

# Emission Technology of non-road mobile machinery in EU and other markets

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**LIEBHERR**

# Agenda

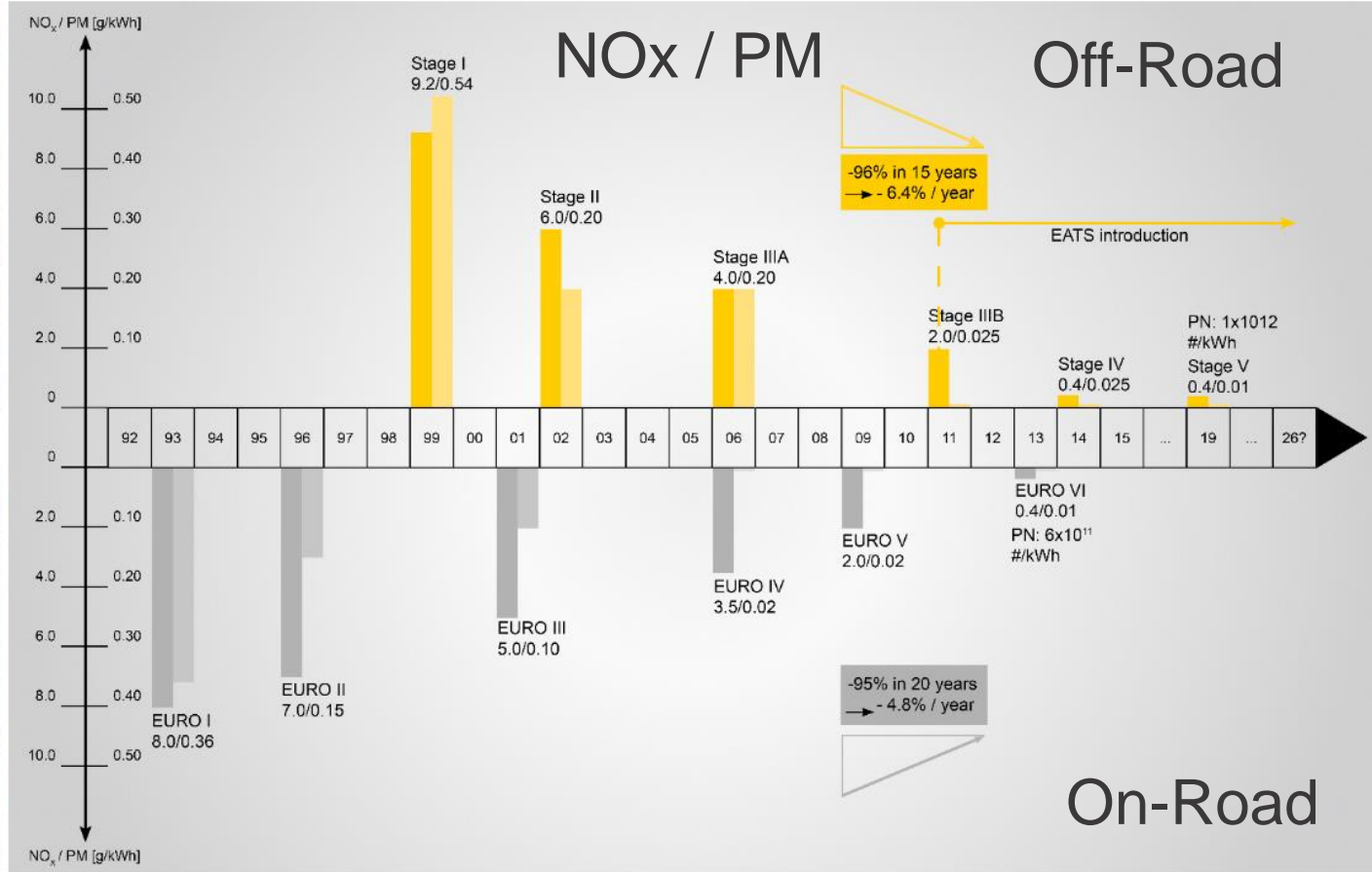
- 1 **emission legal Framework: from Stage IIIB toward Stage V**
- 2 EATS solutions
- 3 Emission Concept for Global market
- 4 Customer Needs
- 5 challenges in daily use in off-road applications
- 6 Outlook & Summary

# Emission limits Chronology: On- vs. Off-highway



130<kW<560

>3.5t

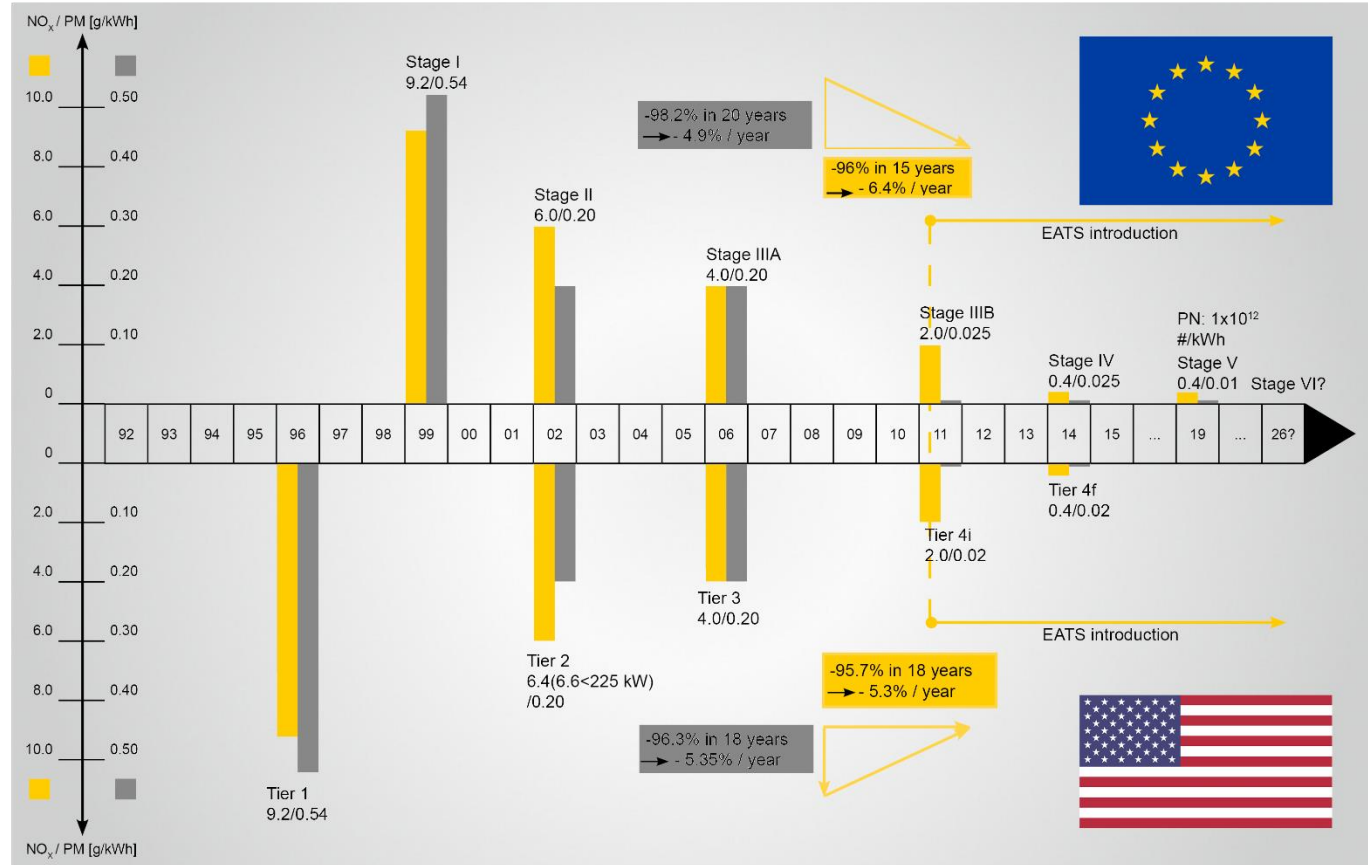


**///** Emissions reduced of **96%** in 15 years for Off-highway vehicles  
**Challenge for the engine manufacturers !**

# Emission limits Chronology: EU vs. USA

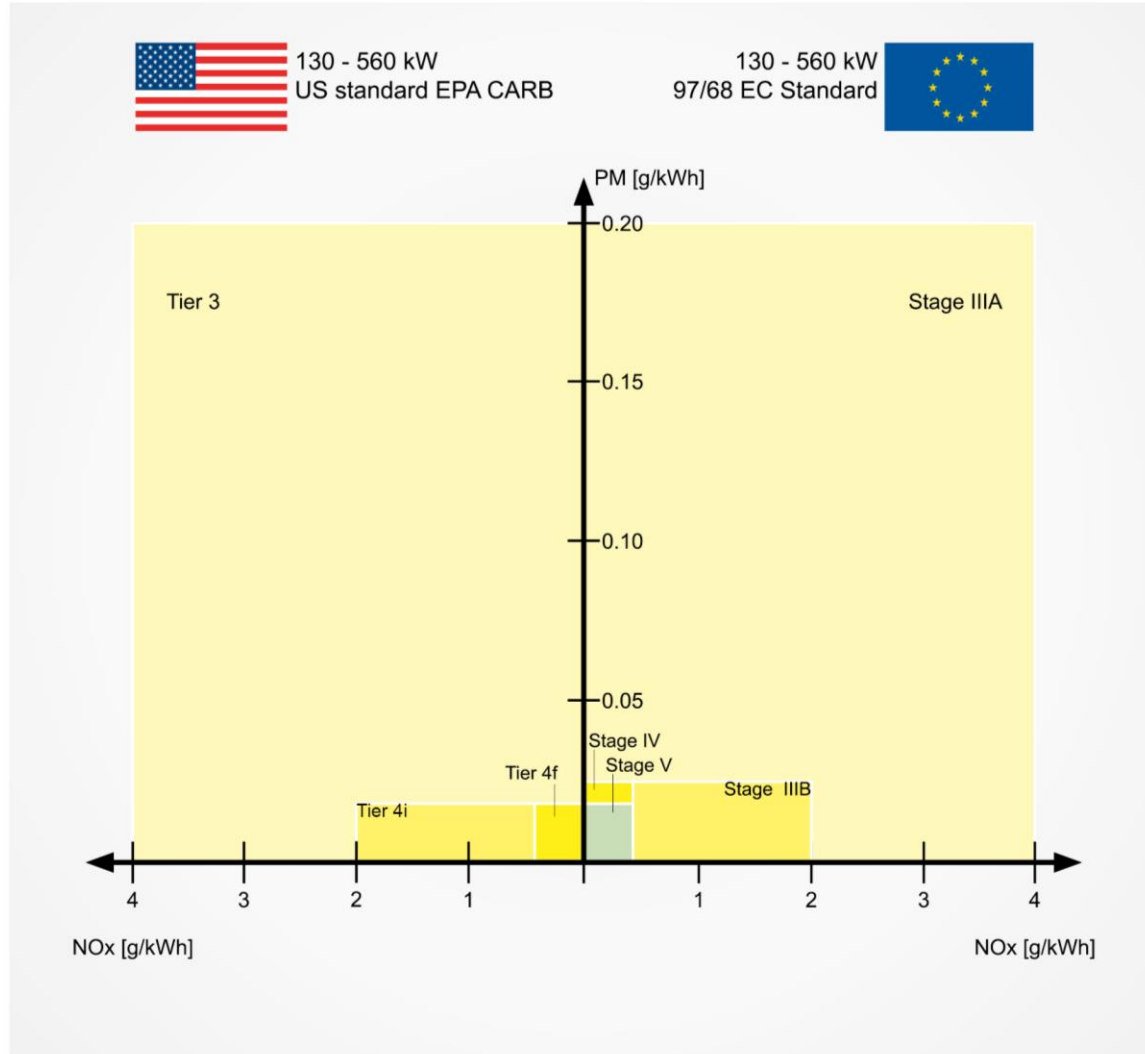


130<KW<560



Starting from 2019 and the introduction of Stage V in Europe (Particulate number counting): different legislation for EU and USA → **Challenge for the engine manufacturers !**

# Legislation : Stage V starting from 01.01.2019 in the EU



130<P[kW]<560

	NOx [g/kWh]	PM [g/kWh]	PN [#kWh]
Tier 3	4	0.2	
Stage IIIA	4	0.2	
Tier 4i	2	0.02	
Stage IIIB	2	0.025	
Tier 4f	0.4	0.02	
Stage IV	0.4	0.025	
Stage V	0.4	0.015	1x10 <sup>12</sup>

there are no changes in the US legislation

P>560 [kW]

	NOx [g/kWh]	PM [g/kWh]	PN [#kWh]
Tier 4f	3.5	0.04	
Stage V	3.5	0.045	--

there are no changes in the US legislation

# PEMS (Portable Emissions Measurement System)

System set-up on WL566



TPA

battery pack including power distribution

OBS-system with case

Control PC

damper plate

GPS-sensor and weather station

gas bottles (fuel gas, synthetic air) for use of FID

35 IAV 10/2018 TP-C1 DLz Status: draft, confidential

## 22.11.2019 – Press information

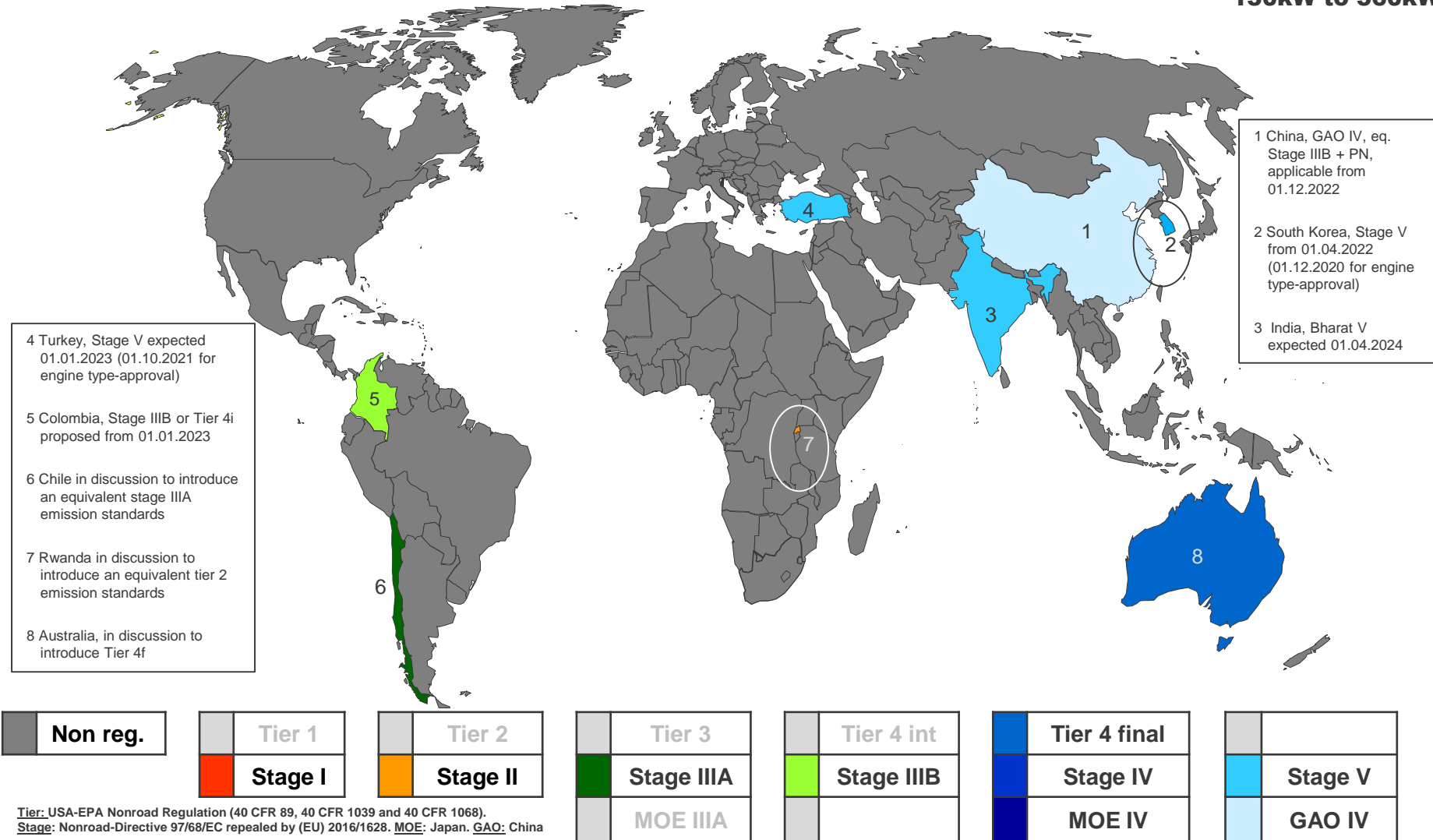
- Liebherr cranes comply with stringent Euro VI c standard in real driving conditions
- Ehingen-based crane manufacturer is delighted with the good results of the extensive PEMS (portable emission measurement system) test series
- Emissions comparable to heavy long-distance trucks



ISM: In Service Monitoring

# NRMM Emissions Regulations - In discussion

130kW to 560kW

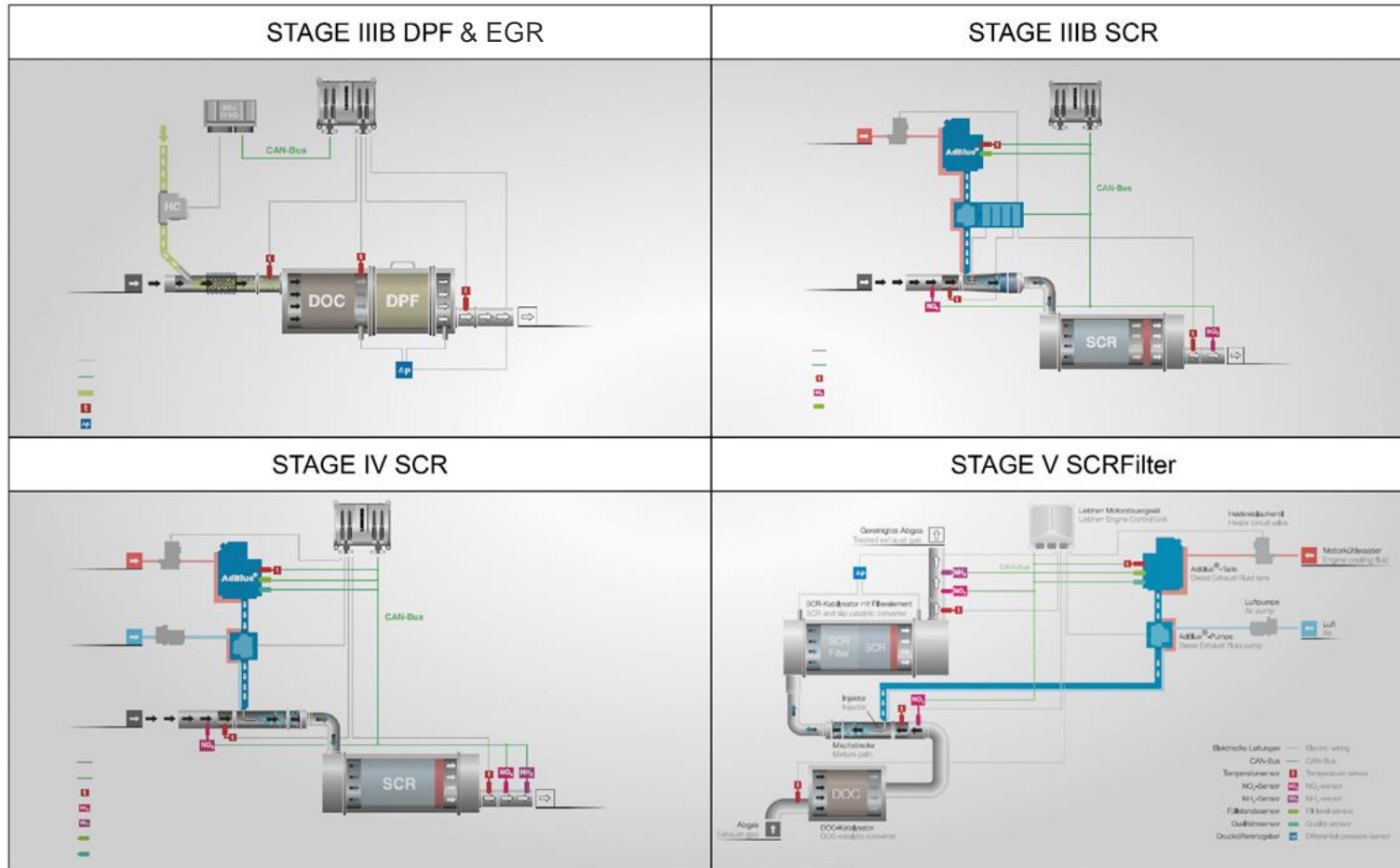


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# Liebherr EATS solutions $130 < P[\text{kW}] < 560$ development from Stage IIIB /Tier4i to stage V

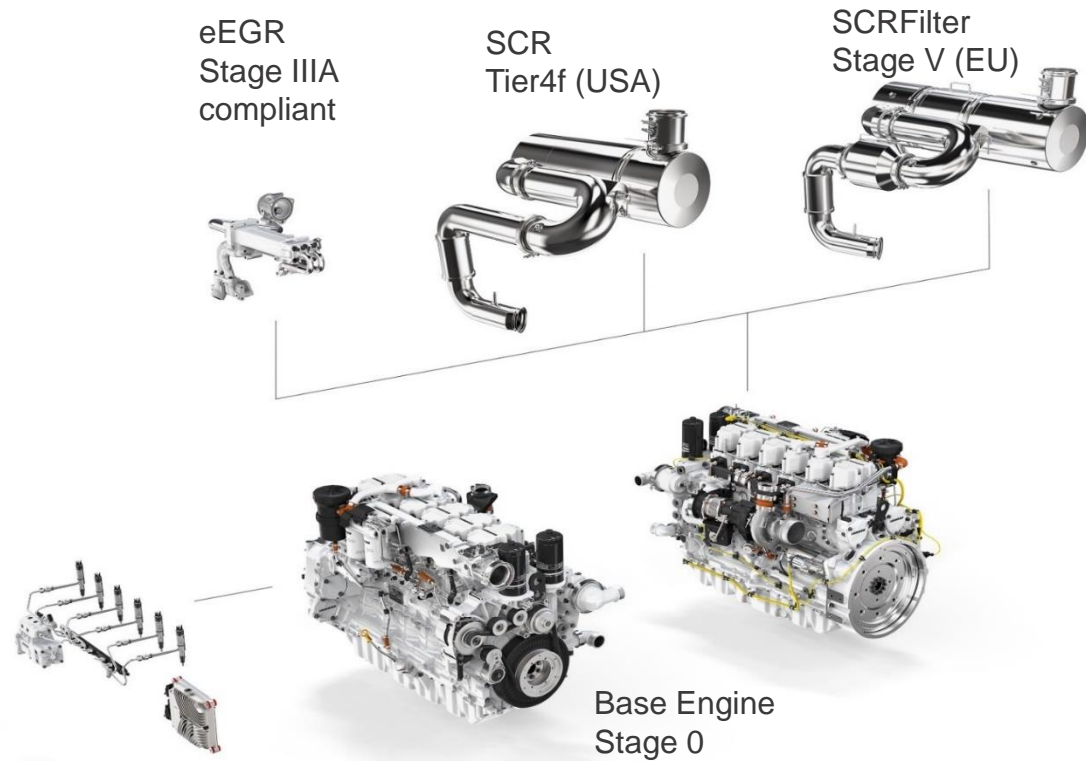


2011 to 2019 → Market introduction of 4 different EATS Systems within 8 years

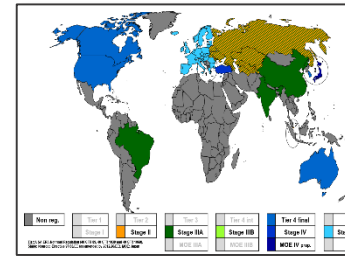
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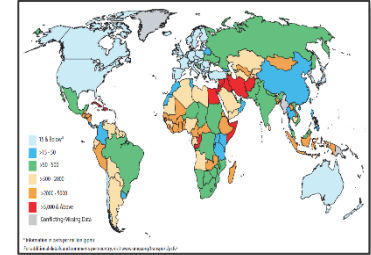
# EATS – Single Basis for 4 Emission Levels



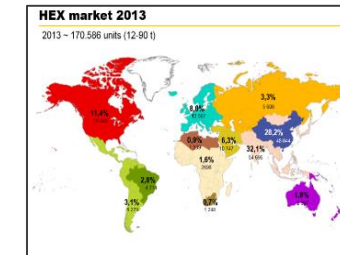
Emission limits



Fuel quality (sulfur)



Market share

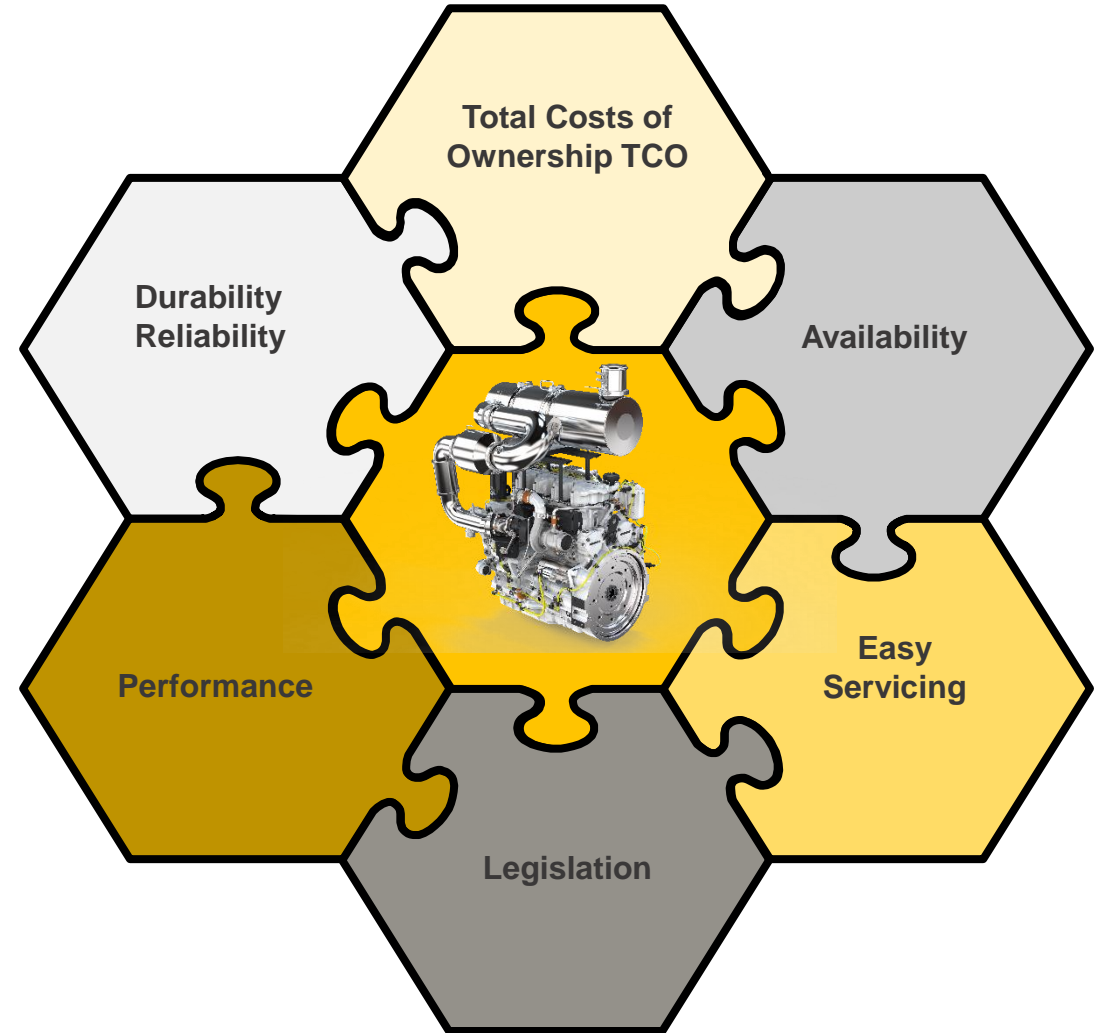
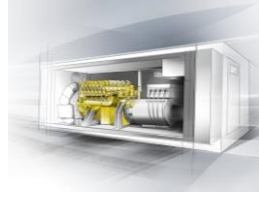


High flexibility necessary for Exhaust After Treatment System to fulfill worldwide emission standards

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# Customer expectations?

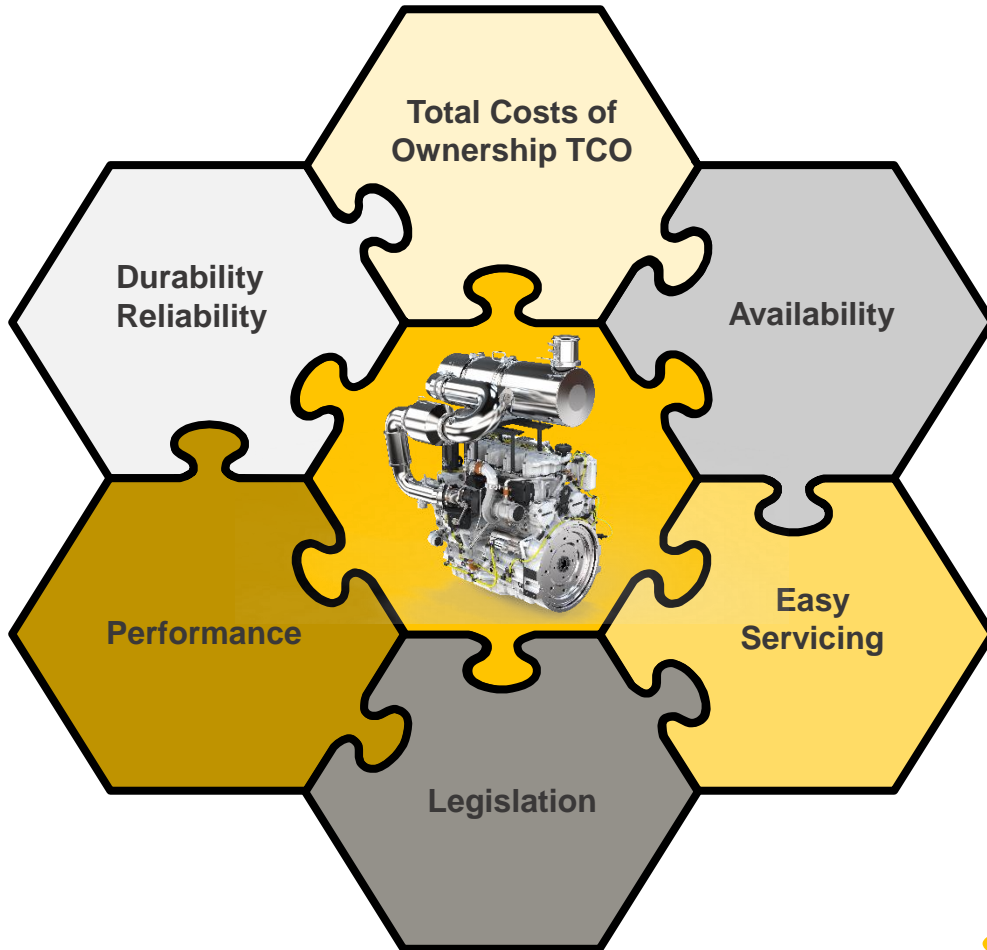


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# Emission Technology of non-road mobile machinery in EU and other markets

## Challenges & Development drivers



### ■ Legislation

- Emission compliance, Emission durability period
- Select components/technologies which could be used for different market (e.g. T4f vs Stage V)

### ■ Performance

- High Conversion efficiency

### ■ Total Costs of Ownership

- Fluid consumption
- Regeneration (impact on fuel consumption)

### ■ Durability / Reliability

- Use well proven technology, perform extended field test

### ■ Easy Servicing

- Particulate Filter cleaning
- Extended oil change interval

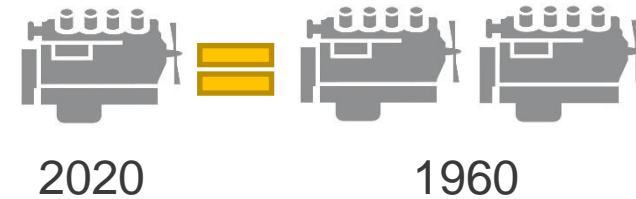
### ■ Availability

- Reduce downtime

# Power unit development

## Mechanical engine – 140 years of development

- Constant increase in power density
- 1 engine in 2020 = 2 engines of 1960



## Software

- Software introduced in engines in the 90s
- 2005: IIIA Engine – 1'600 parameters in Software
- 2020: Stage V – 50'000 parameters !!

## Exhaust After Treatment System for heavy duty

- EATS introduced in 2005
- Constitutes up to 30% of the total cost of a power unit



# Customer sensitivity

## Why are customers now aware of EATS issues?

- **European legislation – Liebherr`s main market**



- **2011 - Stage IIIB**

- Only On-Board diagnostic lamps activation in case of an EATS failure = case of inducement
- No Effect for our customers beside “Christmas tree” flashing in the dashboard
- Low amount of claims → Late awareness of issues for After Treatment System

- **2014 - Stage IV - Introduction of engine derating in the inducement legislation**

- Stage IV legislation demands an engine derating in case of an inducement
- Higher amount of claims → impact on machine availability!

## Example Urea Quality Sensor

### History of Urea Quality Sensor

- 2011 - IIIB : introduction of Urea + SCR for Liebherr Systems
  - 2014 – Stage IV / T4i : Urea quality sensor mandatory
- 
- Technology developed for on road passenger cars and trucks
  - The available technology for an urea quality sensor is not robust enough for off-highway applications



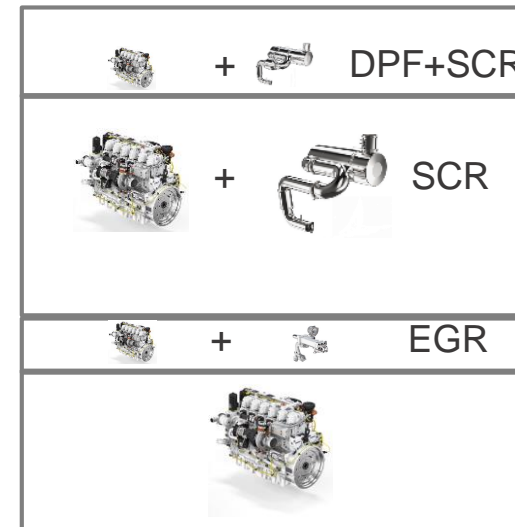
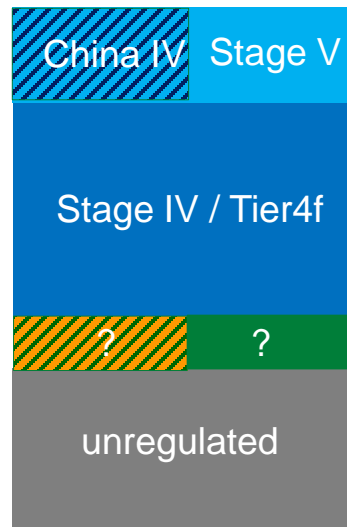
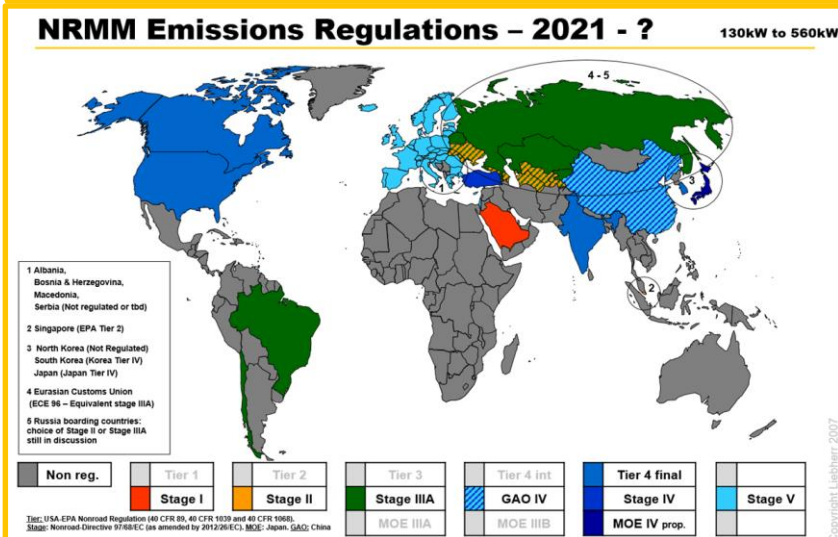
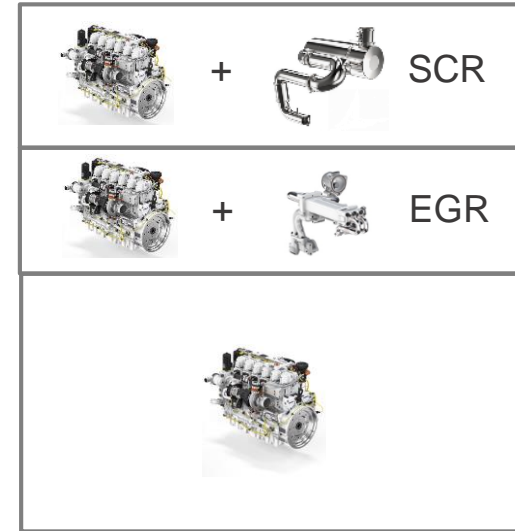
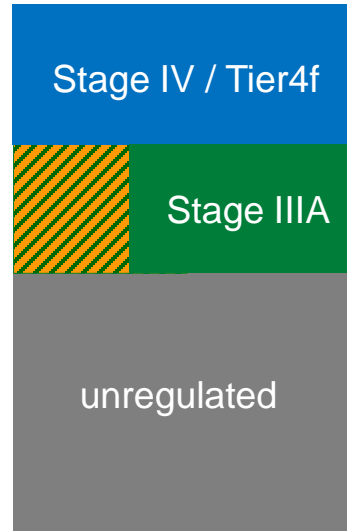
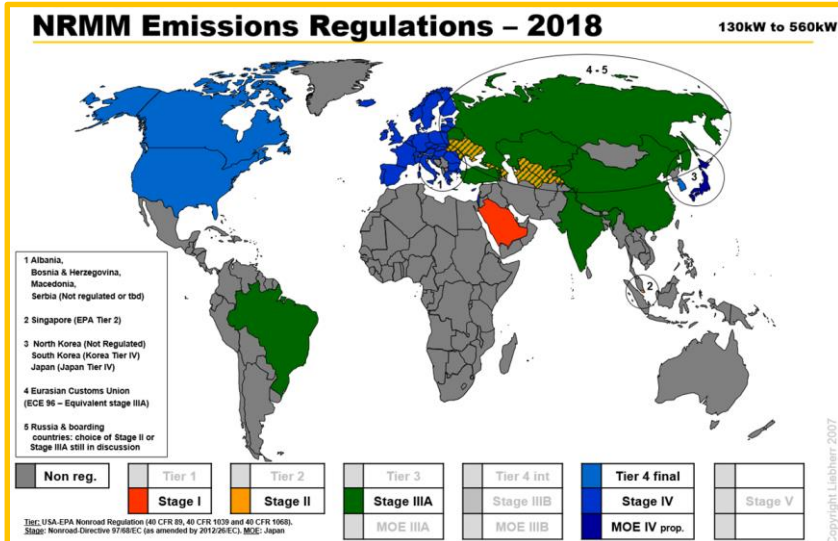
Difficult to find a mature product on the market, very recent technology!

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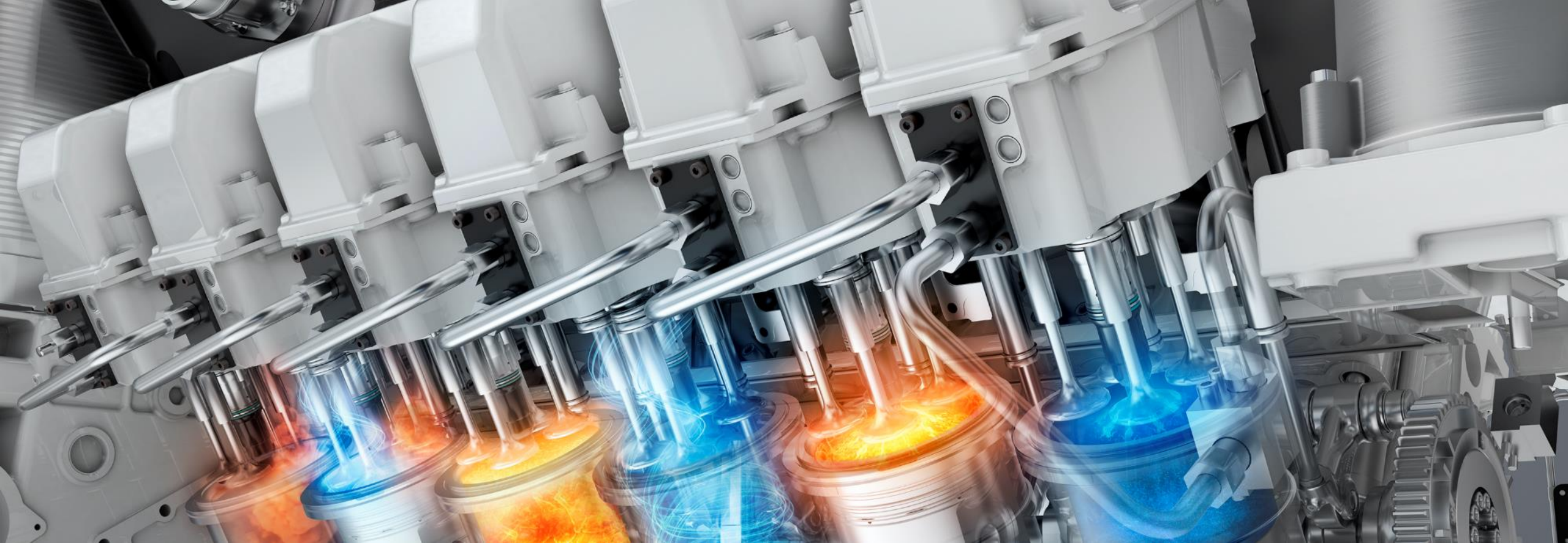
# Emission Technology of non-road mobile machinery in EU and other markets

## Outlook WW Emission solutions 2016 – 2021...2030 ?



## Summary

- For stage IIIB there were two possible paths to reach the goal ( EGR + DPF or SCR). This phase allowed to accumulate experience with both systems.
- Since Phase IV, an SCR system has become essential to achieve the goal (NO<sub>x</sub>)
- The choice of Liebherr was to maximize the performance of the SCR system and not to use EGR
- Stage IV and Stage V engines without EGR have clear advantages in off highway applications
- The better fuel efficiency overcompensates the higher consumption of AdBlue
- With the introduction of Stage V in Europe there is no more alignment between EU and USA for P<560kW
- As the engines themselves become simpler, the robustness and reliability of the entire AGN system is a challenge, since the legal inducement can stop a machine in case of problems.



Thank you!