



Shaping the Future – Innovations for Efficient Mobility

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Overview: current and upcoming regulations

Year	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Emission standards	Euro 5			Euro 6					post-Euro 6		
CO ₂ target				130 g/km 100% fleet					95 g/km proposal, 100% fleet		
NEDC/ WLTC	NEDC-based testing								WLTC-based testing		
RDE	development and measurement phase					limit ≤ cf • crit. emission limit					

Upcoming emissions standards require considerable technological improvements

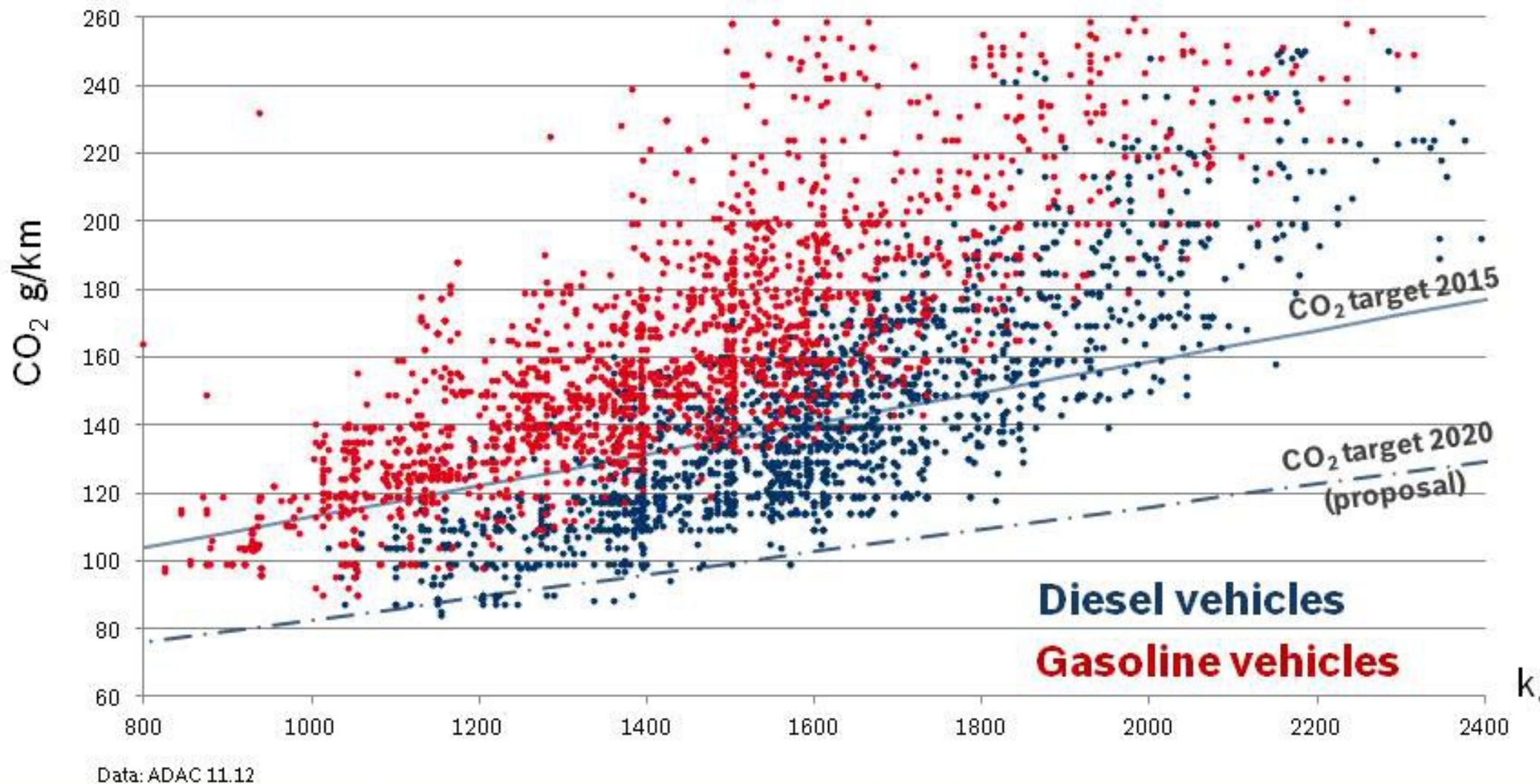
NEDC: New European driving cycle; **WLTC**: Worldwide harmonized light vehicles test cycle; **RDE**: Real driving emissions; **cf**: compliance factor; **RDE procedure**: not finalized; Post-Euro 6: assumed

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CO₂ emissions of vehicles on sale in EU, 2012

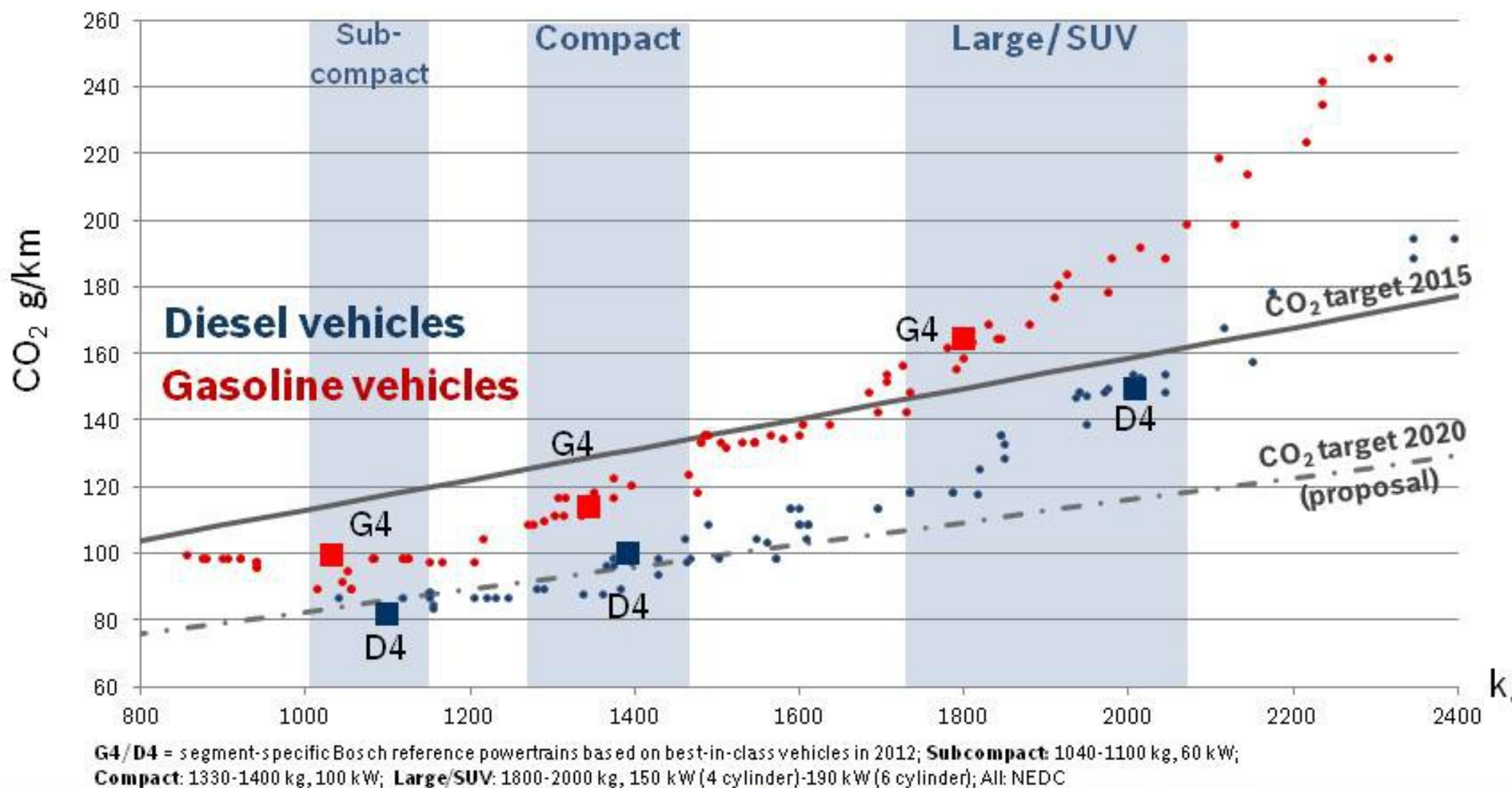


CO₂ targets more challenging for heavier vehicles



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Best-in-class vehicles in EU, 2012

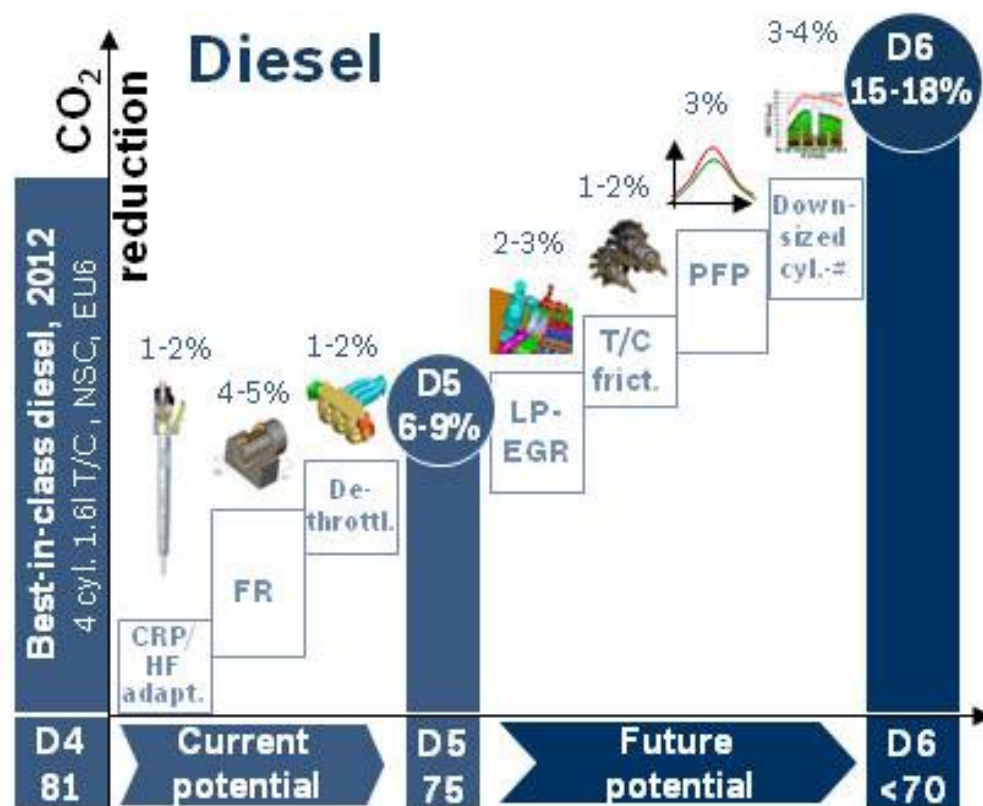


Best-in-class vehicles already within 2015 targets in 2012

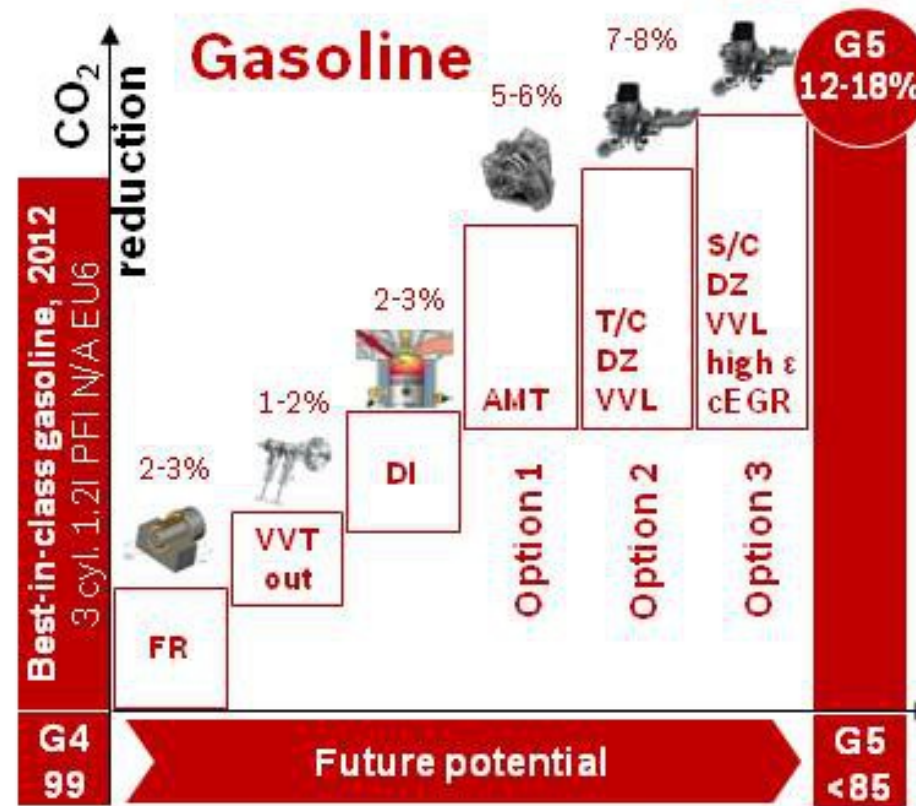


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CO₂-reduction packages for subcompacts*



CRP/HF = common-rail pressure / hydraulic flow | LP-EGR = low-pressure EGR system
FR = friction reduction | De-Thrott. = de-throttling engine | PFP = low-peak firing pressure | T/C = turbocharger | NSC = NOx storage catalyst



VVT = variable valve timing | DI = direct injection | FR = friction reduction engine
AMT = automated manual transmission | T/C = turbocharger | S/C = super-charger
DZ = downsizing | VVL = variable valve lift | high ε = high compression
cEGR = cooled exhaust gas recirculation | N/A = naturally aspirated

Diesel and gasoline powertrains offer further CO₂-reduction potential of up to 18%

*60 kW, 2020, NEDC



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Boost recuperation system (BRS) – “Eco Hybrid”



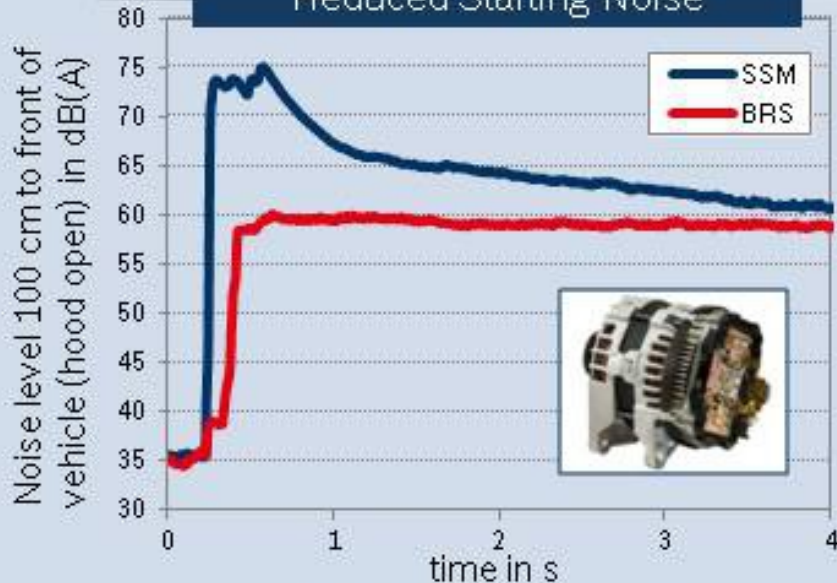
Features

- Electrical machine delivering up to 10 kW
- Energy supply from brake energy recuperation
- Electrical boost function

Customer benefits

- Approx. 7% fuel-efficiency improvement in NEDC (without coasting, basis: start-stop)
- Very short & comfortable ICE restart feasible, enabling start-stop and coasting
- Reduced starting time, noise and vibration
- Cost-efficient entry system for electrification
- Fun to drive (e-boost)

Reduced Starting Noise

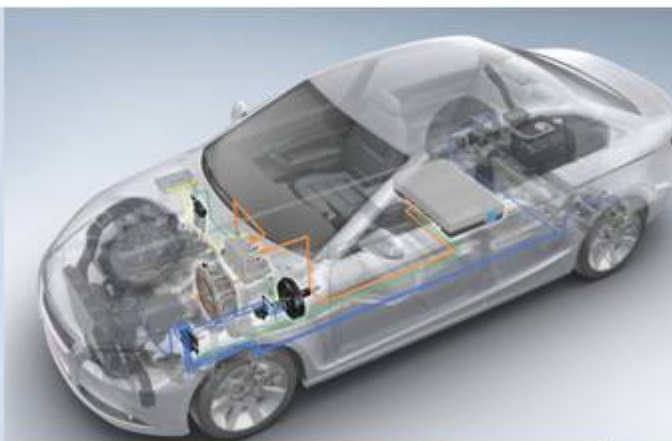


BRS: cost-effective CO₂ reduction combined with greater driving comfort

SSM: start-stop starter motor, ICE: internal-combustion engine



Strong hybrids (HEV)



High-voltage battery

Lithium-ion battery
0.8 – 1.5 kWh



Power electronics module

DC link voltage 100 – 300 V
DC/DC converter 1.5 – 3 kW



Electric motor

traction drive
20 – 40 kW



Features

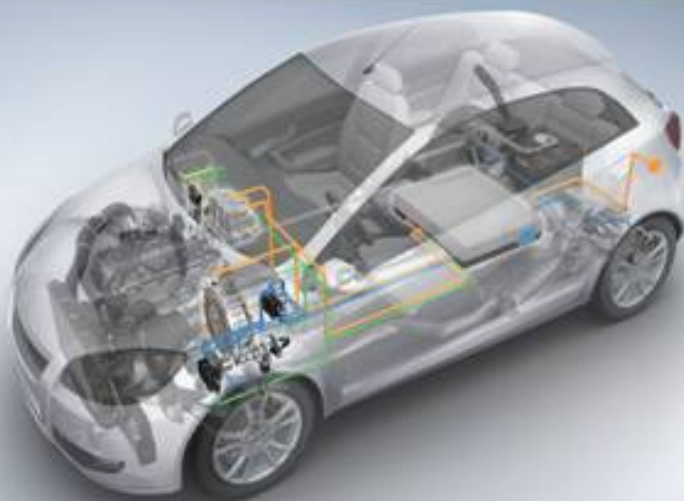
- Electric motor, starting from 20 kW (CO₂-optimized)
- Integrated or separate motor generator (IMG, SMG)
- Electrical energy supply from brake energy recuperation
- E-drive capability (defined by battery size)
- Future development: further cost reduction via component integration and economies of scale

Customer benefits

- Up to 15 % fuel-efficiency improvement in NEDC
- Best-in-class urban fuel economy of non-plug-in powertrains
- Green image (electric drive) + driving enjoyment (e-boost)
- Increasing TCO benefit for end-customer

Concept offers CO₂ reduction and electric driving experience

Plug-in hybrids (PHEV)



High-voltage battery

Lithium-ion battery
4 – 12 kWh



Power electronics module

DC link voltage 250 – 450 V
DC/DC converter 1.5 – 3 kW



Electric motor

traction drive
30 – 80 kW



Features

- Combination of efficient ICE* & electric driving (comfort)
- CO₂ reduction and driving enjoyment
- Attractive due to legislation and consumer expectations
- Electrical energy supply from charge spot (230/400 V)
- Optimal layout in terms of cost/benefit and customer acceptance: 50 km el. range and 120 km/h max. el. speed
- Future: market penetration from upper vehicle segments

Customer benefits

- 50-90% fuel-efficiency improvement in NEDC (e-range)
- Electric driving ranges sufficient to allow access to low-emission zones
- Green image (electric drive) + driving enjoyment (e-booster)

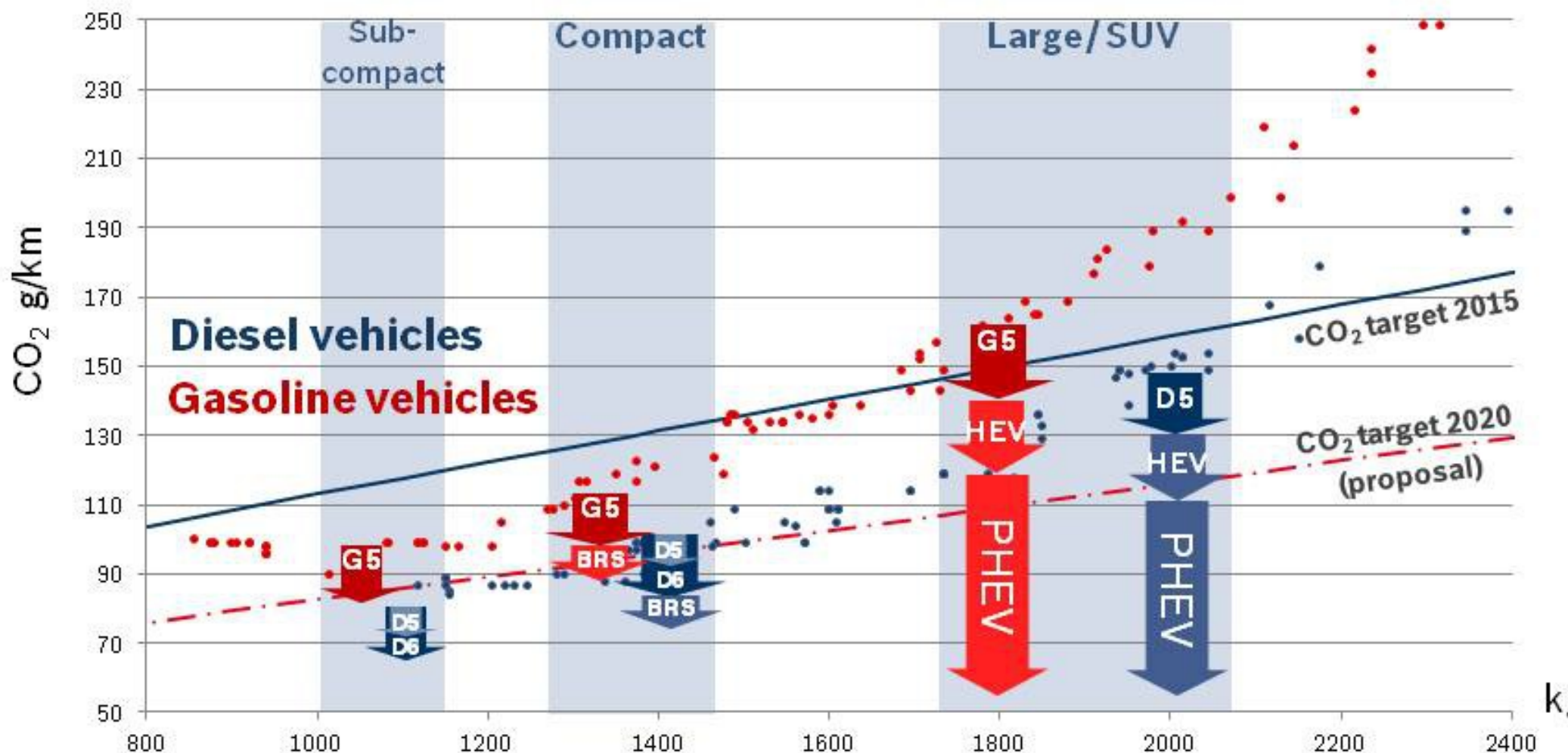
Concept combines advantages of ICE and EV at very low CO₂ emission level

*ICE: internal-combustion engine



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Hybrid solutions to close CO₂ gaps



Different Hybridization foreseen to fulfill market requirement

Strategy to achieve proposed CO₂ target for 2020

Subcompact



Highly efficient powertrain is sufficient and cost effective,
no electrification is necessary
Hydraulic Hybrid as a possible new product offer

Compact



Highly efficient powertrain with best cost/benefit ratio + light
electrification for gasoline powertrain (boost recuperation
system)

Large/SUV



Highly efficient powertrain with appropriate electrification for
maximum cost efficiency (HEV and PHEV)



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Thank you for your interest!



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