



## Technologien zur Erreichung der CO2 – Grenzwerte bei Pkw

## Technologies to achieve the CO2-targets for passenger cars

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**Gasoline Systems**

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## Agenda

Market drivers for future vehicle developments

CO2 – emissions legislation

Status

- CO2 emissions of vehicles sold in Europe

- Technology trends

Potentials of powertrain measures

- Engine measures

- Start stop coasting

- E-mobility

- Combinations of different measures

Summary

## Major market drivers for powertrain improvement

### Fuel Economy / CO<sub>2</sub>

- CO<sub>2</sub> fleet targets  
W-EU: 130/95g CO<sub>2</sub>/km  
US CAFE: 34,1 mpg in 2016
- Fuel availability ("Peak Oil")

### Variants

- Globalization
- Powertrain & vehicle diversification
- Fuel differences

### Fun to Drive

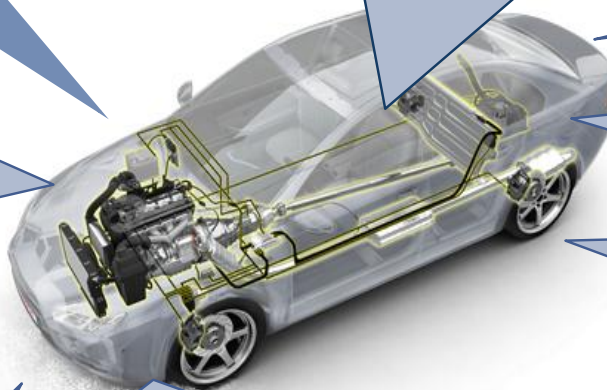
- Power and low end torque
- Response time (dynamics)

### Driving comfort

- Noise, vibration, harshness
- Shift- & launch quality
- Easy driving

### Quality and Safety

- Reliability, Robustness
- ISO26262



### City Restrictions

- Ban on driving
- Specific traffic lane, parking

### Emissions & Diagnosis

- EU6 (PM/PN, ext. EOBD)
- LEV III (SULEV20, PM)
- Worldwide Driving Cycle
- Real Driving Emissions

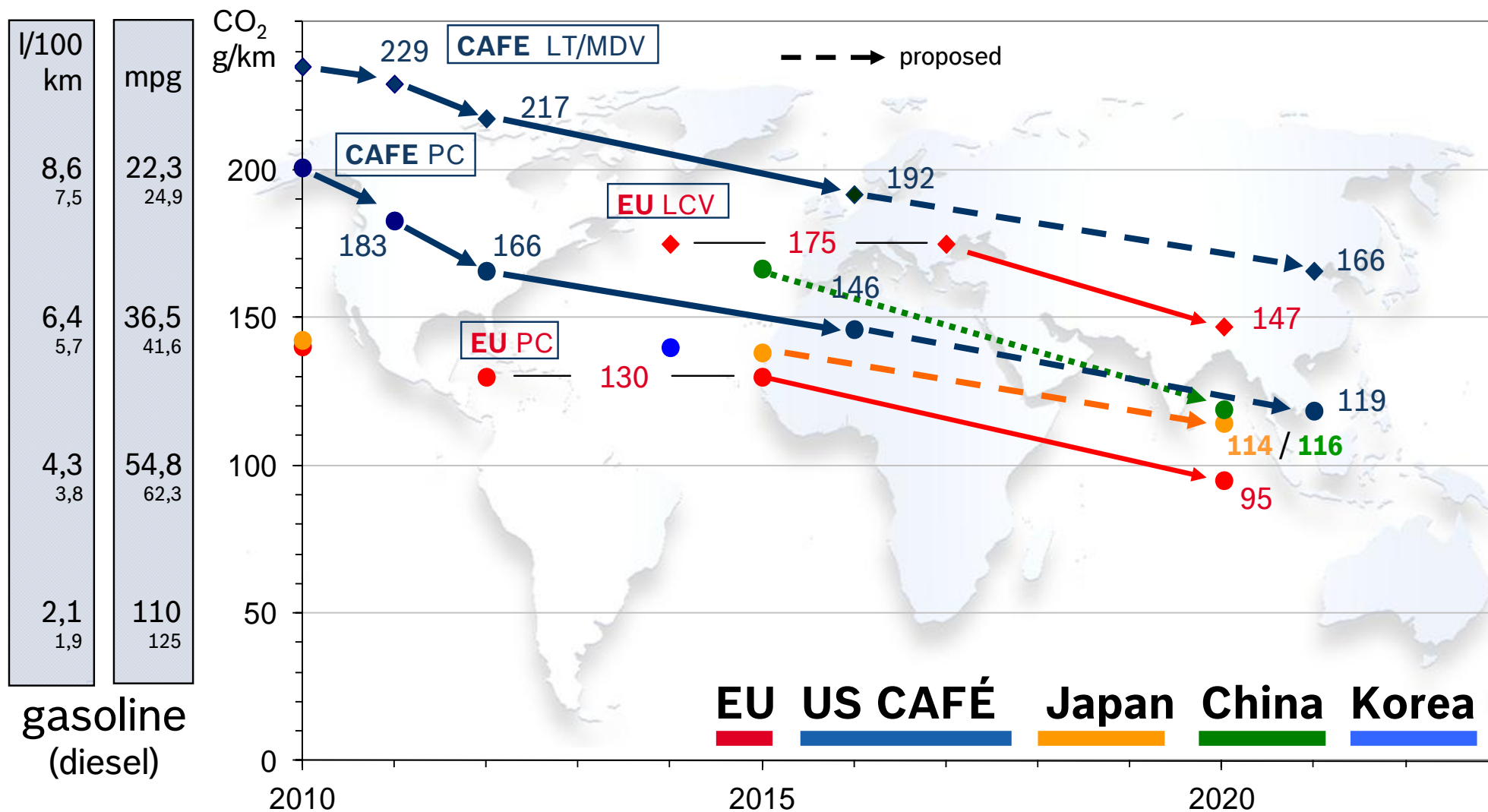
### Image & Emotions

- Fuel Economy Labeling
- Willingness to pay for green image and emotions

### Costs

- Affordable mobility (price, TCO)
- OEM entry efforts (invest, E&A)
- Incentives and taxation

## Development CO<sub>2</sub> Fleet Targets

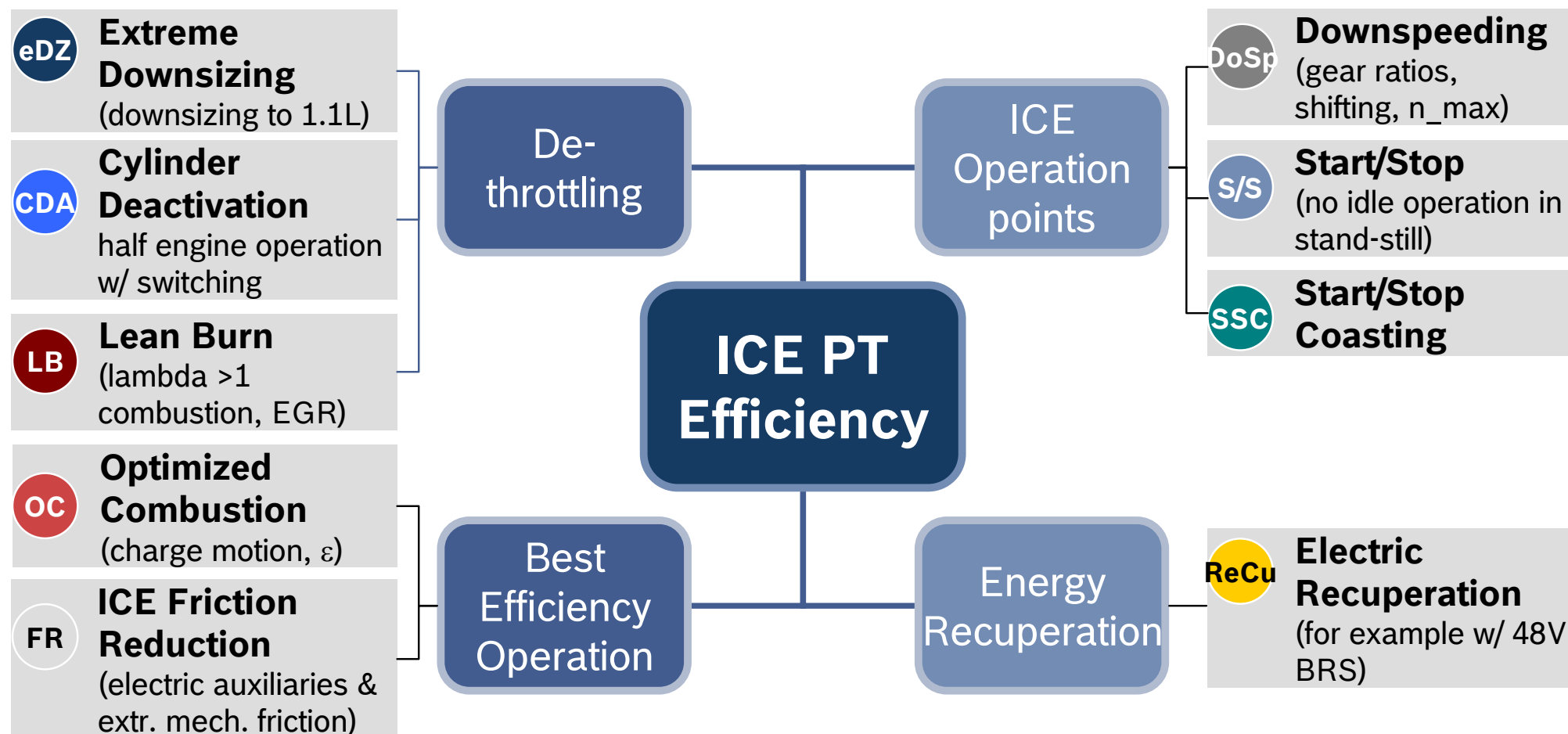


CAFE = Corporate Average Fuel Economy PC = Pass. Cars LT / LDT = Light Trucks (pick-ups, vans, SUVs) MD(P)V = Medium Duty (Pass.) Vehicles LCV Light Commercial Vehicles

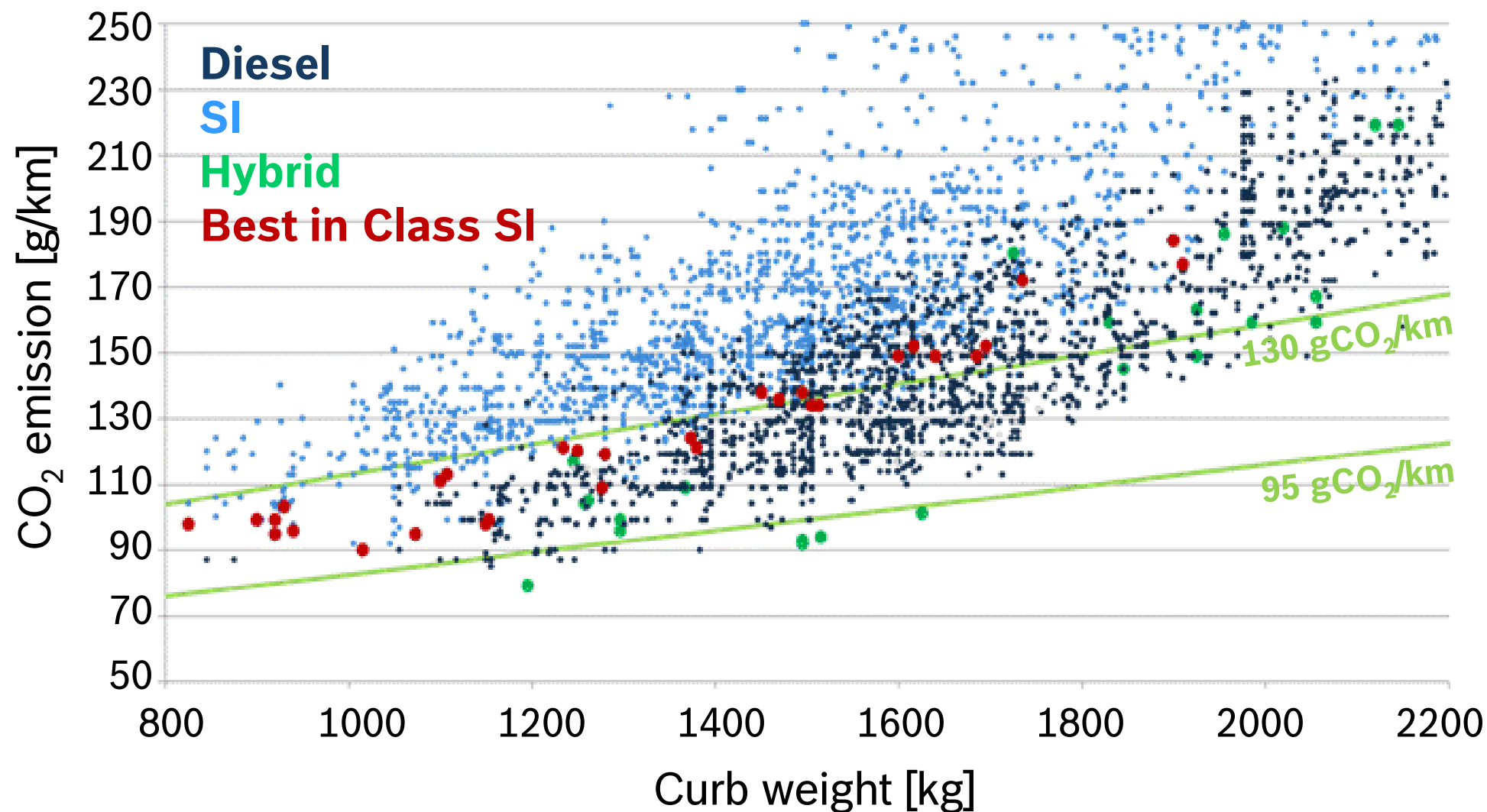
### Gasoline Systems



## Overview GS engine measures for efficiency



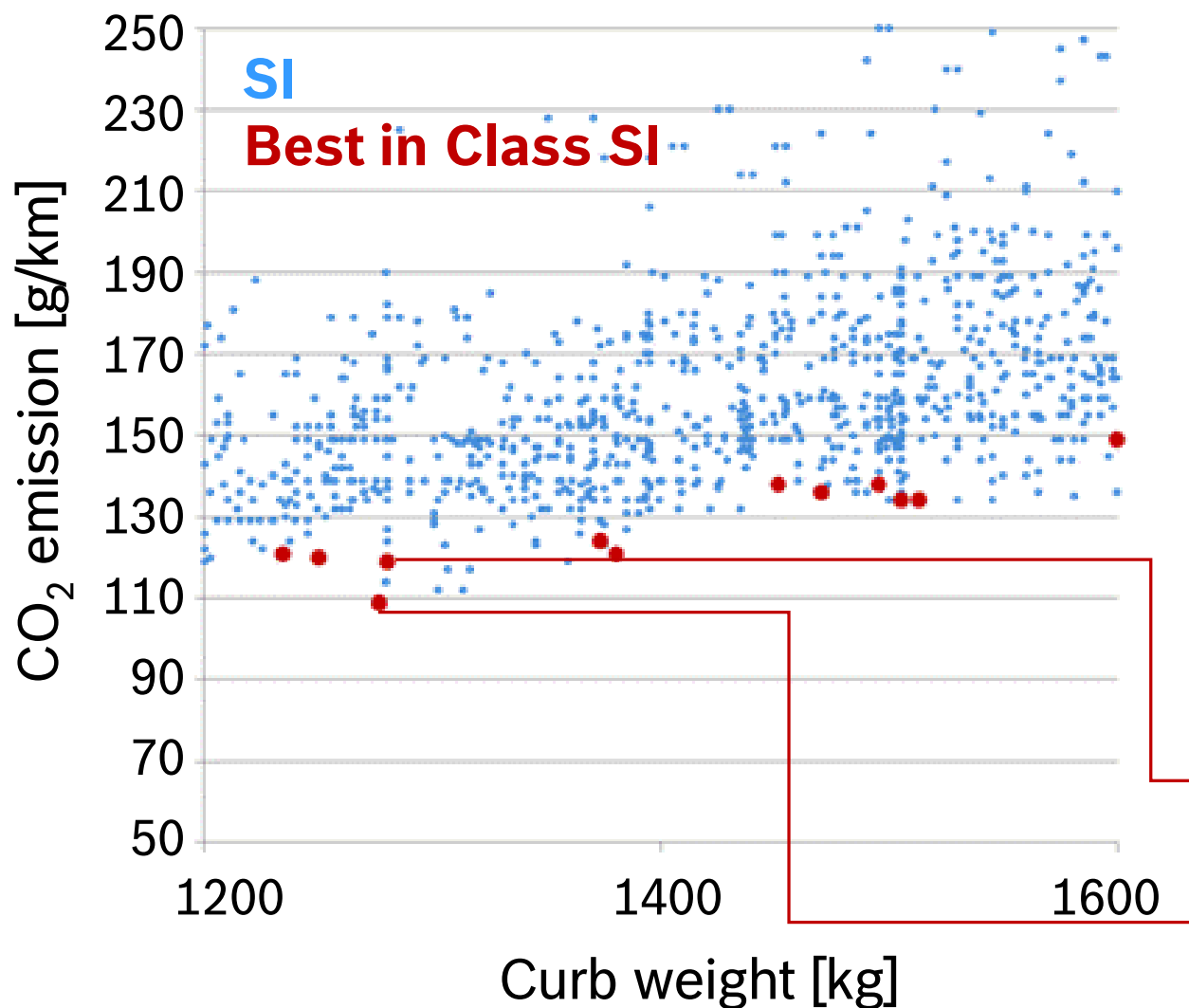
## Europe: Overview Vehicle CO<sub>2</sub> emissions



Quelle: DAT CO<sub>2</sub>Leitfaden



## Europe: Cars with low CO<sub>2</sub> emissions



### Technologies:

Start/Stop	12 of 12
Controlled Auxiliary	12 of 12
Friction reduction	12 of 12
Downsizing / TC	11 of 12
VVT	11 of 12
Downspeeding	10 of 12
Direct Injection	9 of 12
VVL	3 of 12

### Best in Class

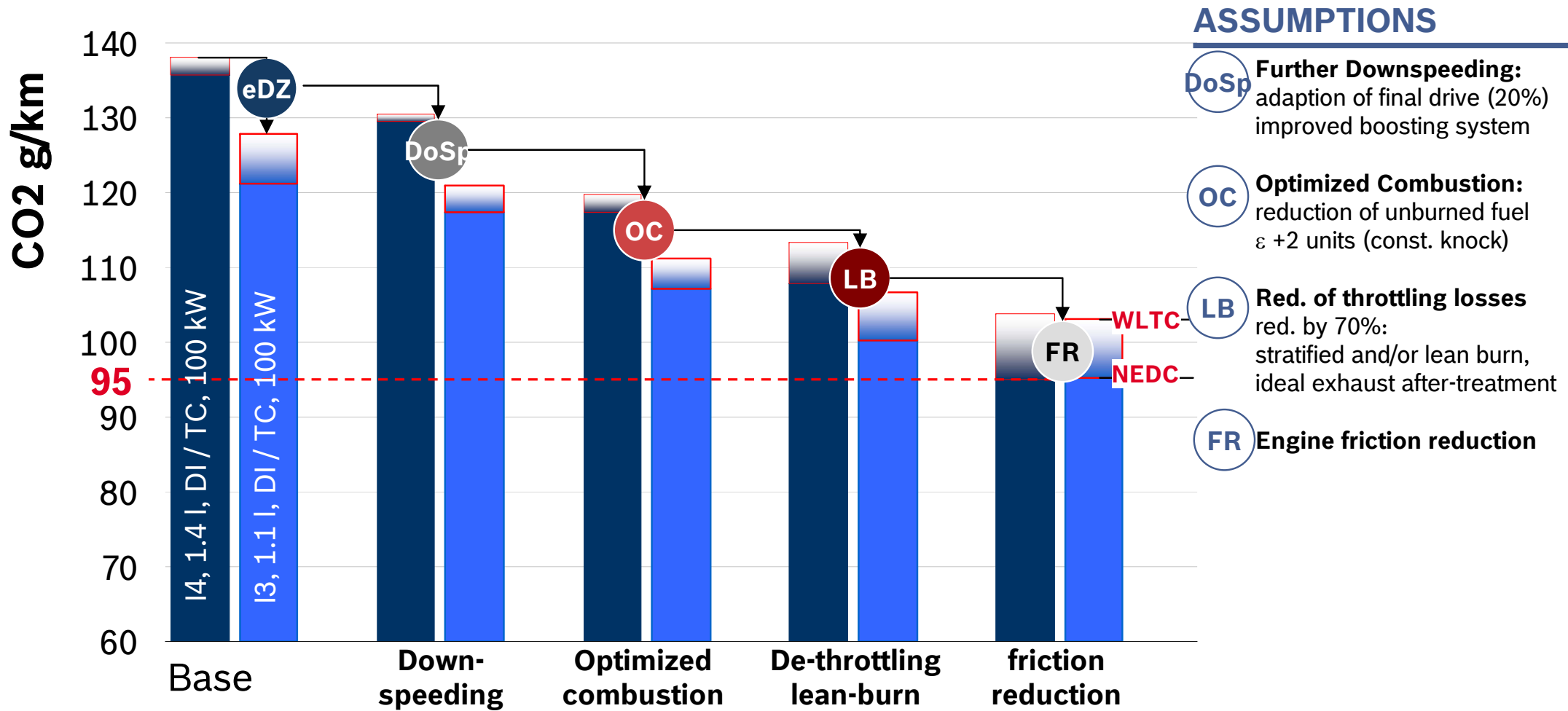
1.4l DI T/C, 90 KW, 120 gCO<sub>2</sub>/km with Cylinder Deactivation

1.0l DI T/C, 74 KW, 109 gCO<sub>2</sub>/km with extreme Downsizing

Quelle: DAT CO<sub>2</sub>Leitfaden

# Technologies to achieve the CO2-targets for PC

## FE for Compact Class vehicle \*

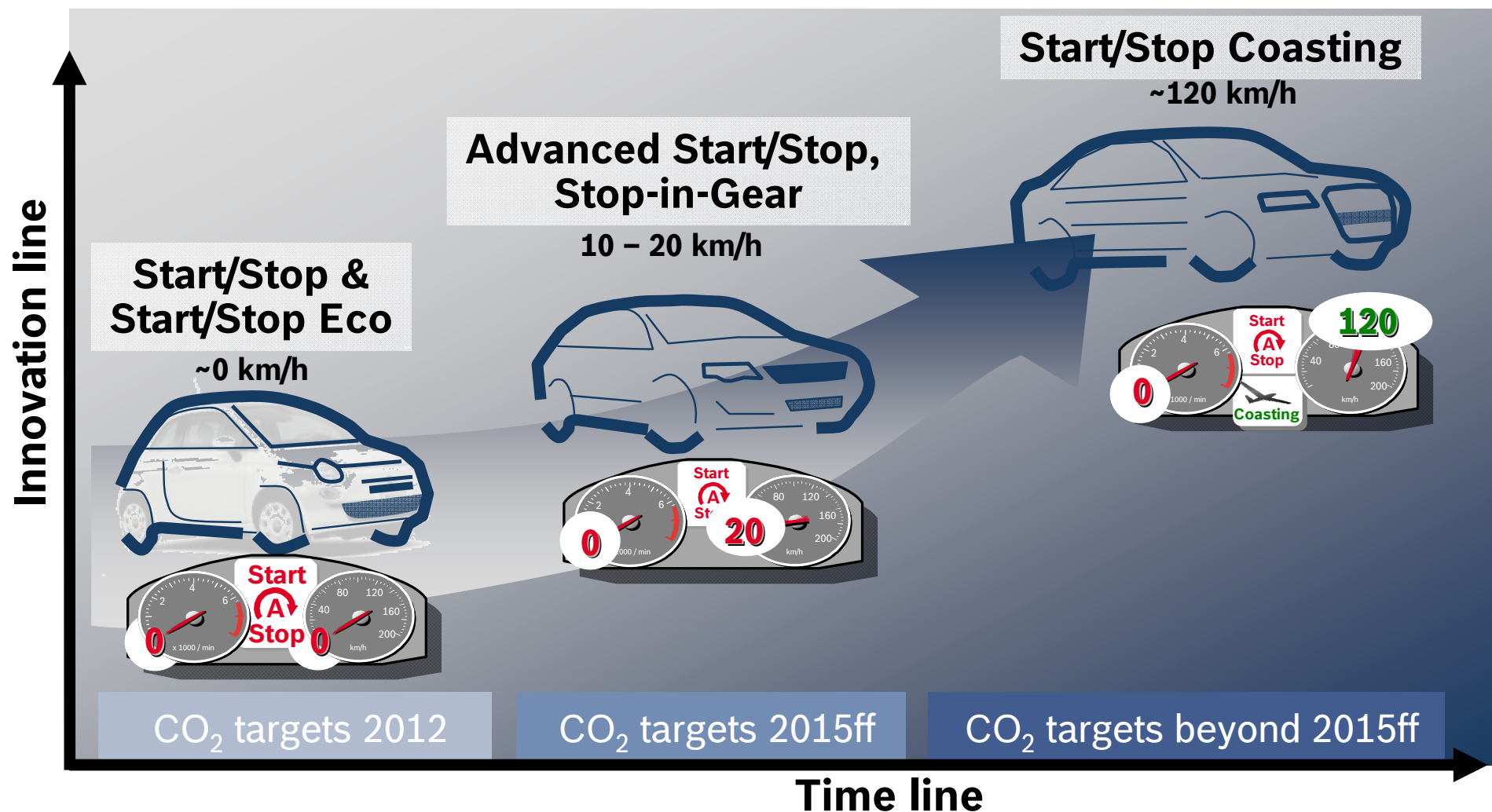


\*) 1400 kg, MT





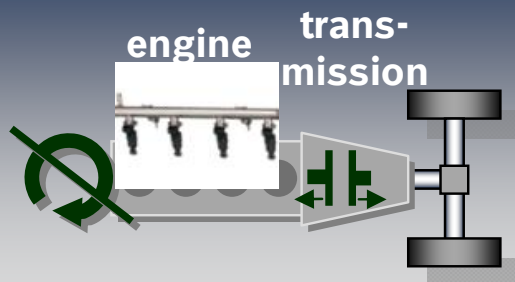
## Evolution of Start/Stop



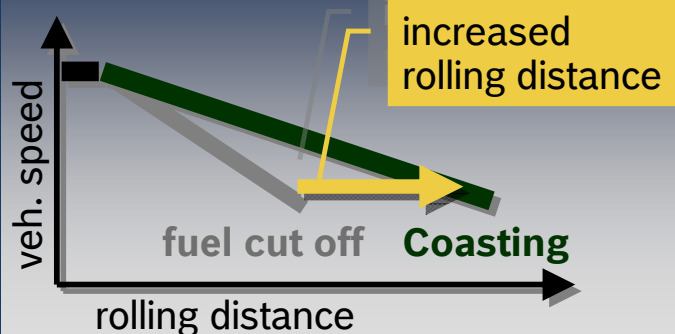
## „Start/Stop Coasting“ (SSC): Overview

### Start/Stop Coasting

drivetrain open & engine off



effect: reduced drag torque



system requirements

#### → starter system



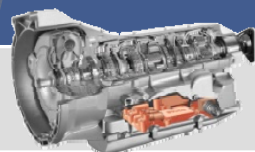
starter cycles, CoM ability, start time, NVH  
→pinion starter & clutch start OR  
advanced starter systems/BRS (up to 600k starts)

#### → power net



cyclic load & redundancy (~37% engine-off time in comparison to ~10% with Start/Stop)  
→two energy sources (e.g. 2 batt.-PN)

#### → transmission



DCT - dry, AMT

none

AT, CVT,  
DCT - wet

advanced hydr. system,  
el. oil pump, ...

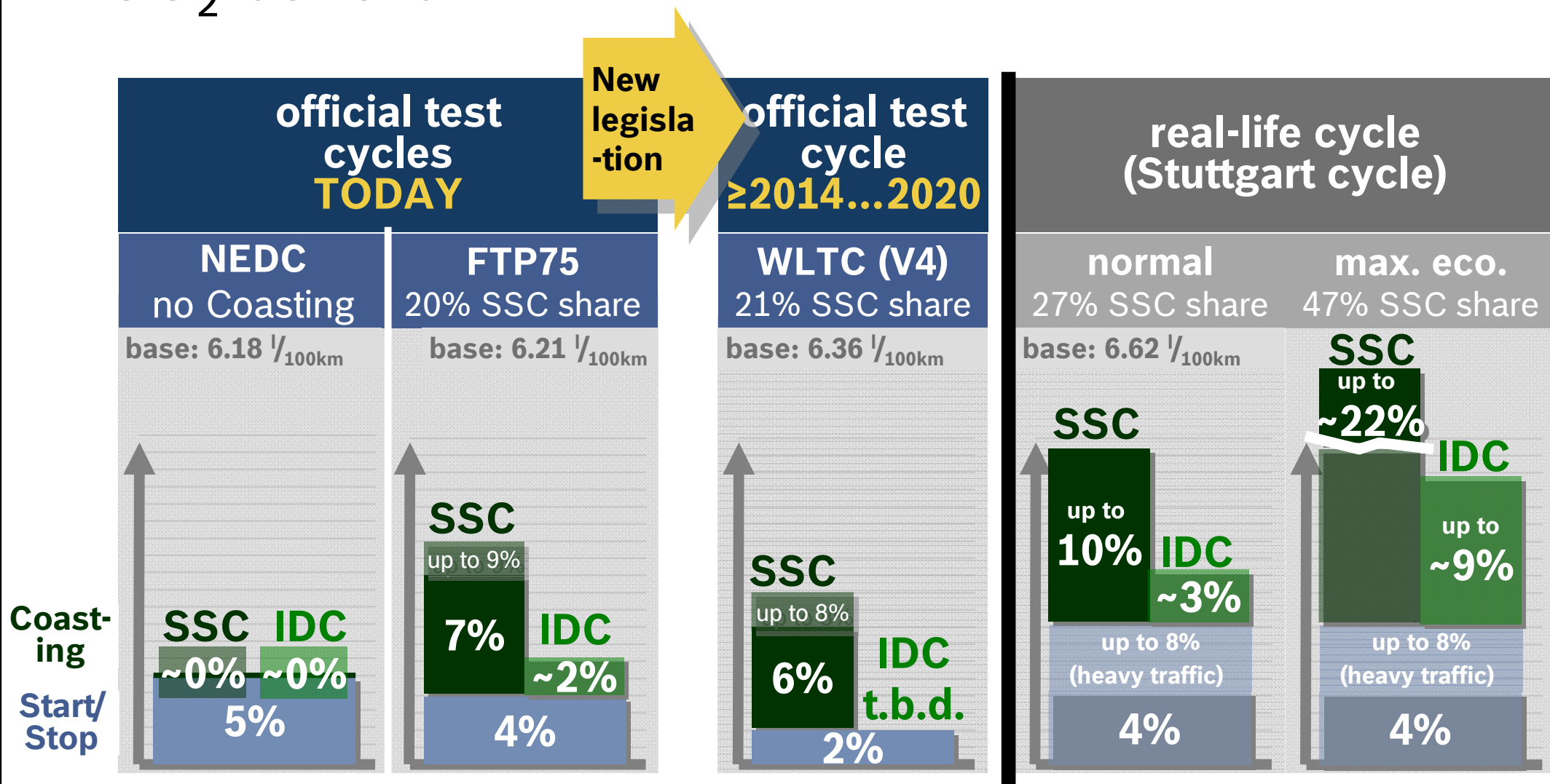
#### → steering



electrification: el./el.-hydr. power steering  
→base in most vehicles

# Technologies to achieve the CO<sub>2</sub>-targets for PC

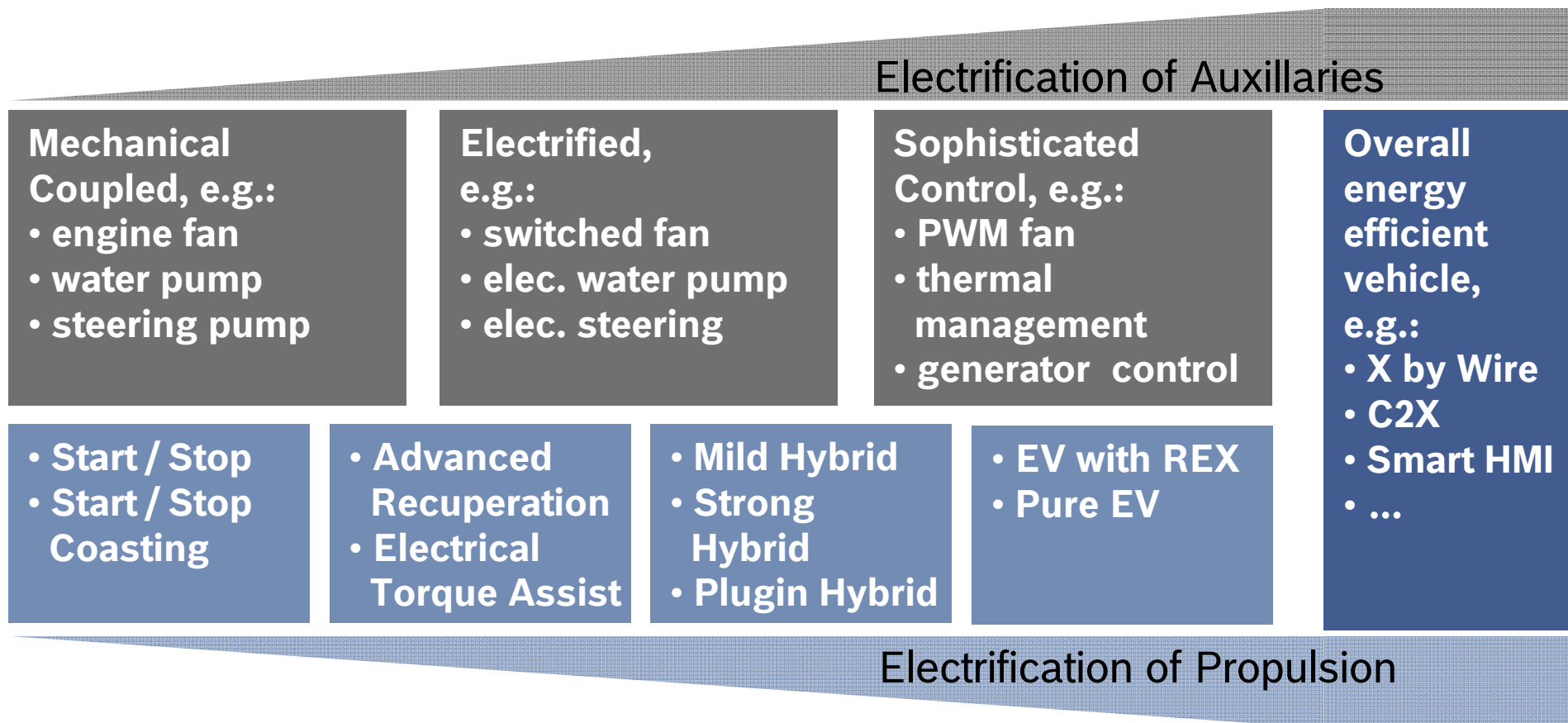
## CO<sub>2</sub> benefit



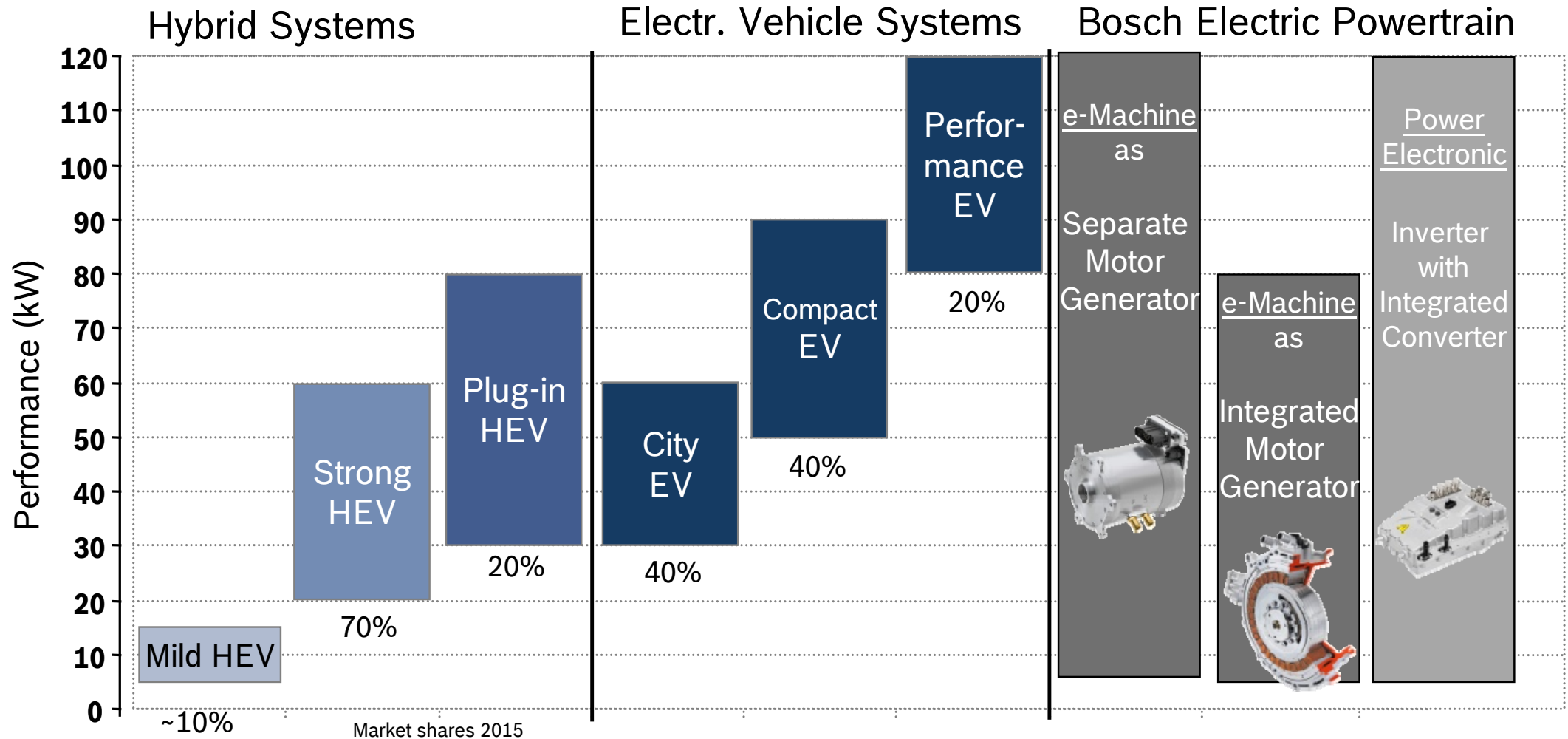
base: Compact Class, 1.4L DI-TC gasoline, 7-gear DCT (dry, el-hydr), w/o St/St, w/ intelligent generator control, Power net: P<sub>el</sub>=300W



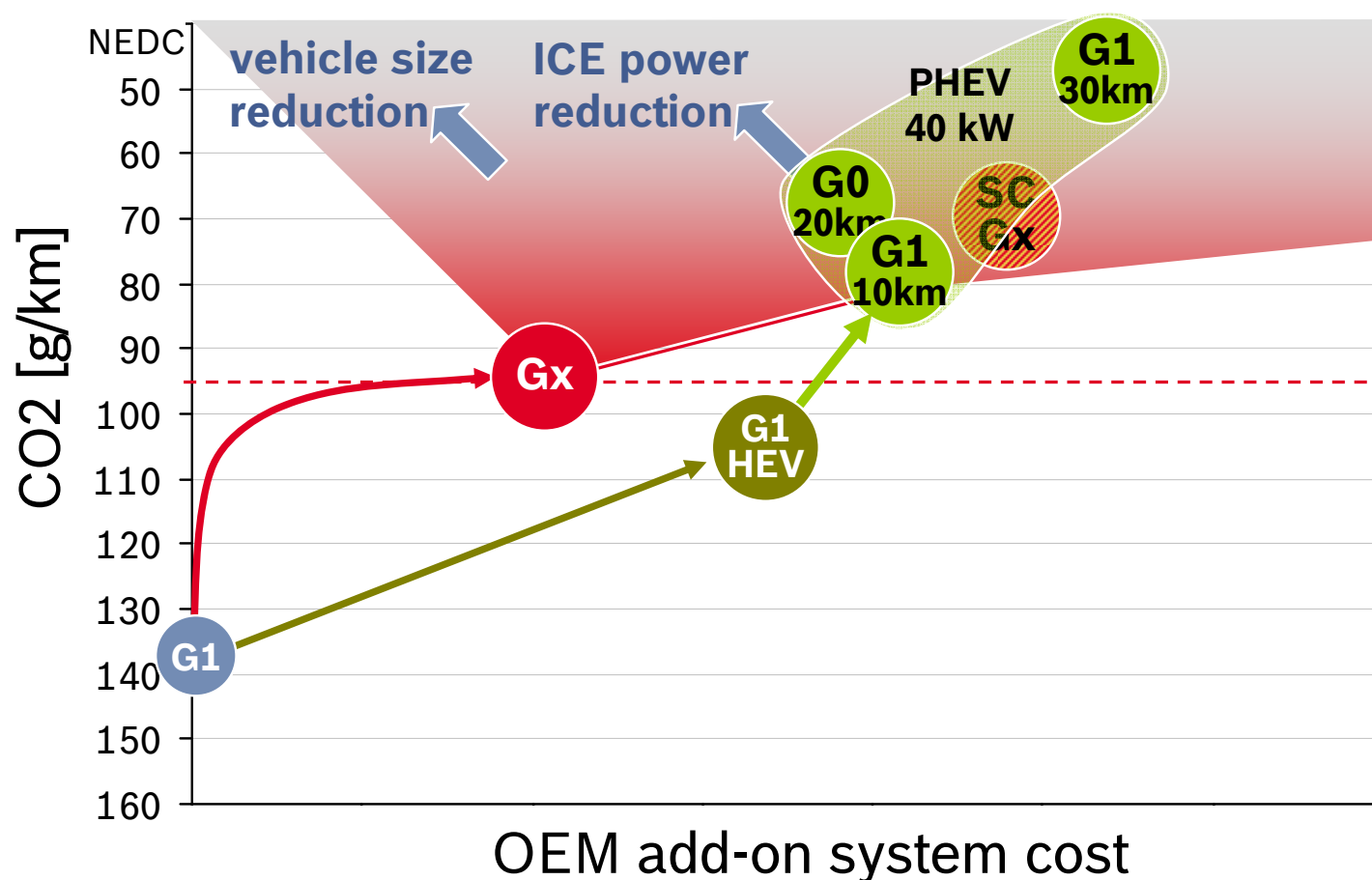
## Powertrain Electrification



## e-Drive System



## CO2-benefit vs. cost for CC vehicle base 2020



- G1 Base**  
→ I4, 1.4 l, DI / TC, 100 kW
- G... ..km PHEV**  
→ Real-life CO2 depends on driving range patterns.  
→ Higher driving performance due to electric add-on torque.  
→ Min e-range required to satisfy consumer expectations of e-motion
- SI-ICE**  
→ Highest CO2/cost-benefit w/ cost efficient measures.  
**Gx** → 95g for gasoline w/ ICE measures possible
- SC Gx** → w/ BRS and mass+cw×A reduction (SC class)

## Summary

The CO<sub>2</sub> limit of 130 g/km can be achieved with today's technologies for SI engines in compact class

This was achieved by a summary of detail optimizations

Downsizing and Gasoline direct injection are mainstream measures

Coasting allows further reduction of more than 10%

Additional improvements are only achievable with hybridisation

Willingness to pay for electrified powertrains depends on tangible end consumer benefits