

# Diesel controversy –Temporary shock or paradigm shift in powertrain?

Impact of the diesel controversy  
on OEMs and suppliers



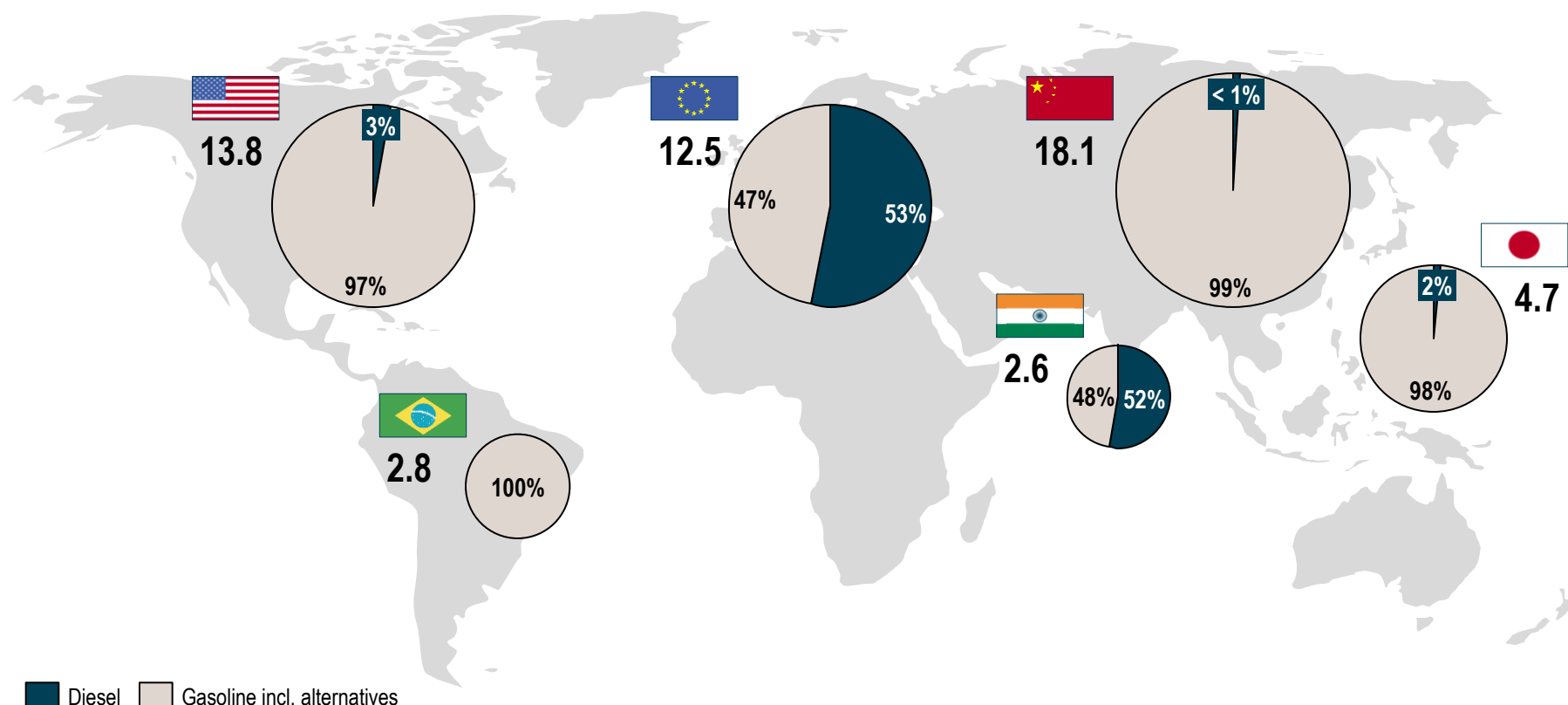
## Executive summary

- > European OEMs have utilized the fuel-efficient diesel powertrain as a **key lever to reduce corporate fleet CO<sub>2</sub> emissions**, especially in the EU due to 2020/21 CO<sub>2</sub> vehicle emission targets. These targets are basically impossible to reach without diesel
- > We therefore expect diesel to **remain a key pillar** in OEMs' powertrain strategies, especially in Europe
- > The current debate about diesel will, however, **further drive innovations** in combustion<sup>1)</sup> and after-treatment of diesel due to increasing regulatory requirements and standards, and will **enforce test cycle implementation** aiming to reflect Real Driving Emissions (RDE)
- > In order to fulfill RDE regulations, diesel will become **cleaner** (with emission levels similar to gasoline engines), but also **more expensive**
- > The resulting cost increase will **accelerate the substitution** process from diesel to smaller gasoline engines, especially in lower vehicle segments. Diesel will still remain dominant in the upper vehicle segments but total diesel share in Europe will decline in the coming years
- > **OEMs** therefore have to further accelerate alternative powertrain solutions. **Suppliers** have the opportunity to implement innovative solutions for the further control of diesel RDE, and should also step up their preparations for alternative powertrains

1) Such as homogeneous combustion and HCCI

# In the global core passenger car markets, the diesel powertrain is mainly a European phenomenon with more than 50% of new sales

New sales of passenger cars, 2014 [m units]

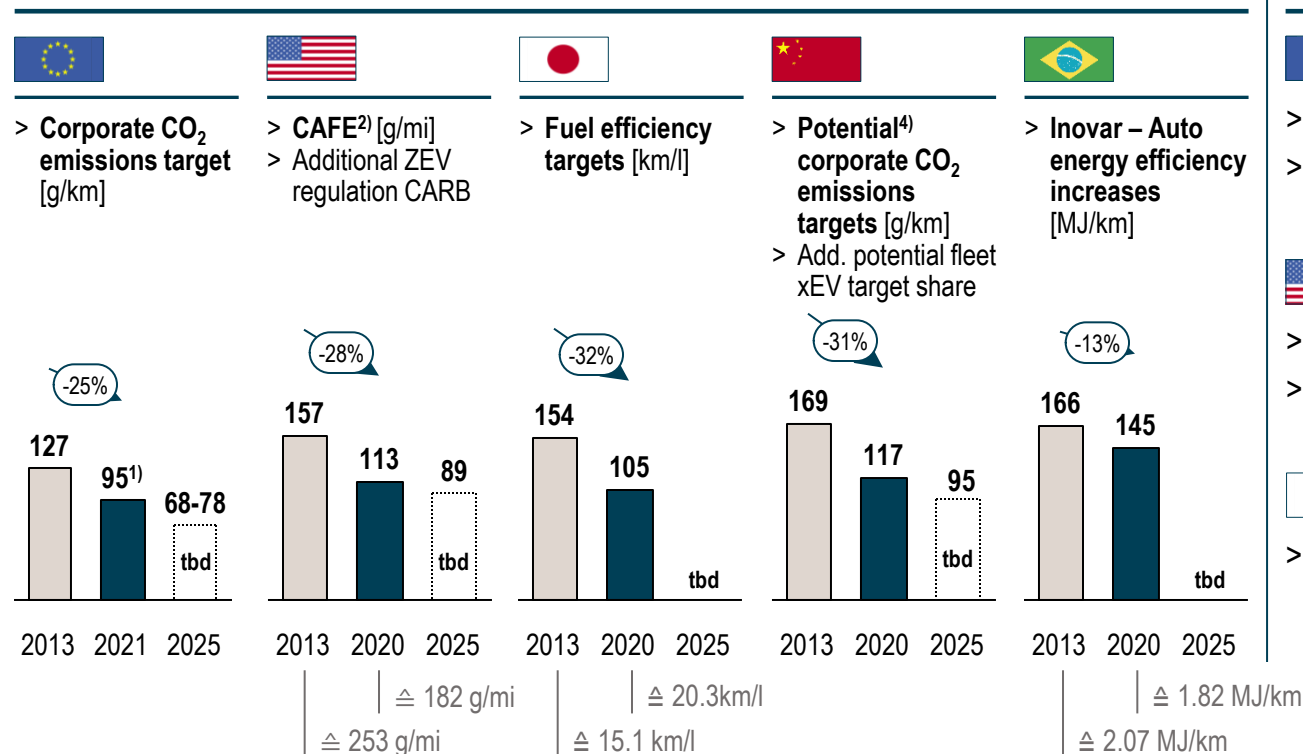


Europe = EU-28

# Emission regulations increase pressure on automotive OEMs to improve CO<sub>2</sub> emissions, fuel efficiency and exhaust gas emissions




## Assessment of CO<sub>2</sub> emissions/fuel consumption and toxic gas emission regulations

### 1 CO<sub>2</sub> emissions/fuel consumption



1) Average weight-dependent CO<sub>2</sub> emissions target 2) Only for passenger cars  
 3) End customer pull for low CO<sub>2</sub> emission/low fuel consumption powertrain and/or alternative powertrains 4) No decision made yet 5) Euro 6c test cycle WLTC: to be confirmed

### 2 Toxic exhaust gas emissions (NO<sub>x</sub>, PM, HC)

-  > 2014: Euro 6b emission standard
- > 2017: Euro 6c with implementation of RDE<sup>5)</sup>, additionally WLTP
-  > Tier II Standards
- > Low Emission Vehicle Program (LEV2, LEV3)
-  > 2009: post new long-term standards JC08 mode cycle

# Diesel powertrain utilizes its better CO<sub>2</sub>/fuel efficiency compared to gasoline especially in the upper vehicle segments

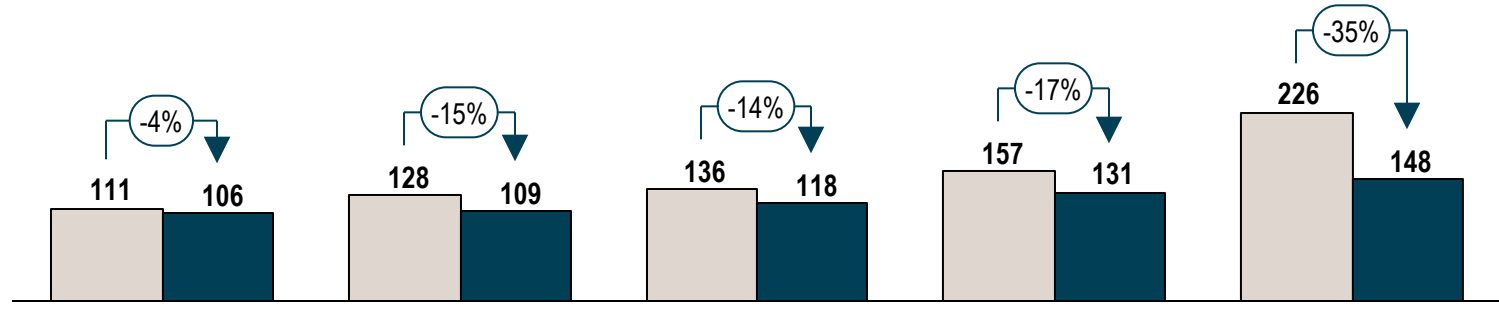
CO<sub>2</sub> emissions by segment/body type in EU-28, 2014



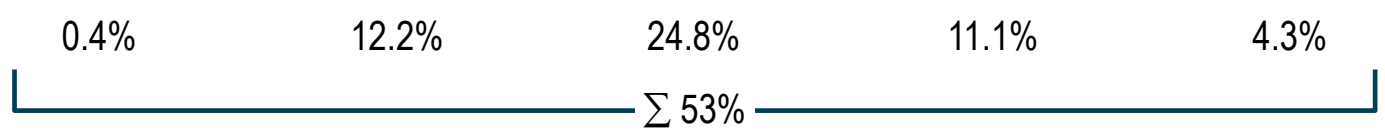
Segment



Avg. CO<sub>2</sub> emissions<sup>1)</sup> [g/km]



Diesel share of total sales

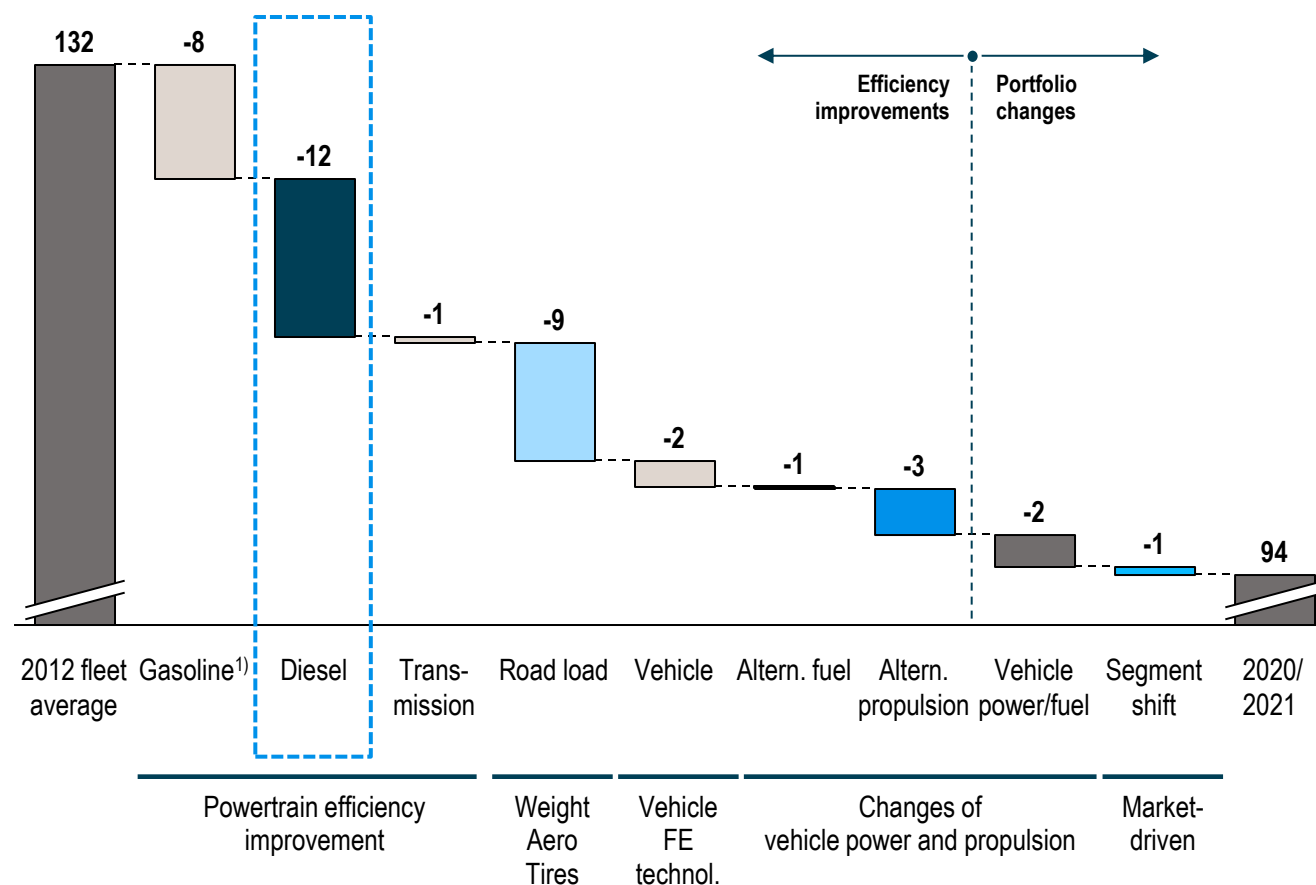


Gasoline Diesel

1) Based on comparison of performance peer groups

# Diesel efficiency improvements will be the main lever to reduce fleet emissions for European OEMs to reach 95 g/km target in 2020/2021

EU volume OEM<sup>1)</sup> fleet avg. CO<sub>2</sub> emission reduction levers until 2020/2021 [g/km]

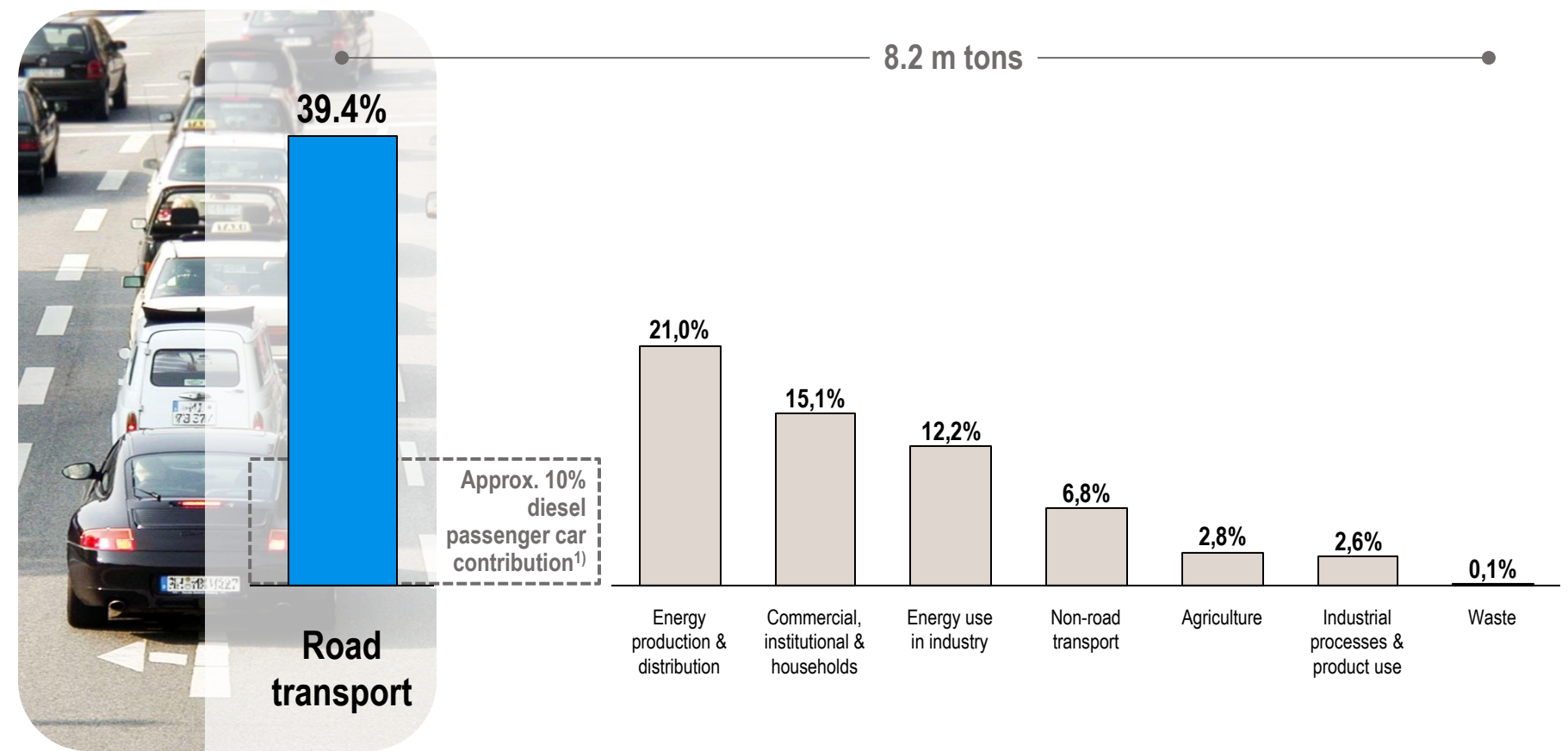


- > Regarding reduction of fleet average CO<sub>2</sub> emissions, diesel efficiency improvement is a key lever to reach the target from the CO<sub>2</sub> emission regulations in 2020/2021
- > A gap of 12 g/km could not be closed with other powertrain technologies if diesel were to be abandoned
- > Therefore, the improvement of diesel efficiency has to be a key pillar of the OEM's CO<sub>2</sub> reduction strategy

1) Exemplary OEM 2) Including CNG/LPG engine technology improvements

# As of today, the road transport sector is the largest source of NO<sub>x</sub> emissions in Europe – Diesel is a major contributor

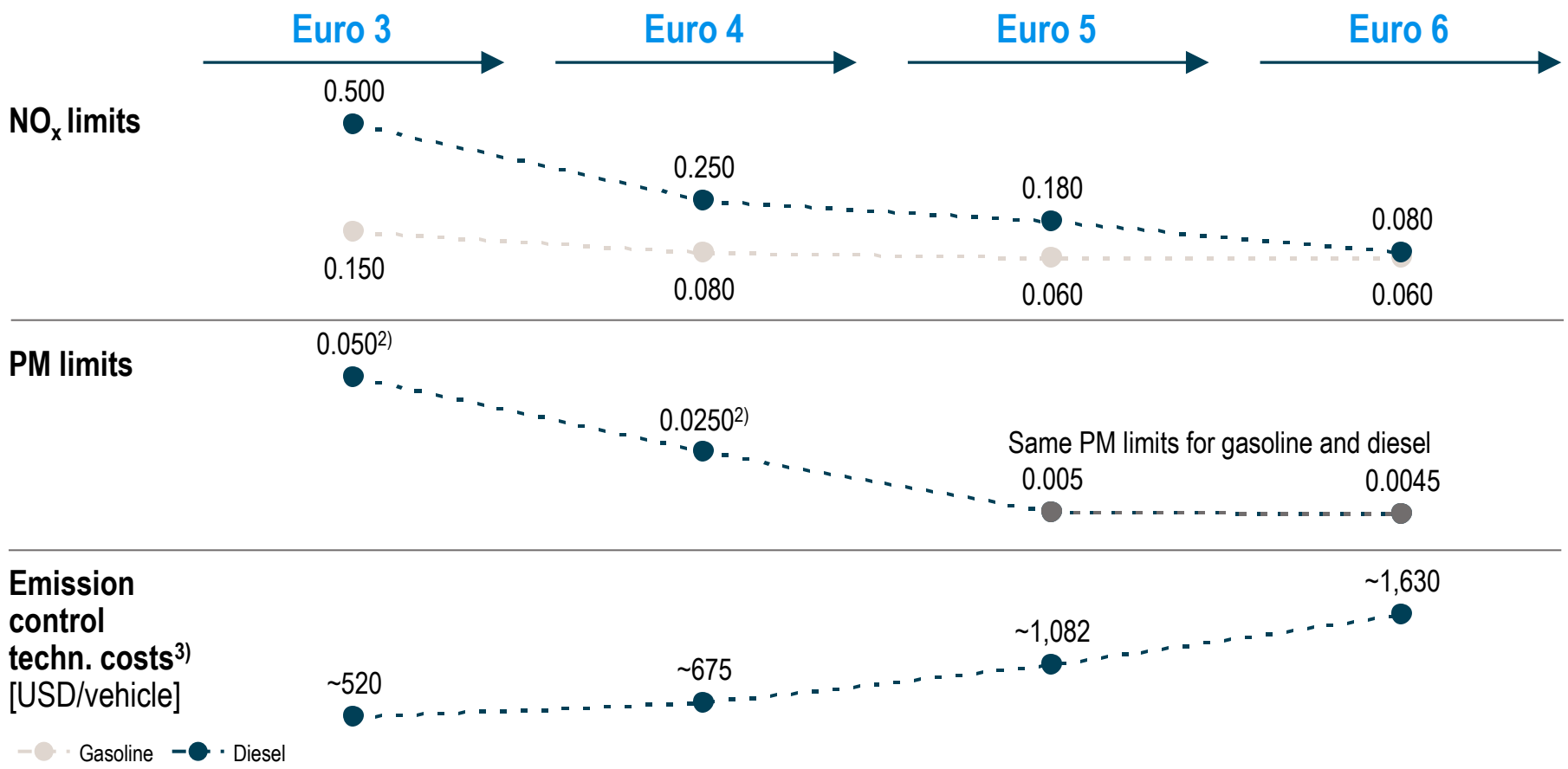
NO<sub>x</sub> emissions by sector in EU-28, 2013 [%]



1) In Germany, as of 2012

The diesel's NO<sub>x</sub> and PM limits have approached the level of gasoline but also lead to increases in emission control costs

Toxic emission limits<sup>1)</sup> of diesel vs. gasoline passenger cars NEDC [g/km]

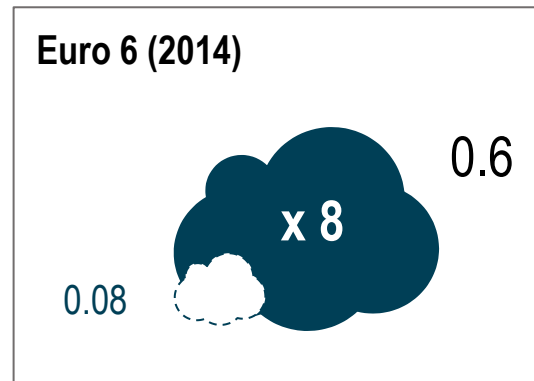
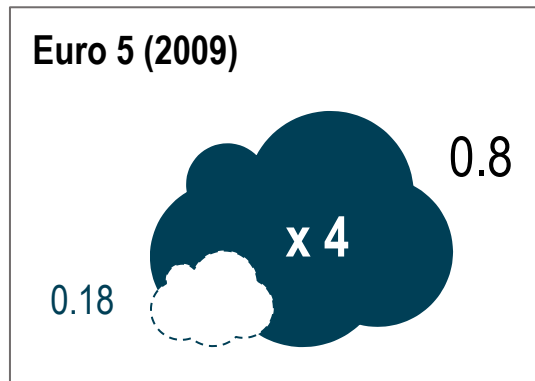
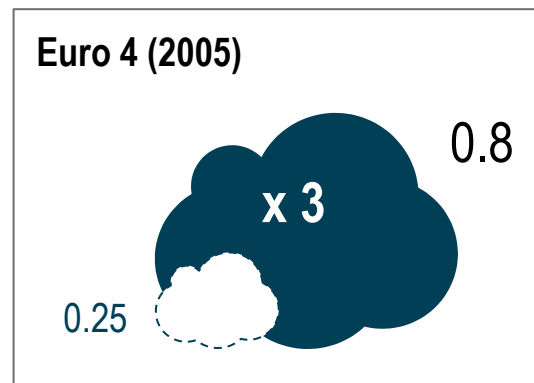
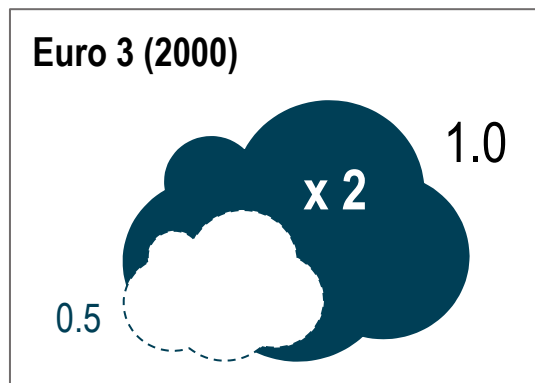


1) All emission limits as tested in New European Drive Cycle (NEDC) 2) Only for diesel 3) For a 2.0 liter diesel engine in 2010



# Nevertheless, the discrepancy between real emissions and EU limits for diesel cars has substantially increased since 2000

NO<sub>x</sub> emissions: Diesel passenger cars NEDC [g/km]



**Euro 6c (2017)**

- > Implementation of **new Real Driving Emission tests (RDE)** is expected
- > **Reducing the RDE of the diesel powertrain** becomes a **challenge** for OEMs and suppliers
- > Manufacturers will need to find solutions for **good CO<sub>2</sub> efficiency, low real NO<sub>x</sub> emissions** and **good driving experience**

● Measured on road    ○ Cycle limit

# The 2025 outlook for diesel – Decrease of diesel share in nearly all major automotive markets is expected

## 2025 worldwide outlook and drivers for the use of diesel in passenger cars



- > **Customer interest** in diesel in the US market **will decline** due to the recent controversy; **diesel fuel price remains higher** than gasoline
- > Main **local car makers** will focus on **efficient gasoline engines** and electrification
- > Diesel will only be offered in some **niche market segments**



- > **European OEMs** will still **focus on diesel** technology due to existing investments and **CO<sub>2</sub> emission targets**
- > Diesel powertrain is getting **more expensive**, partly due to implementation of RDE cycles with Euro 6c
- > Diesel will **lose market share** (esp. in **smaller vehicle segments**)



- > Chinese **government** is heavily promoting the development of **battery electric vehicles (BEV)**
- > **Diesel engines will not play any role** in China for **passenger cars**
- > Diesel engines are only **relevant for trucks**



- > **Ban of diesel engine** passenger cars **in place**
- > Fierce competition with **ethanol/flex fuel** (local production)
- > **No uptake of diesel engines** in passenger cars expected



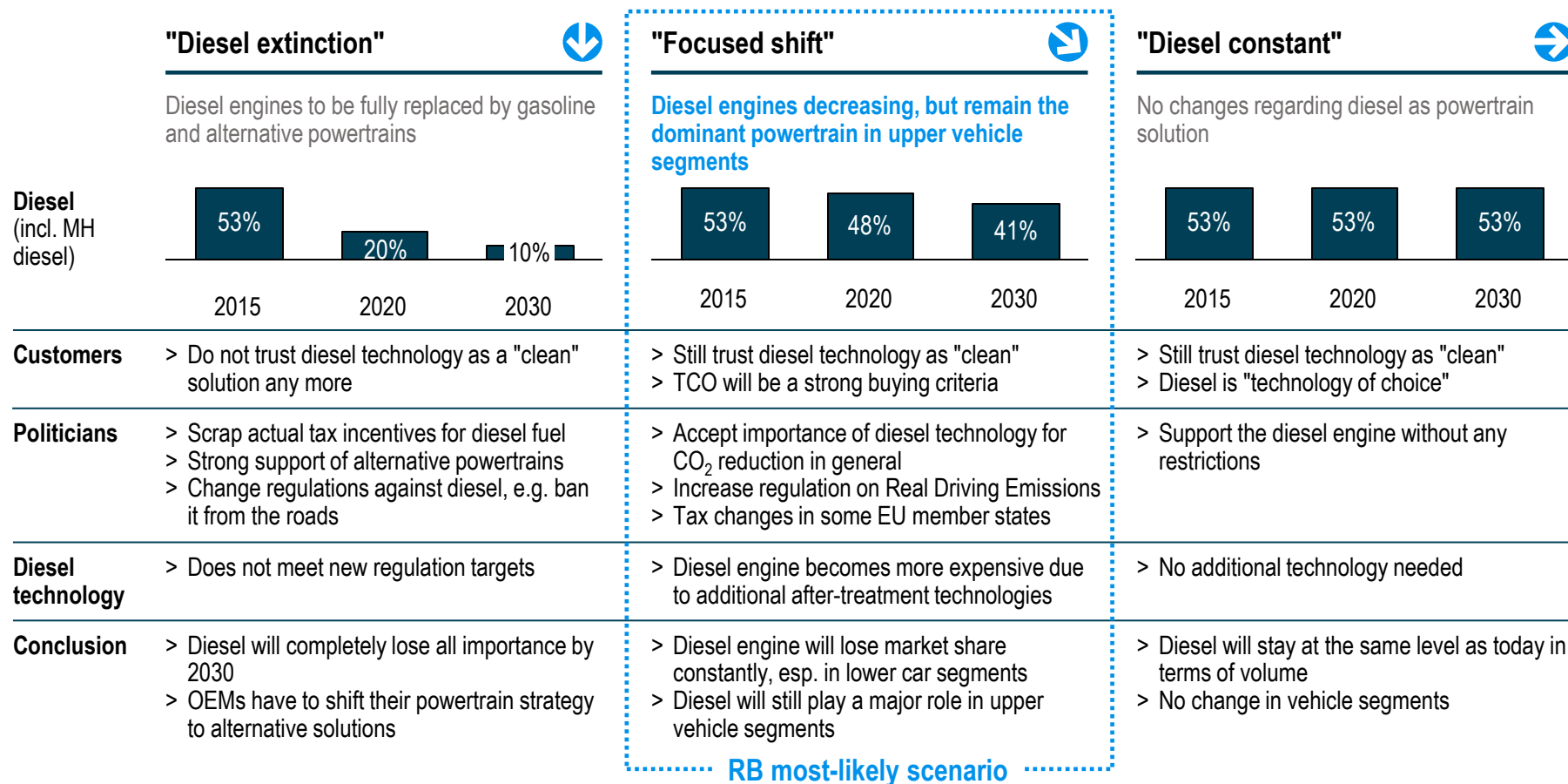
- > **Diesel fuel has a price advantage** even without subsidies
- > **Sales of diesel-fuelled cars** expected to **keep on rising**



- > Strong focus of **Japanese OEMs** in **alternative powertrain** technologies (i.e. hybrid and electric vehicles)
- > Government **subsidies for alternative powertrains**
- > **No major share of diesel engines** in passenger cars expected

# Three scenarios on future of diesel possible in Europe 2030 – "Most likely" is decrease of diesel with shift toward upper car segments

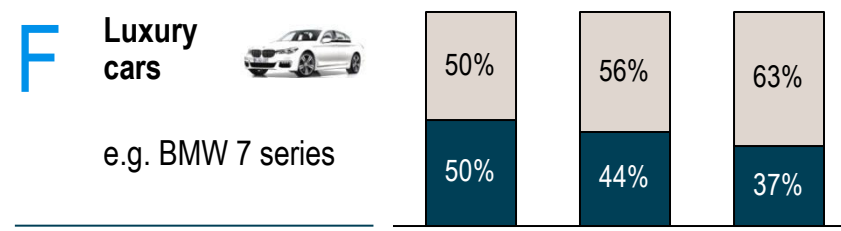
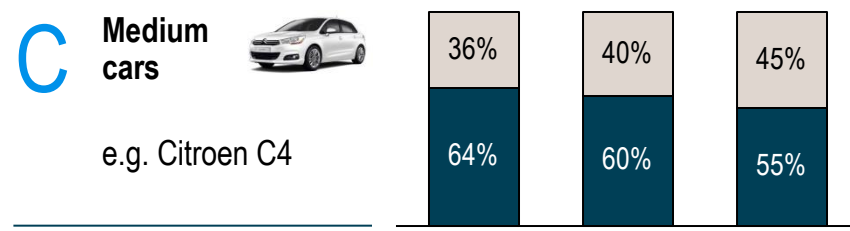
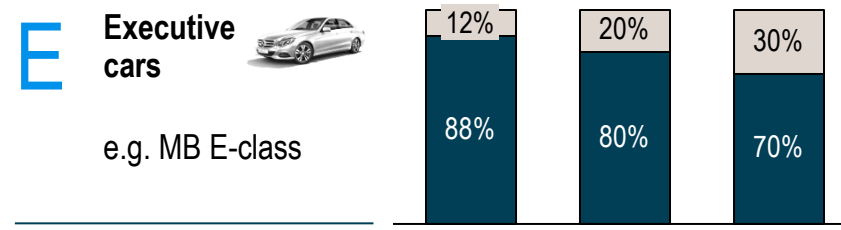
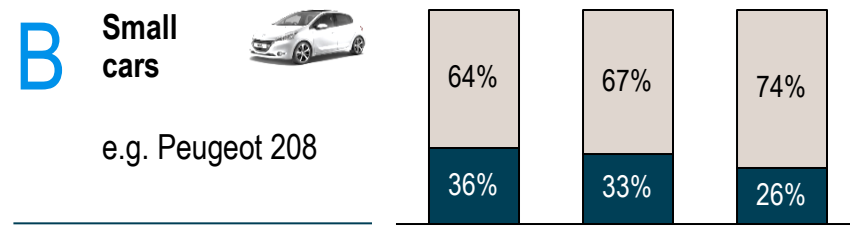
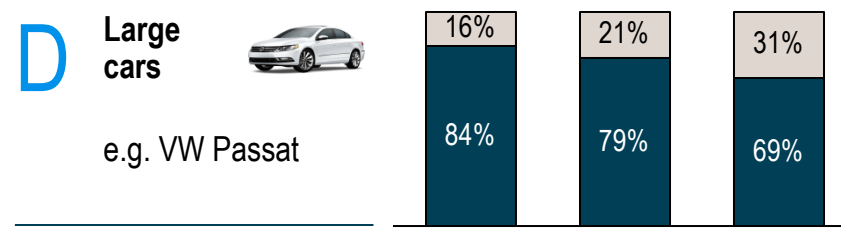
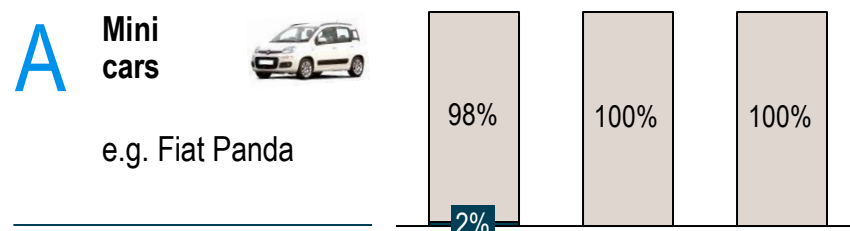
Diesel scenarios in Europe/forecast new car diesel shares in EU-28 until 2030<sup>1)</sup>



1) In % of new car sales

# Diesel powertrain still expected to hold dominant position in upper passenger car segments despite decline in diesel share by 2030

"Focused shift": New car diesel forecast by segment in EU-28 until 2030<sup>1)</sup>



2014      2020      2030

2014      2020      2030



1) In % of new car sales

# Diesel essential for CO<sub>2</sub> reduction by OEMs but higher technology demand to meet regulations – Potential benefits for supplier industry

"Focused shift": OEM and supplier implications

## OEMs

Accept and **close the gap between cycle and Real Driving Emissions** of diesel engines

Develop and **implement (after-treatment) solutions** in order to reduce RDE

Adapt powertrain strategy by **shifting the diesel focus** from lower to upper car segments

Accelerate **implementation of alternative powertrain solutions** (electrification) to meet CO<sub>2</sub> regulations

Successfully **convince car buyers and policymakers** of "The New Clean Diesel"



## Suppliers

Innovative solutions for **more efficient and clean diesel** technologies needed

Innovative solutions for **more efficient gasoline** technologies needed

Higher **demand for alternative powertrain solutions** increases demand for cost-intensive BEV/PHEV cars

Higher **demand for after-treatment solutions** for diesel engines to meet RDE regulations

**Shift** from diesel to gasoline engines in car segments **changes the technology**

**Long-term volume reduction** through increasing demand for BEV cars

Powertrain suppliers

Exhaust syst. suppliers

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