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White Paper

Heavy-duty vehicles CO_2 targets 2030: Which drivetrain technology will win?

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After the passenger car market has been driven by regulation to ever greater CO_2 optimization over the past ten years, it is time for the EU's second-largest cause of greenhouse gas emissions in road traffic: heavy-duty vehicles (HDV) like commercial trucks or buses. Due to ambitious CO_2 reduction targets of 15 % by 2025 and 30 % by 2030, an entire industry is being challenged to realize the most disruptive change in its history with an extremely short lead time and far-reaching consequences for the entire supplier landscape. While in the passenger car sector everything points to rising market penetration of battery electric vehicles, the picture in the commercial vehicle sector is much more diverse. The complexity of regulation, the market as well as the heterogeneous technological development paths make it even more challenging to understand the implications of legislation on the value chain and to anticipate technology strategies.

In this article, we would first like to provide a brief insight into the **legislation** before taking a closer look at the **starting position of CO_2 emissions at HDV**. We then look at the **alternative technology strategies** and their dependence on specific fields of application, and show how corresponding **OEM activities** look in practice. In a **conclusion**, we share our thoughts around the direct implications on the value chain.

The legislation

The regulation[1] aims to reduce tailpipe CO_2 emissions for new registrations of the regulated vehicle fleet by 15 % by 2025 and 30 % by 2030 compared to the 2019/20 baseline period. The class of heavy-duty vehicles (HDV) basically includes buses (vehicle categories M2, M3), trucks (N2, N3) and, in a broader sense, trailers (O). In a first regulatory step, only N2 and N3 vehicles with fixed bodies and tractor-trailers over 16 t technically permitted maximum laden mass (TPMLM) are regulated in accordance with their high market share. Vehicles that belong to the off-highway sector are generally not be taken into account currently, nor are other types of N2 and N3 vehicles. Target values for buses are not to be discussed until 2023 as part of a major review. In terms of tailpipe legislation, only local CO_2 emissions are considered. Initial preliminary investigations into the long-term integration of partial aspects of life cycle assessment (LCA) will be presented as part of a review in 2023. At this point, the crediting of synthetic fuels (e-fuels), which do not yet find a place in the current regulation, will also be examined.

The relevant vehicles are classified into nine subtypes according to the vehicle type's usual use profile (urban, regional, long-haul) and other technical characteristics, with a separate specific target value determined for each of the subtypes based on the 2019/20 values. Vehicle manufacturers are then assigned to their specific target value which has to be achieved based

[1] Regulation (EU) 2019/1242

on their fleet composition. Thus, for both the determination of the OEM target values and the determination of the CO_2 emissions, the sub-types must be offset against each other. This offsetting is carried out on the basis of the typical average payloads and annual mileages defined in regulatory terms for the individual sub-types - in effect, this results in regulation in the dimension [CO_2/t-km]. Zero-emission vehicles are considered separately and not weighted by their average payload. Additionally, for the calculation of zero emission credits, the restriction to the abovementioned selected HDV types does not apply. This makes the electrification of rather small HDV in particular attractive.

The starting position

The emissions in the individual subgroups determine the future targets of the manufacturers. According to preliminary data from the base period 2019-2020 (as of June 2021)[2], vehicles from the most common subgroup 5-LH (4x2 tractors for long-haul operation) cause an average of approx. 783 g CO_2/km against the background of the operational profile attributed to them.

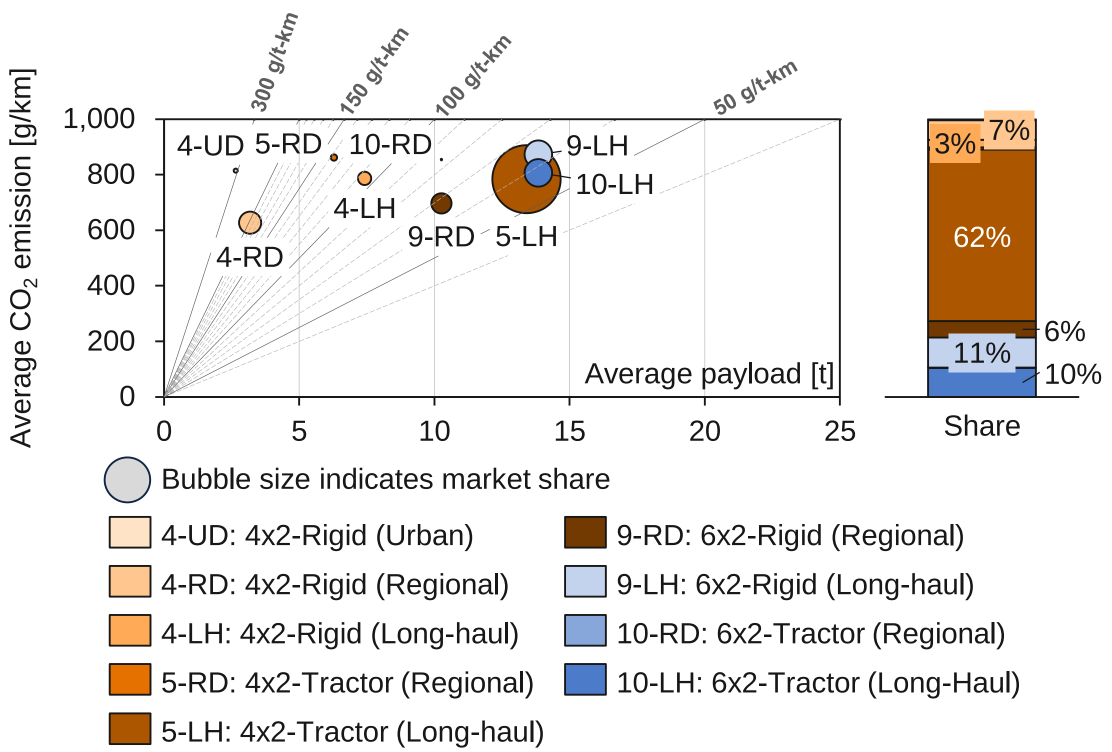

Fig. 1: Average CO_2 emissions by vehicle subgroup in EU baseline period
Source: fka, based on EEA data

[2] Monitoring of CO2 emissions from heavy-duty vehicles; https://www.eea.europa.eu/data-and-maps/data/co2-emission-hdv

From the regulatory average payload (incl. empty runs) of 13.4 t, this yields specific CO_2 emissions of 58 g CO_2 / t-km. In contrast, vehicles with an urban or regional mission profile have much higher specific emissions in view of their driving profile; for example, vehicles in subgroup 4-RD achieve specific CO_2 emissions of just under 200 g CO_2 / t-km. If the performance of the individual manufacturers is compared, it becomes apparent that all manufacturers are at a very similar level. The CO_2 emissions of the worst-performing OEM in subgroup 5-LH are just 8 % higher than those of the top performer. The range of the reported CO_2 emissions of the individual vehicles is just ca. +/-10 %. Compared with passenger car manufacturers in individual segments, this is extremely low, indicating that efficiency is a high priority and efficiency optimization is already well advanced.

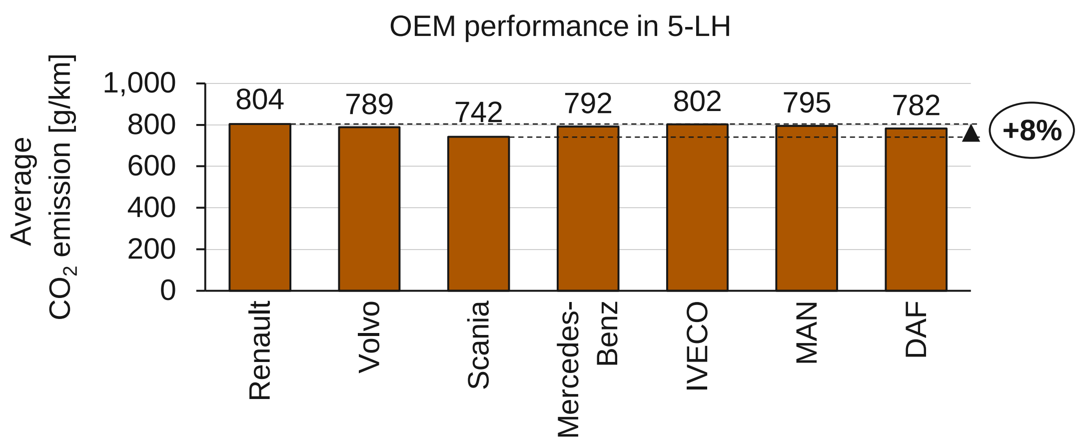

Fig. 2: OEM CO_2 fleet performance in subgroup 5-LH; Source: fka, based on EEA data

So far, electrified powertrains play only a minor role in registration figures. Just 0.4 % of all newly registered trucks over 3.5 t TPMLM in 2020 have an externally rechargeable traction battery, i.e. plug-in hybrids (PHEV) and battery electric vehicles (BEV). Other alternative powertrains accounting for 2.9 % are virtually all vehicles running on gas. Vehicles with hydrogen fuel cells do not play a role on the market at present. This means that almost 97 % of new registrations are still diesel-powered.

The alternative technology strategies

As in the case of passenger cars, CO_2 emissions from heavy commercial vehicles can be reduced by minimizing driving resistance or by increasing the efficiency of energy supply on the drive side. The optimization of driving resistances is often only possible by limiting the utility such as the loading volume, which is hardly accepted in the commercial vehicle sector in particular. The discussion is therefore being conducted primarily with regard to the choice of the right drivetrain type.

On the basis of the conventional internal combustion engine drive train, maximum savings of five to 15 % can still be achieved, while full hybridization - depending on the mission profile - can achieve savings of up to 20 %.[3] In contrast, hydrogen combustion engines (H_2 ICE) as well as BEVs or fuel cell electric vehicles (FCEV), allow tailpipe emissions to be avoided completely, and this is at least possible locally in the case of PHEVs and catenary electric vehicles (CEV). All approaches except e-fuels can in principle also contribute to CO_2 reduction in the context of the regulation, but for all alternative forms of propulsion the concrete mapping in the VECTO simulation environment is not yet given. Technologically, these are relatively mature technologies or technologies that can be developed quickly. For the use of e-fuels, only adaptations in the engine, fuel-carrying parts and exhaust gas aftertreatment are required; for H_2 ICE, a corresponding pressure or cryogenic tank must also be provided. For fuel cell and battery electric vehicles, the main challenges are in the area of cost reduction and scaling.

	Diesel ICE	eFuels-ICE	H2-ICE	HEV	PHEV	BEV	CEV[1]	FCEV
Local ZEV capabilities	×	×	✓	×	✓	✓	✓	✓
CO_2 Potential	15 %[2]	+/- 0 %	100 %	20 %[3]	*	100 %	*	100 %
Reflection in legislation	✓	×	(✓)	(✓)	(✓)	(✓)	×	(✓)
Technological readiness	●	◕	●	◕	◕	◕	◔	◑
Maturity of Infrastructure	●	◑	◔	●	◑	◑	○	◔

[1] CEV: Catenary Electric Vehicle
[2] Includes measures on transmission and auxiliaries
[3] Total potential of optimized diesel ICE and hybridization
* Reduction potential highly depending on use case

✓ Yes / fulfilled
(✓) Partly fulfilled
× No / not fulfilled

Fig. 3: Aggregate evaluation of drivetrain technologies; Source: fka

It is obvious that the achievement of the target by 2030 at the latest can no longer be ensured on the basis of diesel ICE and simple mild- and full-hybrid concepts alone. BEVs and FCEVs, and to a limited extent also H_2 ICE vehicles, are therefore the promising solutions for HDV. The creation of a corresponding infrastructure suitable for the specific requirements of HDV (e.g. charging capacity from 350 kW DC to more than 500 kW DC or full-coverage H_2

[3] Simplified assumptions on potentials based on "Support for preparation of the impact assessment for CO_2 emissions standards for Heavy Duty Vehicles – Full Report"

infrastructure for correspondingly high refueling rates) is being pushed by manufacturers and increasingly put on the agenda by political actors.

In the long term, BEVs and FCEV will represent the decisive technological options for CO_2 reduction beyond the limits of (hybridized) diesel ICE. Whereas BEV will gain relevance already in the near future, FCEV might come to the fore towards the end of the decade. In perspective, the race for the dominance of ICE vs. BEV vs. FCEV is already in full swing. The determinant for the winning concept will be the usage profile of the vehicles in terms of operating environments and trip lengths.

The key aspect here is the limitation of the battery-electric range. Current vehicle concepts promise purely electric ranges of around 300 km - significantly higher ranges are difficult to realize against the then prevailing restrictions in terms of weight and charging volume. In this respect, the current gravimetric and volumetric energy density of battery systems is the key technological hurdle. Until a reliable public charging infrastructure for commercial vehicles is available, the use of battery electric vehicles is therefore mainly attractive for routes that can be served within one day, if possible with the opportunity to return to the own depot. If necessary, existing charging infrastructure at the destination can also be used.

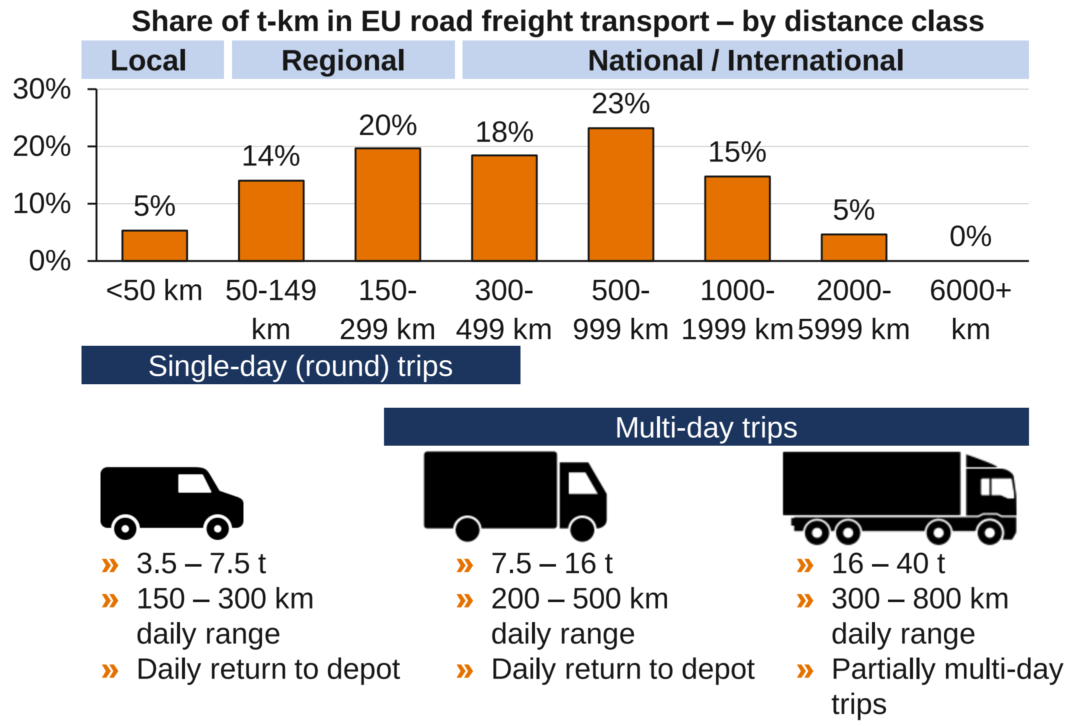

Fig. 4: Distribution of usage profiles; Source: fka, based on EUROSTAT data

Statistically, almost 40 % of freight transport performance in the EU, weighted as t-km, is performed over a distance of up to 300 km. Medium-duty commercial vehicles with 7.5 t –

16 t TPMLM are frequently used here. For these routes, there is a particularly high market potential for battery electric vehicles. For the remaining approx. 60 % of the freight transport performance, fuel cell vehicles suitable for long distances appear to be interesting in perspective, which, however, also require the existence of an area-wide infrastructure. Depending on the regulatory framework, e-fuels and H_2 ICE could also be considered in principle for meeting the demand for transport.

The OEM activities

The HDV market in the EU is highly consolidated. Just five manufacturer groups account for 99% of new registrations in the regulated HDV segments. Accordingly, individual technology decisions - even more than in the passenger car sector - have a far-reaching impact on the future.

This general orientation is also confirmed in the manufacturer strategies in the form of concepts and initial small series. According to an announcement by Daimler Trucks, series production of the Mercedes-Benz eActros (25t TPMLM; 200 km range) will begin before the end of 2021, and the corresponding long-haul variant eActros LongHaul (500 km range) is to be introduced by 2024. The portfolio will be completed by vehicles from other Group brands, e.g. the Fuso eCanter. In parallel, fuel cell vehicles such as the GenH2 truck with a targeted range of 1,000 km are being presented and announced for customer testing by the middle of the decade. This strategy can be observed analogously at the other major HDV manufacturers in Europe like Volvo, Scania, MAN, DAF etc. This underlines that already by 2025 BEV will contribute to the reduction of CO_2 fleet emissions of the manufacturers and thereafter the competition between BEV and FCEV will intensify.

Conclusion

HDV CO_2 regulation in the EU is starting with a few vehicle segments, but has already become a megatrend in technology and market development. Current insights into CO_2 emission data show how challenging it will be to meet future targets, as the conventional combustion engine technology path has already been optimized to a great extent. There are indications that battery electric vehicles could soon be used in higher volumes for many short- and medium-haul transportation tasks. Hydrogen and fuel cells will play a key role in ensuring sustainable long-haul logistics, especially for high ton volumes.

Suppliers in particular are faced with the challenge of providing the HDV market with precisely tailored technology offers in the respective segments. Expensive misallocation of development efforts should be avoided in any case, which requires in-depth market and technology analysis. The next years will be crucial to be among the beneficiaries of the biggest upheaval in the history of the HDV market!

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About the fka GmbH

For 40 years, fka has been internationally known as an innovative engineering service provider for the automotive industry. Driving the world by developing ideas and creating innovations is the vision that fka's 160-strong team is committed to.

The team is inspired by a passion for efficient, safe and fascinating mobility. As one of the first companies on the Campus Melaten in Aachen, the spin-off of the Institute for Automotive Engineering of RWTH Aachen University demonstrated foresight early on. Interdisciplinary expertise in all aspects of mobility and technological visions, combined with the advantages of the inspiringly creative location, are fka's fuel. Ideas, innovations and unique methodological expertise are shaped into well-founded and validated solutions that give fka's customers the necessary advantage in various fields.

A complete range of services, from consulting and conception to simulation and design, prototype construction and experimental testing, forms the basis for this.

With the motto "Creating Ideas & Driving Innovations", the team already has the mobility of the future constantly in mind.

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