

Diesel controversy –Temporary shock or paradigm shift in powertrain?

Impact of the diesel controversy
on OEMs and suppliers



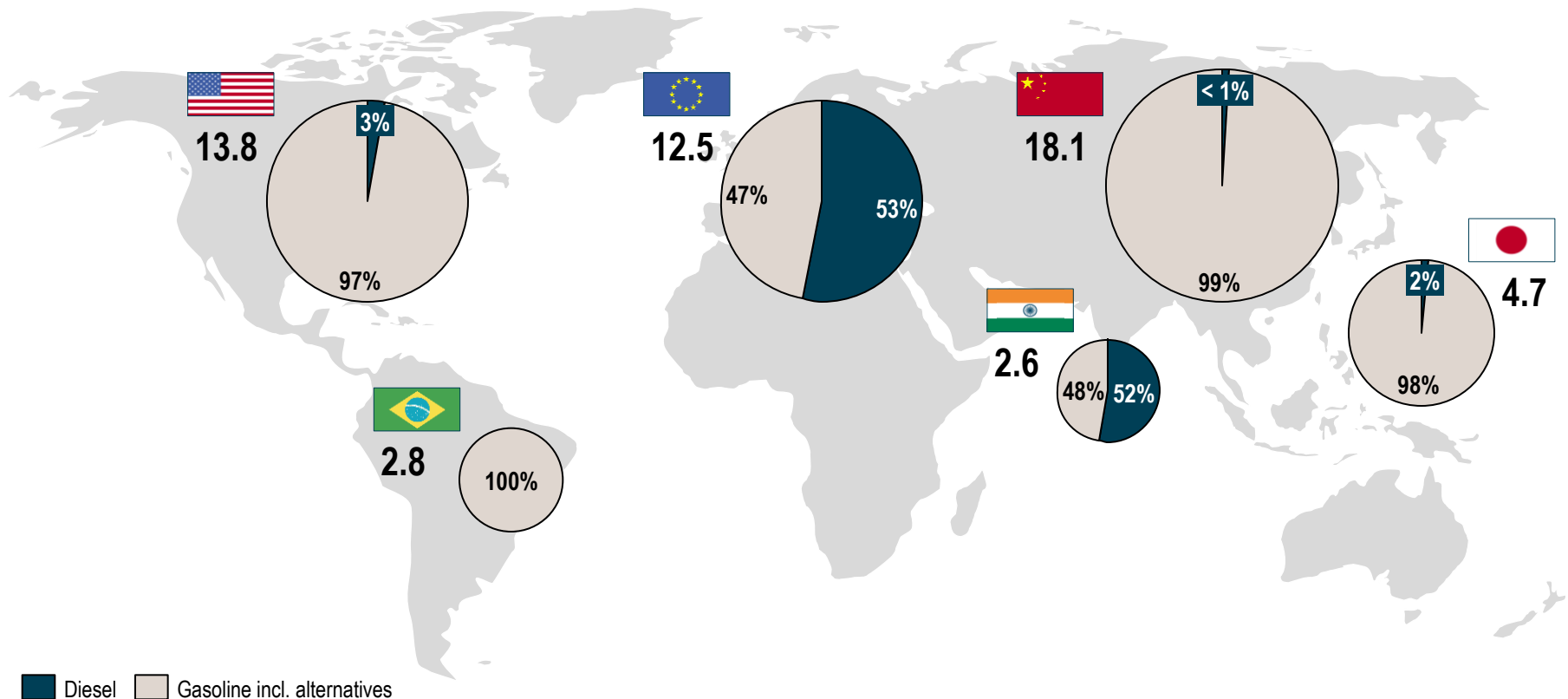
Executive summary

- > European OEMs have utilized the fuel-efficient diesel powertrain as a **key lever to reduce corporate fleet CO₂ emissions**, especially in the EU due to 2020/21 CO₂ 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 combustion¹⁾ 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]

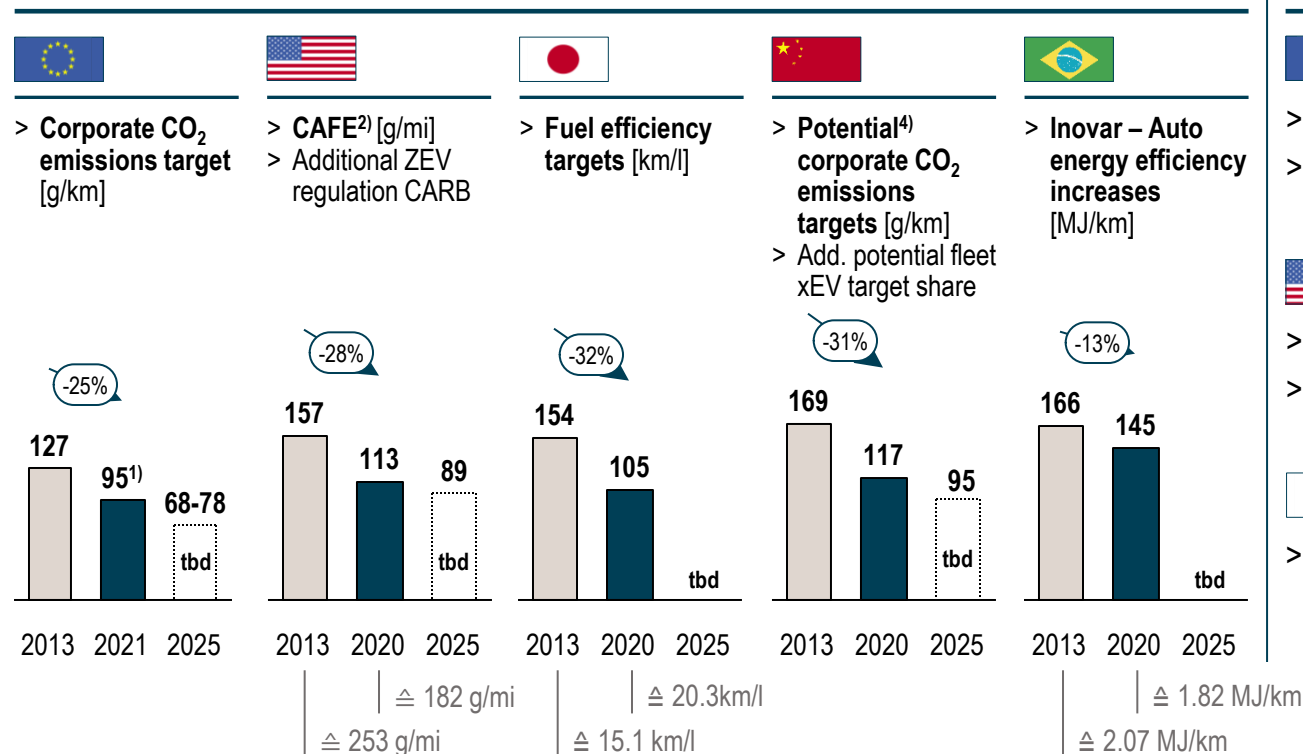


Europe = EU-28

Emission regulations increase pressure on automotive OEMs to improve CO₂ emissions, fuel efficiency and exhaust gas emissions




Assessment of CO₂ emissions/fuel consumption and toxic gas emission regulations

1 CO₂ emissions/fuel consumption



1) Average weight-dependent CO₂ emissions target 2) Only for passenger cars
 3) End customer pull for low CO₂ 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_x, PM, HC)

-  > 2014: Euro 6b emission standard
- > 2017: Euro 6c with implementation of RDE⁵⁾, 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 CO₂/fuel efficiency compared to gasoline especially in the upper vehicle segments

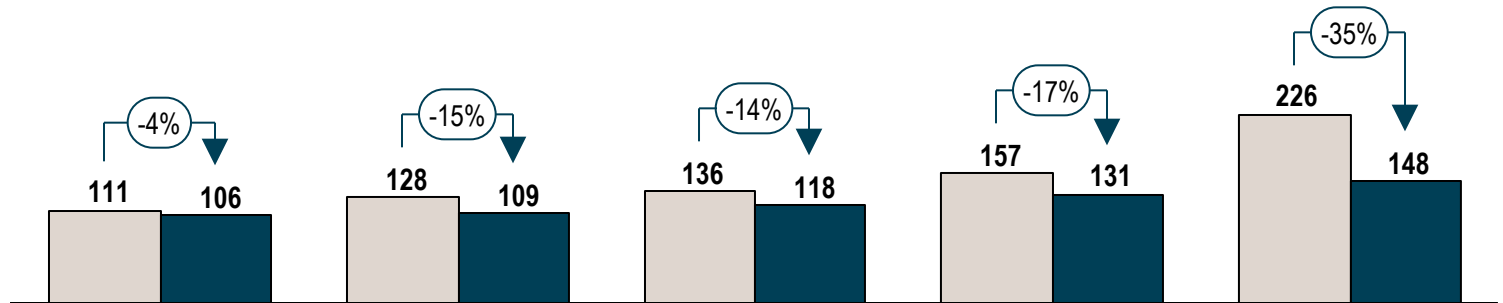
CO₂ emissions by segment/body type in EU-28, 2014



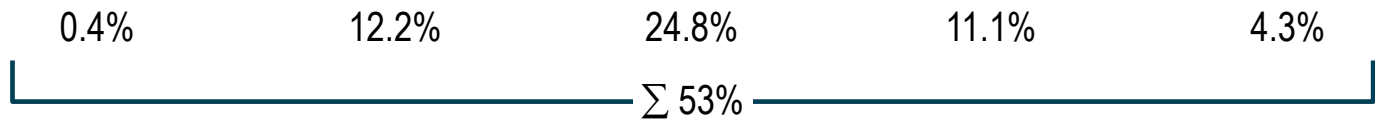
Segment



Avg. CO₂ emissions¹⁾ [g/km]



Diesel share of total sales

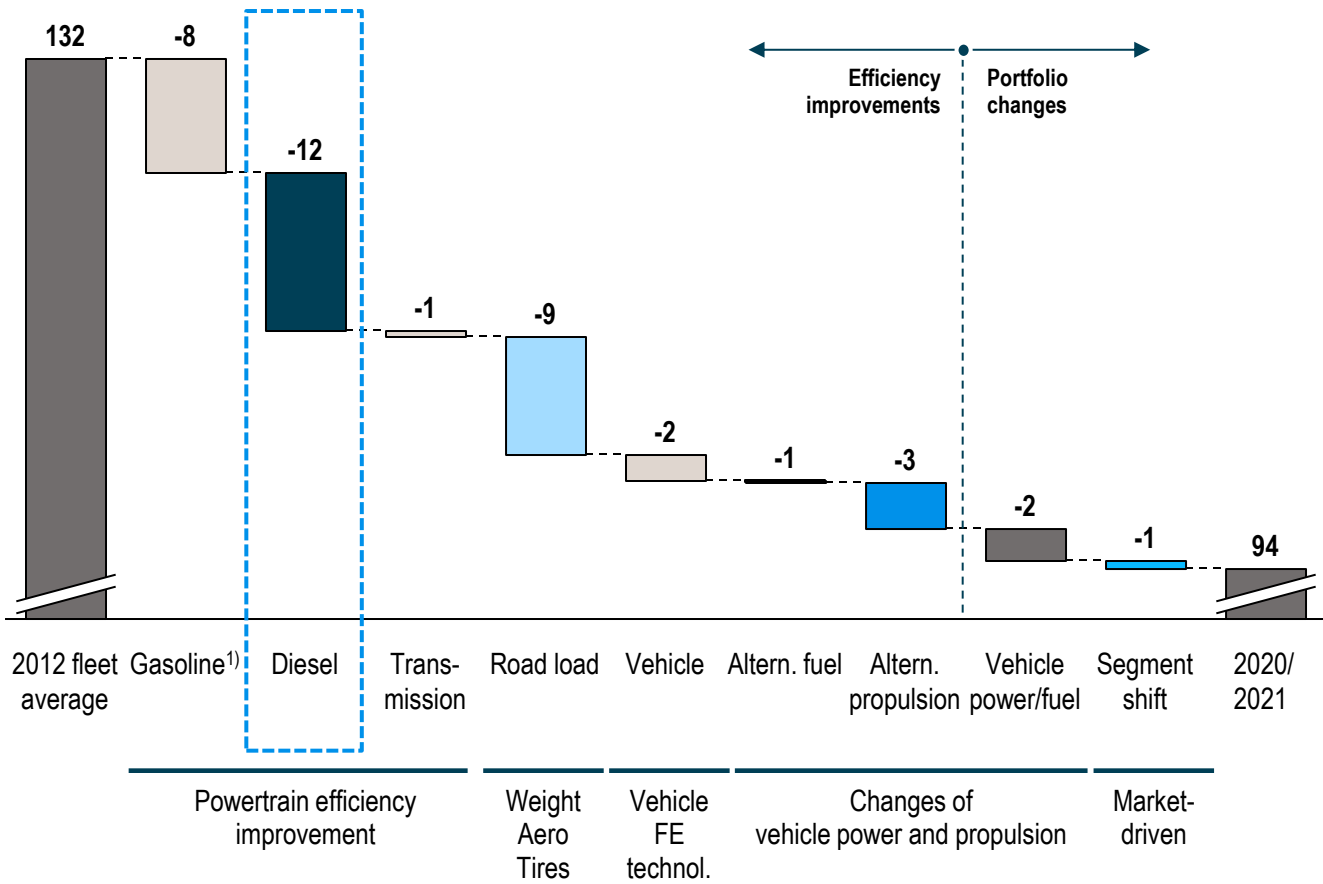


Gasoline Diesel

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 OEM¹⁾ fleet avg. CO₂ emission reduction levers until 2020/2021 [g/km]

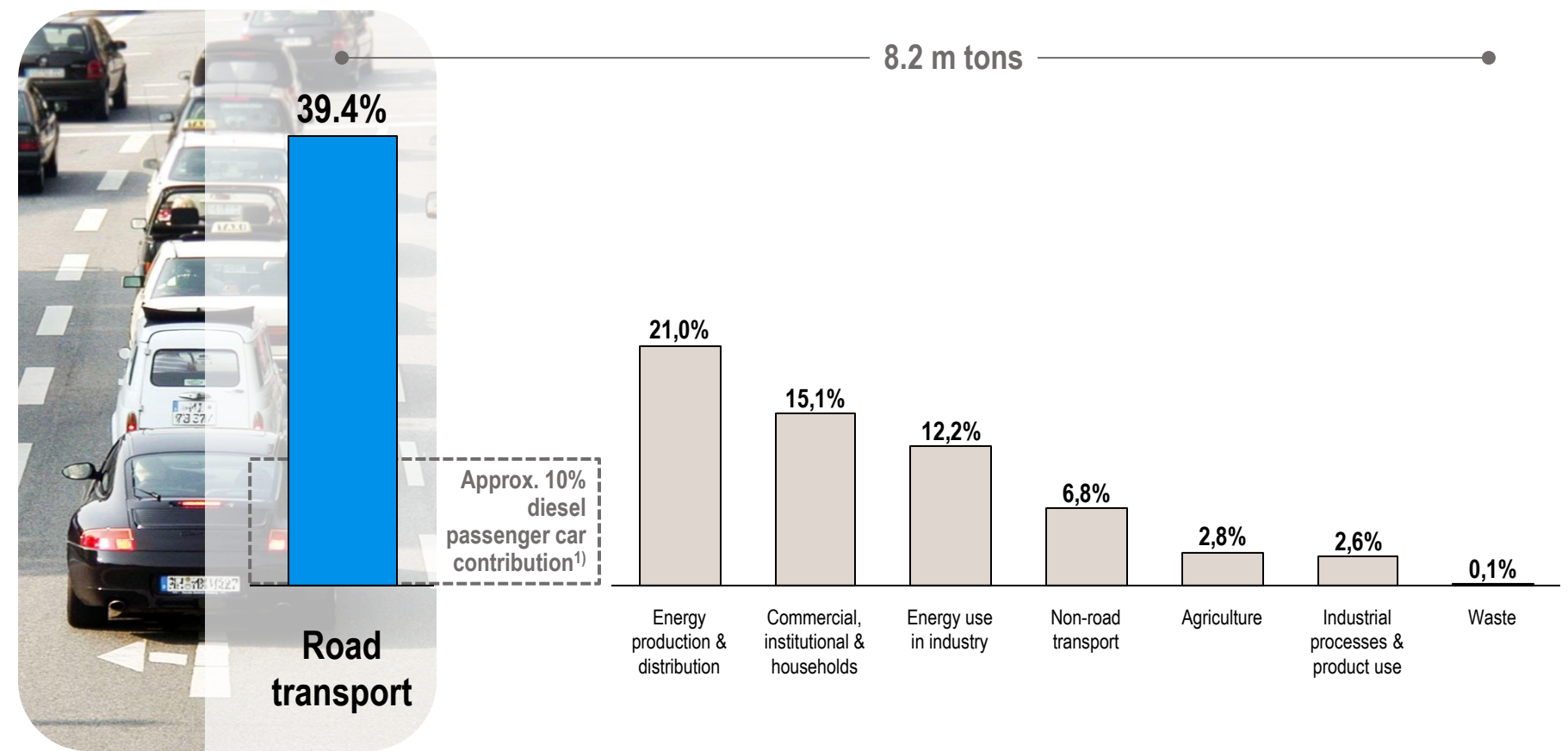


- > Regarding reduction of fleet average CO₂ emissions, diesel efficiency improvement is a key lever to reach the target from the CO₂ emission regulations in 2020/2021
- > A gap of 12 g/km could not be closed with other powertrain technologies if diesel were to be abandoned
- > Therefore, the improvement of diesel efficiency has to be a key pillar of the OEM's CO₂ 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_x emissions in Europe – Diesel is a major contributor

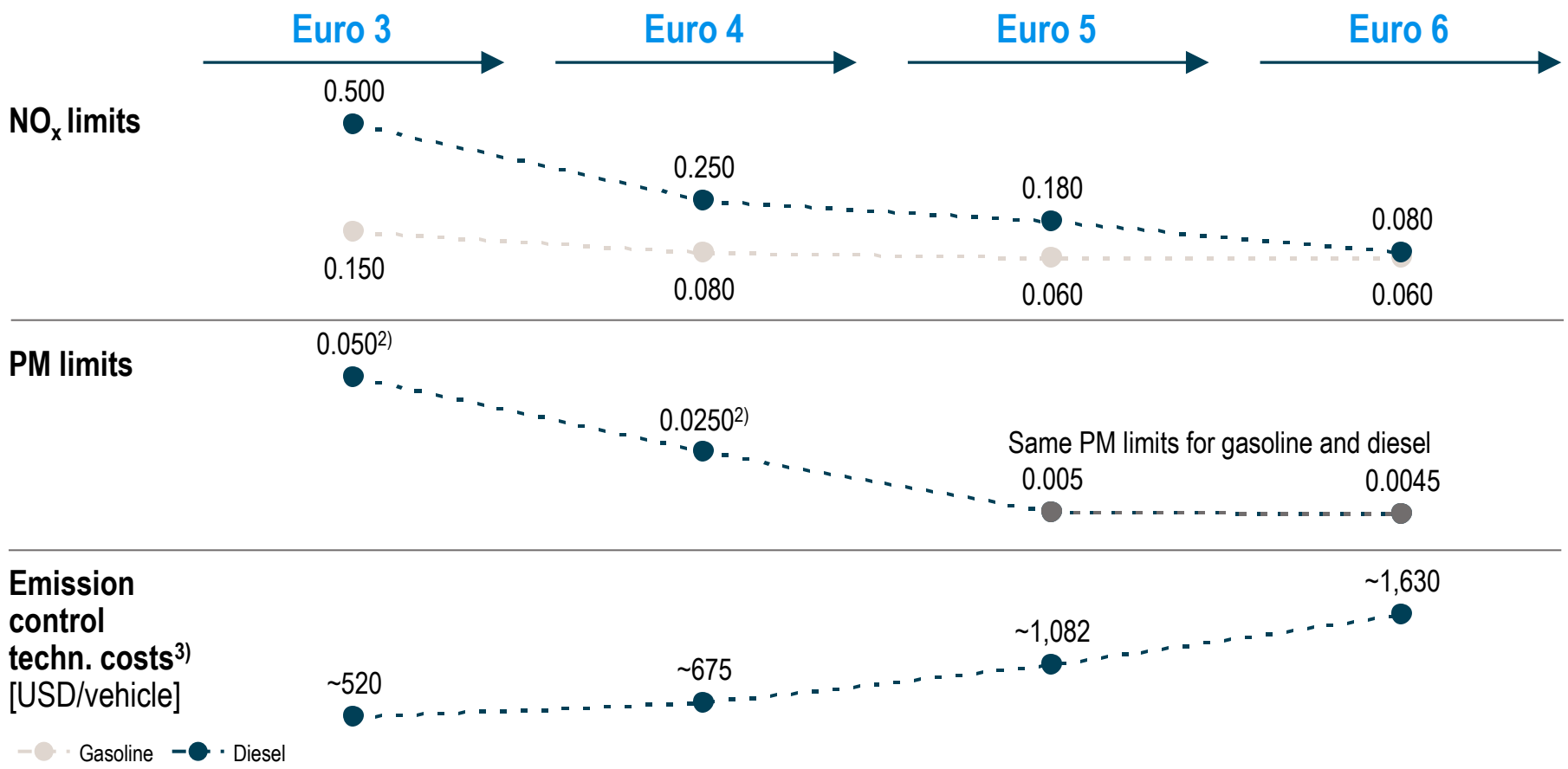
NO_x emissions by sector in EU-28, 2013 [%]



1) In Germany, as of 2012

The diesel's NO_x and PM limits have approached the level of gasoline but also lead to increases in emission control costs

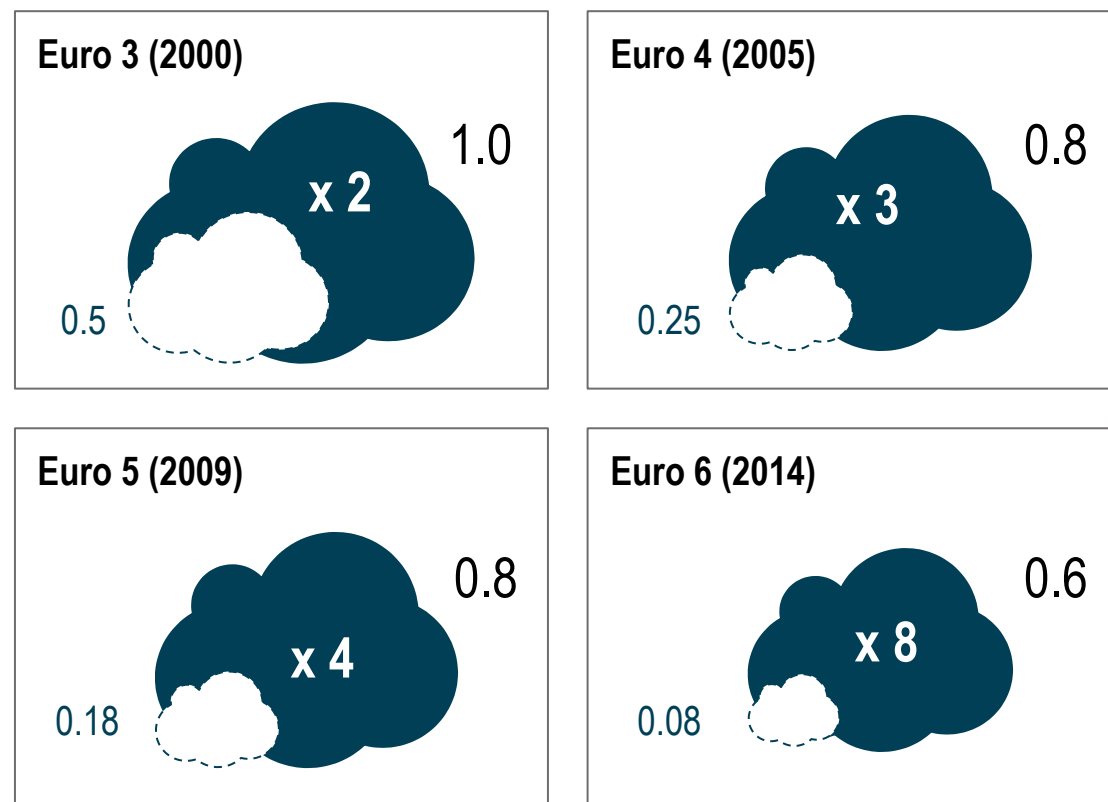
Toxic emission limits¹⁾ of diesel vs. gasoline passenger cars NEDC [g/km]



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_x 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 CO₂ efficiency, low real NO_x 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 **CO₂ 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



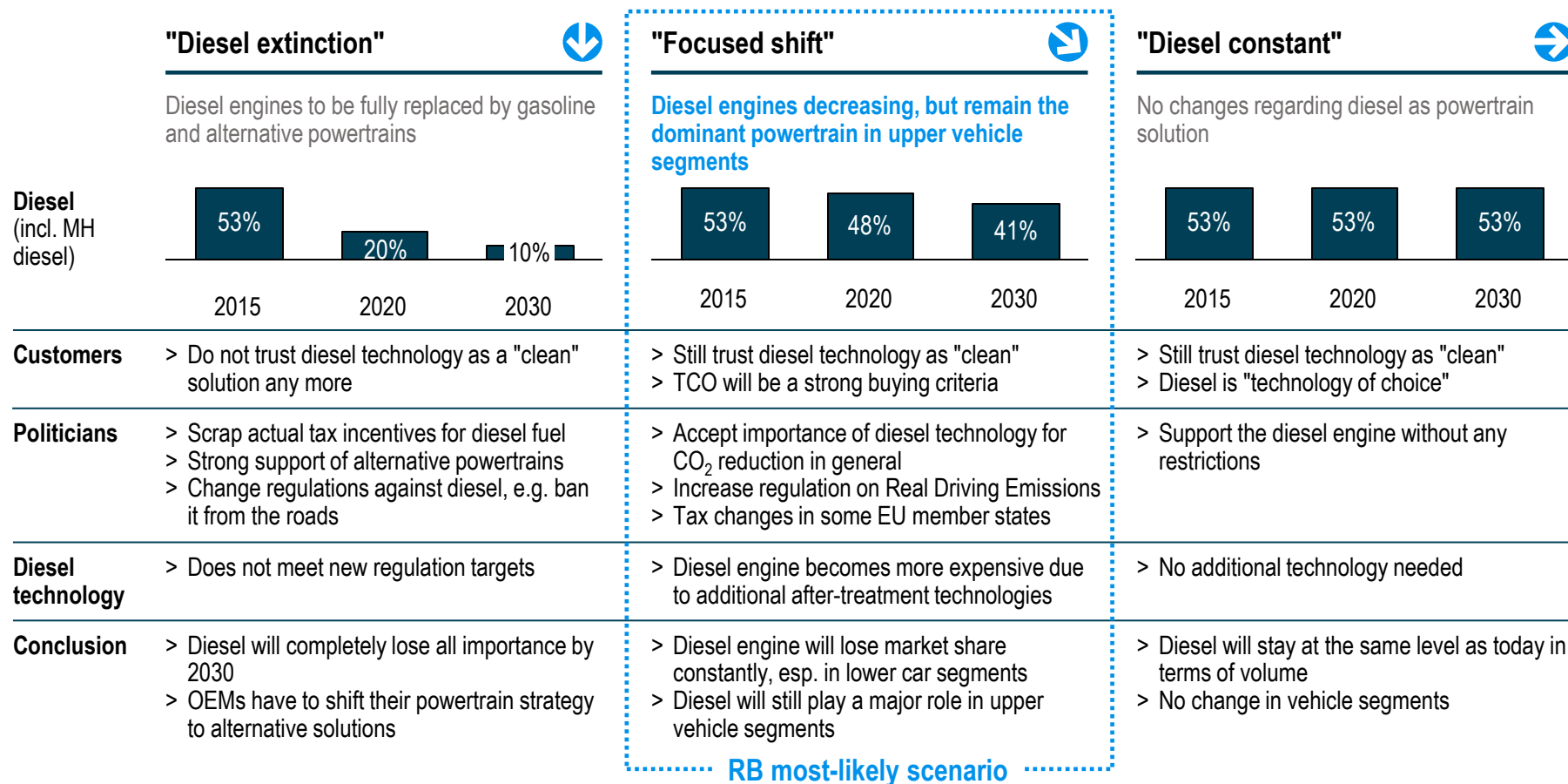
- > **Diesel fuel has a price advantage** even without subsidies
- > **Sales of diesel-fuelled cars** expected to **keep on rising**



- > 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

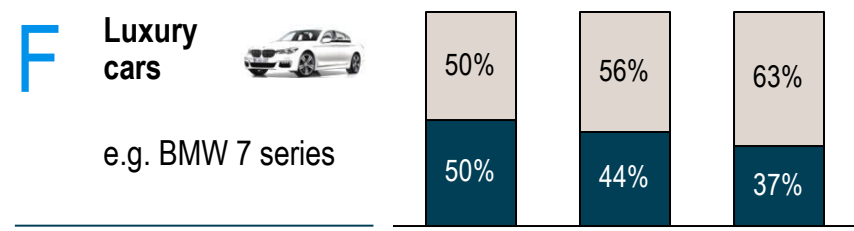
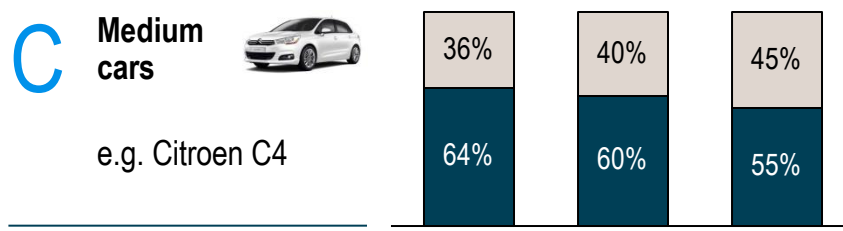
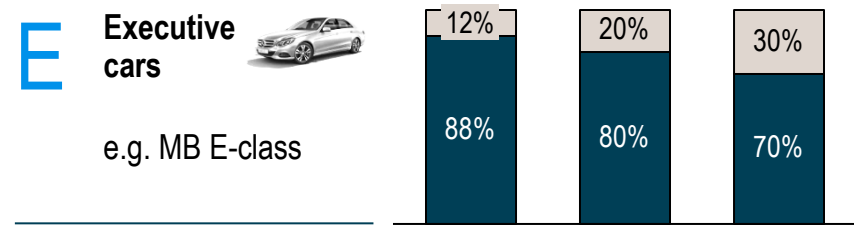
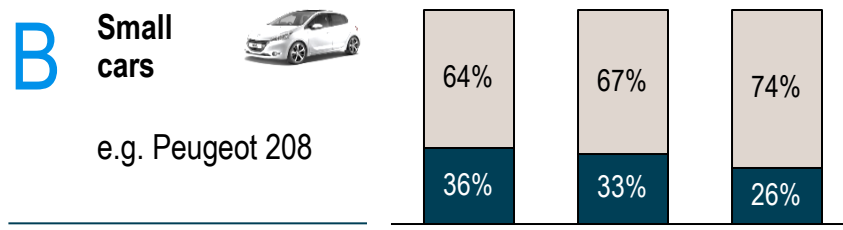
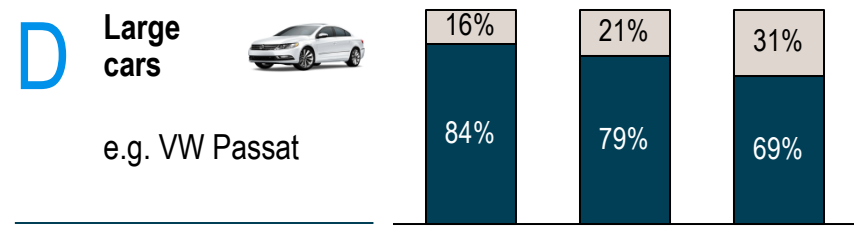
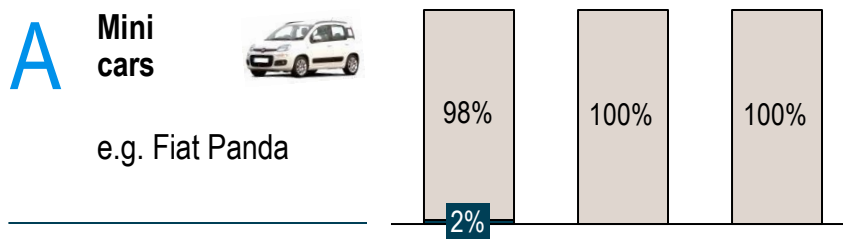
Diesel scenarios in Europe/forecast new car diesel shares in EU-28 until 2030¹⁾



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 2030¹⁾



2014 2020 2030

2014 2020 2030



1) In % of new car sales

Diesel essential for CO₂ 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 CO₂ 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

Roland
Berger

