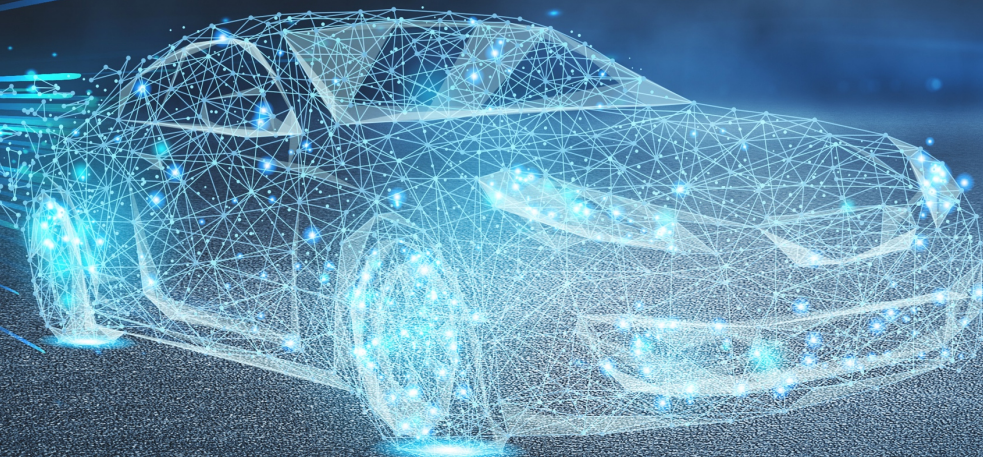


CAPITAL  
MARKETS  
DAY **POWERING  
AHEAD**

  
**umicore**  
*materials for a better life*

**Seoul, Korea**

6 June 2018



# Unprecedented growth in Automotive Catalysts



SPEAKER

*Pascal Reymondet*

*Executive Vice-President Catalysis*



# Agenda

## Business profile

Light Duty Vehicles

Heavy Duty Diesel






Key takeaways





# Business model

**At Automotive Catalysts we develop technologies which allow our customers to meet automotive emission legislation at the lowest Total Cost of Ownership**

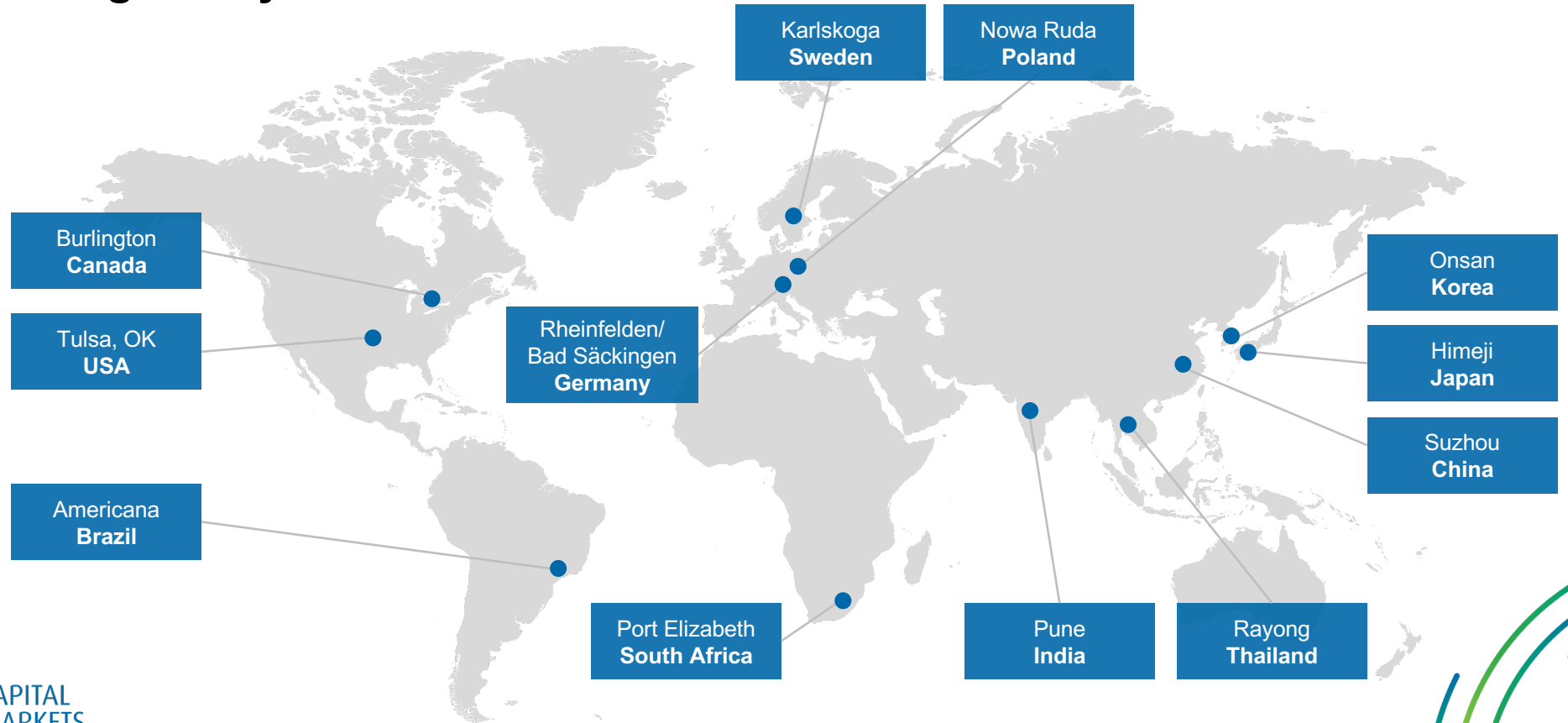
<p><b>Complete catalyst systems to reduce exhaust gas emissions</b></p>			<p><b>Customer focus</b></p>
	<p><b>People engagement</b></p>	<p><b>Operational excellence</b></p>	
<p><b>Global manufacturing &amp; technical footprint</b></p>			



# Global Production Footprint

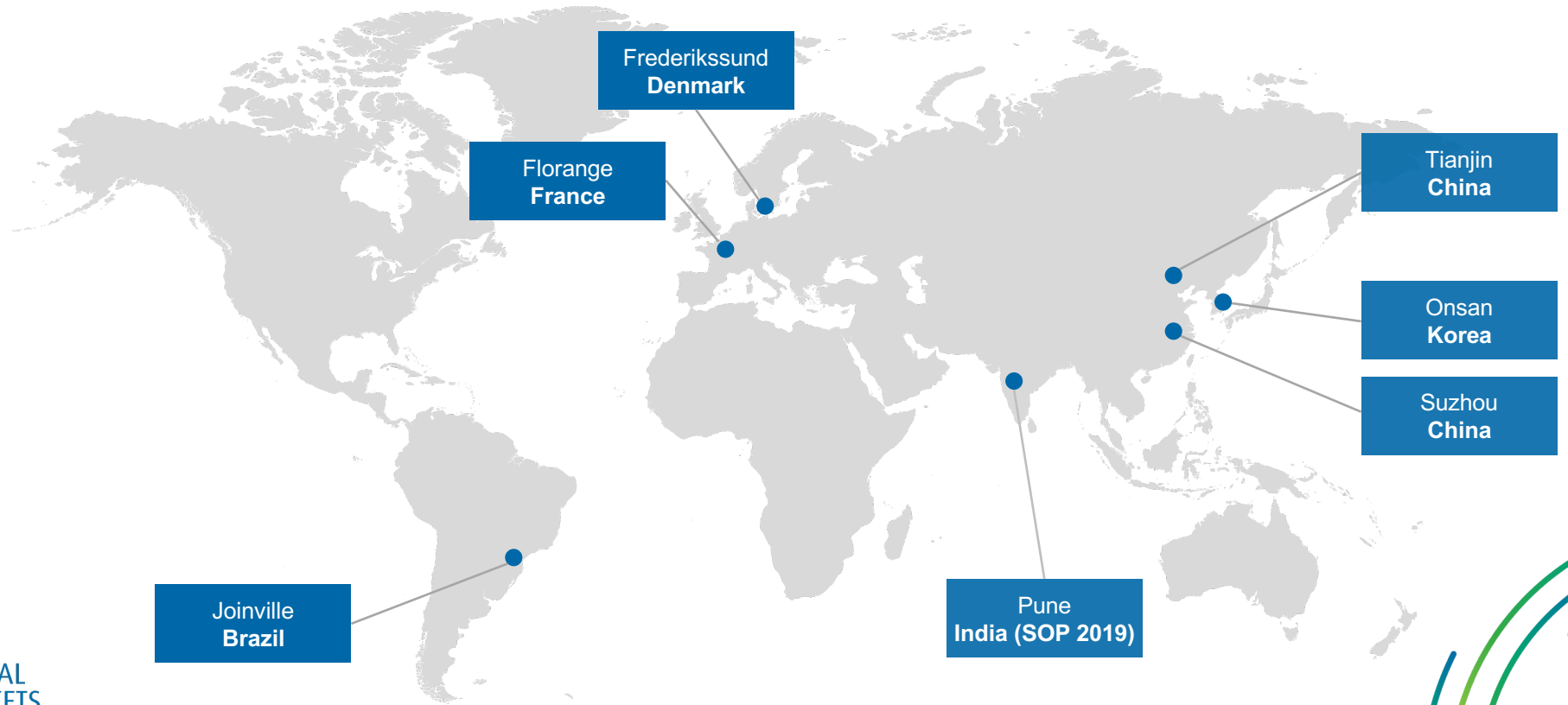


## Light duty vehicles



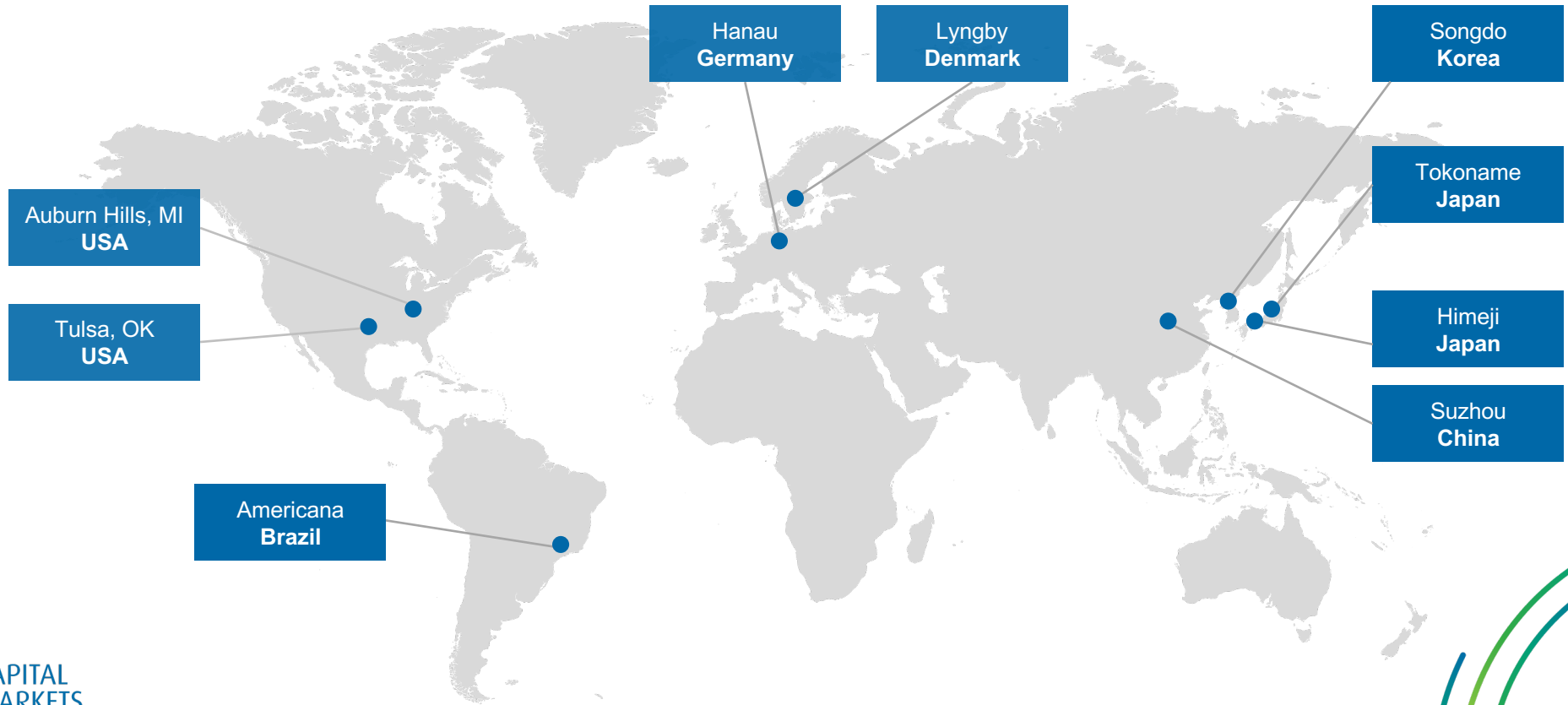
# Global Production Footprint

## Heavy duty diesel



# Global Footprint

## R&D and Technical centers





# Recent additions through M&A



# A clear trend towards clean mobility

“ EU rolls out stricter car emission tests

Reuters 31/08/2017

“ Europe bolsters regulatory clout over carmakers.

Bloomberg 19/04/2018

“ Bharat Stage VI: India revises standards specifications for petrol and diesel.

Reuters 18/01/2018

“ China 6 emission standard to be implemented in 2020.

Autonews 11/05/2018



COMMENTS FROM THE PRESS

# Agenda

Business profile

**Light Duty Vehicles**

Heavy Duty Diesel

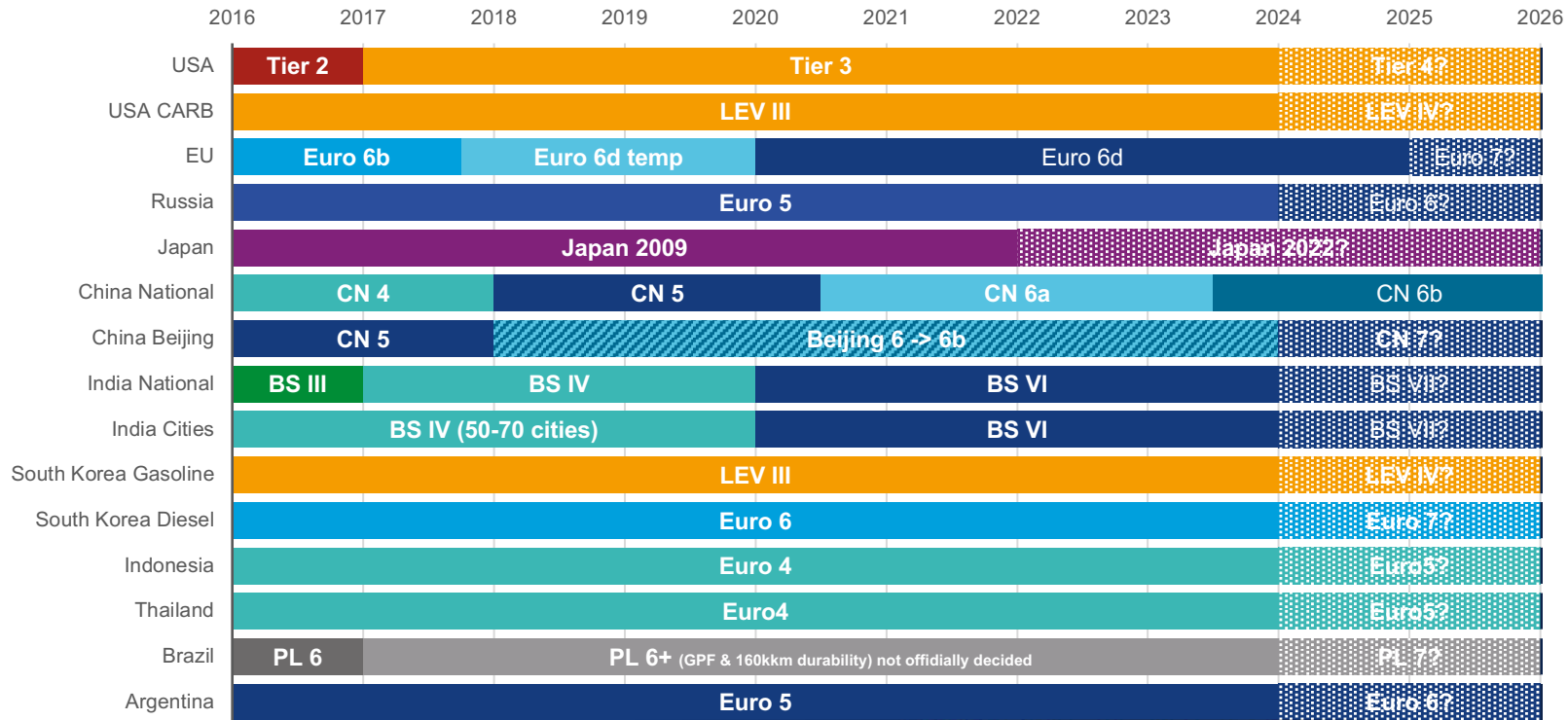
Key takeaways





# More stringent emission norms across regions

## No tolerance for pollution



# China, Europe and India on the verge of massive tightening of emission norms

2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026

2



1



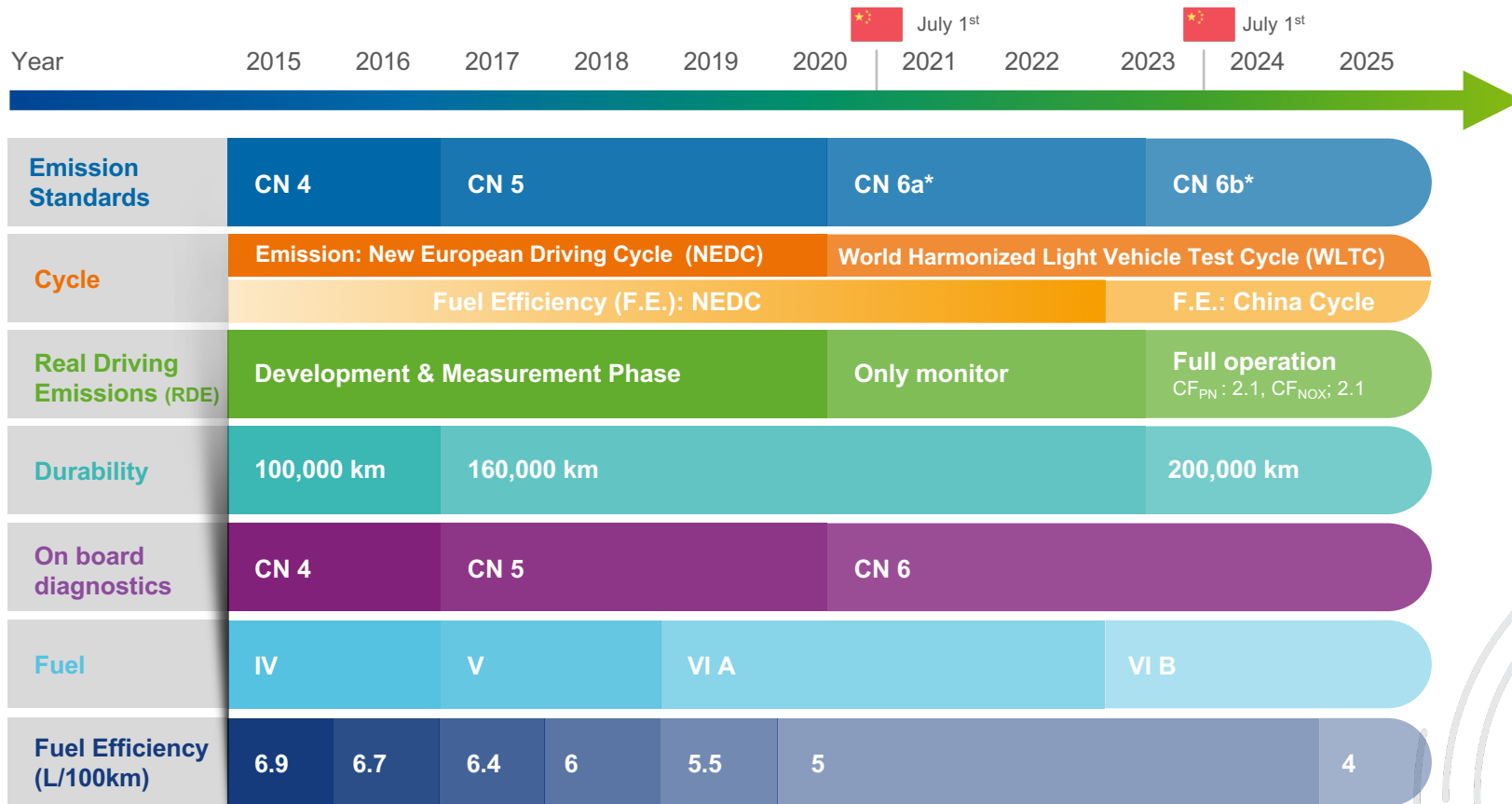
3





China

# China changes its role from follower to pace setter



\*Fuel neutral; Particulate Number (PN) and Particulate Mass (PM) required for all engines.







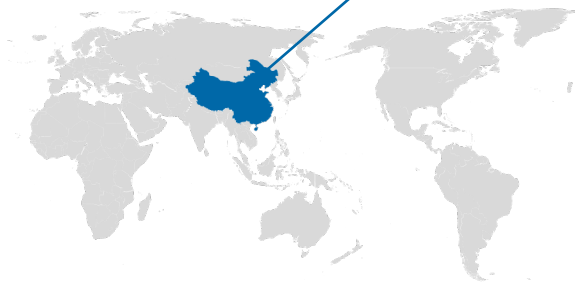
China

# China's huge gasoline fleet will become much cleaner



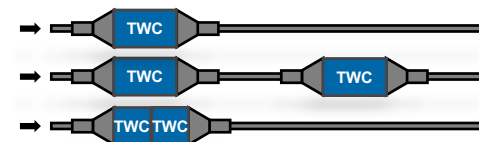
CHINA LDV MARKET BY 2025

34 million



## China 5: current

Gasoline PM limit of 4.5mg/km



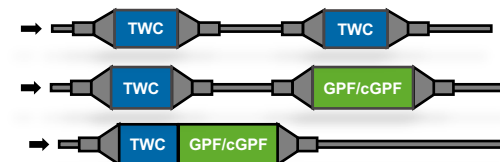
Single or double Three Way Catalyst

## China 6a: July 2020

More stringent CO, HC, NOx limits

Gasoline PN limit of  $6 \times 10^{11}$

> 1.7x value vs. China 5

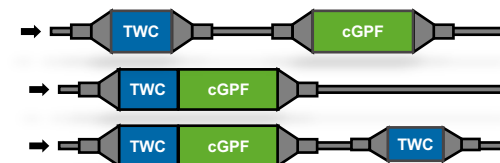


Partial introduction of particulate filters (cGPF) for gasoline engines

## China 6b RDE: July 2023

- Gasoline PN limit of  $6 \times 10^{11}$
- Conformity factor (CF) 2.1x under RDE
- HC and NOx further reduced

> 2.4x value vs. China 5



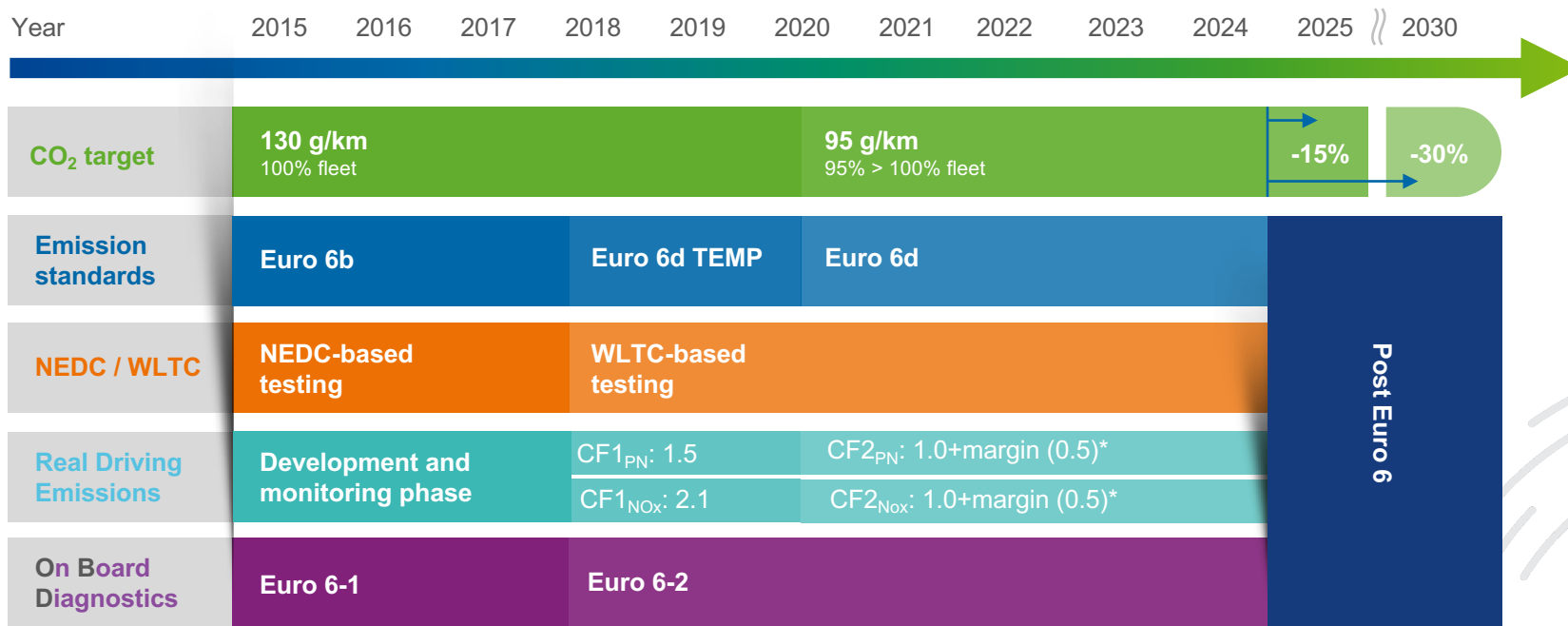
cGPF for all gasoline engines



Source: IHS  
May 2018

CAPITAL  
MARKETS  
DAY POWERING  
AHEAD

# Significant impact from new European testing regime



☰ All dates: New type approval Passenger Cars  
\*annual review and revision as a result of improved quality of PEMS procedure or technical progress



# RDE calls for massive fitment with gasoline particulate filters

EURO 6 REGION  
LDV MARKET  
BY 2025

20  
million

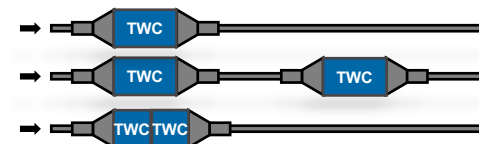


Source: IHS  
May 2018

\* For all new vehicles sold

## Euro 6b: current

Gasoline PN limit of  $6 \times 10^{11}/\text{km}$

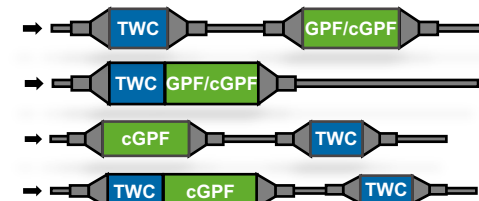


Single or double Three Way Catalyst

## Euro 6d temp: Sept. 2018\*

Gasoline PN limit of  $6 \times 10^{11}/\text{km}$  with  
PN CF 1.5x under RDE

> 1.8 x value vs. Euro 6b

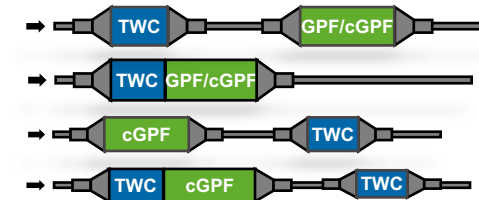


GPF/cGPF for almost all GDI engines

## Euro 6d final: Jan. 2021\*

Gasoline PN limit  $6 \times 10^{11}$  with  
PN CF 1.0-1.5x under RDE

> 2.2 x value vs. Euro 6b

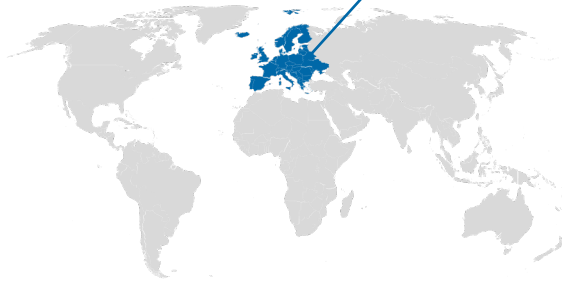


cGPF for ~80% of all GDI engines  
and 50% of MPI engines

# RDE calls for more complex diesel catalysts

EURO 6 REGION  
LDV MARKET  
BY 2025

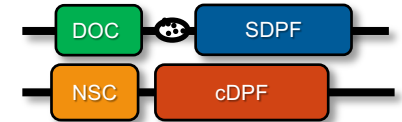
20  
million



Source: IHS  
May 2018  
\* For all new vehicles sold

## Euro 6b: current

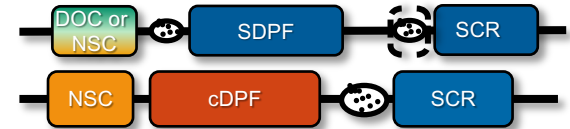
NOx emission limit of 80 mg/km



NSC or SCR for NOx and particulate filters

## Euro 6d temp: Sept. 2019\*

NOx emission limit of 80 mg/km  
with NOx CF 2.1x under RDE

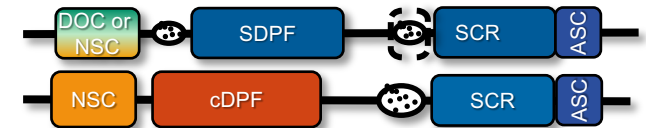


Majority with SCR

> 1.3x value vs. Euro 6b

## Euro 6d final: Jan. 2021\*

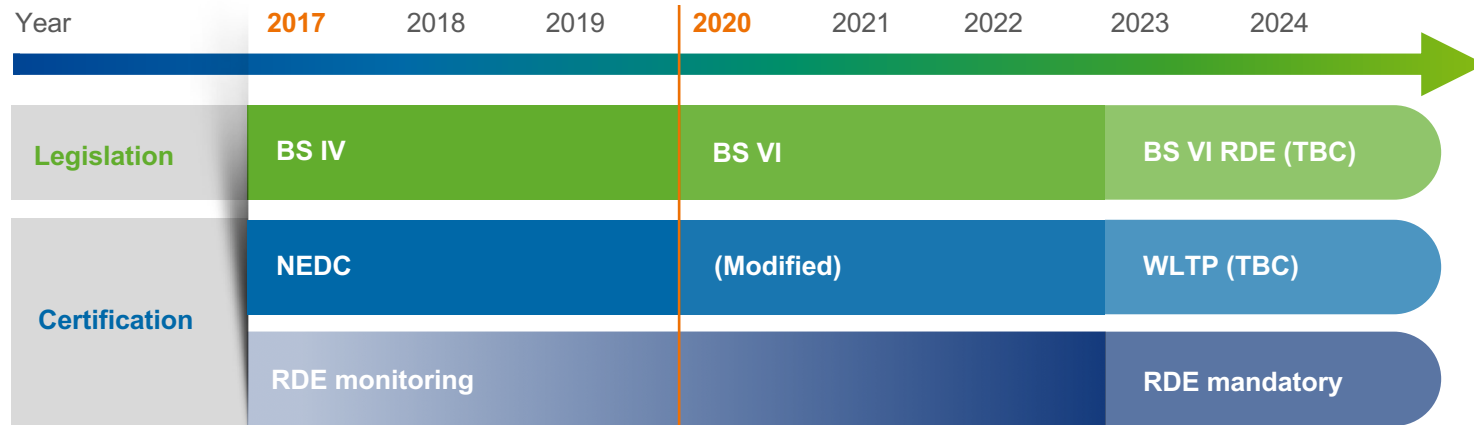
NOx emission limit of 80 mg/km  
with NOx CF 1.0-1.5x under RDE



Additional „underfloor SCR / ASC“  
with twin urea dosing

> 1.5x value vs. Euro 6b

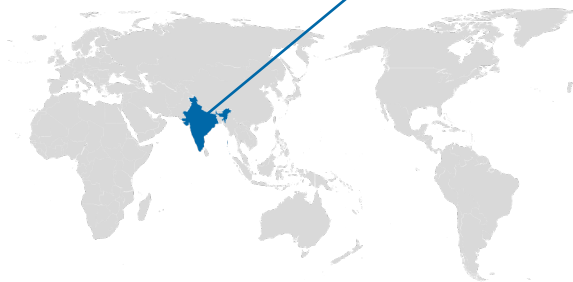
# India leapfrogs from Bharat Stage IV to VI



# Introducing similar norms to Euro 6b for gasoline...

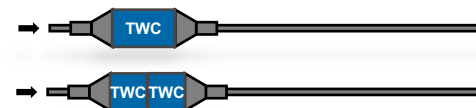
INDIA  
LDV MARKET  
BY 2025

8  
million



## Bharat Stage IV: current

No gasoline particulate limit

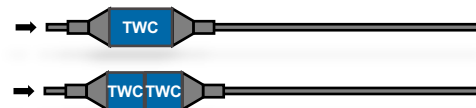


Single or double Three Way Catalyst obligatory but no stringent control

## Bharat Stage VI: 2020

Gasoline particulate limit of  $6 \times 10^{11}/\text{km}$

> 1.5x value vs. BS IV

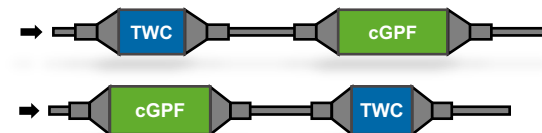


Single or double Three Way Catalyst volume increase

## Bharat Stage VI RDE: 2023 (TBC)

Gasoline particulate limit of  $6 \times 10^{11}/\text{km}$

> 3x value vs. BS IV



cGPF for all GDI engines

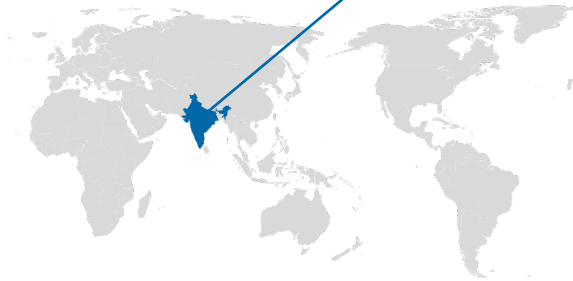


Source: IHS  
May 2018

# As well as for diesel

**INDIA  
LDV MARKET  
BY 2025**

**8  
million**



## Bharat Stage IV: current

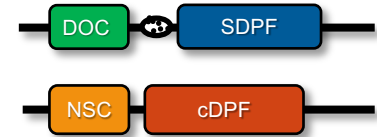
NOx emission limits of 250mg/km



*Oxidation catalyst required with particulate filter optional*

## Bharat Stage VI: 2020

- NOx emission limit of 80mg/km
- Particle emission limit 6 x10<sup>11</sup>/km



*Particulate filters (DPFs) and active NOx treatment (NSC or SDPF) required for all diesel engines*

**> 3 x value vs. BS IV**



Source: IHS  
May 2018



# Tightening emission norms drive massive value uplift

## Average Value Gasoline Catalyst

## Average Value Diesel Catalyst



### China 6

- 2020: value x 1.7 vs. current
- 2023: value x 2.4 vs. current



### Euro 6d

- 2019: value x 1.8 vs. current
- 2020: value x 2.2 vs. current



### Bharat VI

- 2020: value x 1.5 vs. current
- 2023: value x 3.0 vs. current



### Euro 6d

- 2019: value x 1.3 vs. current
- 2020: value x 1.5 vs. current



### Bharat VI

- 2020: value x 3.0 vs. current

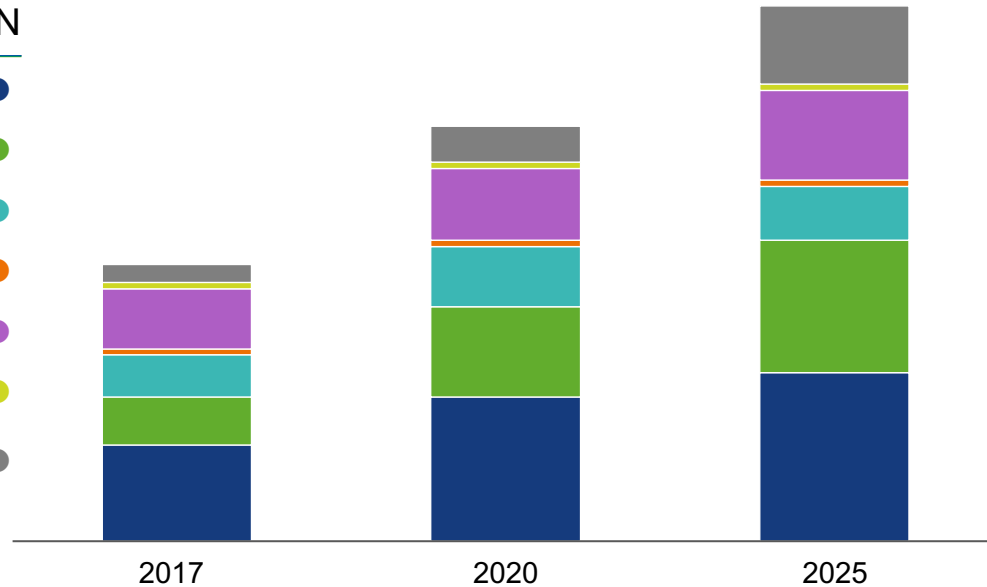
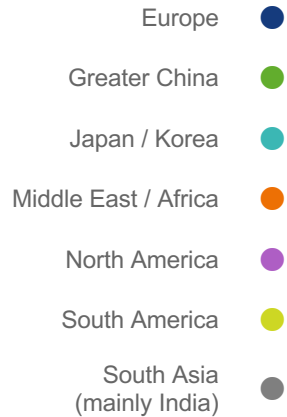
x2

Upside value of up to 20% for pHEV catalysts

x1.5

# Leading to massive growth in the light duty vehicle market

## MARKET VALUE EVOLUTION BY REGION



Excluding the upside potential of hybrid cars

> Global LDV market nearly doubling in value by 2025

> China representing the lionshare of the value increase



Source: IHS data and Umicore estimates

# Umicore best positioned to capture this growth



**Gaining significant share in growing gasoline segment**

**Disproportionate share of GPF platforms won in Europe and China**



**Smaller player in light duty diesel**

# Agenda

Business profile

Light Duty Vehicles

**Heavy Duty Diesel**

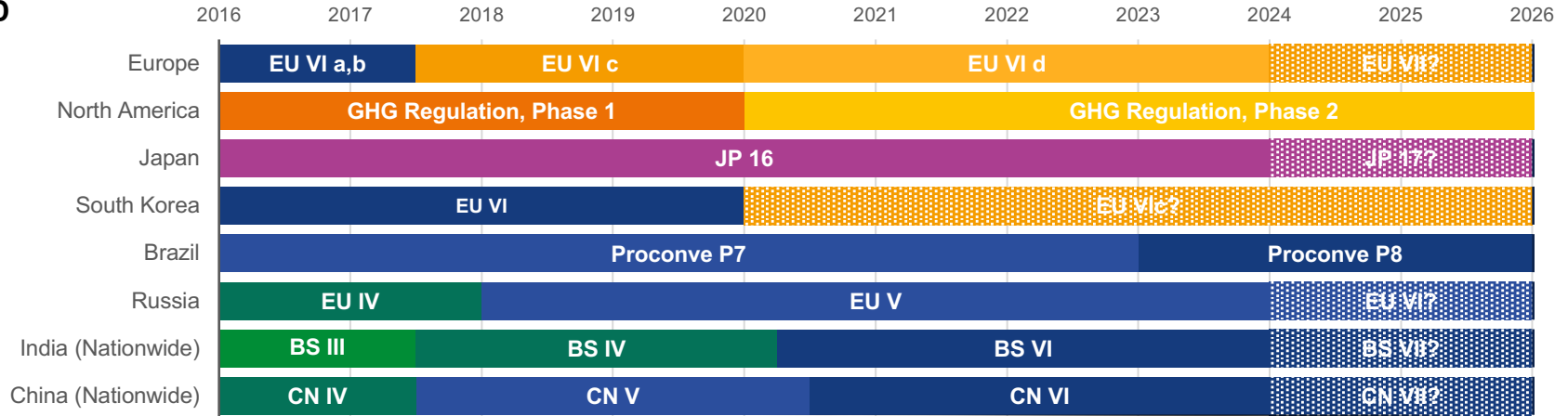
Key takeaways



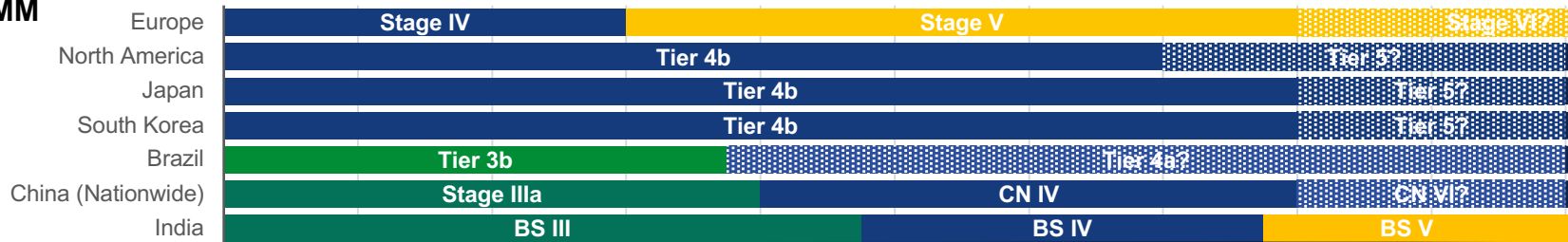
# Global emission standards for HDD continue to tighten



## HDD



## NRMM



NRMM = non-road mobile machinery

# China and India on the verge of massive tightening of emission norms

HDD

2016

2017

2018

2019

2020

2021

2022

2023

2024

2025

2026

2

India (Nationwide)

BS III

BS IV

BS VI

BS VII?

1

China (Nationwide)

CN IV

CN V

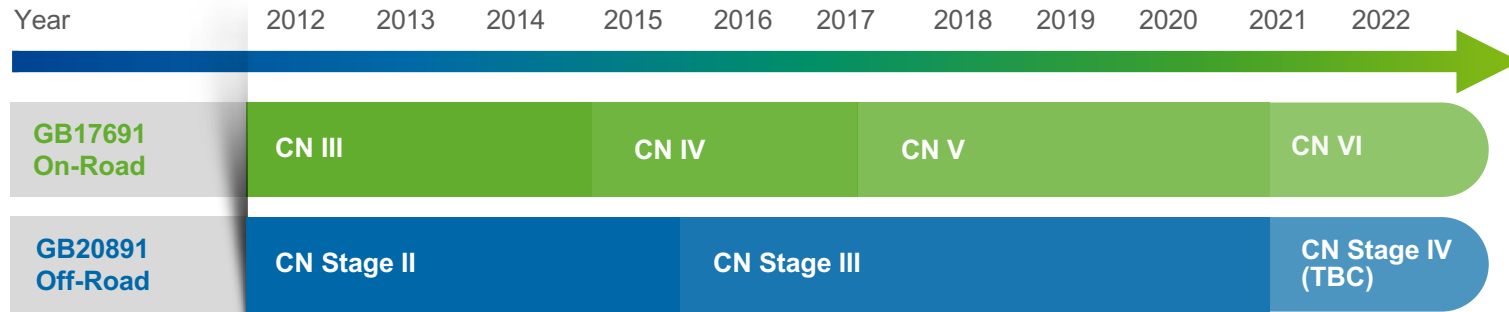
CN VI

CN VII?



China

# China VI to significantly toughen HDD emission standards







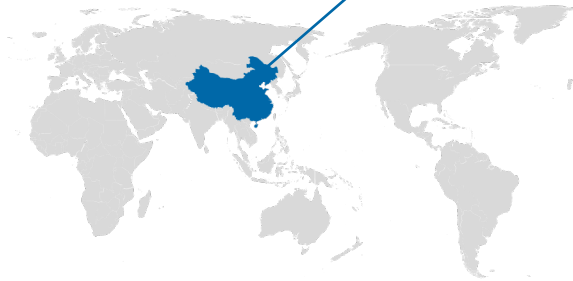
China

# More advanced catalytic systems for HDD in the largest market globally



CHINA  
HDD MARKET  
BY 2025

3.6  
million



## China V: current

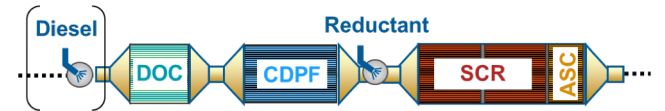
NOx limit of 2000 mg/kWh



SCR for NOx aftertreatment

## China VI: 2021

- NOx limit of 460 mg/kWh
- Particulate number limit  $6.0 \times 10^{11}$



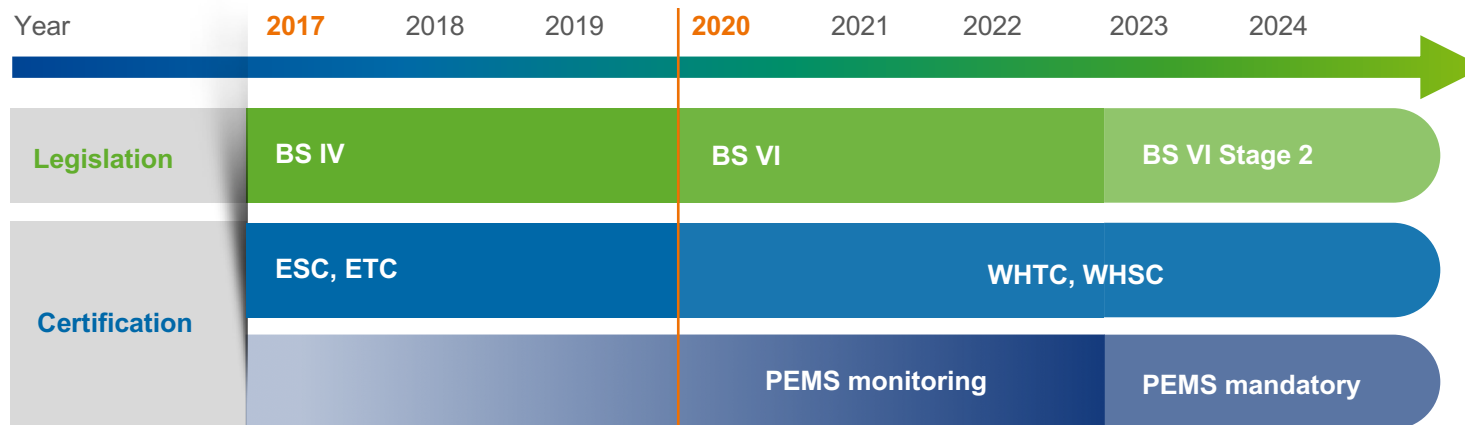
Additional DOC and cDPF necessary

> 2.8 x value vs. China V



Source: KGP & Umicore assumptions  
on-road and non-road engines produced May 2018

# India leapfrogs from Bharat Stage IV to BS VI

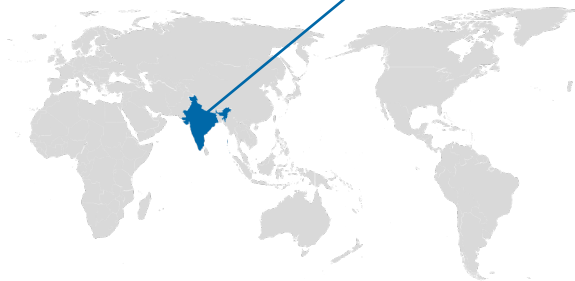


# BS VI calls for significantly more complex catalysts on all on-road HDD



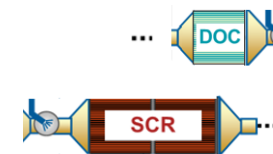
INDIA  
HDD MARKET  
BY 2025

1.1  
million



## Bharat Stage IV: current

NOx limit 3500 mg/kWh



Low SCR penetration

## Bharat Stage VI: 2020

NOx limit 460 mg/kWh



Particulate and NOx treatment necessary

> 4 x value vs. BS IV



Source: KGP & Umicore assumptions  
on-road and non-road engines produced  
May 2018

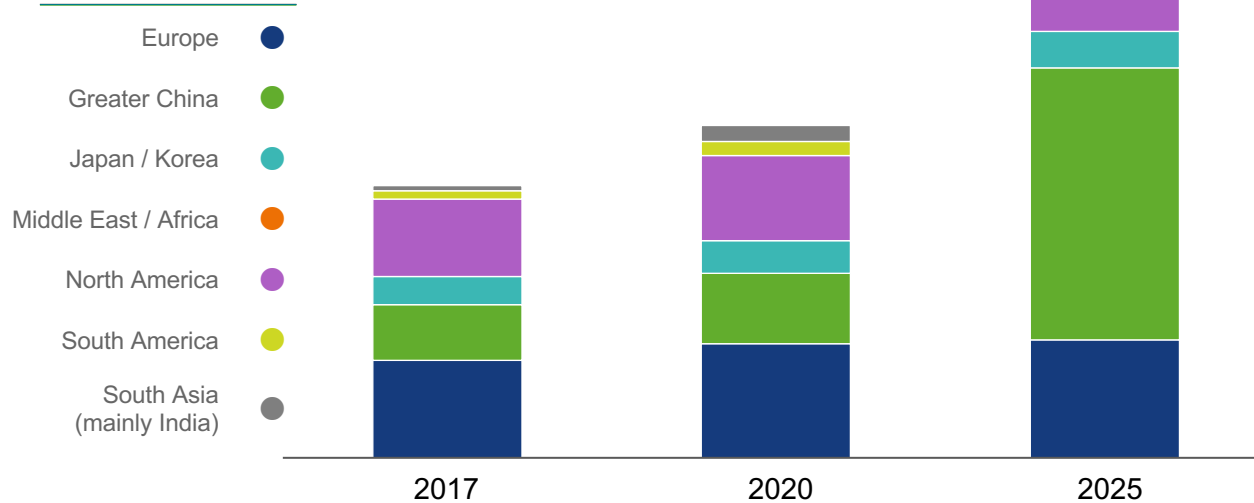
# Tightening emission norms and market growth drive massive value uplift...



≡ Source: KGP and Umicore assumptions  
(expected on-road and non-road engines produced)

# Leading to massive growth in the heavy duty diesel market

MARKET VALUE EVOLUTION BY REGION



- > Global HDD market more than doubling in value by 2025
- > China quintupling by 2025

# Umicore well positioned to capture this growth



**Competitive  
technology  
portfolio**



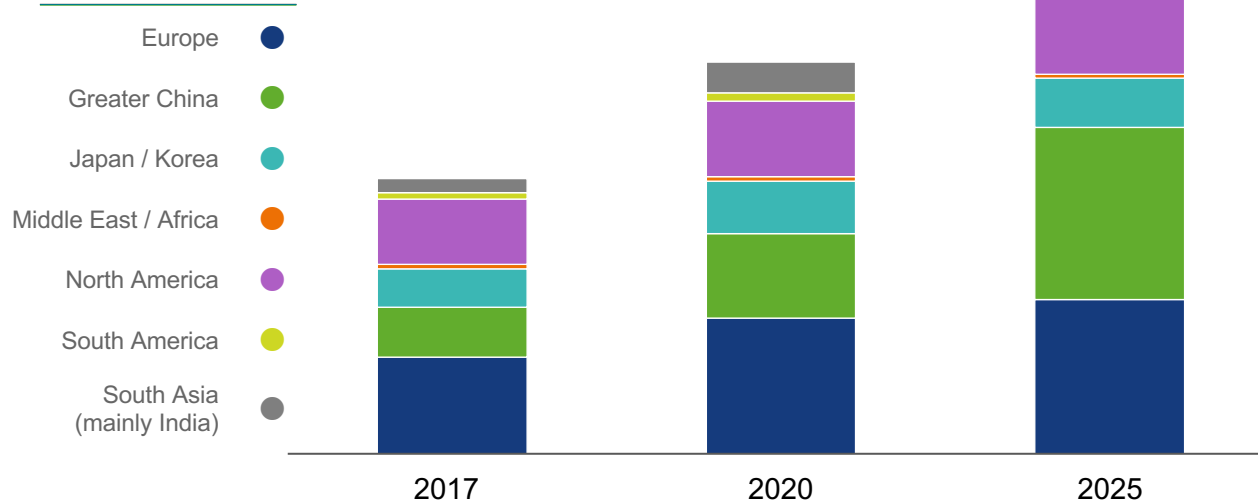
**Strong position  
in China** which  
is becoming the  
largest HDD market



**Development  
partner** of most  
major HDD  
OEMs

# Total LDV and HDD catalyst market set for unprecedented value growth

MARKET VALUE EVOLUTION BY REGION



- > Value growth by far outpacing vehicle production
- > Technology and Innovation play



# Agenda

Business profile

Light Duty Vehicles

Heavy Duty Diesel

**Key takeaways**



# Key takeaways



**Unprecedented value growth driven by advanced catalyst systems for tighter legislation both in LDV and HDD**

**China becoming the pace setter**



**Umicore well positioned to outgrow the market through its technology leadership in key segments**

umicore<sup>®</sup>

materials for a better life