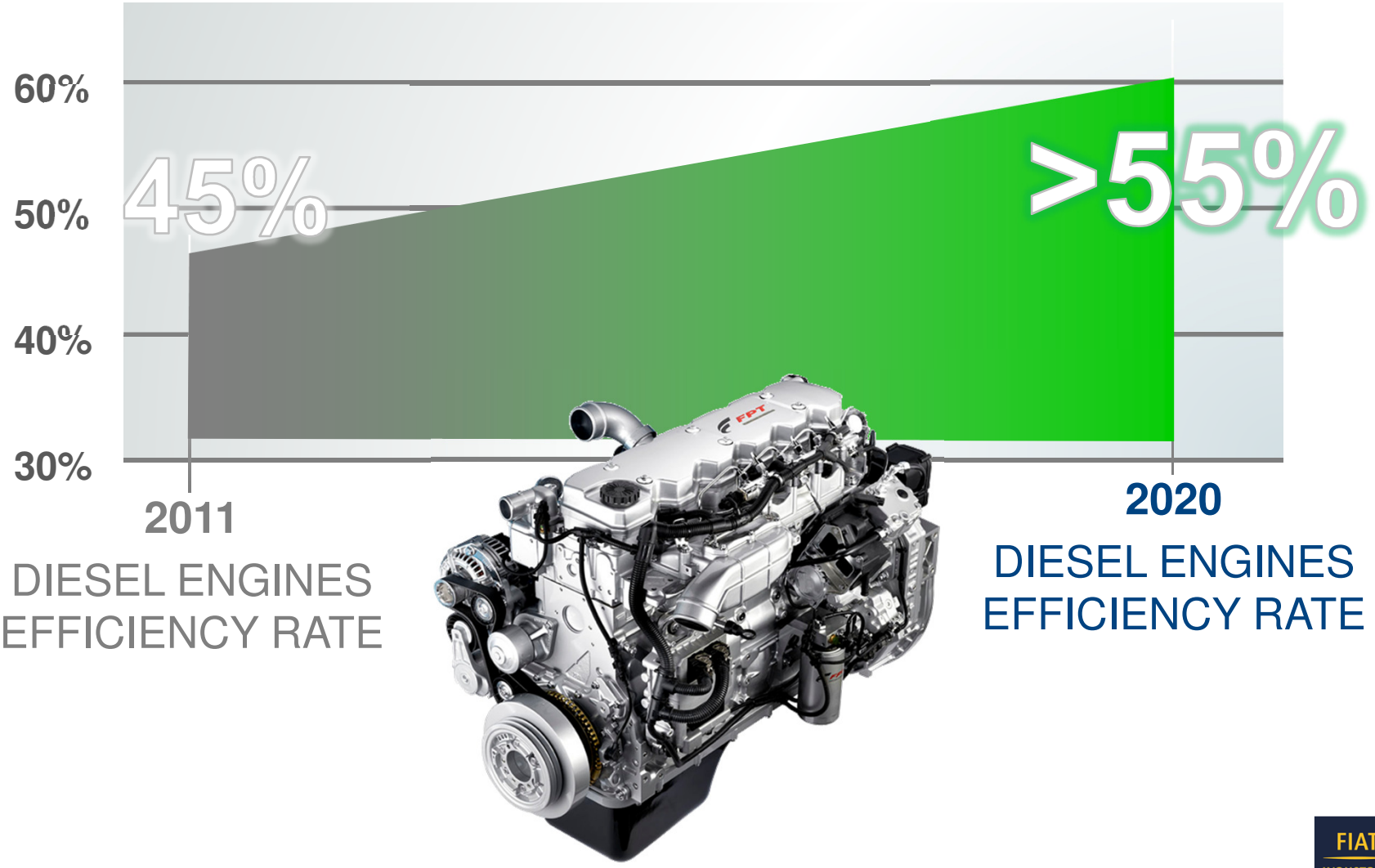
1893 — FIRST DIESEL ENGINE

1980 — FIRST TURBOCHARGED HEAVY DUTY ENGINE

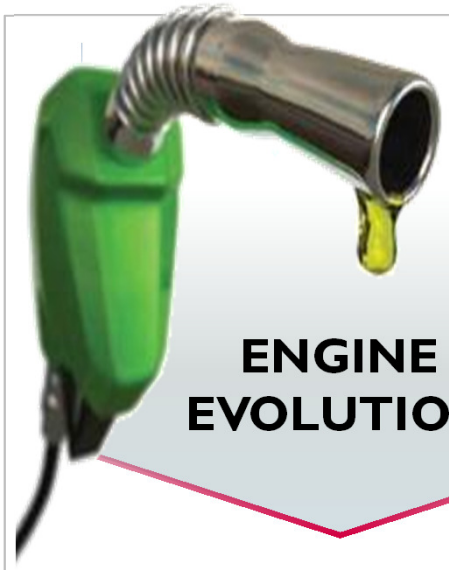
1999 — ADVANCED AIR-HANDLING SYSTEMS

2012 — EURO VI HI-eSCR ENGINES

Future Thermal Efficiency (BTE) Targets



FPT INDUSTRIAL future innovation scenario



HOW TO ADDRESS FUEL CONSUMPTION ISSUE?

ENGINE EVOLUTION

- Combustion efficiency
- FC-optimised gear shifting
- Air handling

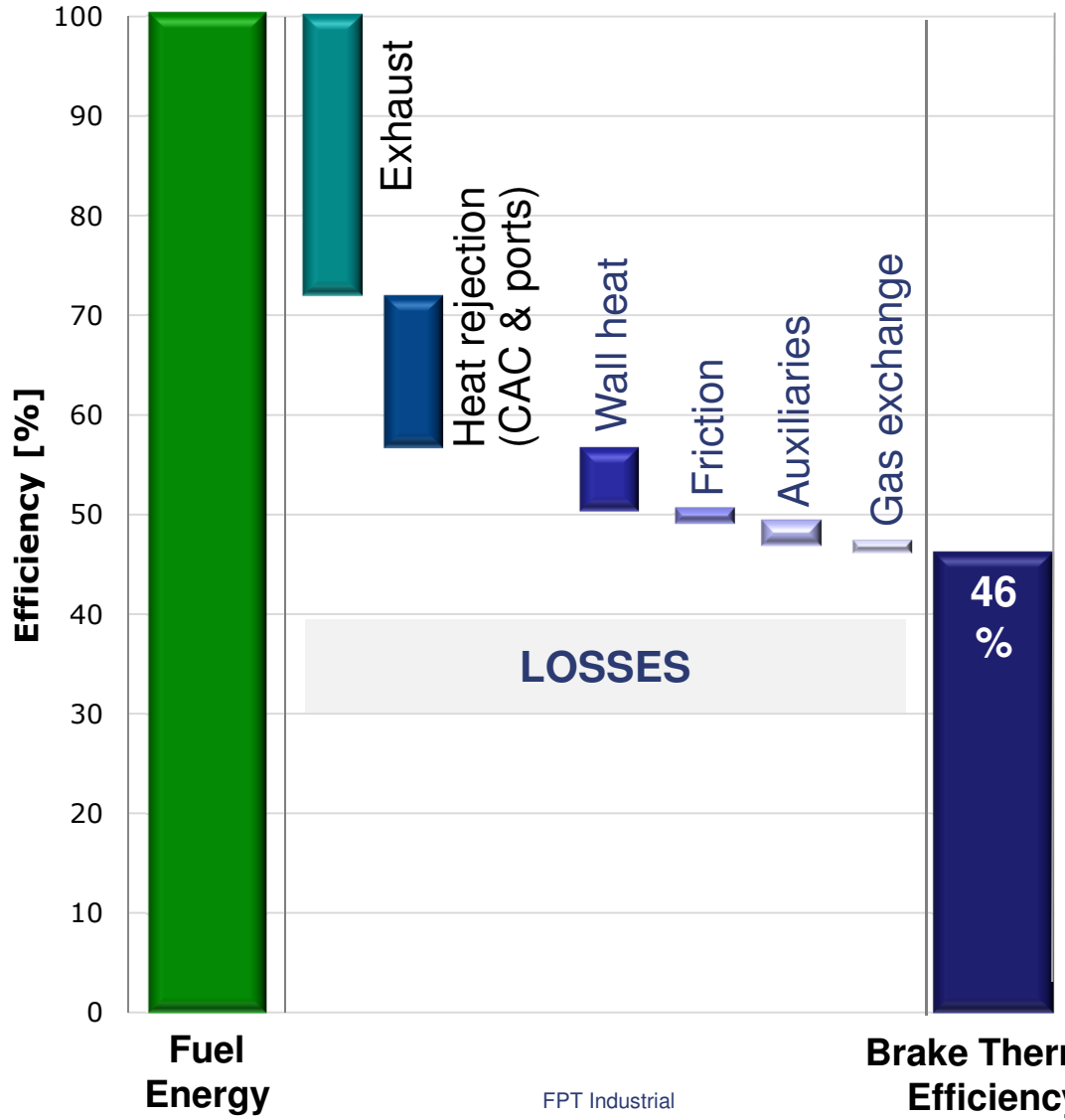
ENERGY MANAGEMENT

- Thermal management
- Auxiliary management
- Friction reduction

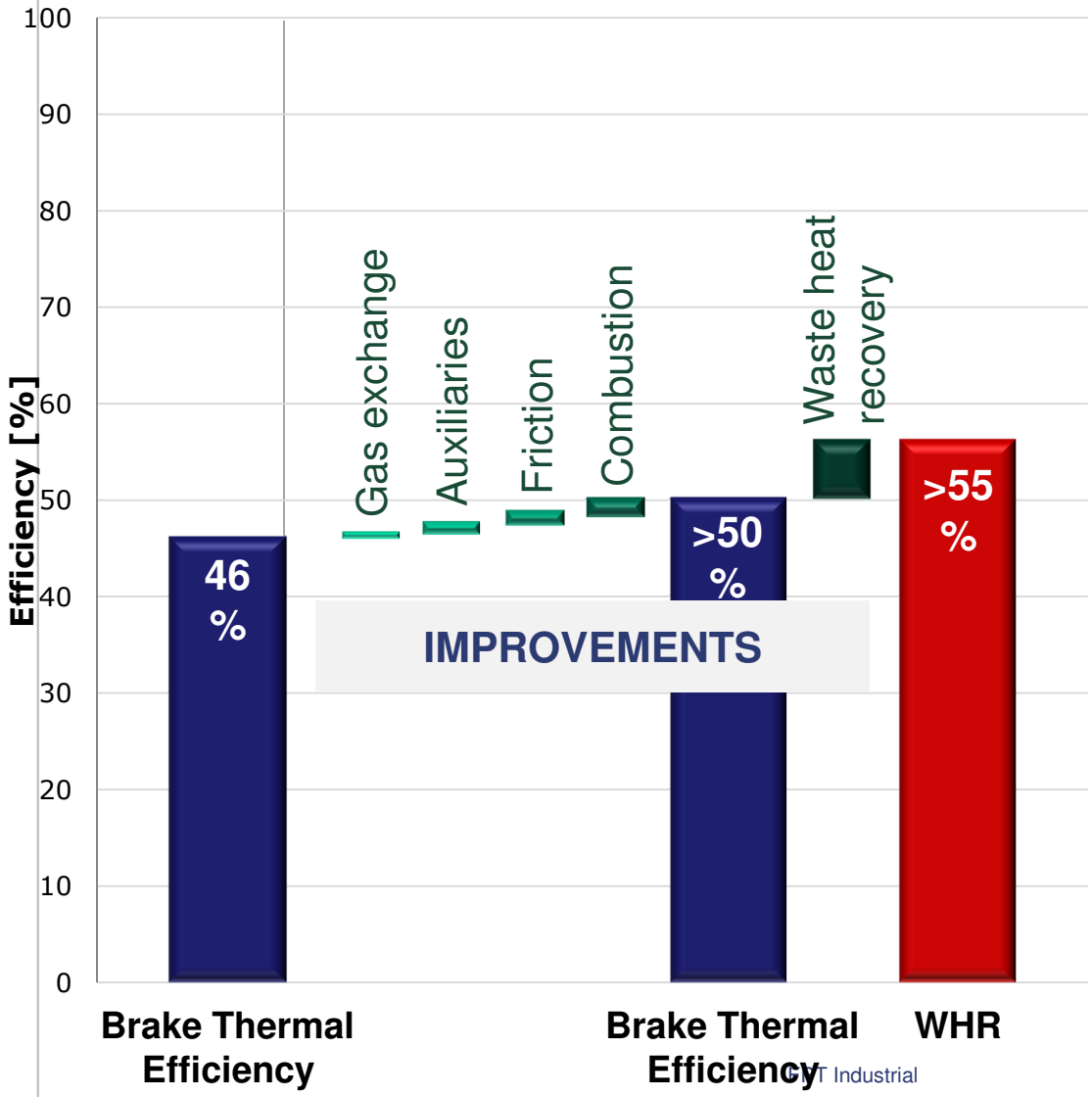
ENERGY RECOVERY

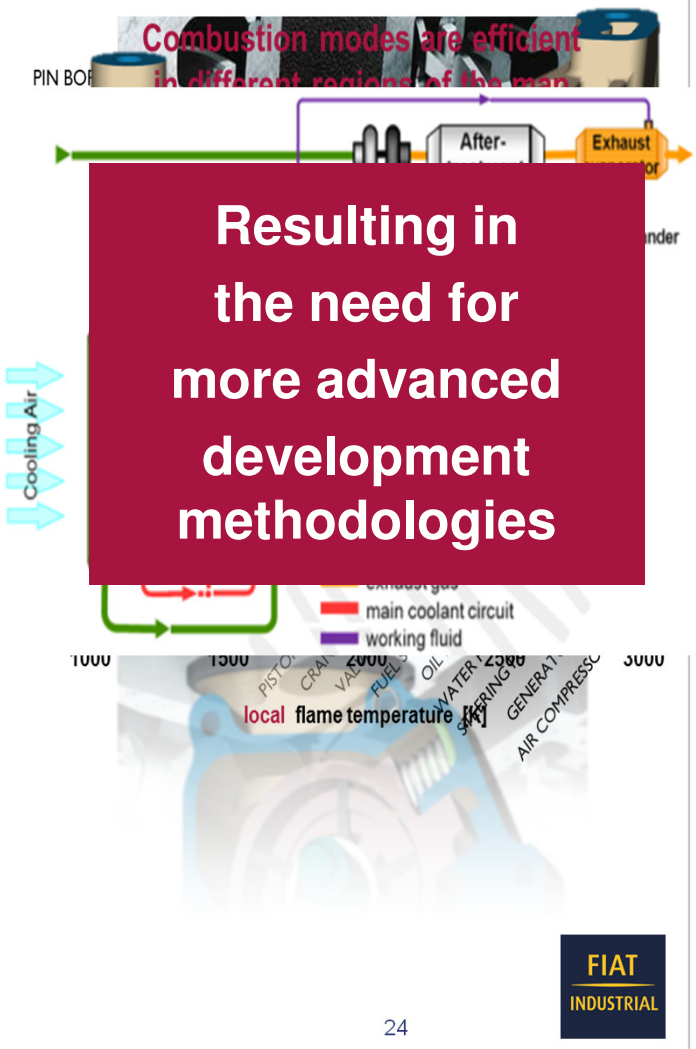
- Advanced turbo systems
- Waste-heat recovery
- Brake-energy recovery

Thermal efficiency today

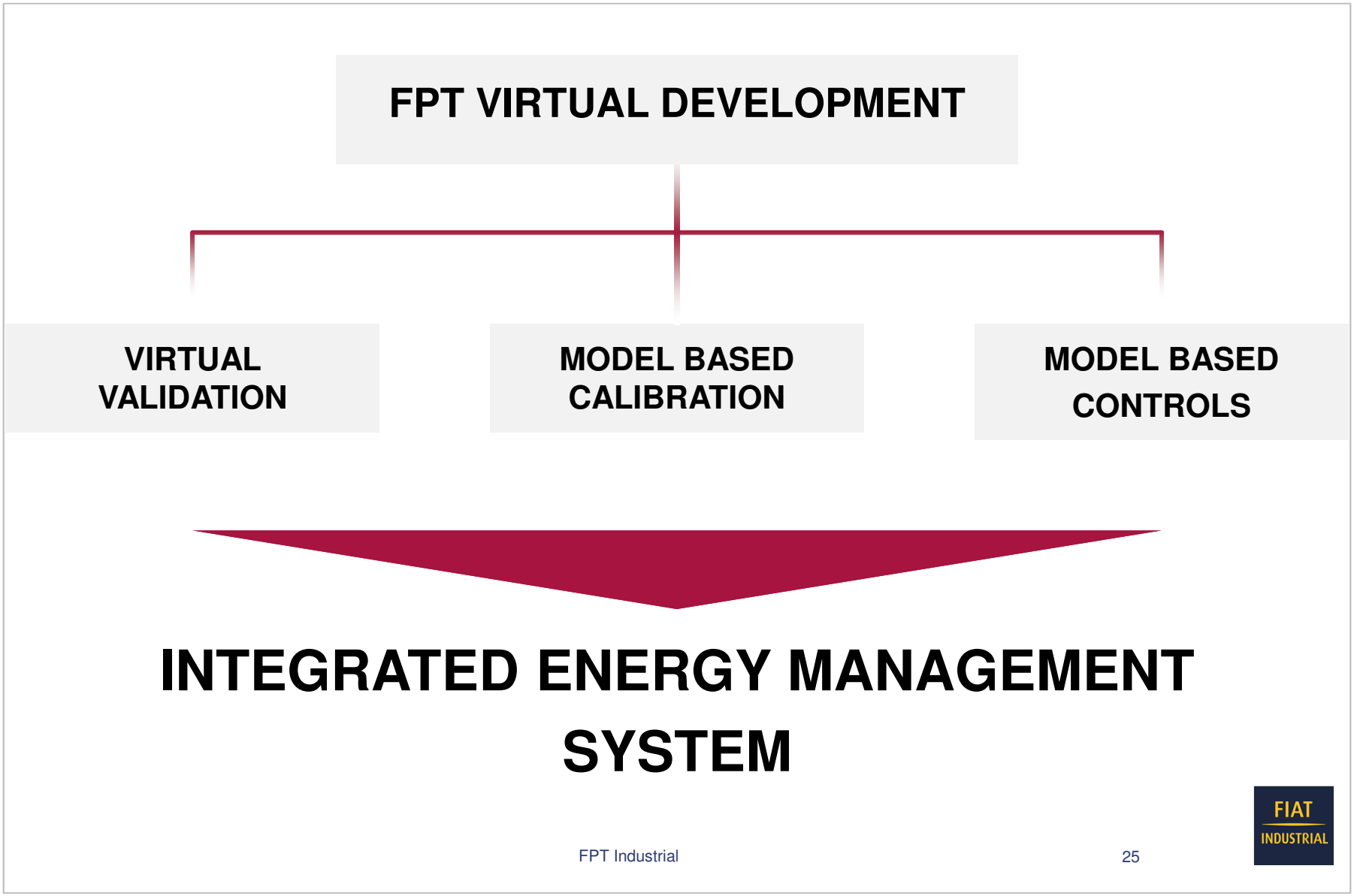


Todays feasible version 2020

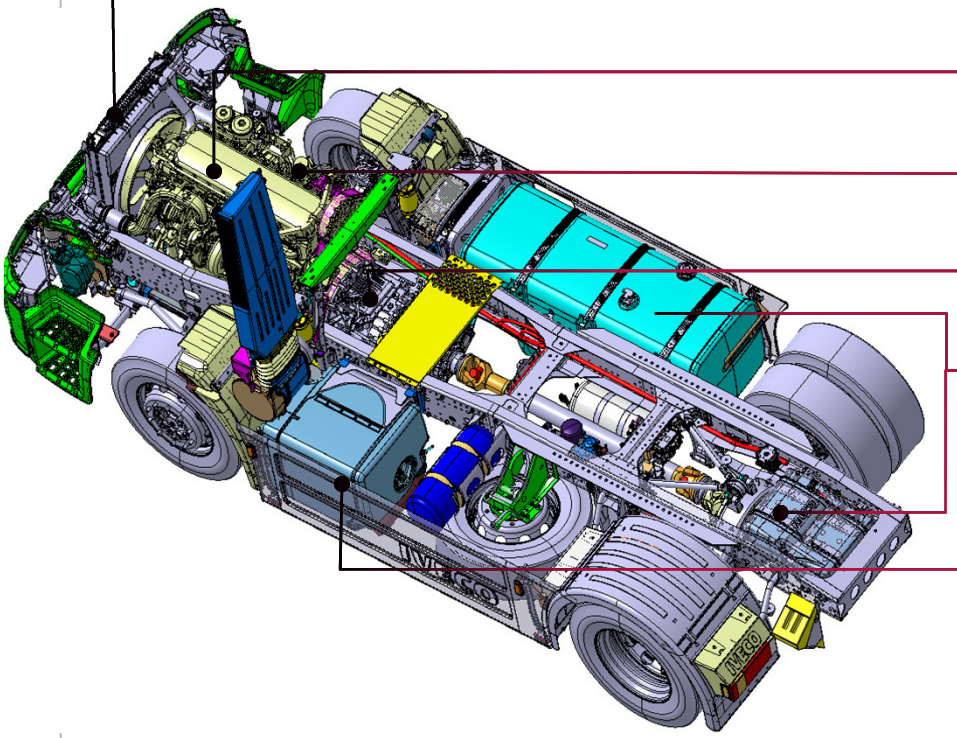




«FPT Virtual Development»



Energy management system



- Cooling system
- Engine
- Auxiliaries
- Gearbox
- Energy storage
- After treatment

(Thermal Management)

Managed with one integral model based control system

HD CO2 European Simulation based approach

Major parts of a „Simulation based approach“

Mandatory data for CO2-declaration implemented in simulation tool

Cycles for each vehicle class

Target speed vs. distance

Slopes vs. distance

Trailer/body specification

Specification of one standard trailer and/or body for each vehicle class

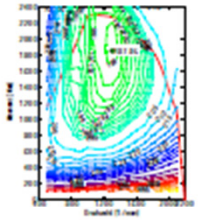
Metrics

g/t-km
g/m³-km
g/passenger-km

Weight definition

Vehicle class specific weight definition for simulation/test

Certified air drag, driveline drag, rolling resistance auxiliary drag



Certified engine fuel map

Certified input data from OEM

Additional OEM specific data:
Transmission and axle ratios
tire sizes, …

Simulation tool
(provided by legislative bodies)

Concept to cover vehicle control strategies

1. **Generic models/algorithms**
   ⇨e.g. driver model for manual transmissions
2. **Generic technology-specific models/algorithms**
   ⇨e.g. models for 1-cyl-aircompressor or 2-cyl-air compressor
3. **Generic models/algorithms + OEM-specific parameter**
   ⇨ e.g. cruise control with OEM 's overspeed/ underspeed limits
   ⇨ OEM's parameter have to be open and need to be verifiable

Result from simulation

⇨CO2/FC values
⇨ Average speed

+

Benefits by ECO-innovations

ACEA CO2 workgroup HDV – October 2012

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Summary and Conclusions

- Euro VI Nutzfahrzeuge have reached near zero emission status.
- The European emission legislation was a good guide line to direct the on-road heavy truck industry to this success.
- Now a paradigmen change is needed.
- Staying at the reached near zero emission level and focussing on efficiency improvements with reduction in fuel consumption and CO2 emission.
- With the introduction of a CO2 directive no further decrease of the already existing emission limits is nesseccary to avoid over-regulation.