



PEUGEOT CITROËN
MOTEURS

*An automotive based diesel engine for
the Non-Automotive market.*

An obvious choice for US Tier 4 final



Summary



Introduction

Emission regulation

Non-road market diesel engine technology

PCM's policy and offer

Results on PSA engines

Conclusion



Introduction

Emission regulation

Non-road market diesel engine technology

PCM's policy and offer

Results on PSA engines

Conclusion



Introduction



powered by

PEUGEOT CITROËN
MOTEURS

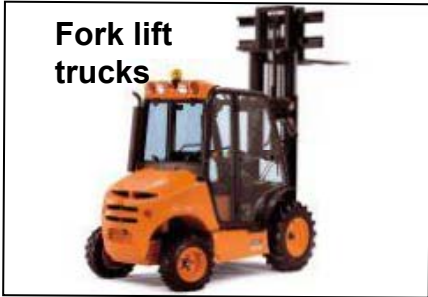
PCM is a division of PSA Peugeot Citroën which sells mechanical components to OEMs.

This activity started in 1898 with Mr Armand Peugeot starting the diesel engine plant in Lille.

PCM has one Century of experience in this business.



Introduction



Fork lift trucks



Construction eqpt



Lawn movers



On road maintenance eqpt



Airport ground eqpt

PCM has a long experience in the sales of automotive engines (gasoline, gas and diesel) for several non-road applications



Agriculture eqpt



Compressor



Fire pumps



Gen set

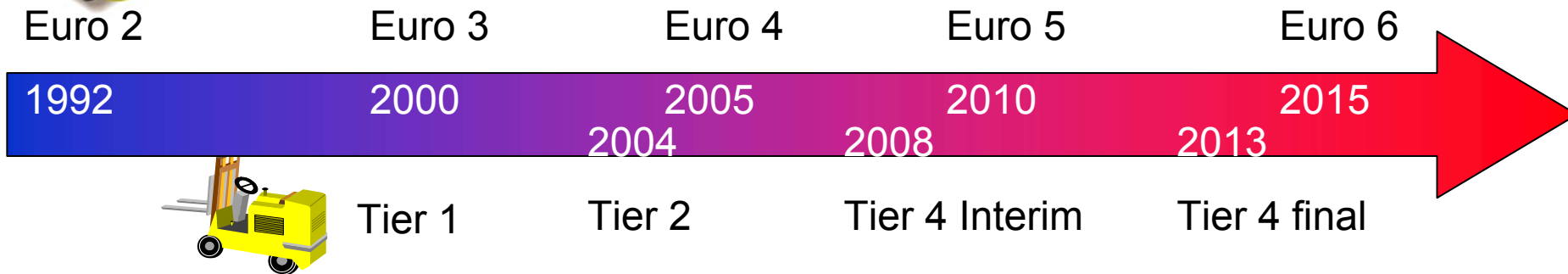


Marine applications



Introduction

Automotive Diesel technology has progressively evolved from indirect injection to common rail and post treatment technology during the last 20 years due to more and more stringent emissions regulations.



The industrial market is going to change completely in the immediate future driven by emission regulations...



Introduction

In such a context PCM believes that Automotive technology will come into force in the Industrial market with competitive advantages:

➤ *Pollutant regulation and*



- *Performance*
- *Consumption*
- *Noise*
- *Weight*
- *Maintenability ...and*

Price !!!



Introduction

Emission regulation

Off-road market diesel engine technology

PCM's policy and offer

Results on PSA engines

Conclusion



Emission regulation

Emission standards for non-road diesel engines

Area possible with PM and Nox post treatment

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | | |
|-------------|--------------------------|------|---------------------|------|-----------------|------------------|------|-----------------|---------------------------|------|---------------------------|-----------------|--------------------------|----------------|----|----|
| 56kW<P<75kW | 6.5 / (1.3 / 9.2) / 0.85 | | 5 / (1.3 / 7) / 0.4 | | | 5 / 4.7 / 0.4 | | | 5 / (0.19 / 3.3) / 0.025 | | 5 / (0.19 / 3.4) / 0.02 * | | 5 / (0.19 / 0.4) / 0.025 | | EU | |
| | - / NOx 9.2 / - | | 5 / 7.5 / 0.4 | | | 5 / 4.7 / 0.4 | | | 5 / (0.19 / 3.4) / 0.02 * | | 5 / (0.19 / 0.4) / 0.02 | | | | US | |
| 37kW<P<56kW | 6.5 / (1.3 / 9.2) / 0.85 | | 5 / (1.3 / 7) / 0.4 | | | 5 / 4.7 / 0.4 | | | 5 / 4.7 / 0.025 | | | 5 / 4.7 / 0.025 | | | EU | |
| | - / NOx 9.2 / - | | 5 / 7.5 / 0.4 | | | 5 / 4.7 / 0.3 ** | | | 5 / 4.7 / 0.03 | | | 5 / 4.7 / 0.03 | | | US | |
| 19kW<P<37kW | 5.5 / (1.5 / 8) / 0.8 | | | | 5.5 / 7.5 / 0.6 | | | 5.5 / 7.5 / 0.6 | | | 5.5 / 7.5 / 0.6 | | | 5 / 4.7 / 0.03 | | EU |
| | 5.5 / 9.5 / 0.8 | | 5.5 / 7.5 / 0.6 | | | 5 / 7.5 / 0.3 | | | 5 / 4.7 / 0.03 | | | 5 / 4.7 / 0.03 | | | US | |

CO / HC+Nox / PM in g/kWh

CO / (HC / Nox) / PM in g/kWh

* Other options can be possible

** PM 0.4 g/kWh if manufacturer complies with the 0.03 g/kWh standard from 2012



EU stage I
 EU stage II
 EU stage IIIa
 EU stage IIIb
 EU stage IV



TIER I
 TIER II
 TIER III
 TIER IV interim
 TIER IV final

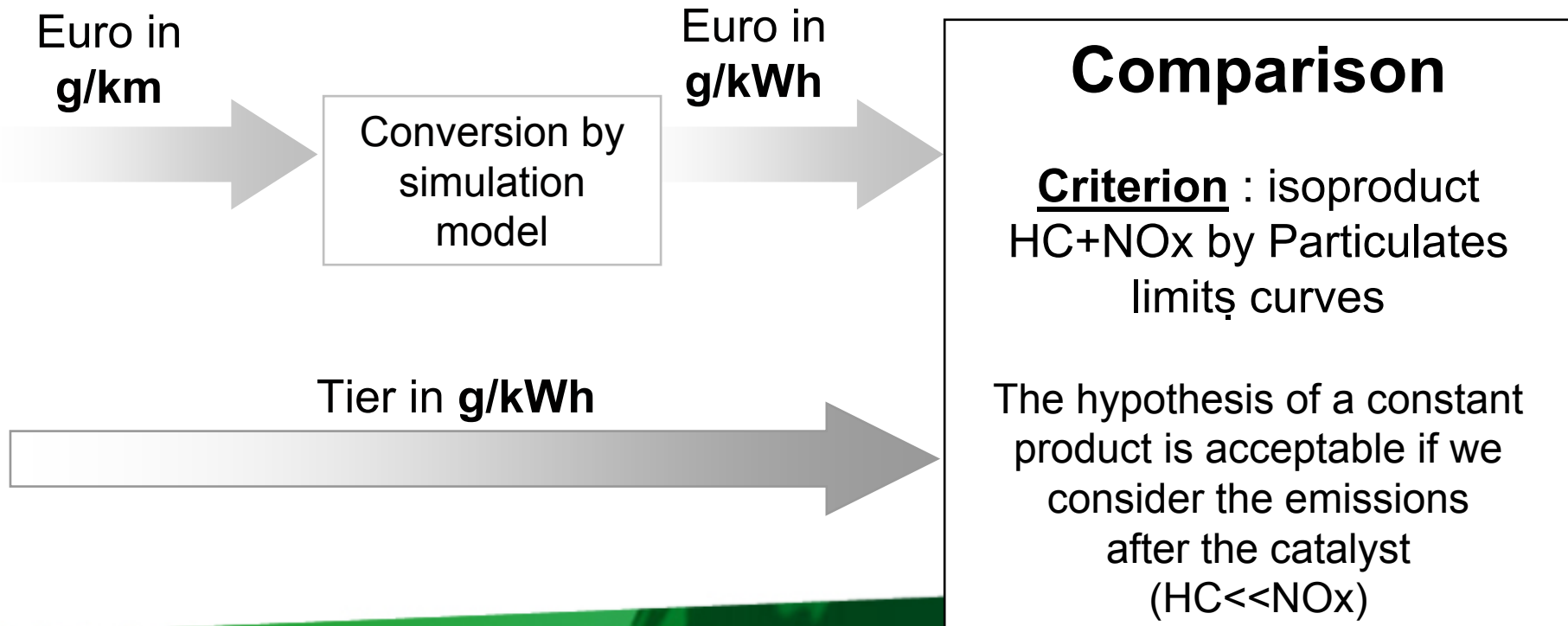
Area possible for PCM without NOX post treatment

PCM goal for TIER4 final : 5,5 / 4,7 / 0,025 for 19 to 56 kW



Emission regulation

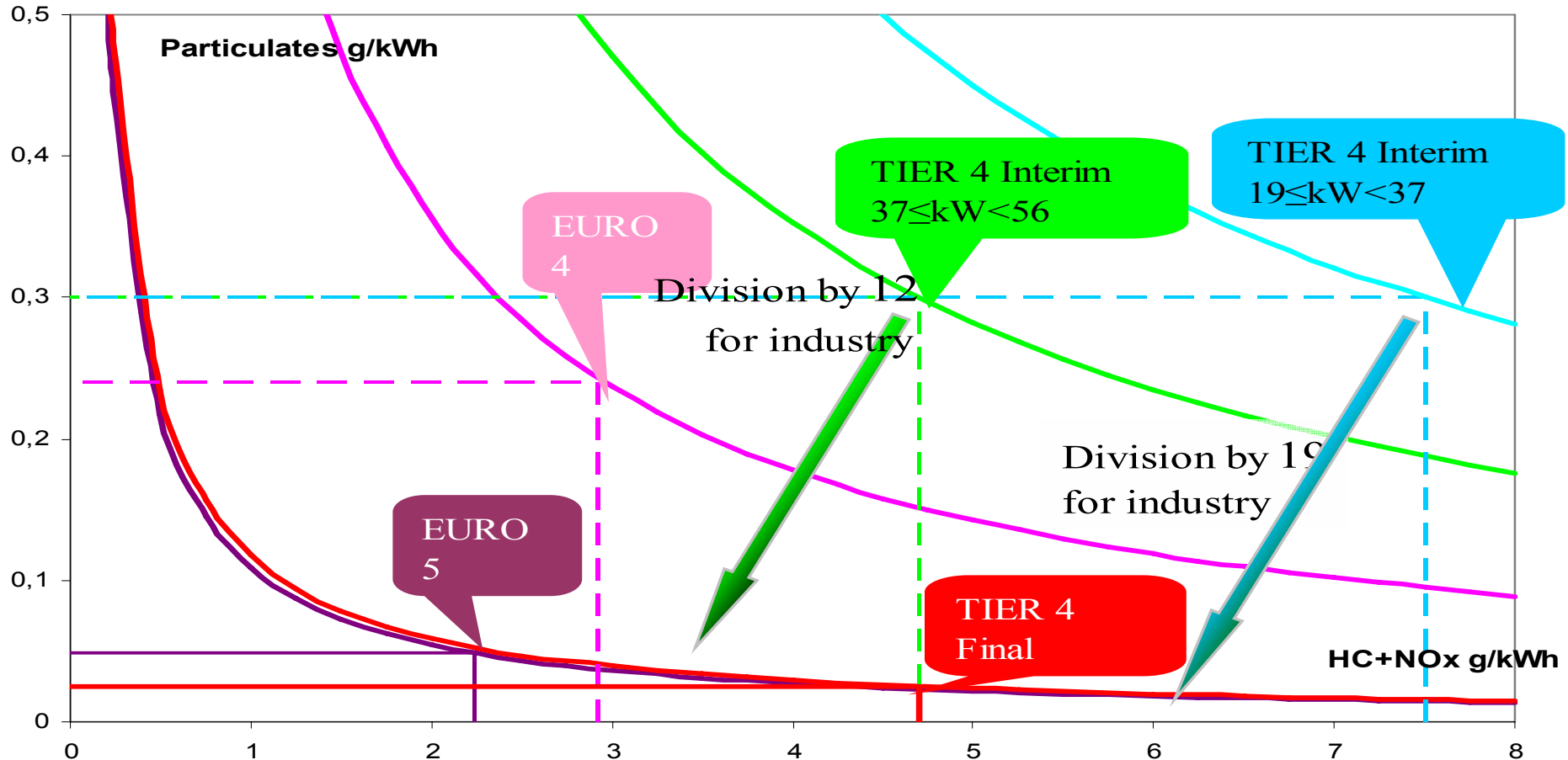
We have converted Euro figures from g/km to g/kWh to compare US EPA Tier with Euro limits - in g/kWh - for a mid size vehicle in the range from 19 to 56 kw.





Emission regulation

The severity can be plotted by the HC+NOx/Particulates balance

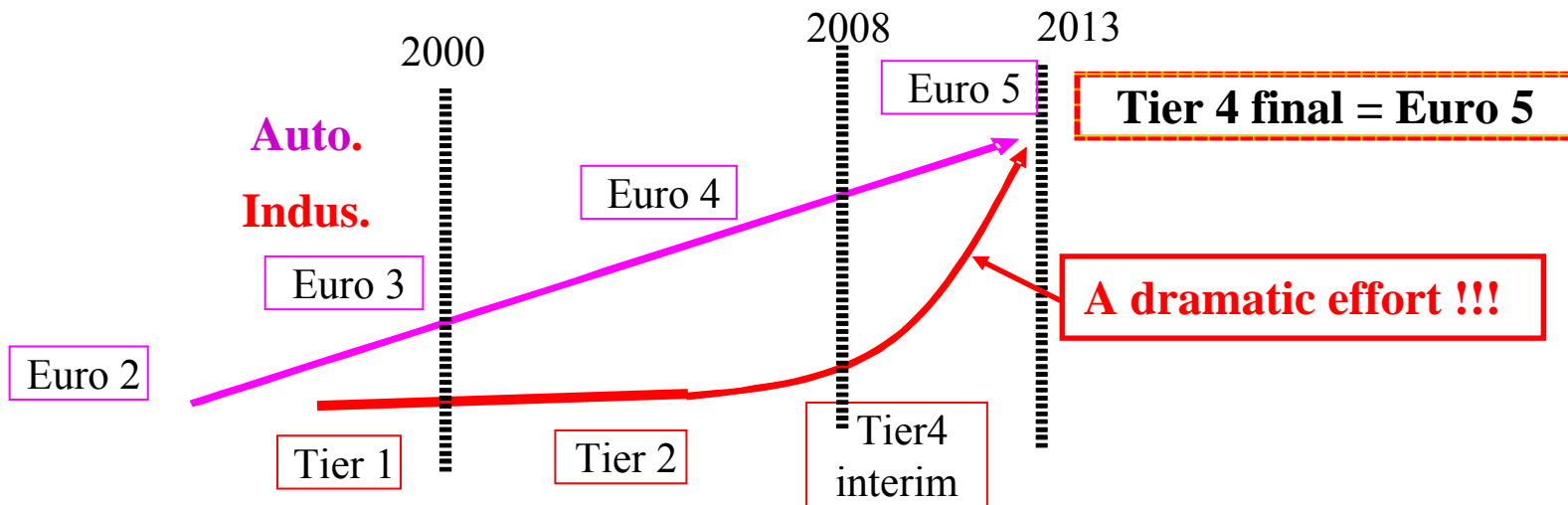


TIER 4 Final is very similar to automotive Euro 5



Emission regulation

- *Industrial Standards will change significantly in a very short time between Tier 4 interim and Tier 4 final*
- *Tier 4 final is very similar to automotive Euro 5*



➔ *The PSA Automotive Euro 5 technology is already available to pass Tier 4 final*



Introduction

Emission regulation

Non-road market diesel engine technology

PCM's policy and offer

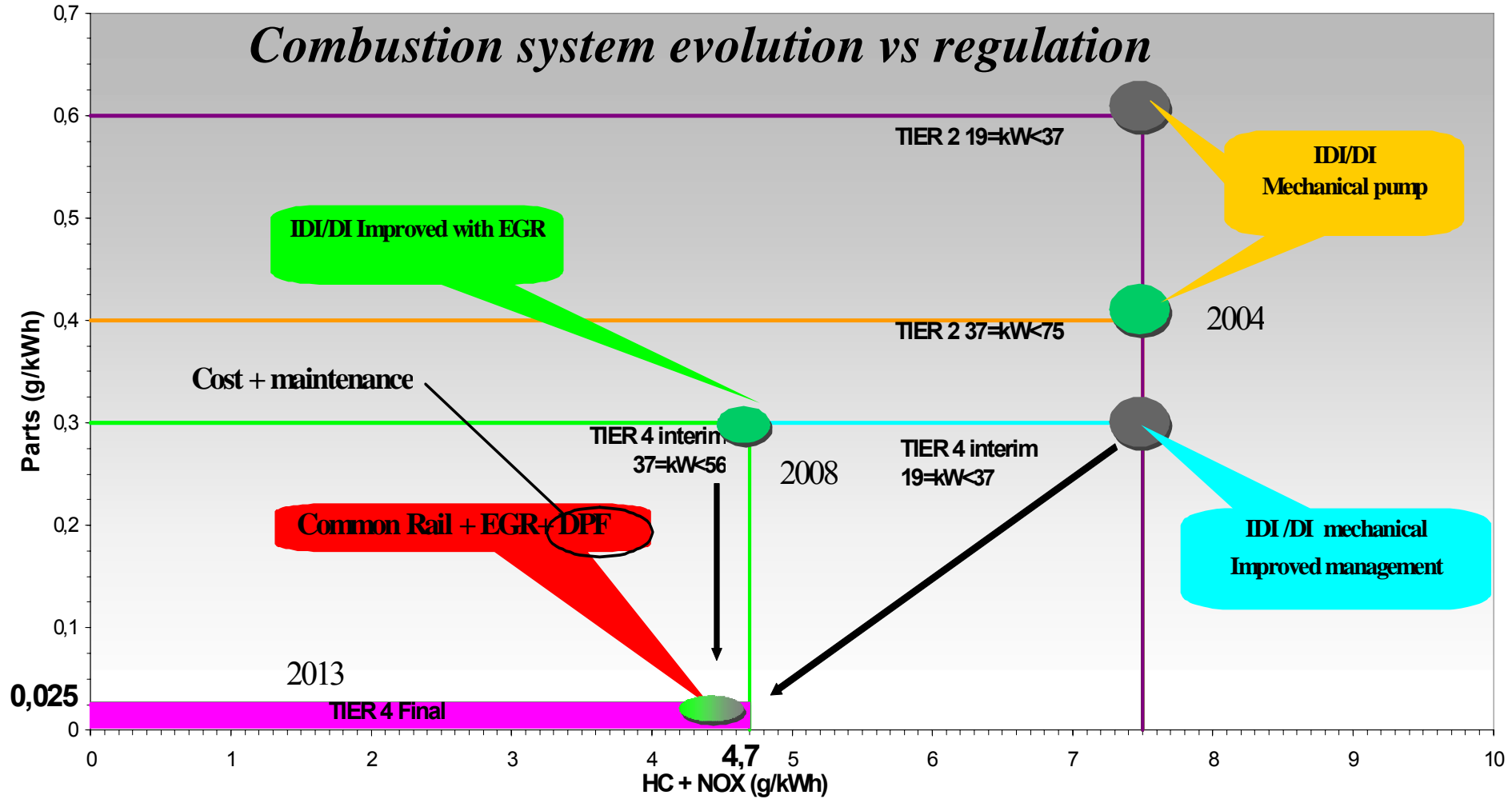
Results on PSA engines

Conclusion



Non-road market diesel engine technology

Combustion system evolution vs regulation



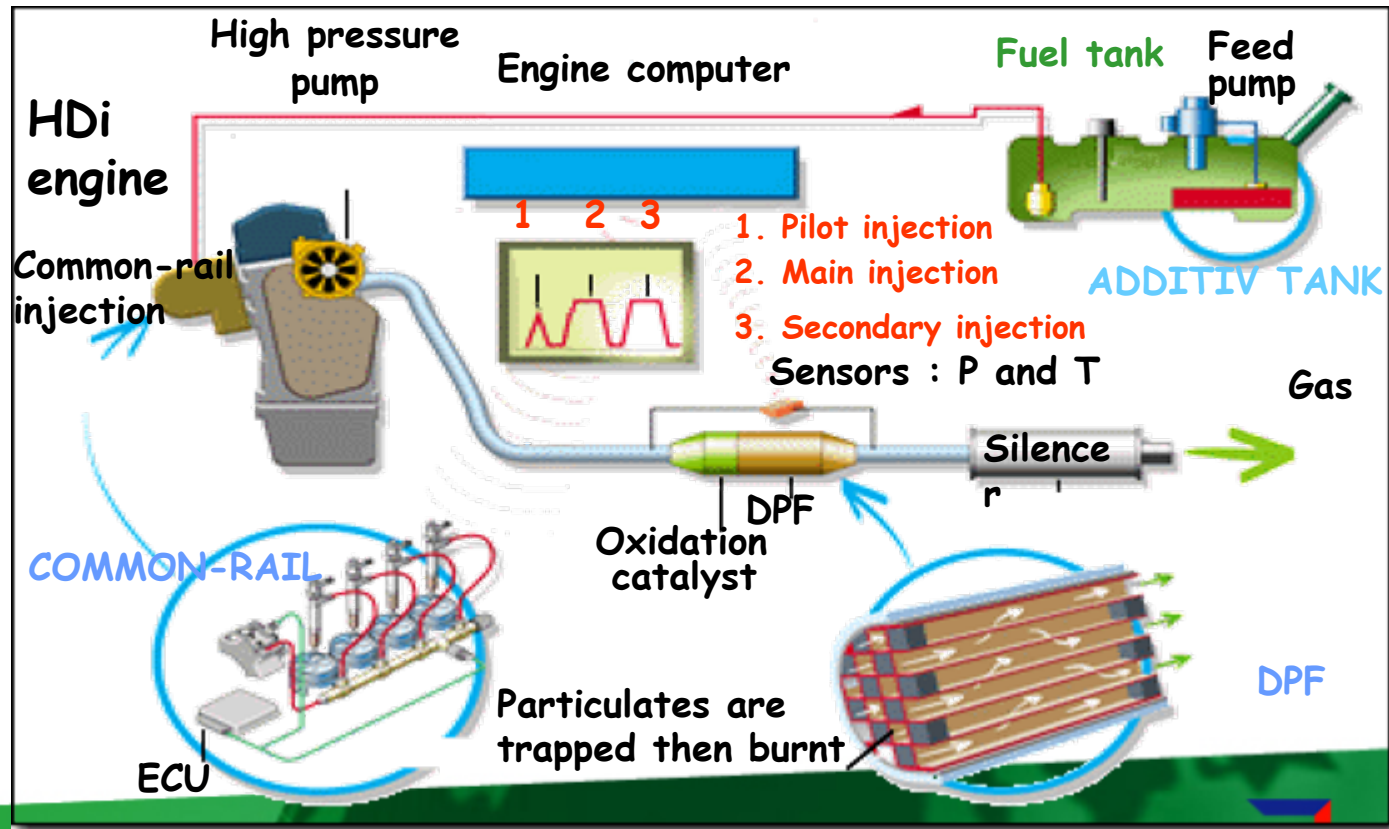


Non-road market diesel engine technology



The direct injection common rail technology commonly associated with post treatment technology for particulates will be mandatory to achieve Tier 4 final

PSA is leader in that technology with 180 number of patents.

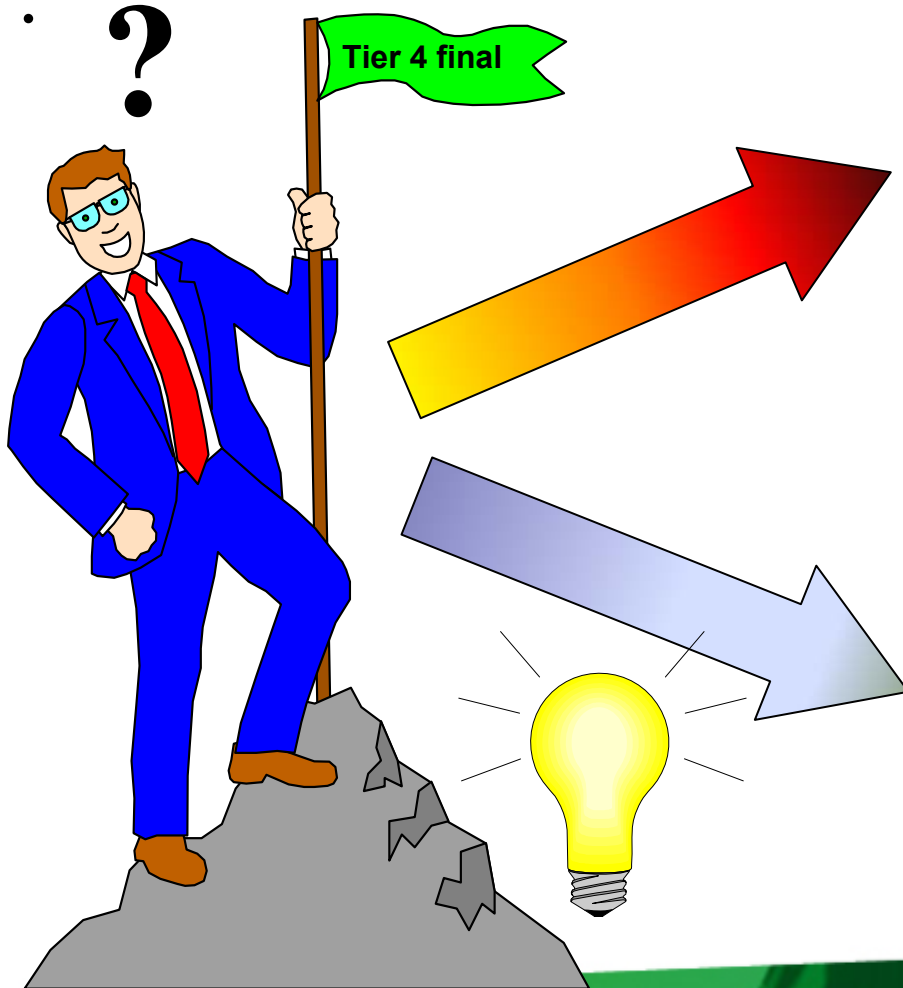




Non-road market diesel engine technology



For engine range <56 kw



DPF which means an increase in costs and complexity.

May we dream of another way to be compliant with Tier 4 final ?



Introduction

Emission regulation

Off-road market diesel engine technology

PCM's policy and offer

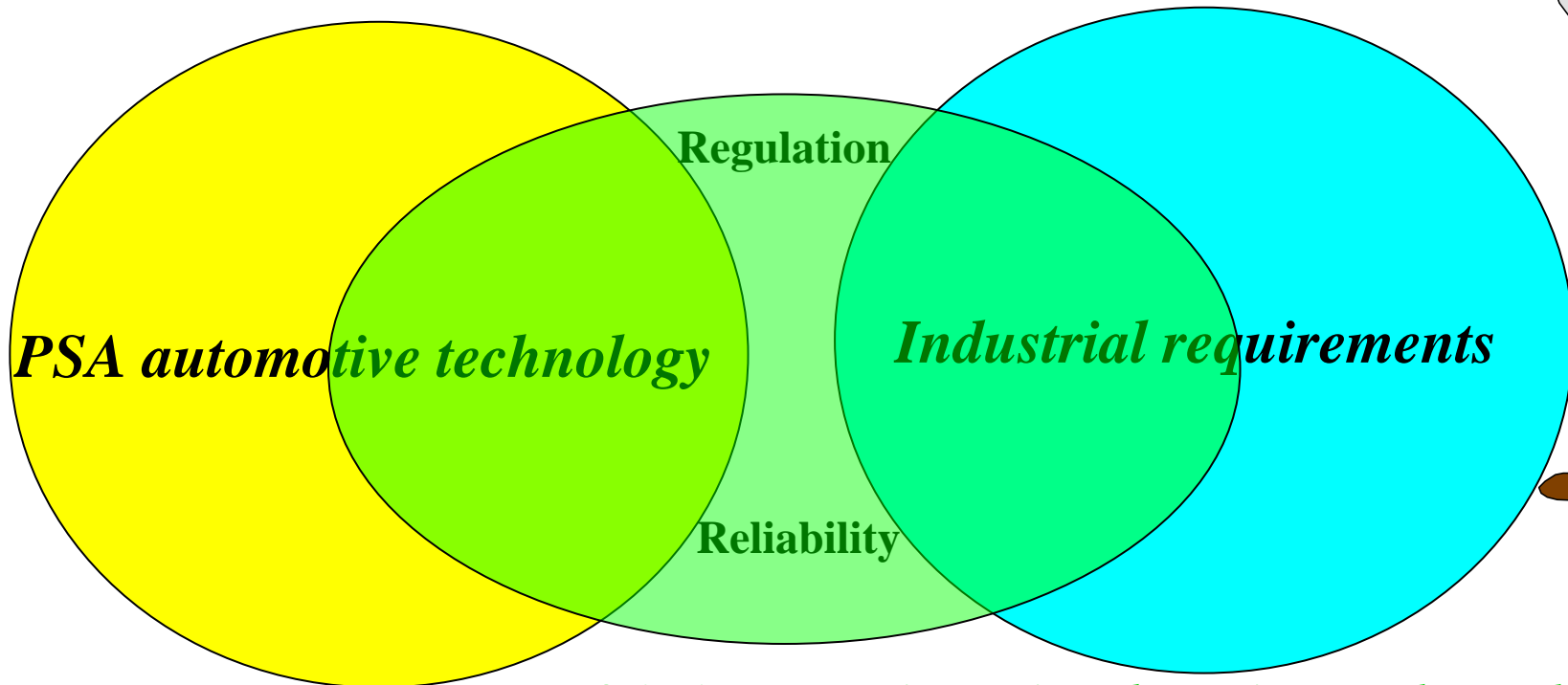
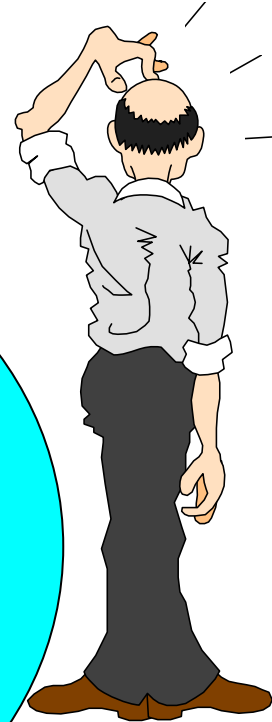
Results on PSA engines

Conclusion



PCM's policy

How to reach industrial requirements with PSA Diesel technology developed for automotive market ?



PSA Automotive Diesel engines adapted to industrial market



PCM's policy – Regulation



Our target :

*To offer a competitive advantage
by avoiding the Particulate Filter (DPF) for
Tier 4 final with a PSA Diesel engine
range up to 56 kw.*



How :

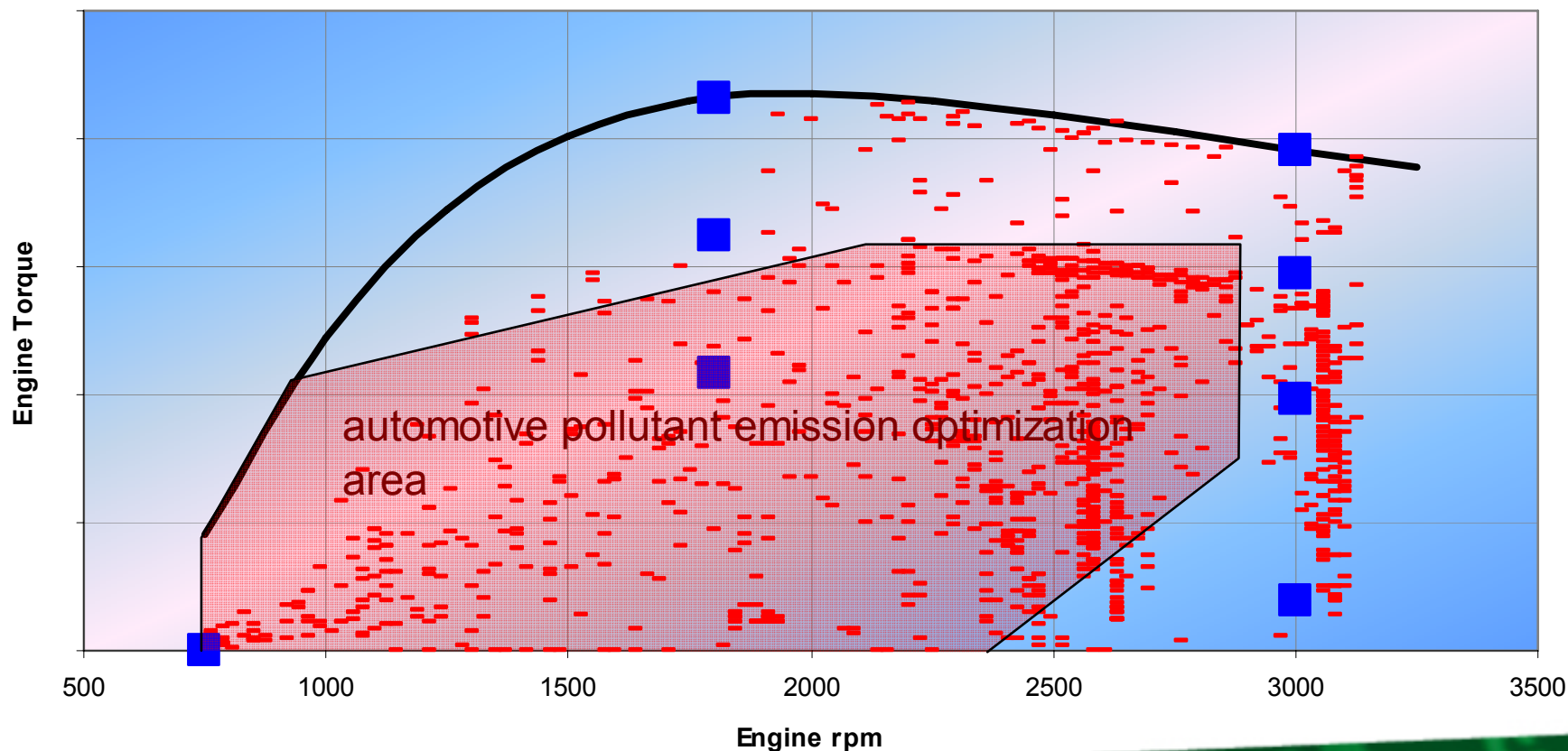
*Based on three common rail generations experience since 1997 and
thanks to sophisticated combustion system developed for Euro 5.*



PCM's policy - Regulation

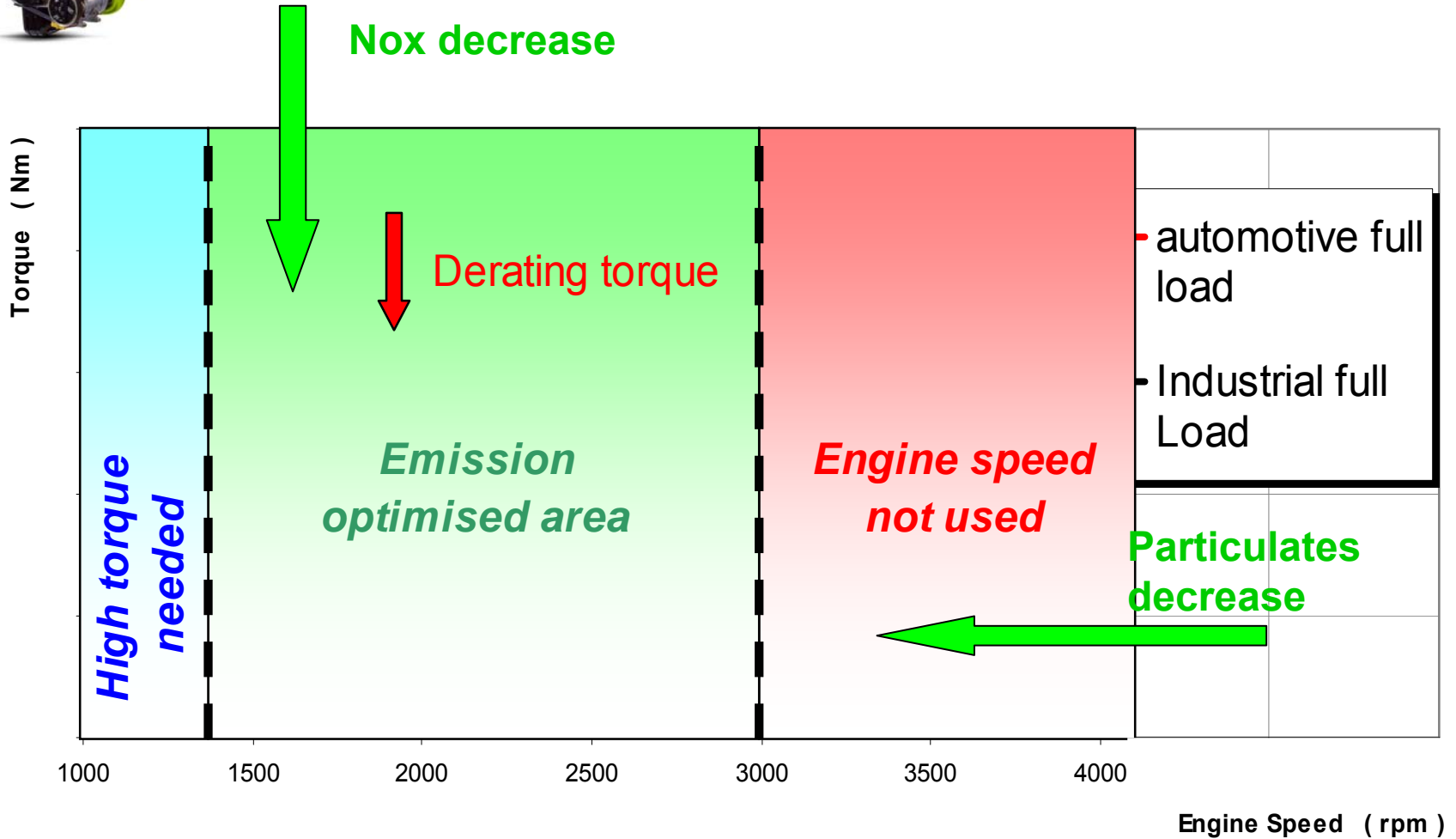
The methodology of testing the engine is different between automobile and non-road regulation

- Transient cycle ■ NRSC (8 points) — Automotive full load



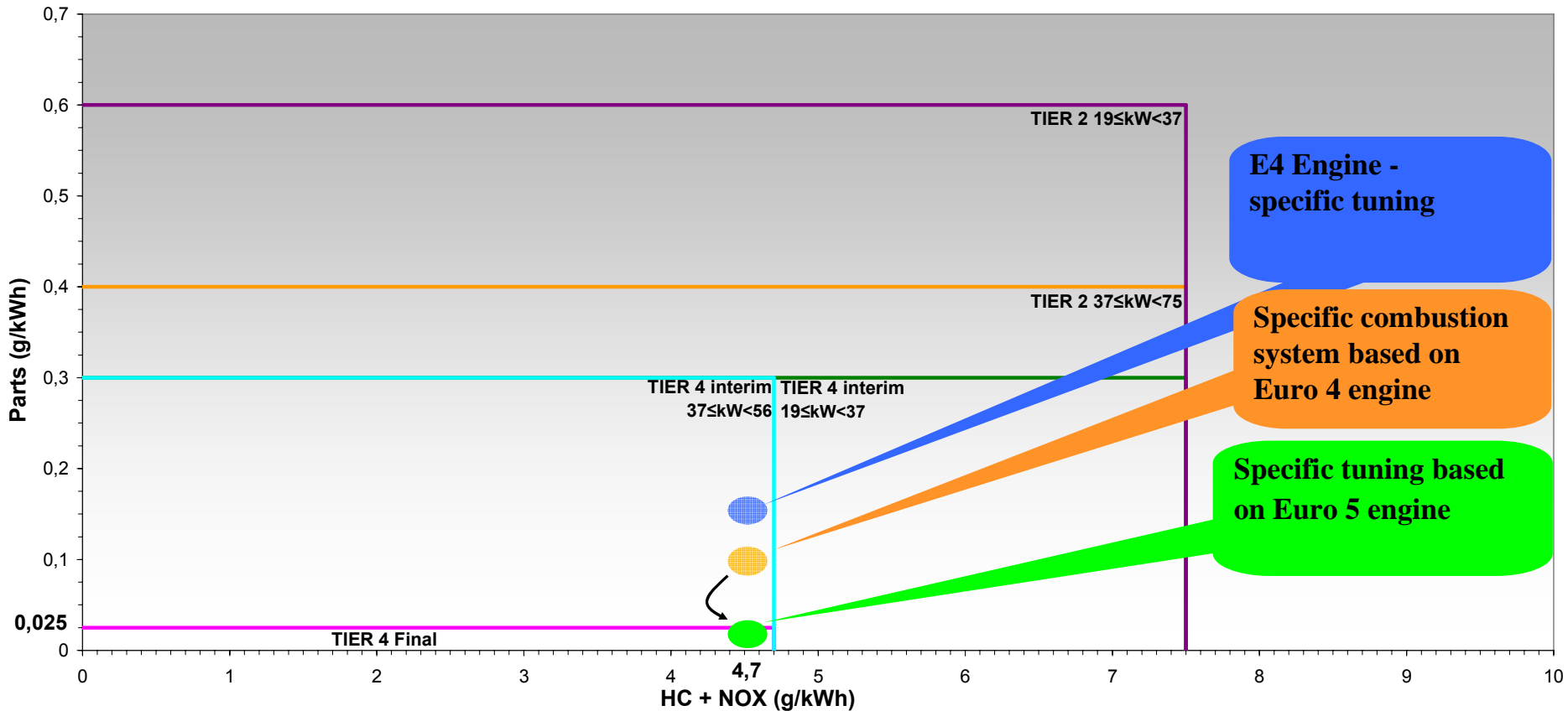


PCM's policy - Regulation





PCM's policy - Regulation



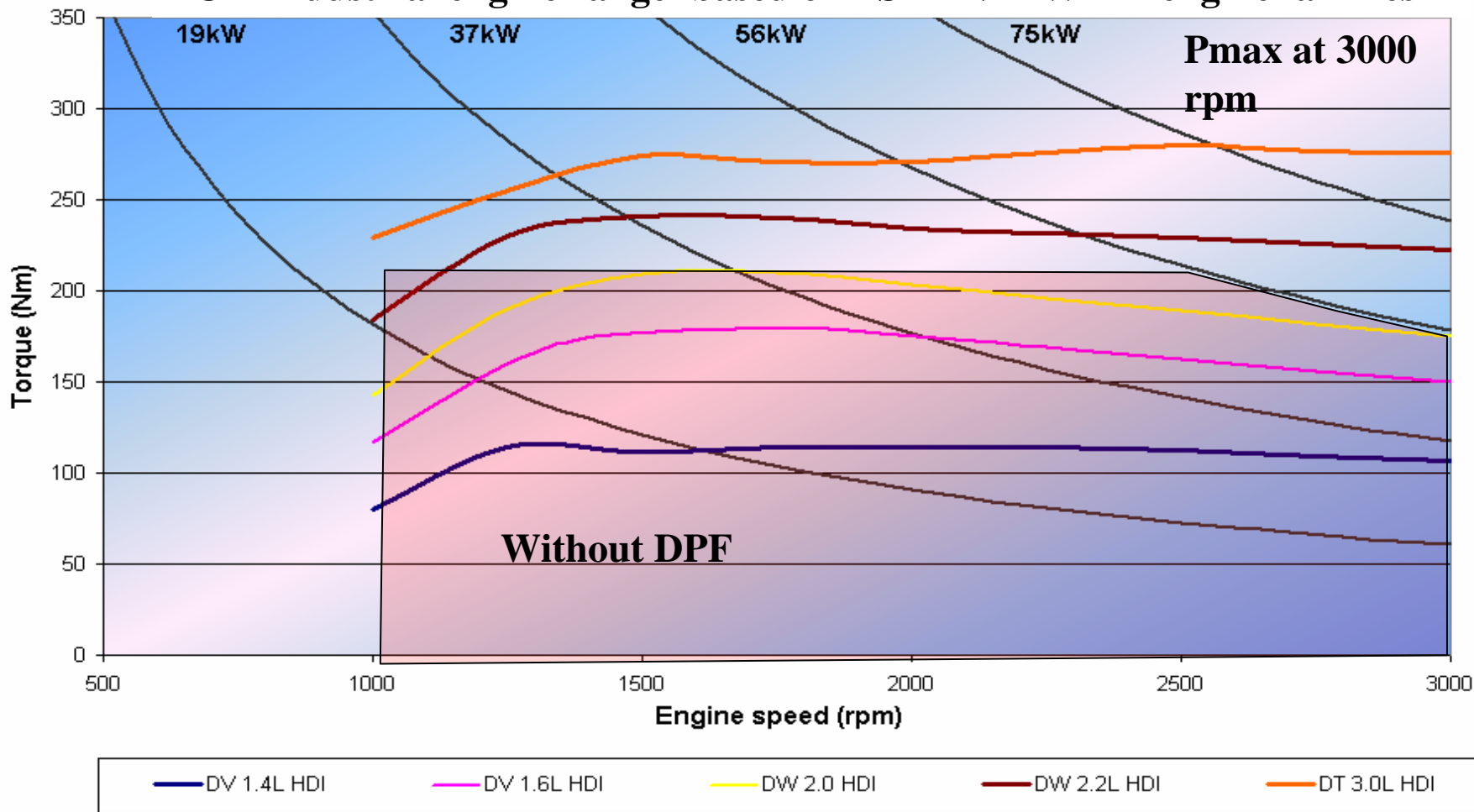
We forecasted to reach Tier 4 Final with Euro 5 technology without DPF



PCM's global offer for industrial applications



PCM industrial engine range -based on PSA DV-DW-DT engine families





PCM's policy - Reliability



From a reliability point of view :

PCM conducted :

- *A long life simulation*
- *Reliability and maintenance assessments related to industrial requirements*

The conclusion is ok

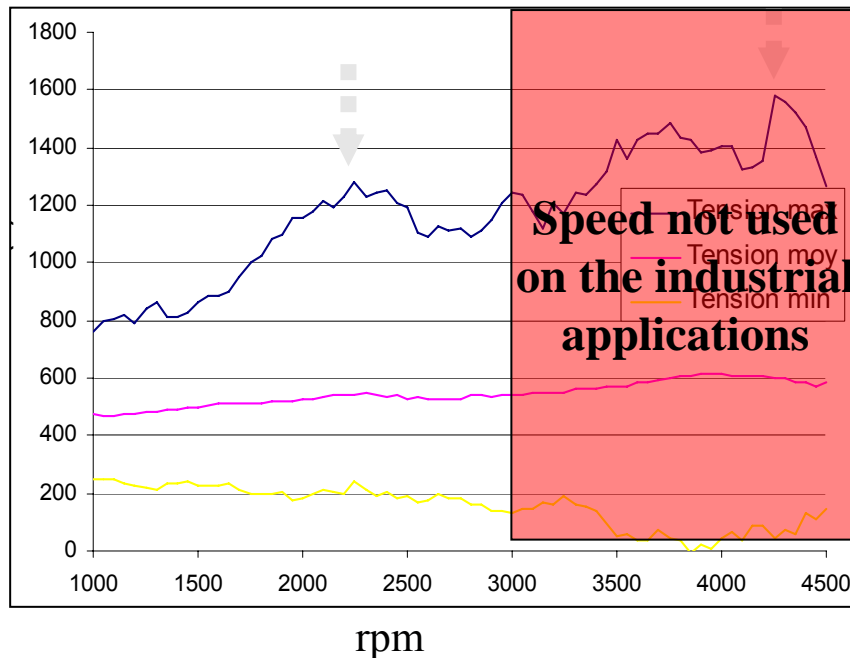


PCM's policy - Reliability

Timing belt: justification

Indus. worst
condition

Auto. worst
condition



Tension
(N)

Speed not used
on the industrial
applications

Dynamic tension

Considering the current situation of automotive life cycle around 150 000 miles and the favourable operation profile (low speed)

➔ The life time of the timing belt is compliant with the industrial machine usage conditions (above 10 000 hours)



Introduction

Emission regulation

Non-road market diesel engine technology

PCM's policy and offer

Results on PSA engines

Conclusion

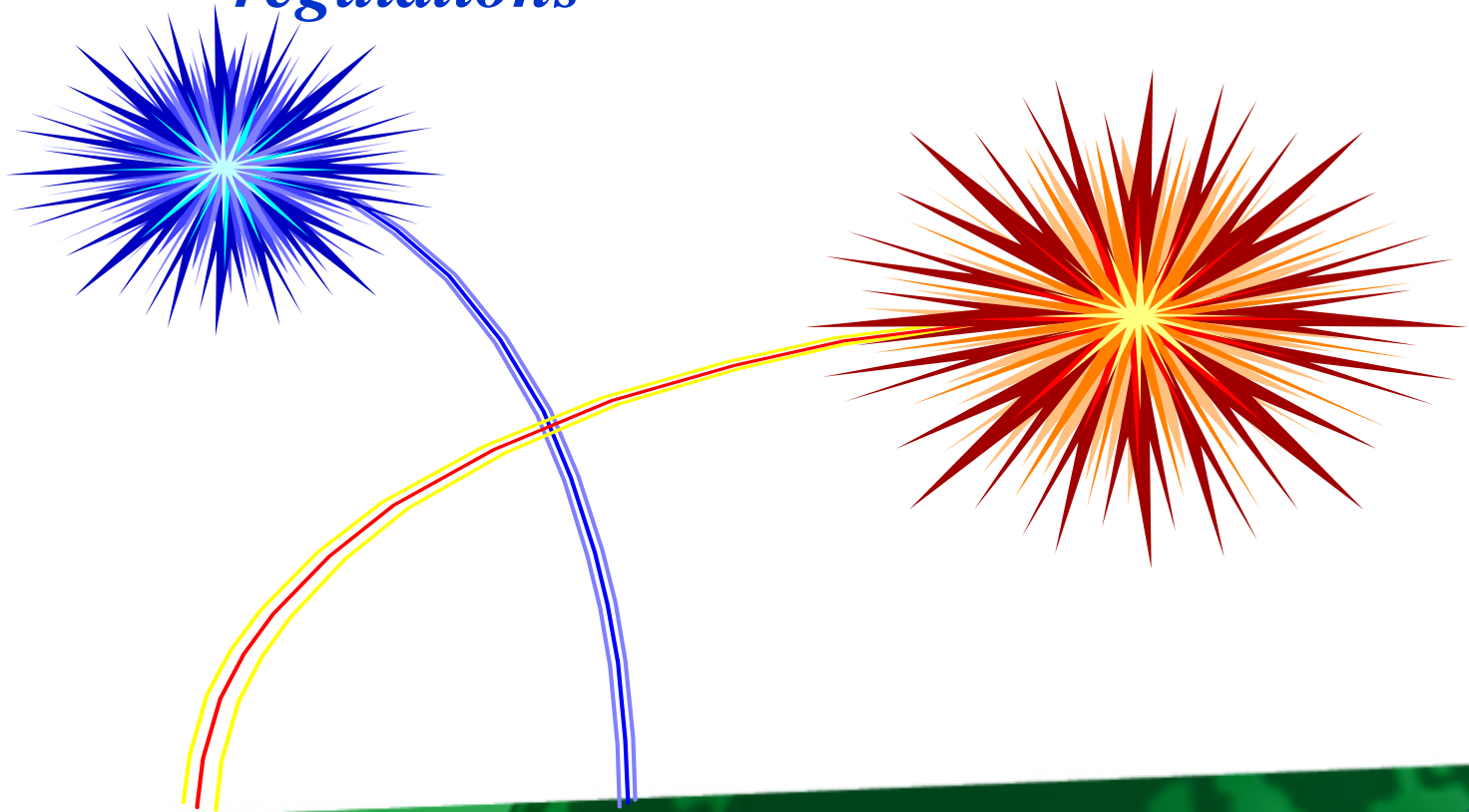


Results on PSA engines



The best of PSA diesel technology :

The best answer to the next « Non-road » regulations





Results on PSA engines

Since 2004, a PCM work team has analysed the industrial engine's needs.

We have forecasted by simulations the situation of our diesel engines :

➡ *versus emission regulation*

➔ *Tier 4 final without DPF*

➡ *versus reliability issues*

➔ *Compliance with requirements*





Results on PSA engines

Beginning 2007, we launched tests on an industrial application with a 1,6 liter Euro 4 engine.

- ➔ *We have measured by UTAC deterioration factors at 3000 hours .*
- ➔ *End 2008, the engine has run 6000 hours.*
- ➔ *We now have emission measurements on Euro 5 engine.*

So we are now able to confirm our predictions on emissions and reliability.





Results on PSA engines

In Partnership PCM launched a test on a genset application

**Genset characteristics : Speed = 1800 rpm
Power = 6 to 24kW**

**Engine used : 1,6l Hdi Euro 4 diesel engine
rated for industrial market at :
47 kW @ 3000 rpm**

**Sensors have been installed on many parts of
the engine to monitor the engine during
operation**



Results on PSA engines - pollutants

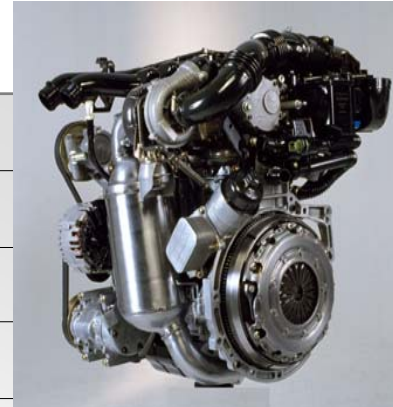
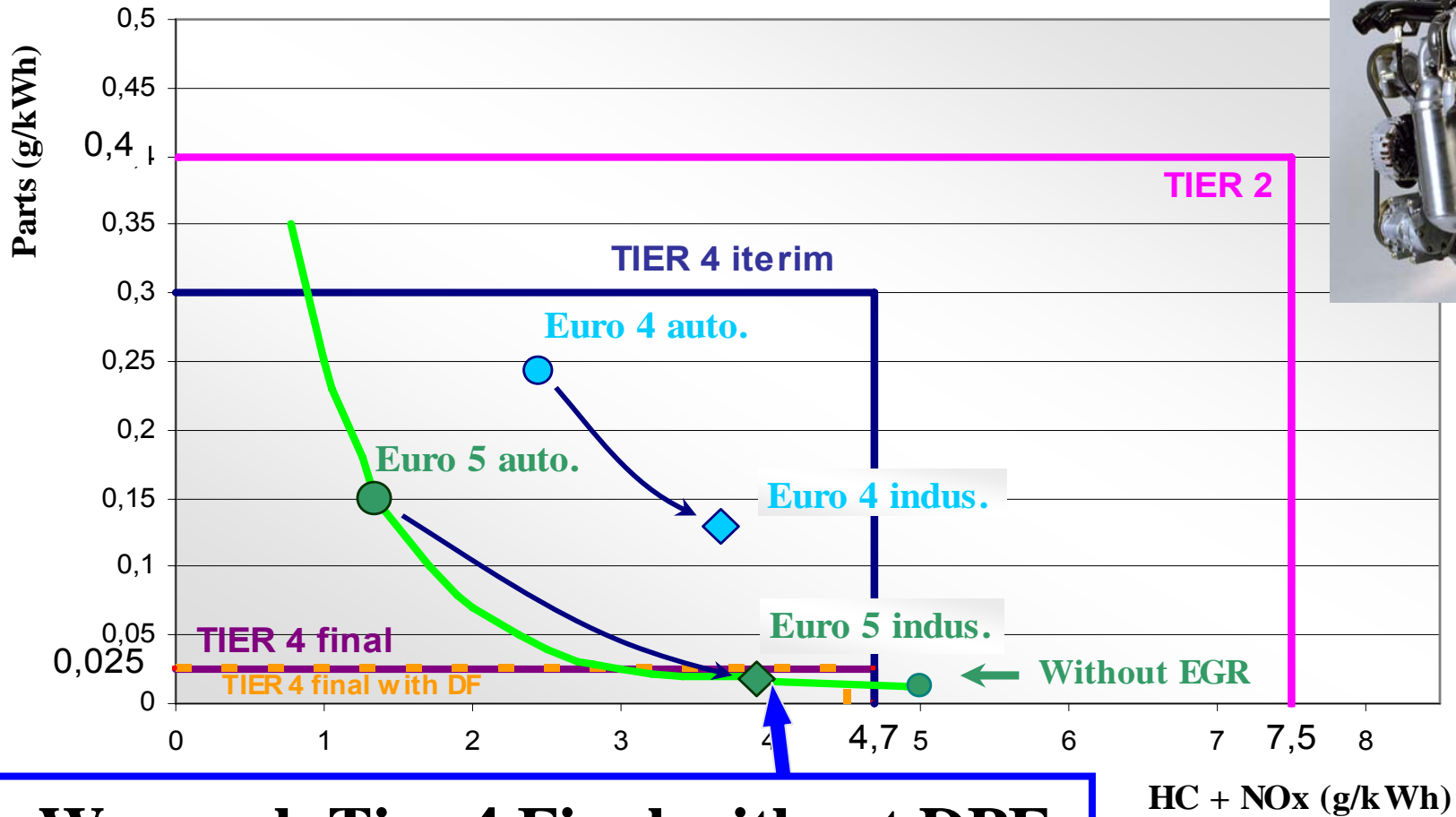
According to the non- road Standard we have homologated Emission Deterioration Factors with French UTAC.

- HC + Nox **DF = 1,1**
- Particulates **DF = 1,0**
- CO **DF = 1,0**

Those DFs are homologated for our future Euro 5 engine less than 47 kW (constant speed and variable speed applications).

Results on PSA engines - Pollutants

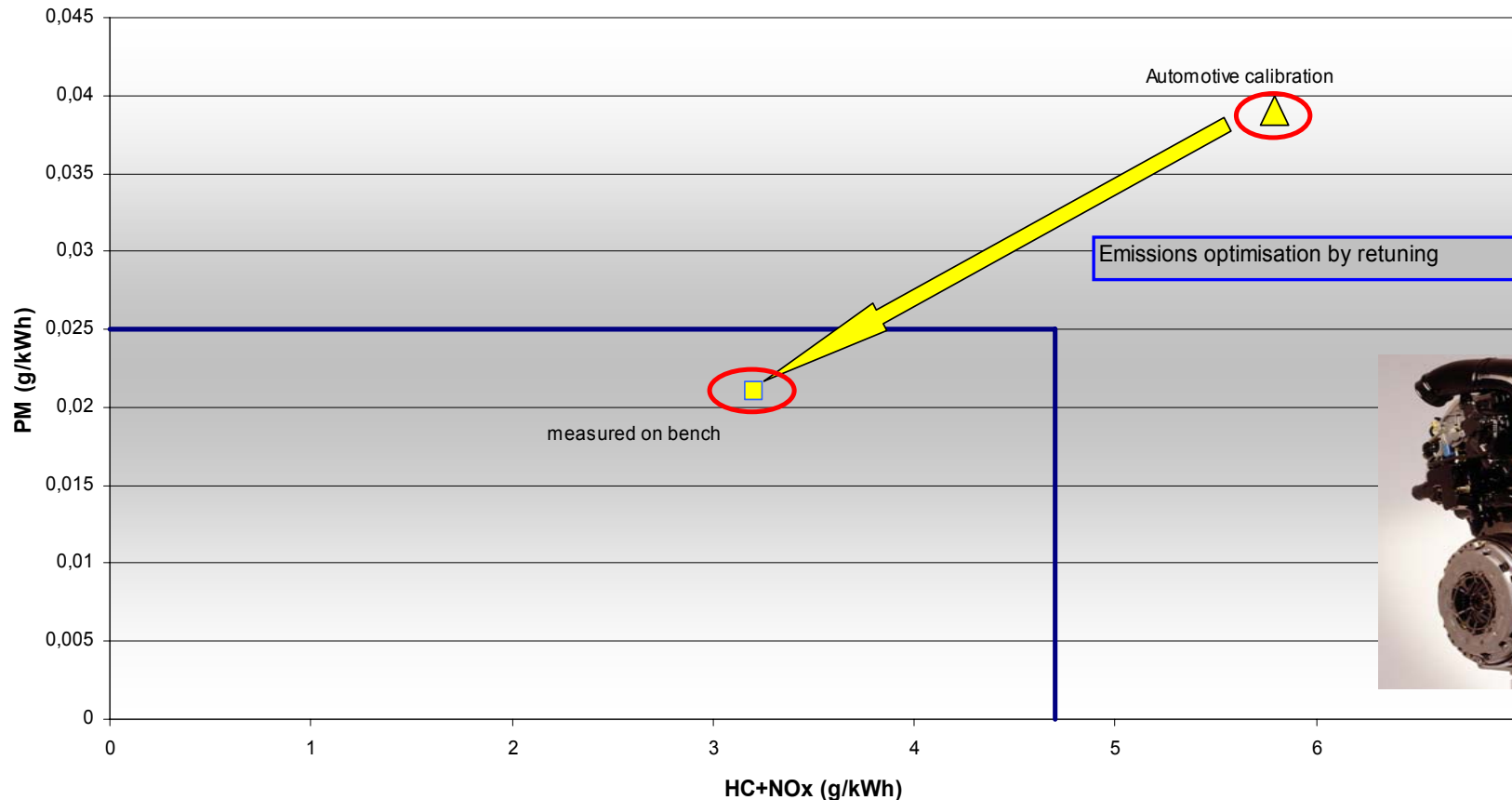
Based on actual 1,6 l engine measurement rated 47kW@3000rpm and homologated DF:



We reach Tier 4 Final without DPF

Results on PSA engines - Pollutants

Based on actual 2,0 l engine measurement rated 55kW@3000rpm



We reach Tier 4 final without DPF



Results on PSA engines

The Additional Benefits of NO DPF



Real Benefits for an application using a PSA Tier 4 Hdi diesel engine without DPF:

- *Reduced cost of a depollution system*
- *Reduced packaging complexity and more room for other essential components*
- *Reduced overall weight of the industrial product*
- *Increased reliability in the field*
- *Reduced cost of field maintenance*
- *One less system of components to homologate, document and service in the field*



Results on PSA engines - Reliability

Results of the endurance test :

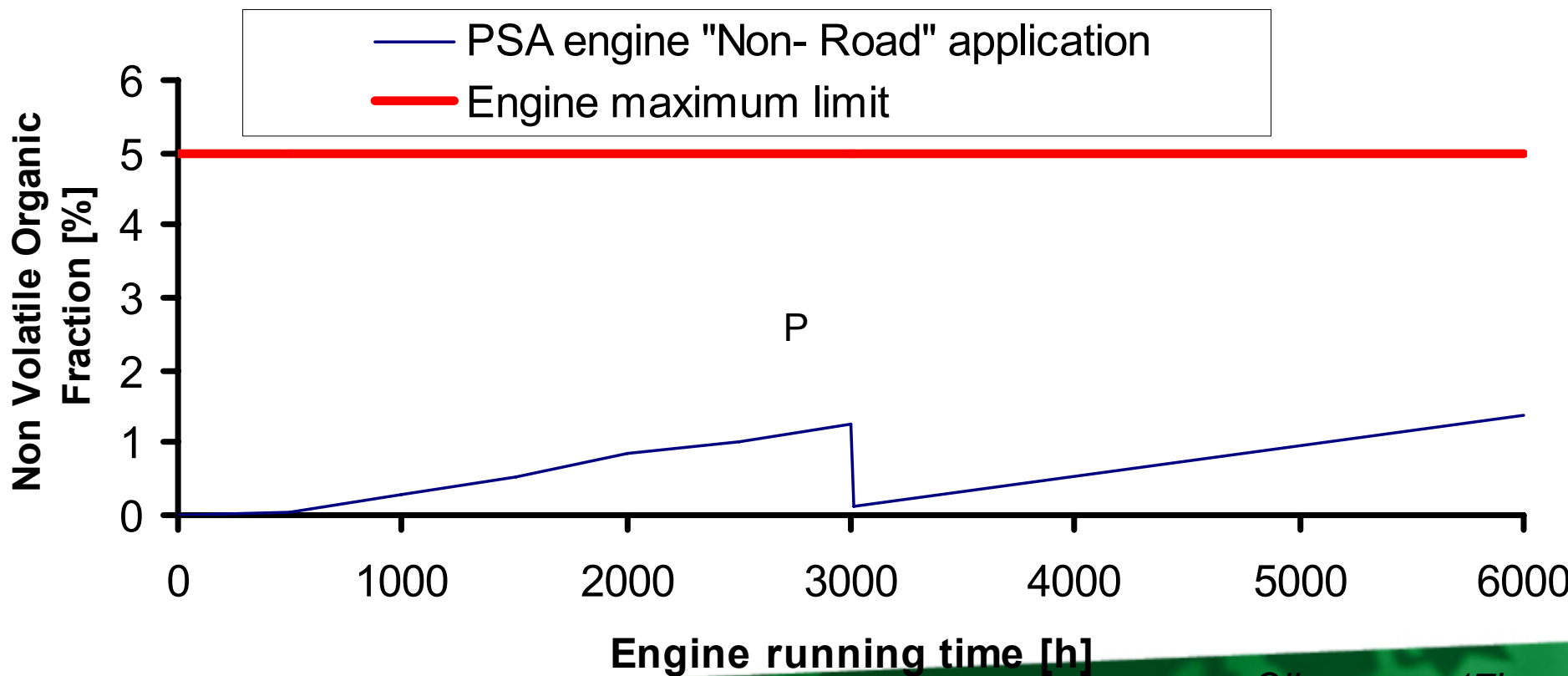
- *6500 hours has been performed and no trouble has been detected so far.*
- *Compliance with 3 000 hours maintenance step is OK.*
- *Or goal is to run 10 000 hours without any change of engine components .*



Results on PSA engines - Reliability

Engine tuning is ok with step maintenance at 3000 hours

SOOT IN OIL
(Non Volatile organic Fraction)

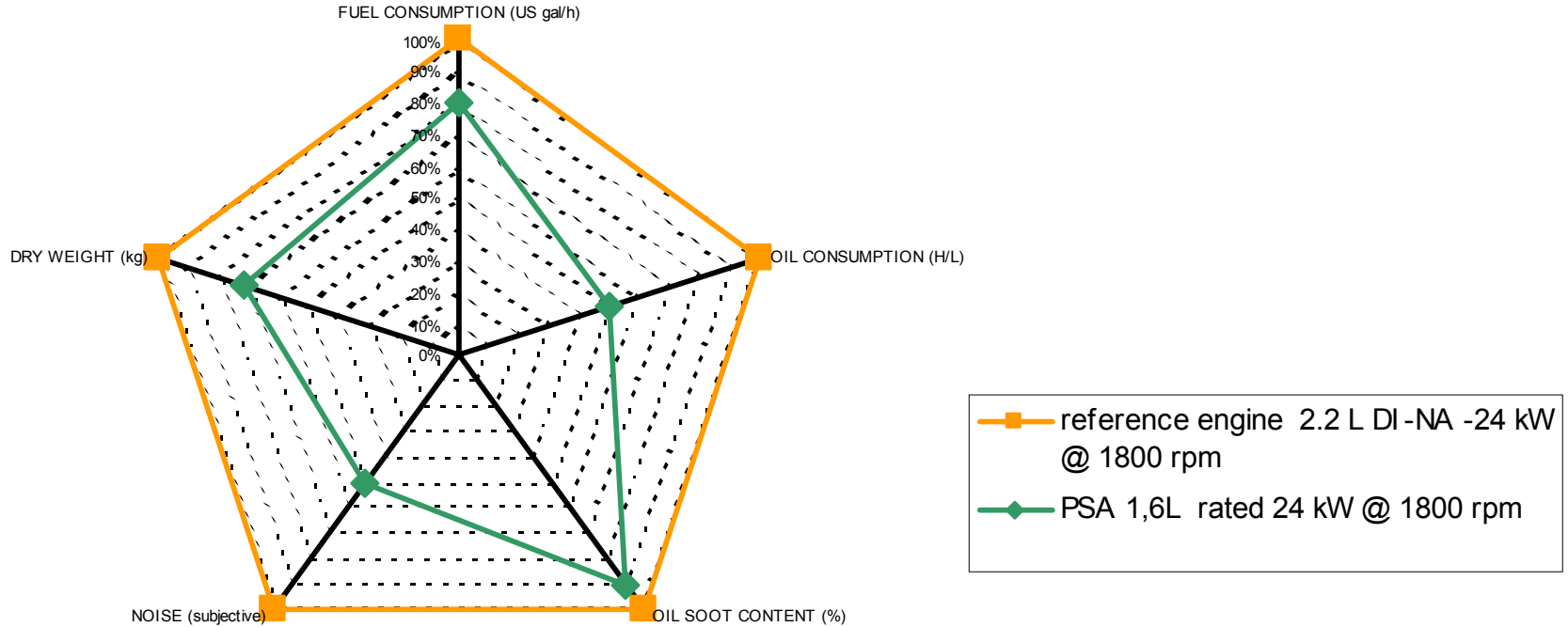


Oil sump = 17L



Results on PSA engines - Performance

Radar of performance compared with the competitor reference engine :





Introduction

Emission regulation

Off-road market diesel engine technology

PCM's policy and offer

Results on PSA engines

Conclusion



Conclusion

- *We confirm we will reach **Tier 4 Final without DPF** with PSA Euro 5 diesel engines for power range up to 56 kw.*
- *The great PSA experience in diesel engines and post treatment technology is also available for power above 56 kw.*
- *We comply, as PCM did before, to **industrial applications reliability requirements** .*
- *PSA engines offer **competitive performance** compared with current industrial diesel engines.*



Conclusion



*In view of such results ,
PSA HDI €5 diesel
engines appear as an
obvious solution to meet
Tier 4 final for the non-
automotive market .*



Conclusion

Go further in the project...

*We are ready to take along major OEMs who wish to join us
in the 2013 Tier 4 final race.*



HDi 1.6l



HDi 2.0l



*Let's build your
project together*

powered by



dominique.desportes@mpsa.com