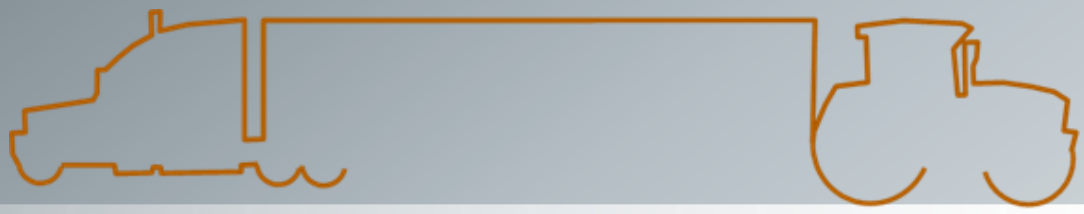
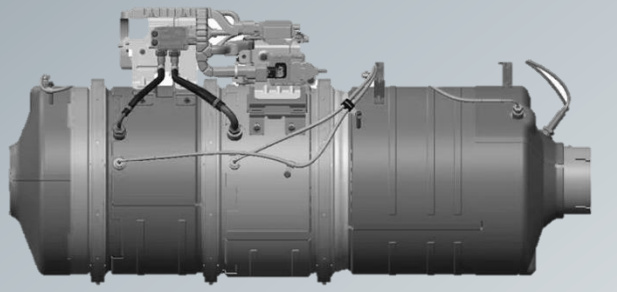


Advancements in Vehicle Emission Control Technologies



August 30th 2016

Steve Johnson

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Summary

- **Real-World Driving Emissions**
  - Introduction
  - Measuring and Controlling
  - Legislation
  - ISC testing
  - Energy efficiency
  - Around the World
- **Conclusion**

Real-World Driving Emissions
Introduction

~ 40%

Divergence between real-world and type-approval CO_2 emissions

4 to 7

Times higher real-world NOx emissions than limits set by Euro 6 standards

Room for improvement

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Real-World Driving Emissions
Introduction

- Trigger for elaboration of RDE test methods are mainly **NO_2 air quality problems caused by vehicles with diesel engines**.

NO_2 Emission ● > 45 µg/m³

PM_{10} Emission ● > 40 µg/m³

Source: European Environmental Agency (2012)

- **Some European areas show very high Particulate Matter (PM) and NO_2 levels.**

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Real-World Driving Emissions
Introduction

- **In-laboratory emissions** are calculated from engine certification cycles (FTP, UDDS,…)
  - Developed during the 1970s — traffic patterns have changed.
  - Not much representative of in-use/on-road operation — only using models to predict real-world performance.

- **Real-world testing** relies on **Portable Emissions Measurement Systems (PEMS)** to check the emissions
  - Avoid the extraction of the engines from machines
  - Enable to check functionality of the emissions control technologies
  - Represent an implicit protection against defeat strategies.

Real-World Driving Emissions
Measuring and Controlling

- **Real-world measurement technologies used or in development**
  - **Portable Emissions Measurement System (PEMS):** installed on vehicle's tailpipe. Limited in size, weight, power consumption compared to laboratory equipment →must have same level of accuracy

  - **Remote Sensing Emission testing:** Technology which uses infra-red and ultraviolet light to detect emissions while vehicles pass by on highways/public roads.

    Efficient for measuring CO, still perfectible for HC and NOx.

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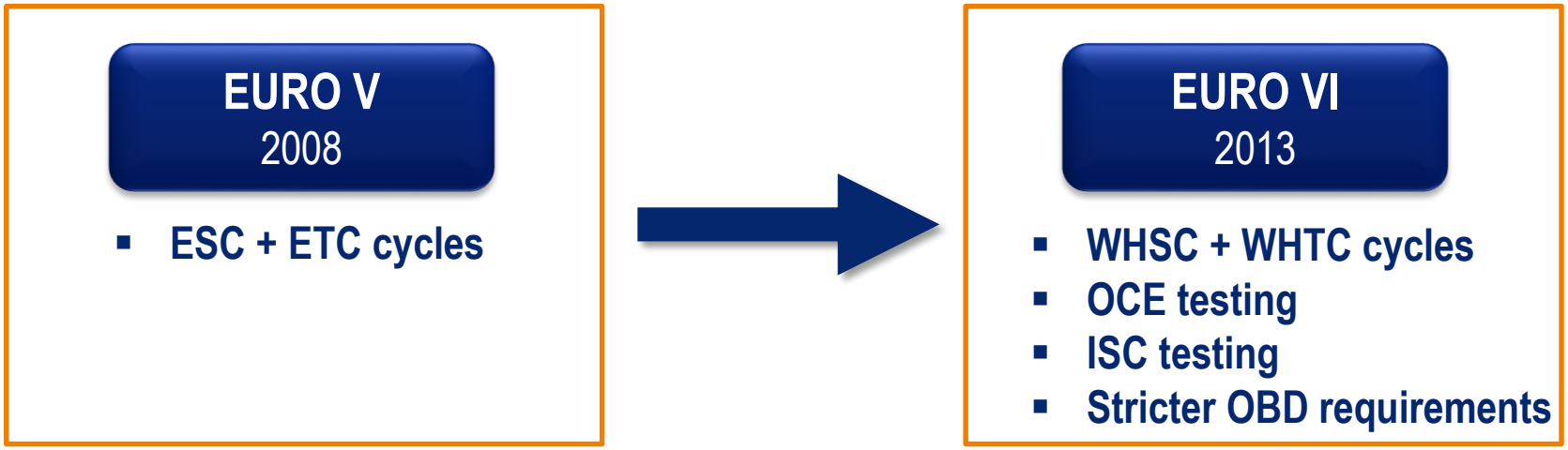
Real-World Driving Emissions
Legislation

- **From 2013 onwards, Heavy-Duty vehicle emissions are required by Euro VI standards to be carried out in normal everyday traffic conditions.**



- **World Harmonized Transient Cycle (WHTC) :** test based on the worldwide pattern of real heavy commercial vehicle use.
- **Off-Cycle Emissions (OCE) testing :** OCE measurements, performed during the type approval testing, follow the NTE (not-to-exceed) limit approach. A control area is defined on the engine map. The control area is divided into a grid. The testing involves random selection of three grid cells and emission measurement at 5 points per cell.

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Real-World Driving Emissions
ISC testing

- **In-Service Conformity (ISC) testing :** Euro VI regulation introduced in-use testing requirements that involve **field measurements using PEMS**.
  - The testing is conducted over a mix of urban (0-50 km/h), rural (50-75 km/h) and motorway (> 75 km/h) conditions, with exact percentages of these conditions depending on vehicle category. First in-use test should be conducted **at the time of type-approval testing**.
  - The total amount of pollutant emitted should be comparable to that emitted during the certification cycle (within a **conformity factor of 1.5**) →NTE limit approach.
  - Cold start and DPF regeneration emissions are not considered yet.
  - The application of PEMS for PM measurement is not straightforward.

- Europe is currently the most advanced region for measuring real-world emissions on HD vehicles, the USA are on the same path with their In-Use Compliance (IUC) testing.

Real-World Driving Emissions
ISC testing

- **SCANIA example**
  - Owner of 3 trailer-mounted mobile test labs.
  - Emissions checked from at least 50 vehicles per year.
  - Trucks are loaded with ballast corresponding to 50 to 60% of their payload.
  - Each test run takes between 3 to 4 hours and is designed to be as realistic as possible (city, rural and highway roads).
  - Once a test lab has been attached to a tractor, it is **connected to the vehicle's OBD system and an exhaust gas analyzer is mounted on the tailpipe**.

Real-World Driving Emissions
ISC testing

- PEMS were proven to exhibit nearly similar performance to laboratory grade equipment and were accordingly **approved by both the USEPA (2005) and the EC (2009)** for use in **engine certification** but also for **in-service compliance (ISC)** – in-use compliance (IUC) in the USA.

- Long term legislation is to change from ISC to RDE as well, meaning it will take cold start and DPF regeneration into account for emission certification in the future.

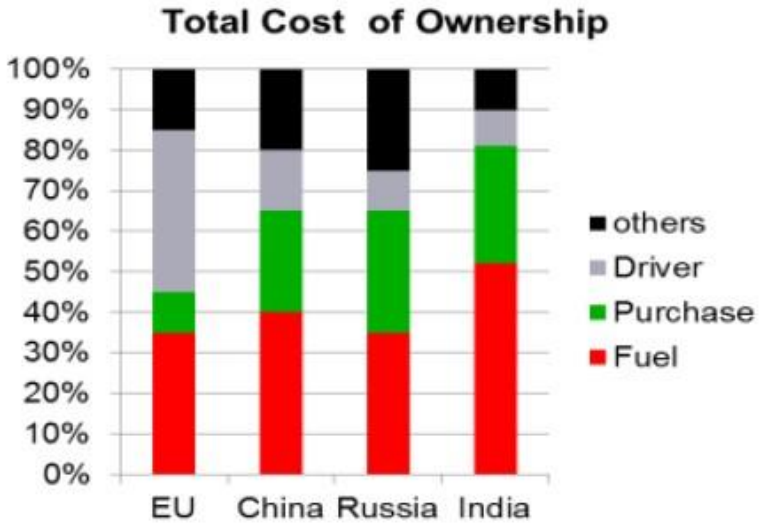
- **The European Union currently has no limits on truck emissions**, unlike other countries such as the United States, China, Japan and Canada, which already have truck fuel efficiency standards.

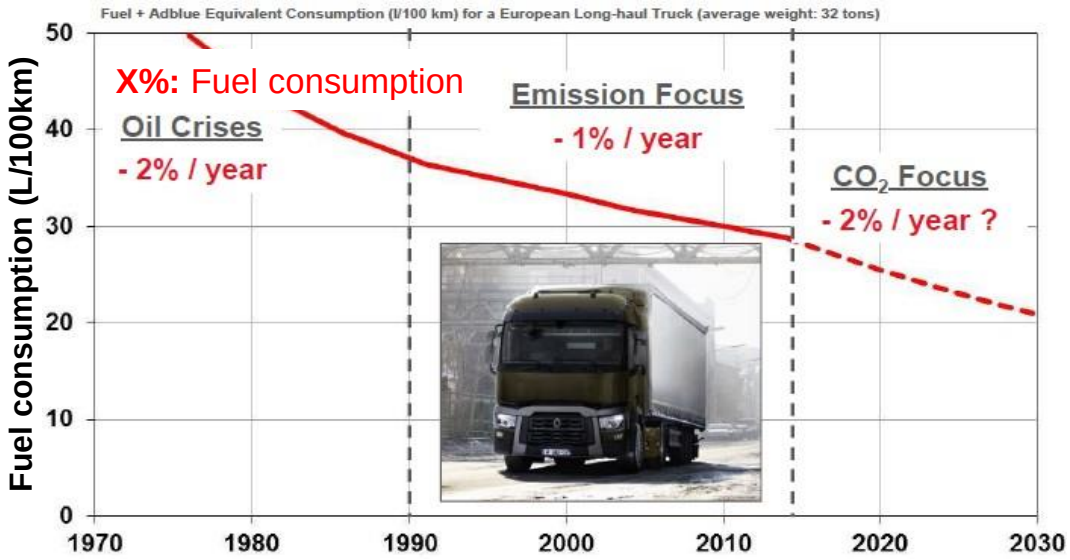
- **The European Commission will set fuel-efficiency standards for HD trucks in order to monitor more closely CO2 emissions from 2020.**

Real-World Driving Emissions
Energy Efficiency

- The next Euro VII regulations should focus on **CO_2 reduction**. This will be achieved mostly by keeping on **reducing the fuel consumption, which is one of the most important cost and factor for truck buyers.** Therefore reduction is already demanded by the market itself.

- **For long-haul trucks, there are still many areas of improvement.**





Source: Renault Trucks (2014)

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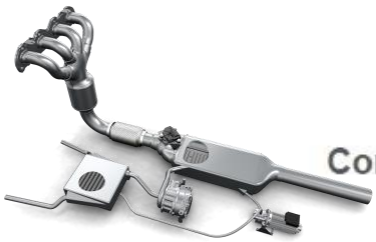
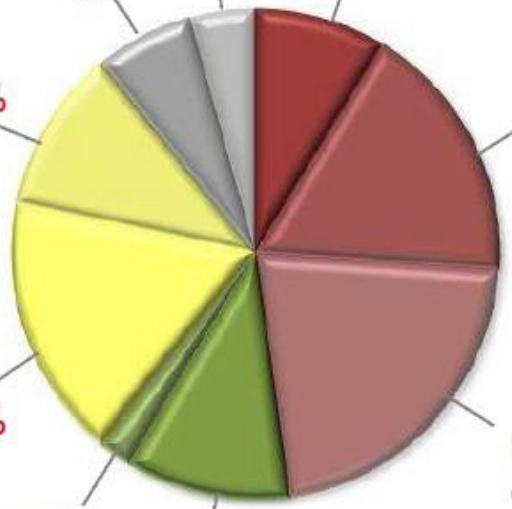
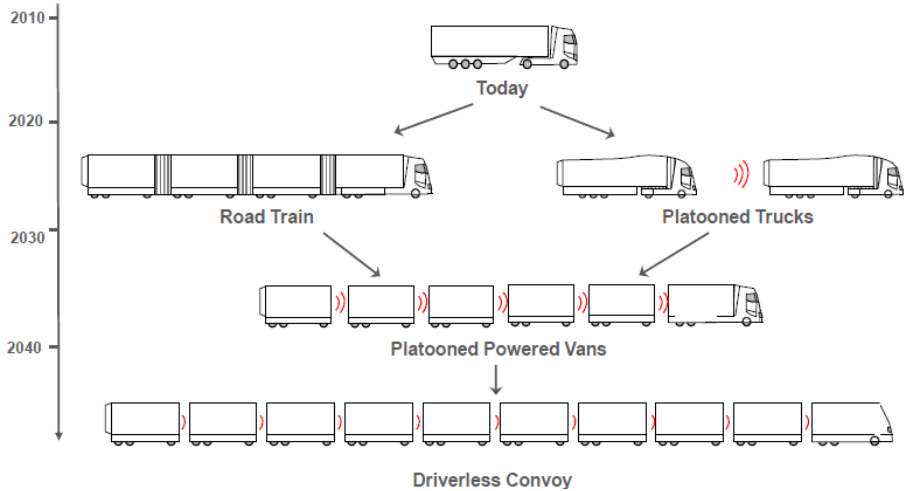
Real-World Driving Emissions
Energy Efficiency







X%: Potential consumption gain from 2015 to 2030

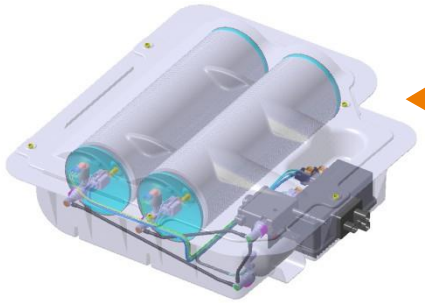
47% total

Source: Renault Trucks (2014)

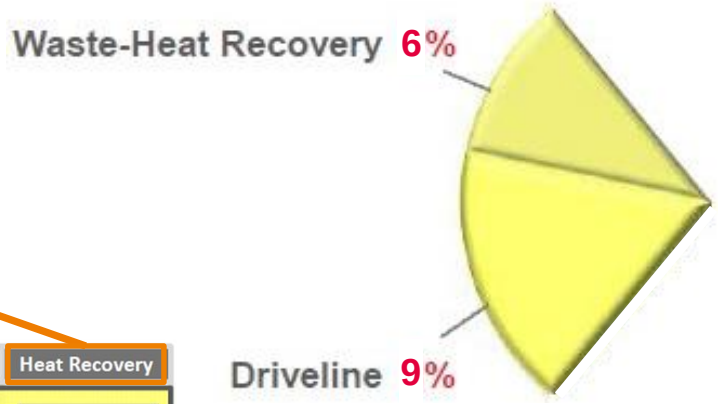
Real-World Driving Emissions
Energy Efficiency

WHRS

EHPG

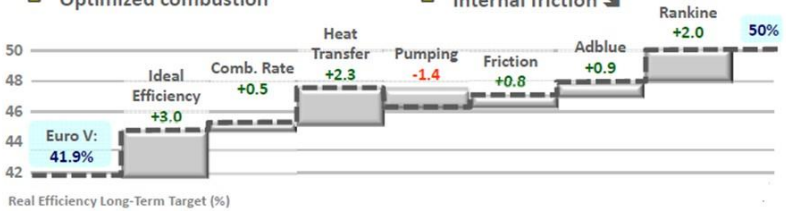


ASDS®



Inner Cycle	Outer Cycle	De-NOx	Combustion	Heat Recovery
Conventional 1-Piston 4-Stroke	Turbocharger One or Two-stage	Mild EGR SR or LR + SCR	Conventional Diesel Diffusion Flame	Second Cycle Rankine EGR & Exhaust

- Right speeding & sizing
- Less cylinders
- Compression ratio ↗
- Smart mild cooled EGR
- Optimized combustion
- Turbocharger efficiency ↗
- Inlet manifold temperature ↘
- Exhaust insulation ↗
- EATS restriction ↘
- Internal friction ↘



- **Faurecia Emissions Control Technologies (FECT)** has an active role to play on **one third** of these future energy savings**.**
- Products like **Waste Heat Recovery System (WHRS)** and **Ammonia Storage Delivery System (ASDS)** are already in production, as well as **Exhaust Heat Power Generation (EHPG).**

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Real-World Driving Emissions
Around the World

- **EU :** Leading the way for real-world emissions.
- **USA :** Not to Exceed (RDE) measurement with PEMS under evaluation.
- **South Korea: No official discussion** on developing and implementing GHG and fuel efficiency regulations in South Korea currently, but as the country has now implemented the most advanced phase of criteria pollutant regulation, it is likely that attention will turn to how and when **such standards could be implemented**.
- **Japan**: Japan was the first country to introduce **fuel efficiency standards in 2005**, which were made fully enforceable in 2015, allowing time for various national standards to converge into one.

Real-World Driving Emissions
Conclusion

- Emissions have **decreased by 90% in 25 years** mostly thanks to the generalization of aftertreatment systems (DPF and SCR).
- PEMS can effectively control vehicle gaseous emissions, accelerate the adoption of novel emission abatement technologies and will thereby contribute to air quality improvements.
- **In-Service Conformity testing** will also soon apply to **Non-road vehicles**.
- For long-haul trucks, most of the energetic gain expected in the next 15 years is linked to the **reduction of the aerodynamic losses**. Important gains should also come from the Diesel engine through **energy recovery systems**.

Thank you for your attention!
Questions?

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Technical perfection, automotive passion