Technology Portfolio Strategies for CO_2 Reduction – Analysis and Approach

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Agenda

- **Status-quo of the EU CO_2 Emission Legislation**
- Our Approach to Define CO_2 Technology Strategies

Future EU CO_2 targets now fixed: -37.5 % until 2030, but 2020/21 targets still challenging

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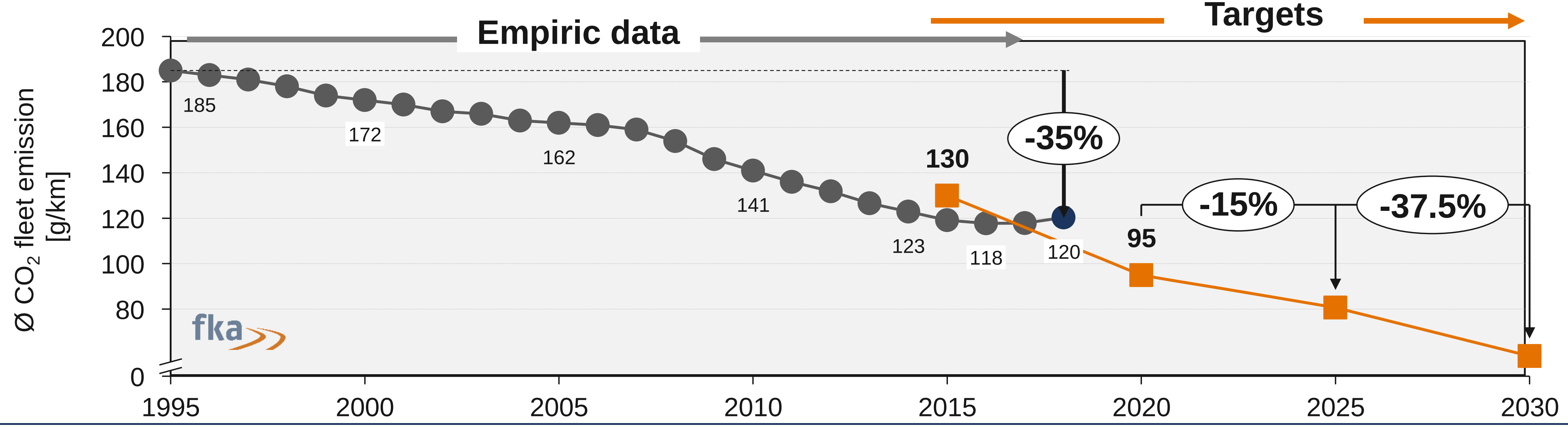
CO_2 fleet emission compared to legislative CO_2 targets

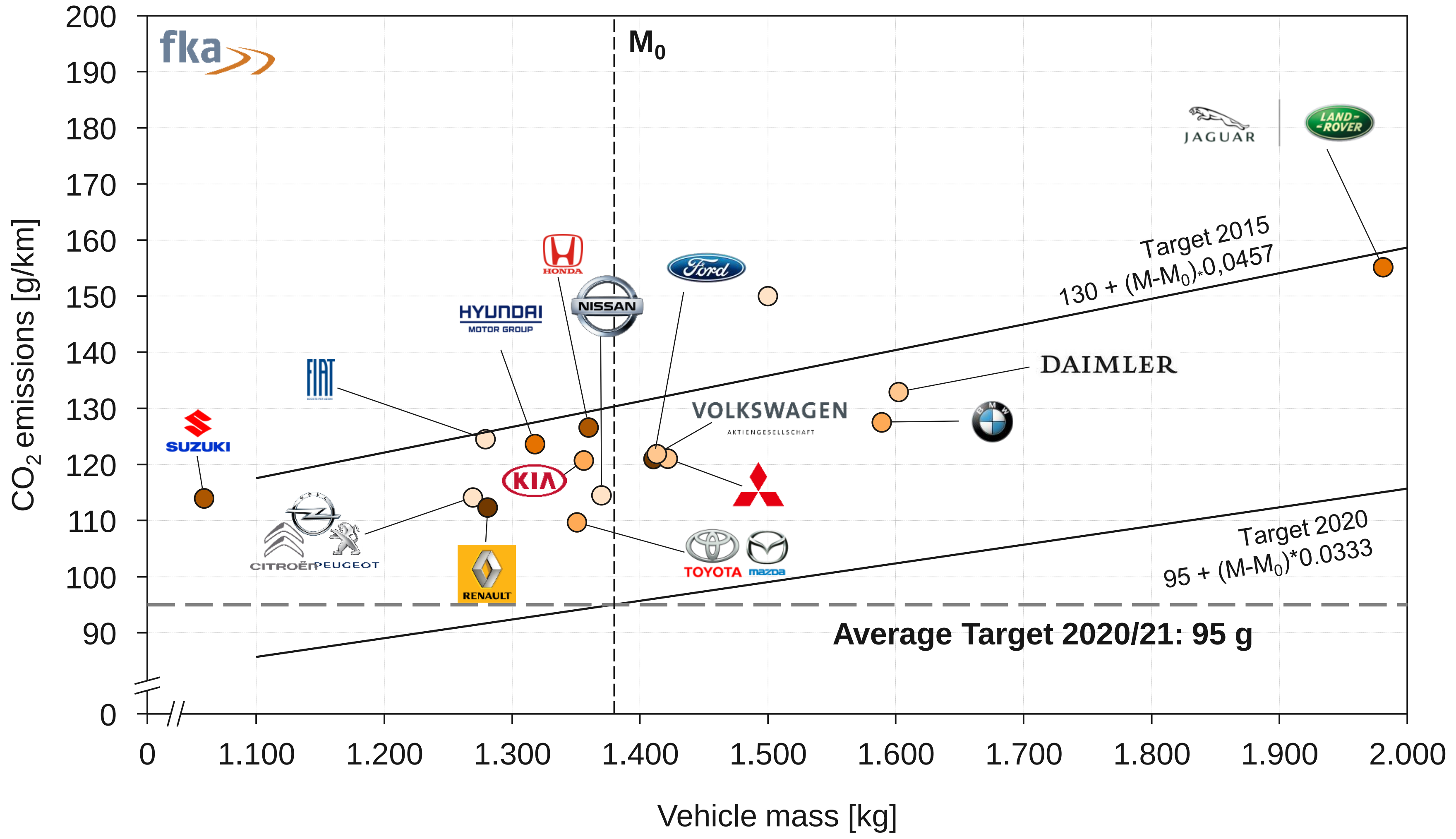


- » CO_2 emissions of passenger cars have significantly reduced, however have not lowered any more since 2016.
- » **At the same time, target values** for 2025 and 2030 have been defined by EU Commission: **15% reduction for 2025**, **37.5 % reduction for 2030**, Base: Measured CO_2 emissions **per OEM in 2021.**
- » Switch to **WLTP-based CO_2** targets testing cycle in 2020 does not directly translate into tightening CO_2 targets increase of target values, a **simulation tool for conversion** (“CO2MPAS”) is provided by the European Commission.
- » The **European legislation is formulated** “technology neutral”, but includes some incentives for BEV and PHEV

Source: EEA, fka

Even regarding the 2020/21 legislation, OEM still face major challenges

Status quo of passenger car CO_2 emissions in the EU (2018)



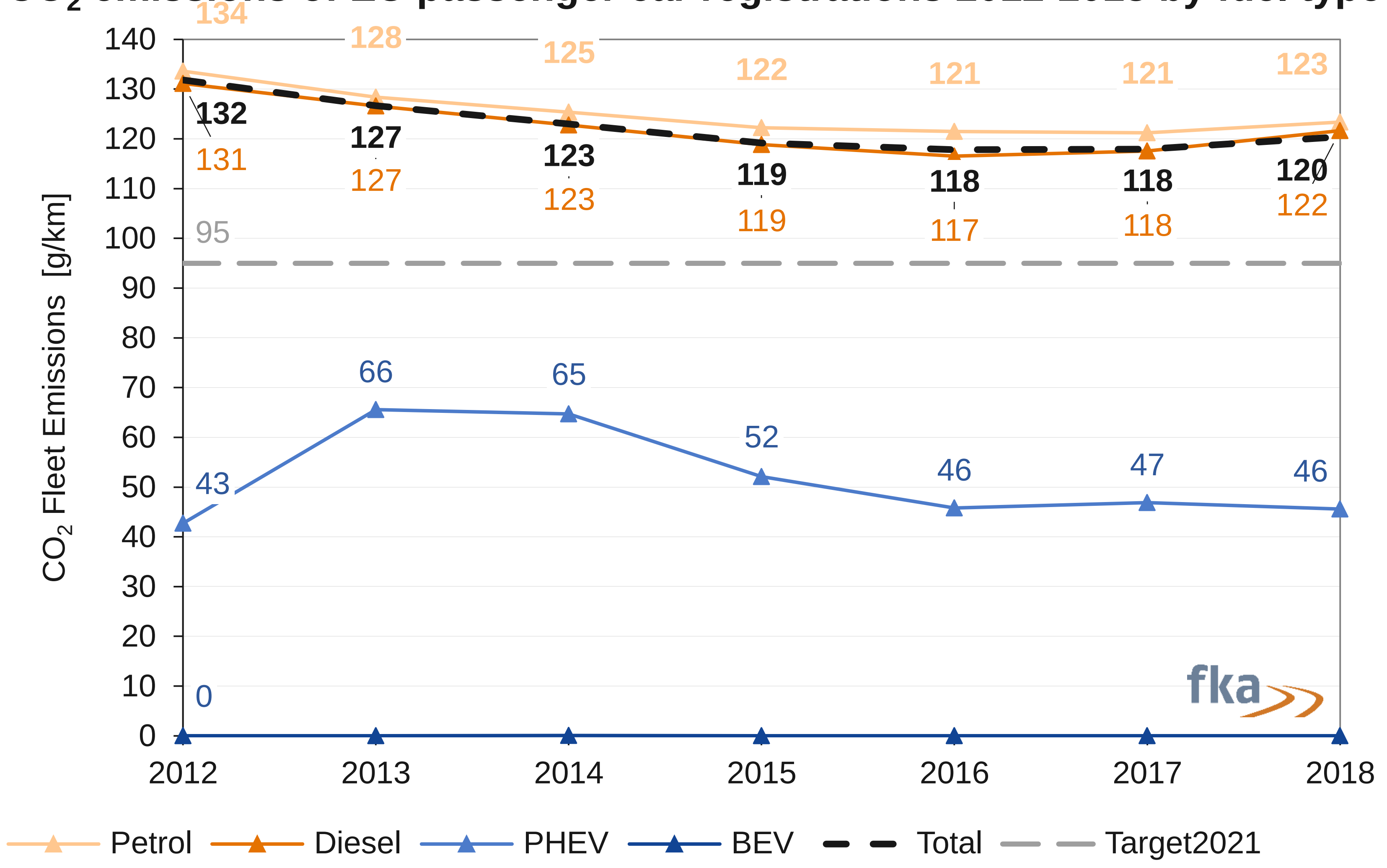
2018 Δ to target 2020/21

	[g/km]	[%]
JLR	-40.1	-25,9 %
FCA	-32.9	-26.4 %
Honda	-32.3	-25.5 %
Hyundai	-30.7	-24.8 %
Daimler	-30.5	-23.0 %
Suzuki	-29.6	-26.0 %
KIA	-26.5	-22.0 %
VW Group	-25.8	-21.1 %
BMW	-25.5	-20.0 %
Ford	-25.0	-20.6 %
Mitsubishi	-24.6	-20.4 %
PSA-Opel	-22.8	-20.0 %
Renault	-20.6	-18.4 %
Nissan	-19.8	-17.3 %
Toyota-Mazda	-15.7	-14.3 %
EU avg.	**-23,2**	**-24,7 %**

Source: EEA, fka

Increasing CO_2 emissions since 2016 makes target compliance 2021 highly challenging

CO_2 emissions of EU passenger car registrations 2012-2018 by fuel type



Results

- » **Total market**: After several years of **CO_2 reduction, emissions are increasing again since 2016**, making target compliance 2021 highly challenging.
- » **This general increase** since 2016 can be observed **for any fuel type.**
- » **BEV (and FCEV)** are **accounted as 0 g/km in the EU tailpipe emission regulation framework.**

Source: EEA, fka

EU market segmentation and consolidation by fka enables insightful analyses.

EU vehicle segment		Conventional: Sedans, Hatchbacks, Station Wagons	Conventional: Vans, Multi Purpose (M), Utility (U)	SUV (J, G)
A	Mini	e.g. Smart fortwo	-	e.g. Suzuki Ignis
B	Small	e.g. Ford Fiesta	e.g. Hyundai ix20	e.g. Ford Ecosport
C	Compact	e.g. VW Golf	e.g. Mercedes B-Class	e.g. BMW X1
D	Medium	e.g. Ford Mondeo	e.g. Ford Galaxy	e.g. Peugeot 5008
E	Executive	e.g. BMW 5-series	-	e.g. Volvo XC90
F	Luxury	e.g. Mercedes S-Class	-	e.g. BMW X7
S	Sport	e.g. Porsche 911	-	-

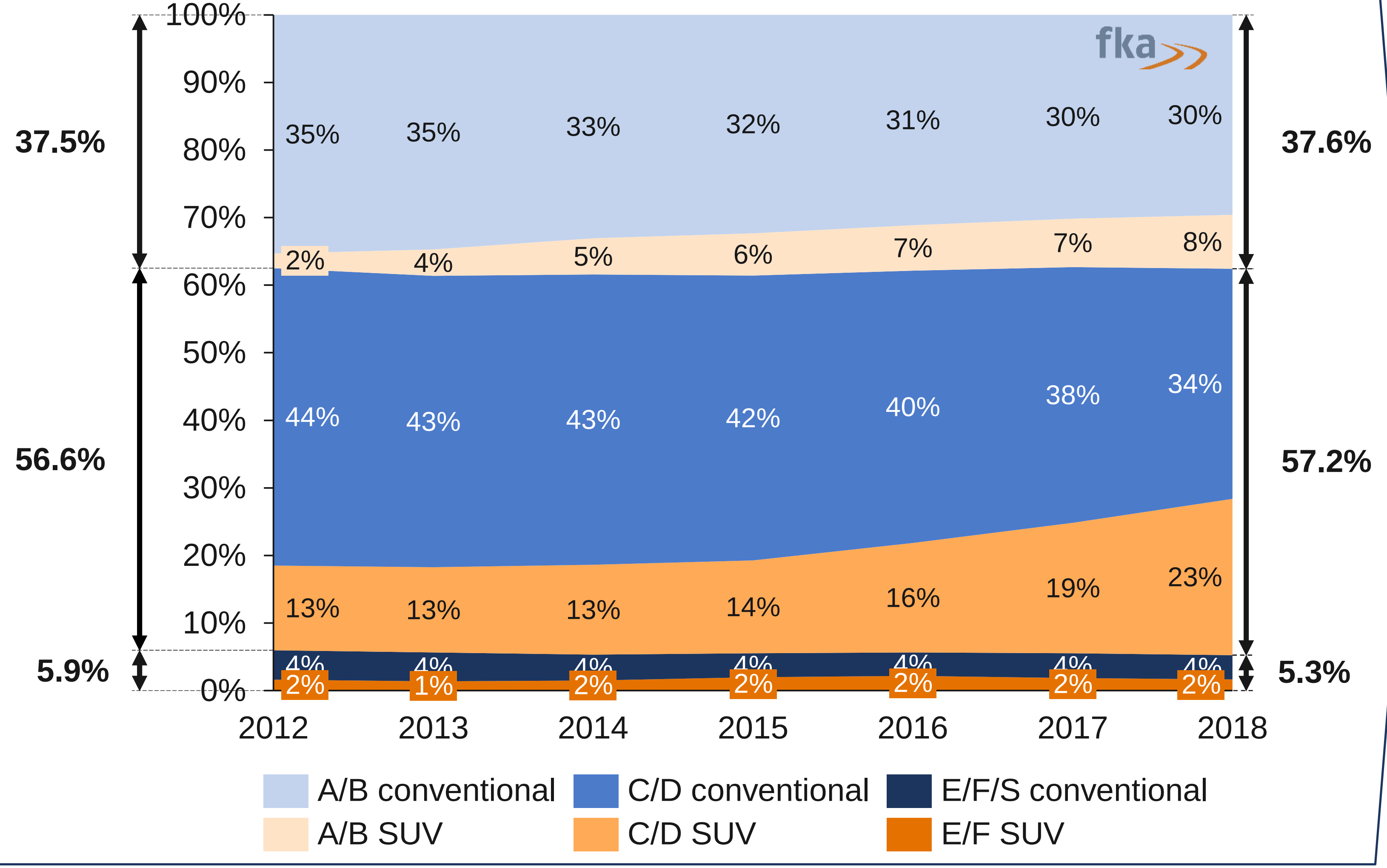
A/B conventional · *C/D conventional* · *E/F/S conventional*

A/B SUV · *C/D SUV* · *E/F SUV*

- **Conventional market segmentation** schemes (e.g. KBA) **consider SUV as one large single segment**, despite its **heterogeneity.**
- **Fka segmentation** takes this into **account** by defining various **SUV segments**, enabling **high-resolution analyses.**

Registrations by consolidated segments: Market segments constant, but trend towards SUV

Segment share of EU passenger car registrations 2012-2018



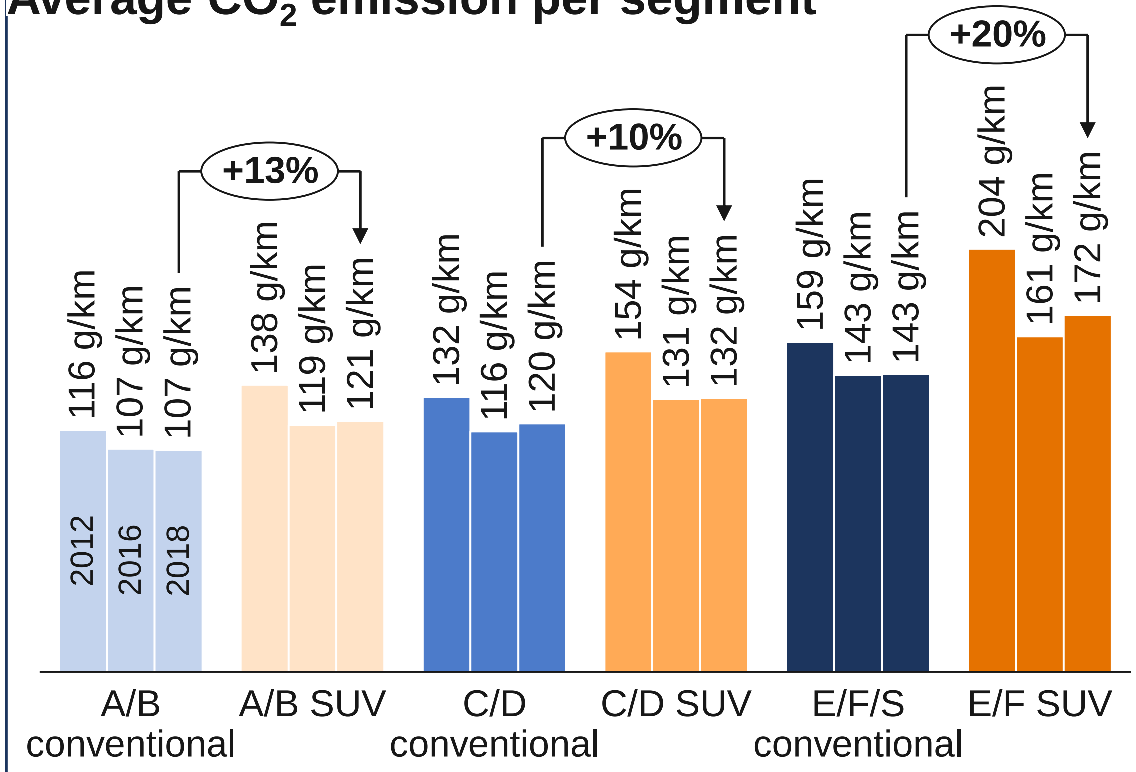
Results

- » **Share of market segments has been constant** for the last few years.
- » **Medium segment** (C, D incl. corresponding SUV) **is clearly dominating.**
- » **Within the market segments**, there is a **clear shift from conventional vehicle** concepts (sedans, hatchbacks, etc) **to SUV, especially** in the **small and medium segments**.

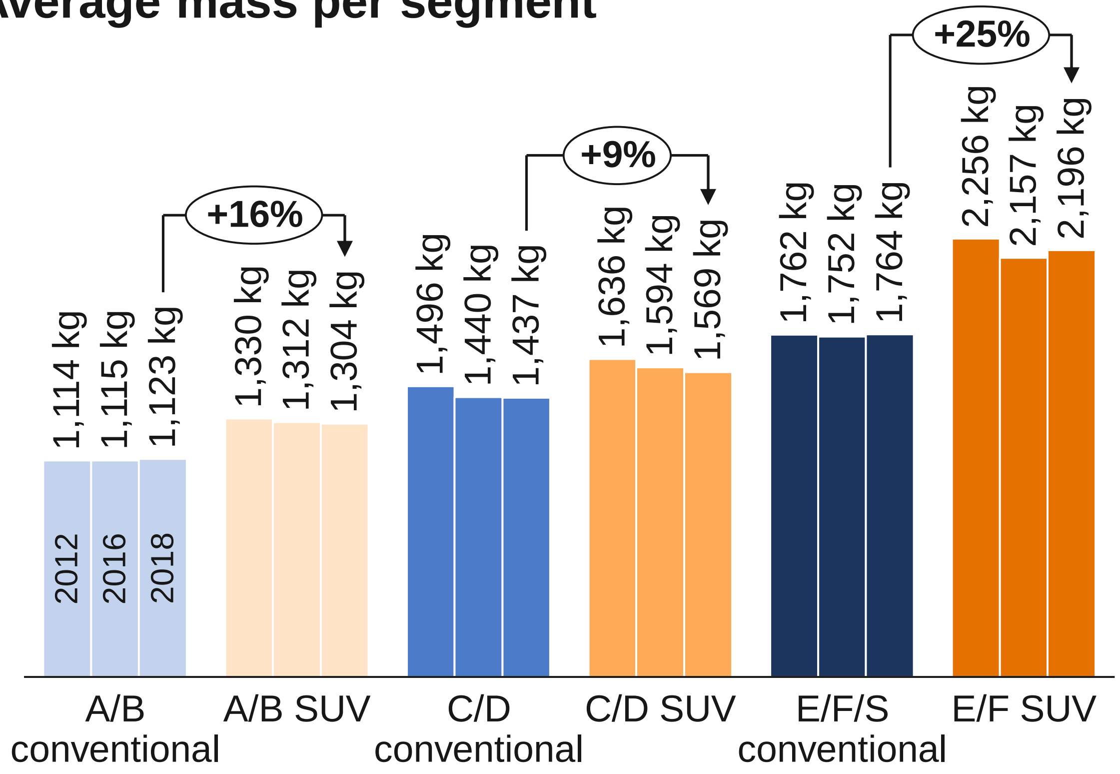
Source: EEA, fka

Trend towards higher CO_2 emissions visible in each segment, however no mass increase

Average CO_2 emission per segment



Average mass per segment



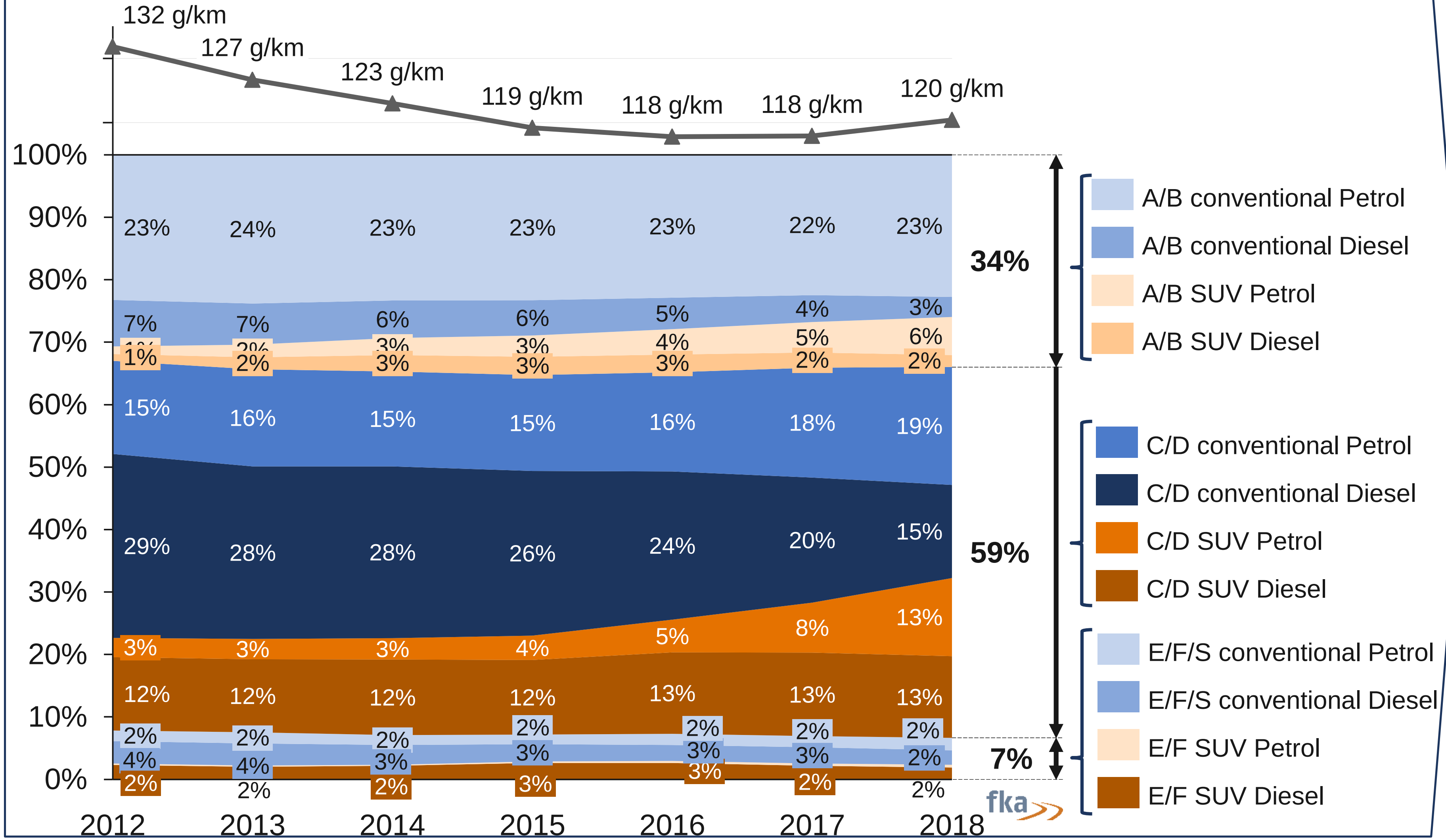
- » **In all vehicle** segments, NEDC **CO_2 emissions have been increasing again since 2016.**
- » CO_2 emissions of SUV are ~ 10 – 20 % higher than those of the comparable conventional vehicles in NEDC.

- » **None of the segments shows a significant increase of the average vehicle mass.**
- » However, the SUV segments are ~ 9 – 25 % heavier than the comparable conventional vehicles segments.

Source: EEA, fka

Contribution of vehicle segments and fuel types to total CO_2 emissions: C/D segment contributes most

De-composition of total fleet emission by segments and fuel types



Results

- **Emission contributions of the market segments** remain **almost constant.**
- **Main change within C/D-segment:** Clear **shift from conventional diesel C/D cars to conventional petrol cars and petrol SUV**
- **Heavy SUV segment (E, F), almost irrelevant for fleet emissions (<3%)**

Source: EEA, fka

Increasing SUV and petrol share has led to CO_2 emission increase of ~ 2 g/km each

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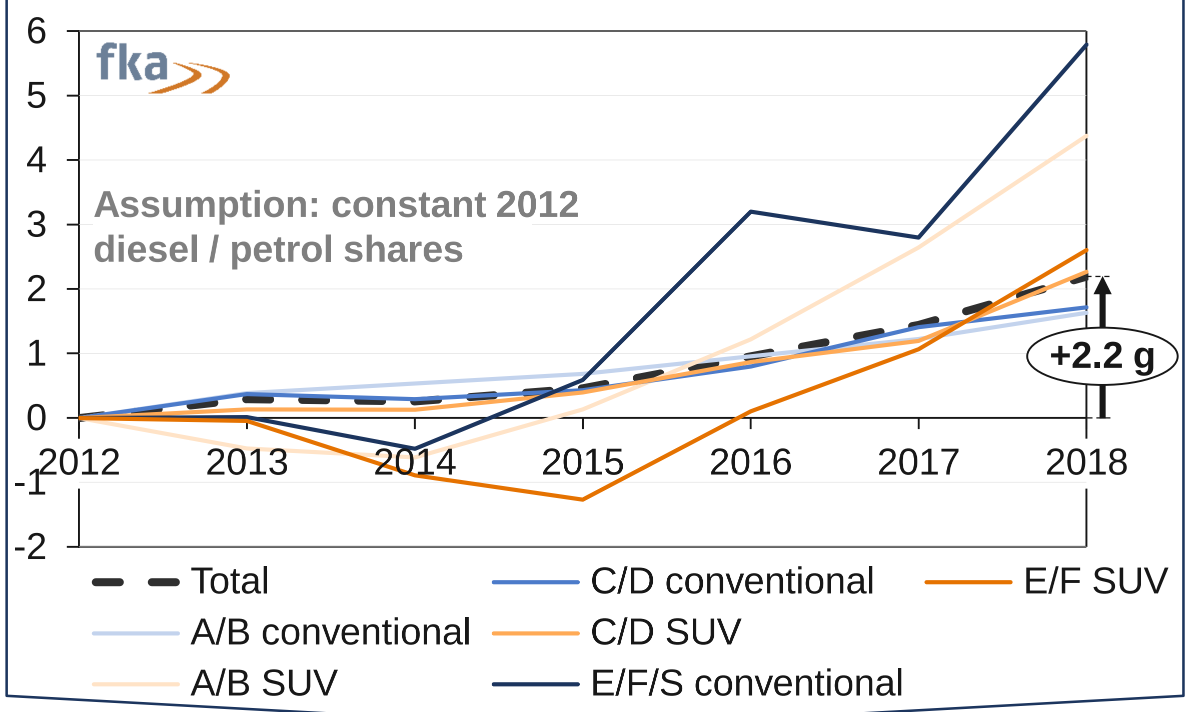
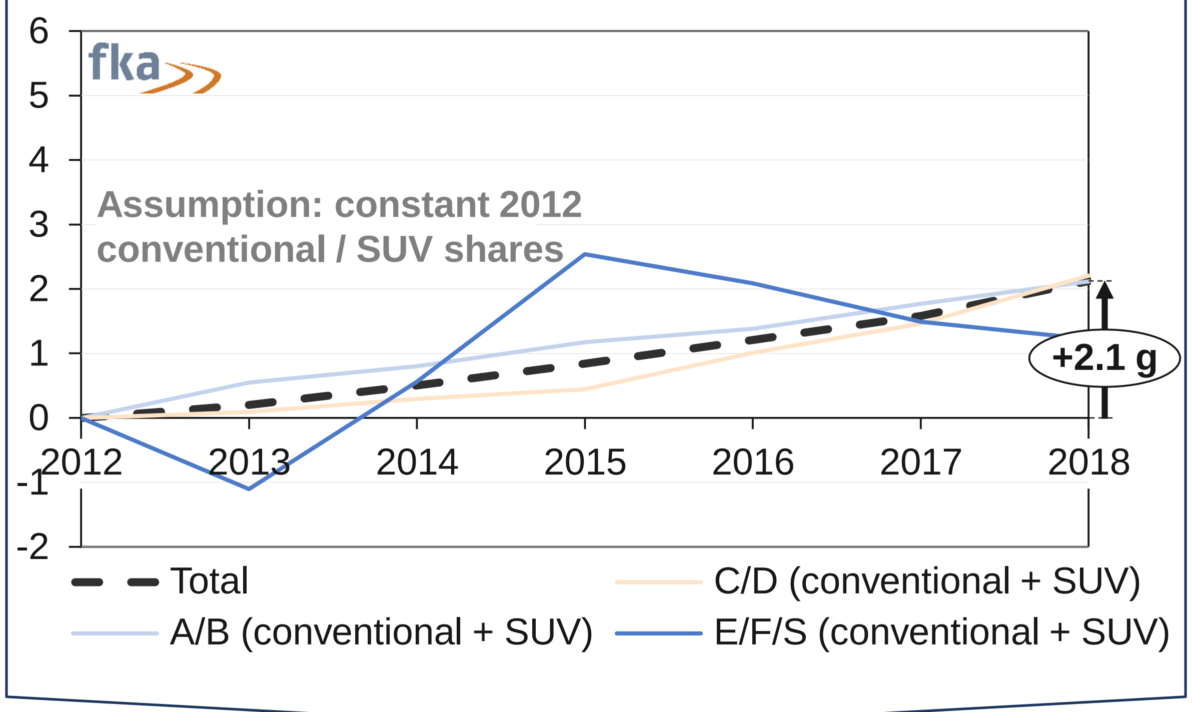
CO_2 emission increase by diesel → petrol shift since 2012 [g/km]



CO_2 emission increase by SUV market growth since 2012 [g/km]



» **Without the diesel/petrol shift** in the recent years, CO_2 emissions could be **2.2 g/km lower.**

» E/F cars and SUV as well as A/B SUV are affected by the change the most.

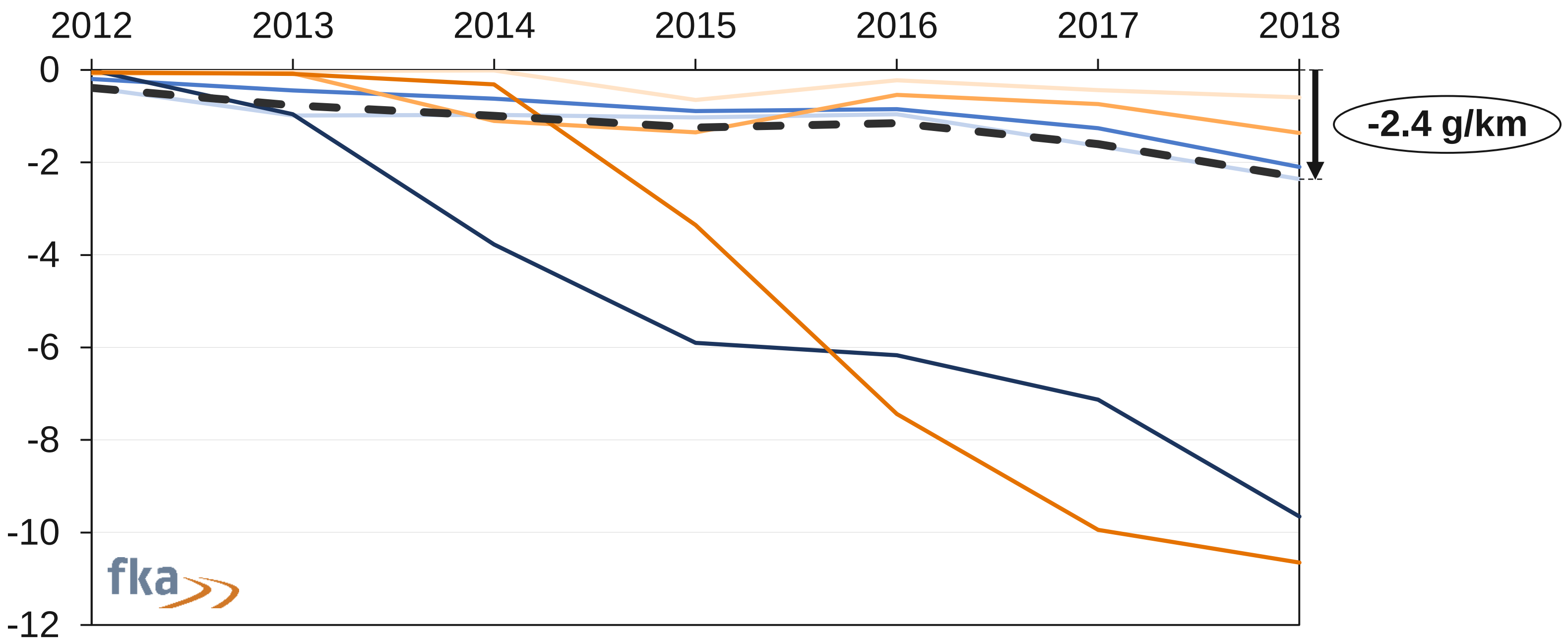
» **Without the trend towards SUV**, the fleet CO_2 emission could **be 2.1 g/km lower.**

» Similar trend towards SUV in the volume segments, slight shift back to conventional vehicles in E/F segment.

Source: EEA, fka

Increasing electrification dampens the increase of CO_2 emissions

Effect of electrification on CO_2 fleet emissions



CO_2 emission decrease [g/km] by electrification (BEV + PHEV)

A/B conventional · C/D conventional · E/F/S conventional · Total
A/B SUV · C/D SUV · E/F SUV

Results

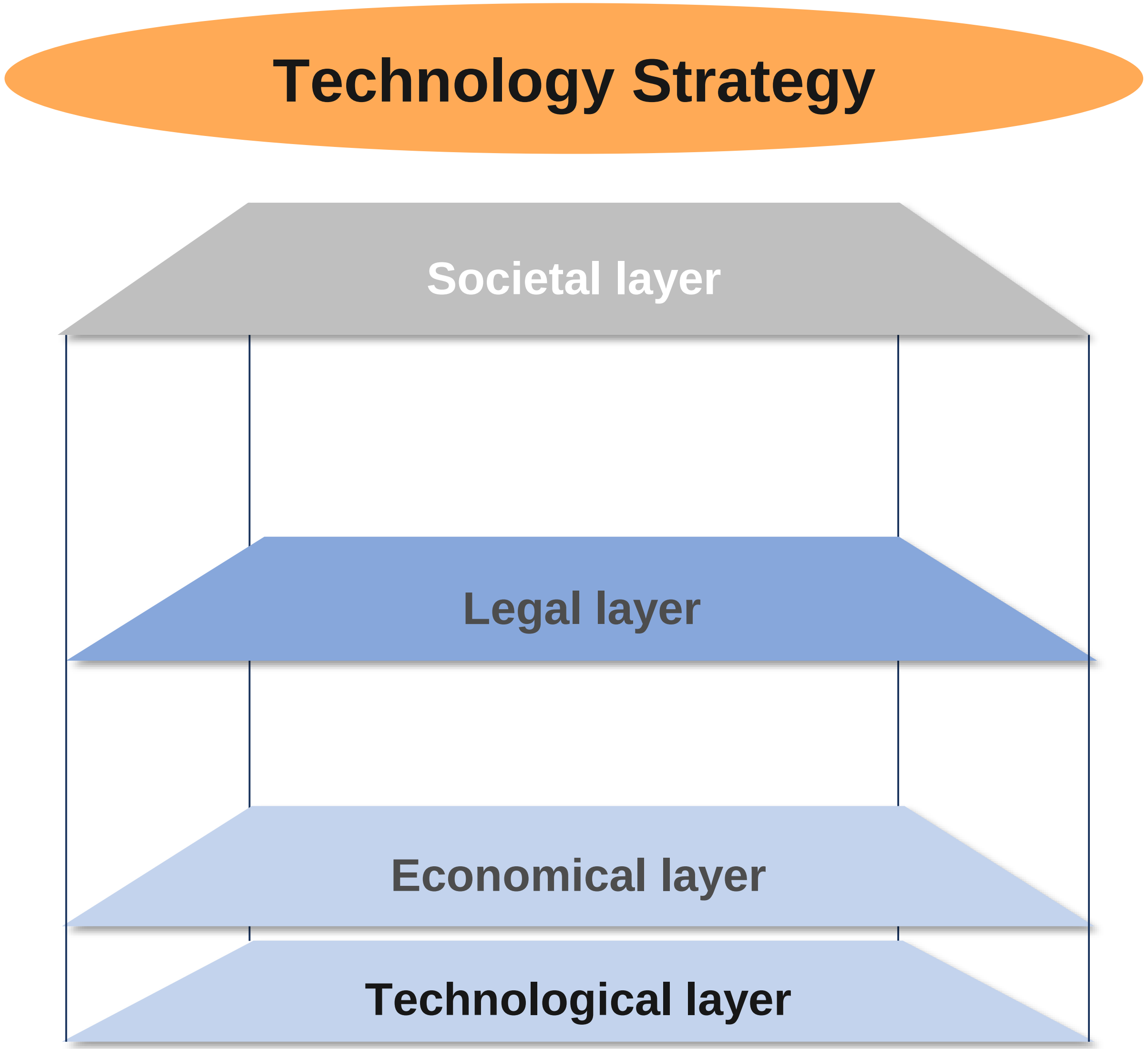
- **xEV** start to **effectively lowering the CO_2 fleet emission in 2018**.
- **Without any electrification**, the CO_2 fleet emission were **2.4 g/km higher.**
- **Electrification effect in the E/F segment** particularly high, however low overall market share.
- In turn, the **effective CO_2 reduction for petrol or diesel-only vehicles has slowed down to near-zero the in the recent years.**

Source: EEA, fka

Agenda

- Status-quo of the EU CO_2 Emission Legislation
- **Our Approach to Define CO_2 Technology Strategies**

Our approach integrates four layers of scope – and leads to a holistic technology strategy.



Holistic technology strategy derivation
- SWOT analysis
- Derivation of strategic implications

③ **Societal layer**

E_2P approach on lifecycle
- GWP vs. technological performance
- Assessment in vehicle fleets

② **Legal layer**

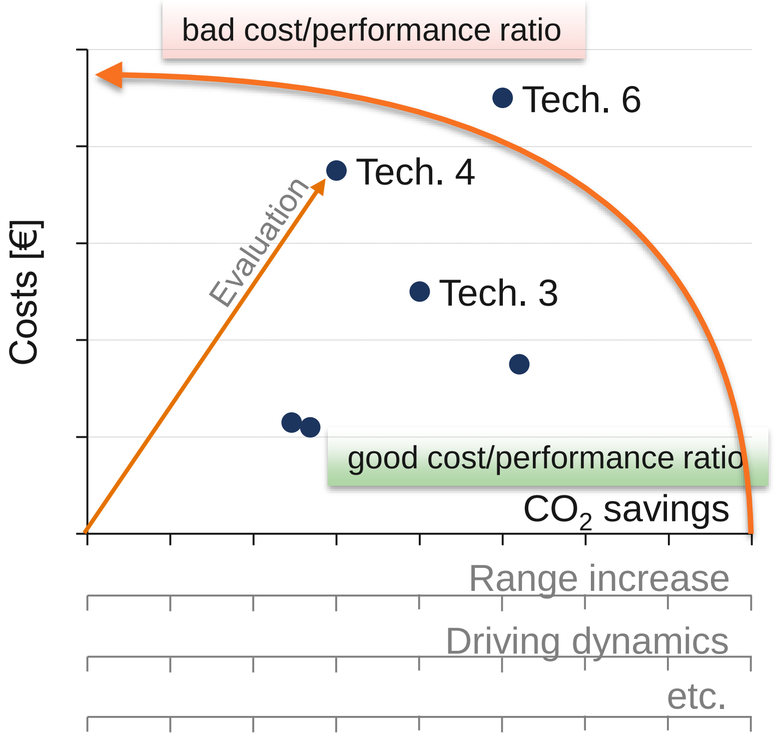
Model-based assessment
- Existing greenhouse gas legislation
- Cost-based vs. market-based approach

① **Technological & economical layer**

Technology analysis
- Quantification of benefits and costs
- Technology clustering

Any technology evaluation starts with a prioritization of technologies, involving evaluation, investigating interactions and clustering.

Evaluation



- Evaluation of at least one economic and one technologic dimension, e.g. CO_2 savings and manufacturing costs.

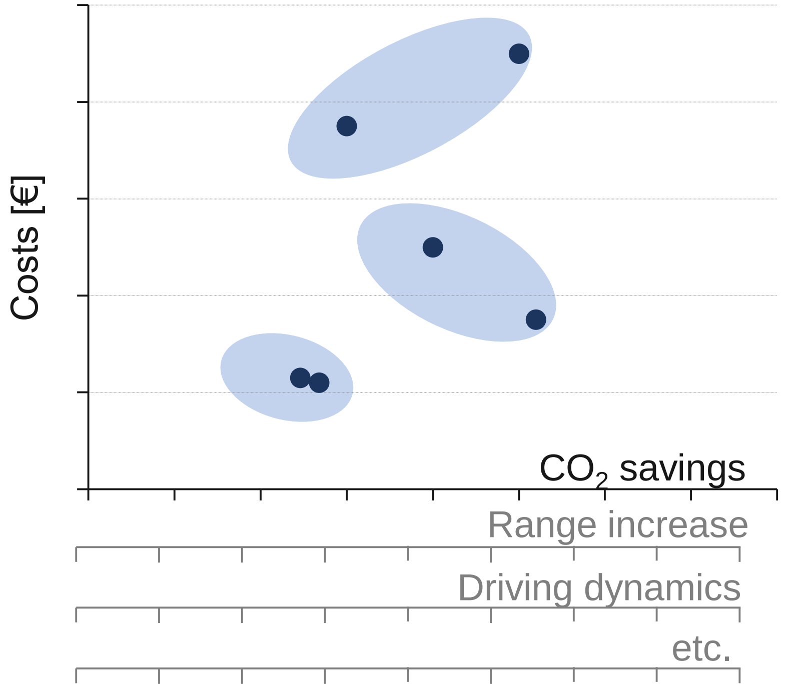
Interactions

	Tech. 1	Tech. 2	Tech. 3	…	Tech. n
Tech. 1		+	0	--	-
Tech. 2	+		--	-	--
Tech. 3	0	--		++	+
…	-	++	++		+
Tech. n	+	0	0	+	

++	strong positive correlation
+	positive correlation
0	No correlation
-	Negative correlation
--	Strong negative corr. / mutual exclusion

- Investigation of interactions
- Mutual exclusion, amplification, attenuation

Derivation of technology packages (clustering)



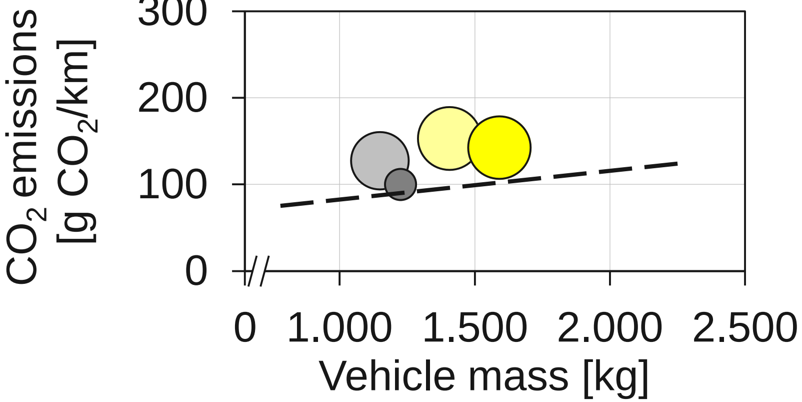
- Formation of technology packages through aggregation of individual technologies
- Technology packages technologically coherent in themselves

Both cost- and market-based assessment have advantages – higher accuracy regarding demand involves higher effort.

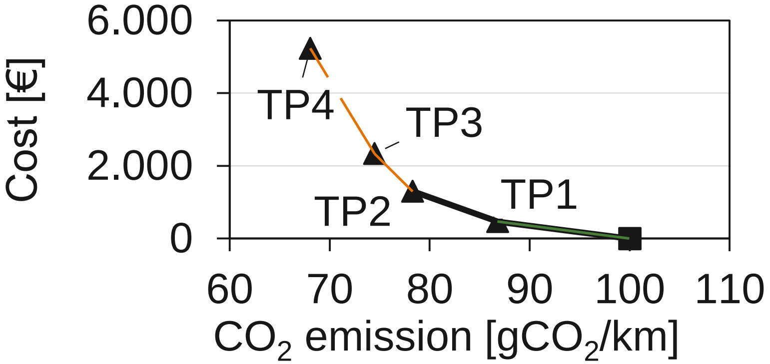
Cost-based assessment

- Optimization of CO_2 compliance costs
- **Cost-optimal** product portfolio by calculation

① Analysis of OEM portfolio



② Derivation of technology-cost curves

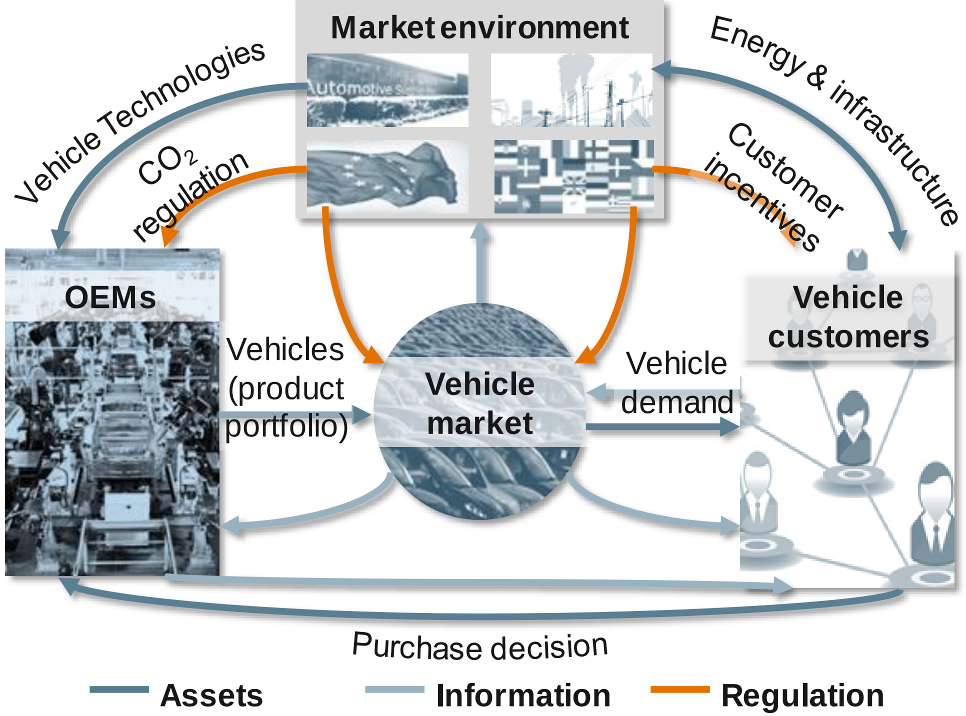


\+ **Quick and easy** estimation of technology relevance

\- High **uncertainty** regarding market **acceptance**

Market-based assessment

- Optimization of OEM KPIs
- **Market-optimal** product portfolio by simulation



\+ Demand as <u>the</u> decisive factor influencing CO_2 compliance

\- **High effort** for modeling and computing

Future R&D strategies of supply chain players have to be defined in accordance to the CO_2 challenge

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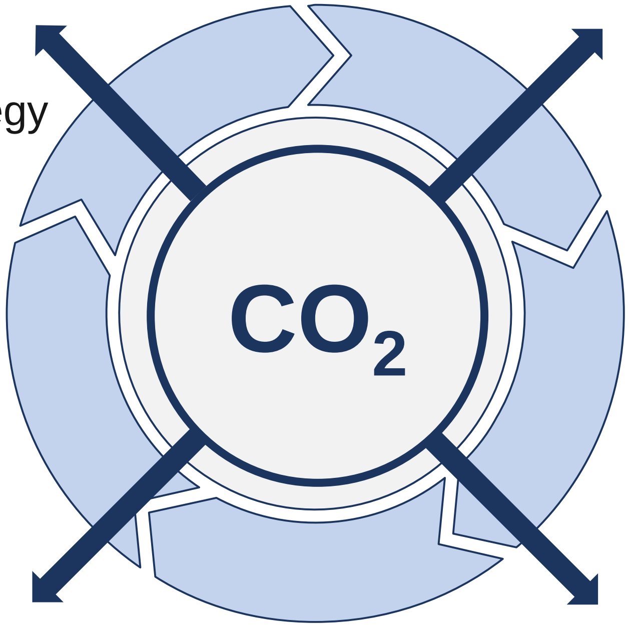
Organizational implications
- Investment strategies, e.g.
  - Technology decisions
  - Production planning
- Organizational adaptions, e.g.
  - Organization of R&D-Teams
  - Setup of CO_2 Product Strategy Teams

Monitoring
- Complementary technologies
- Competitor activities
- Disruption radar



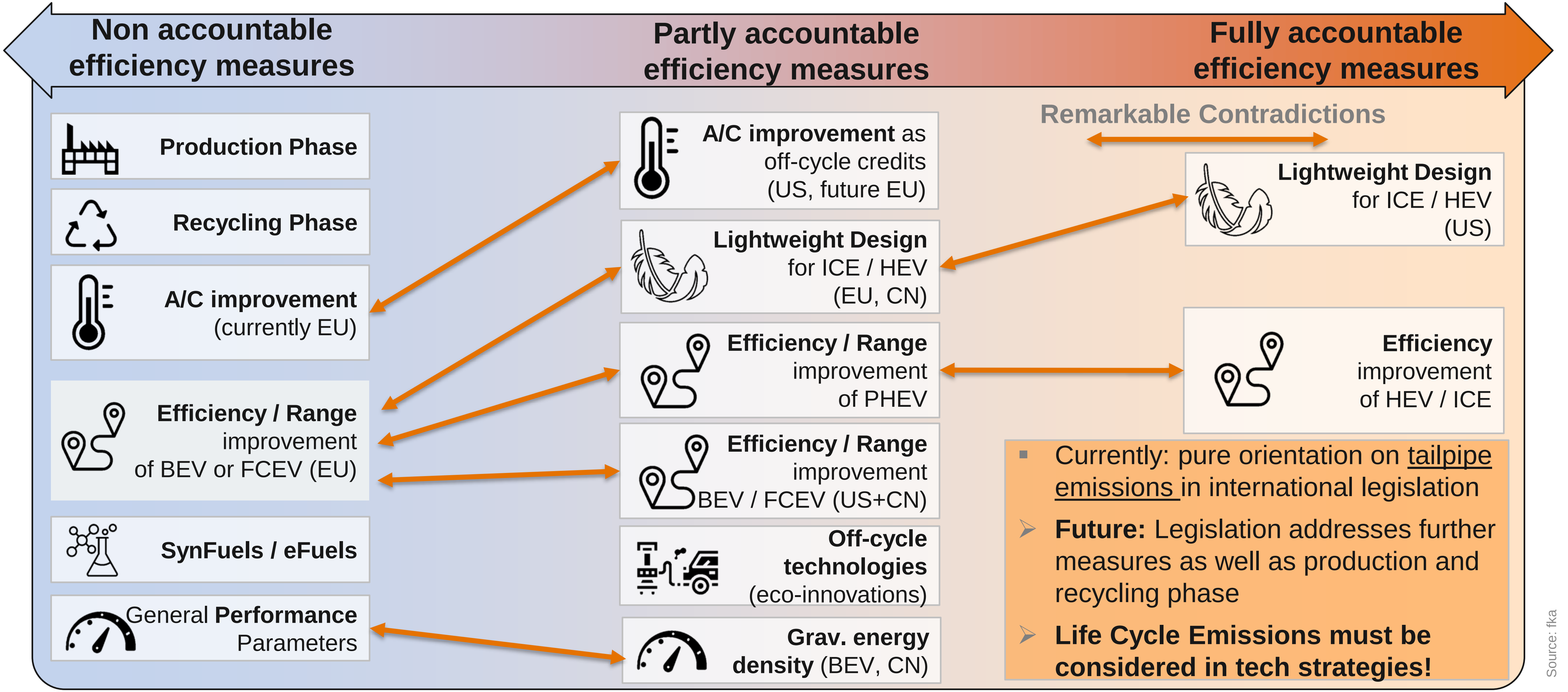
R&D implications
- Direction of further R&D activities
- Setup of concrete R&D projects
  - Process adaptions

Communication
- Exchange with customers
- External communication of technological CO_2 reduction potential on module, vehicle, platform or fleet level.

Further analysis

Source: fka

Outlook: Several efficiency measures are not (fully) accounted in current legislation – e.g. production and EV efficiency



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