Easy Ride: why the EU truck CO_2 targets are unfit for the 2020s

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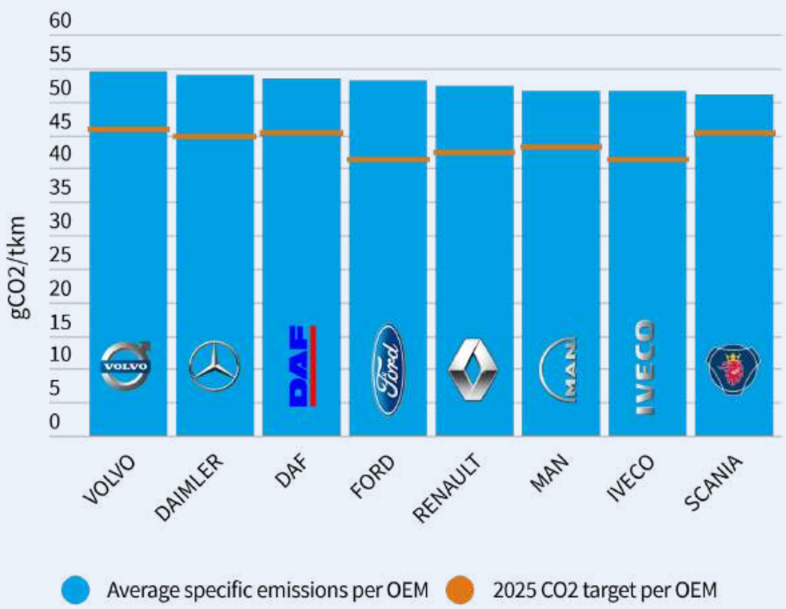
Executive Summary

Truck CO_2 emissions have been continuously increasing for decades (+29% compared to 1990), but the EU remained blind to the evolution of CO_2 emissions from new trucks until 2019 when, for the first time, CO_2 emissions performance standards for new trucks have been set. Until 2019 the emissions of new trucks were not routinely collected, but the first set of data for the trucks in the nine regulated categories sold from July 2019 to June 2020 (called 'reference period') is now publicly available. This will be used as the baseline for the 2025 and 2030 CO2 reduction targets.

In this report, T&E analyses the CO_2 emissions and performance of truckmakers in the reference period. With the EU's heavy-duty vehicle (HDV) standards up for review in 2022, T&E also examines possible compliance trajectories to reach the 2025 CO_2 target and shows that there is significant room to increase the targets already in the second half of the 2020s.

Scania leads the pack while Ford and IVECO are lagging behind their target

The analysis of truck registrations across the nine regulated vehicle sub-groups shows that most vehicles are registered in the long-haul (LH) sub-groups, with 62% in the sub-group 5-LH, which includes typical tractors used for long-haul applications. Scania performed well across all regulated sub-groups compared to other manufacturers, notably with emissions being 5.3% lower in the largest sub-group (5-LH), mainly due to improved aerodynamics. Thanks to this, Scania already benefits from a head start compared to its competitors with a view towards the 2025 target, showing that significant emissions reduction could be achieved with today's technologies.



Source: T&E analysis of the CO2 emissions from heavy-duty vehicles during the reference period (July 1st 2019 to June 30th 2020), published by the EEA in June 2021.

Average specific emissions per OEM during the reference period (2019-2020)

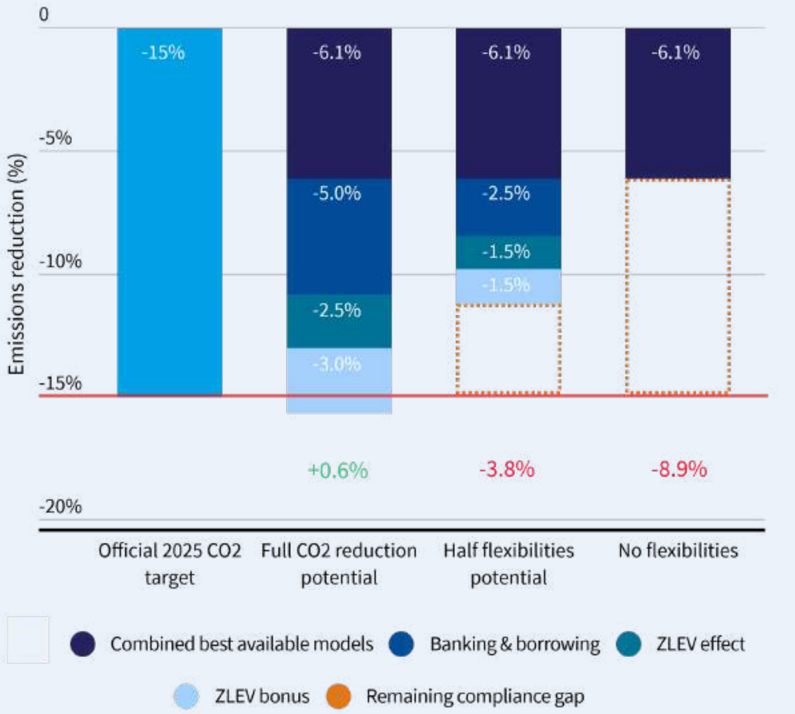
New long-haul trucks are as fuel efficient in Eastern as in Western Europe

When comparing Member States, the distribution of CO_2 emissions from new long-haul trucks is more homogeneous compared to the light-duty vehicle market (15% vs 26% range in country emission values). Whether it is for the largest tractor trailers (sub-group 5-LH) or averaged across all long-haul sub-groups, new vehicles sold in Eastern and Central European countries were as fuel efficient as those in Western European countries, if not even better. This means that adoption of cleaner trucks will benefit Europeans across the EU.

Truckmakers could reach their 2025 CO_2 targets already today

The average reference emissions amount to 52.7 gram of CO_2 per tonne-kilometre (gCO_2/tkm) and constitute the overall baseline for the 2025 and 2030 emissions targets of -15% and -30% respectively. When aggregating the vehicle models with the best CO_2 emission performance from each sub-group, T&E calculations show that existing models would already lead to a CO_2 emissions reduction of 6% compared to the current average. This indicates that, thanks to technologies which are already available today, significant emissions reductions could be achieved immediately.

By selling only 5% zero- and low-emission vehicles (ZLEV) in 2025, OEMs would benefit from a ZLEV bonus equal to a 3% reduction of their emissions, on top of the reduction impact these vehicles already have on the average emissions. The banking and borrowing mechanism will allow OEMs to reduce their 2025 target up to 5% in 2025 thanks to early emissions credits acquired between 2019 and 2024.



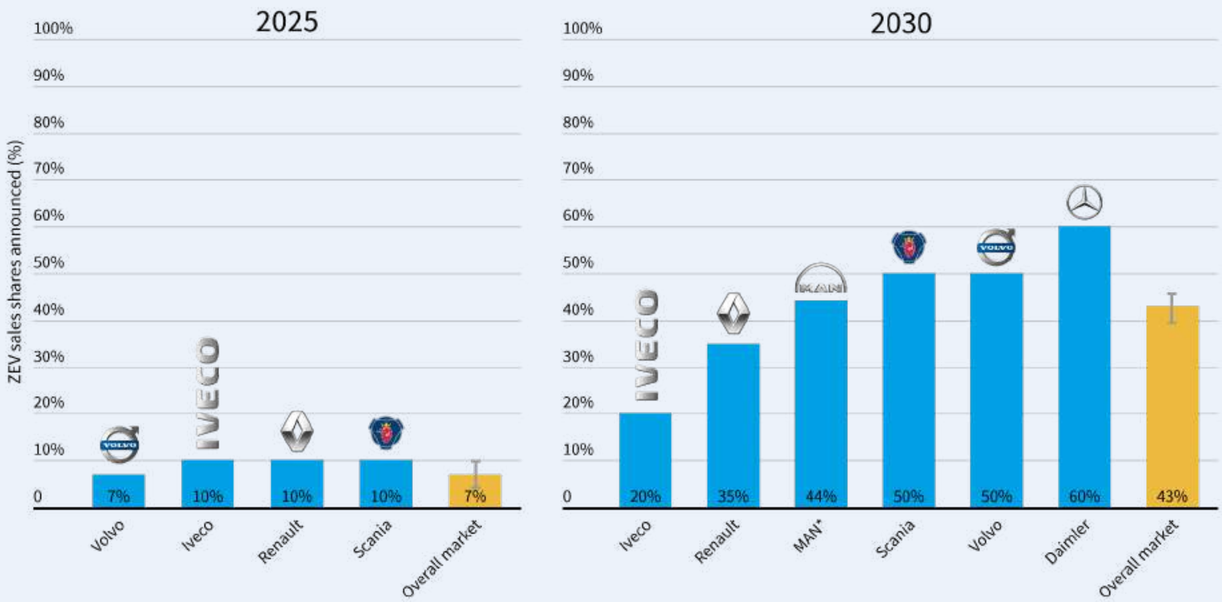
Source: T&E analysis of the CO2 emissions from heavy-duty vehicles during the reference period (July 1st 2019 to June 30th 2020), published by the EEA in June 2021.

Possible 2025 compliance scenarios based on flexibilities and best available models

Combining current fuel efficiency technologies with regulatory flexibilities, such as the ZLEV factor and the banking and borrowing mechanism, could enable **truckmakers to overachieve their 2025 target by 0.6 percentage points.**

The CO_2 standards are lagging behind market dynamics

Even though only a very limited number of ZEVs were reported during the reference period (mainly because of delayed certification process and gaps in the monitoring regulation), most truckmakers have already made ambitious voluntary commitments for ZEV sales. According to their public announcements, these voluntary commitments would take the market to around 7% ZEVs in 2025 and 43% in 2030, much higher than what the current CO_2 standards would deliver. Compared to these announcements, the current 5% ZEVs needed to get the 3% ZLEV bonus from 2025 to 2029 will be very easily reached by most truckmakers.

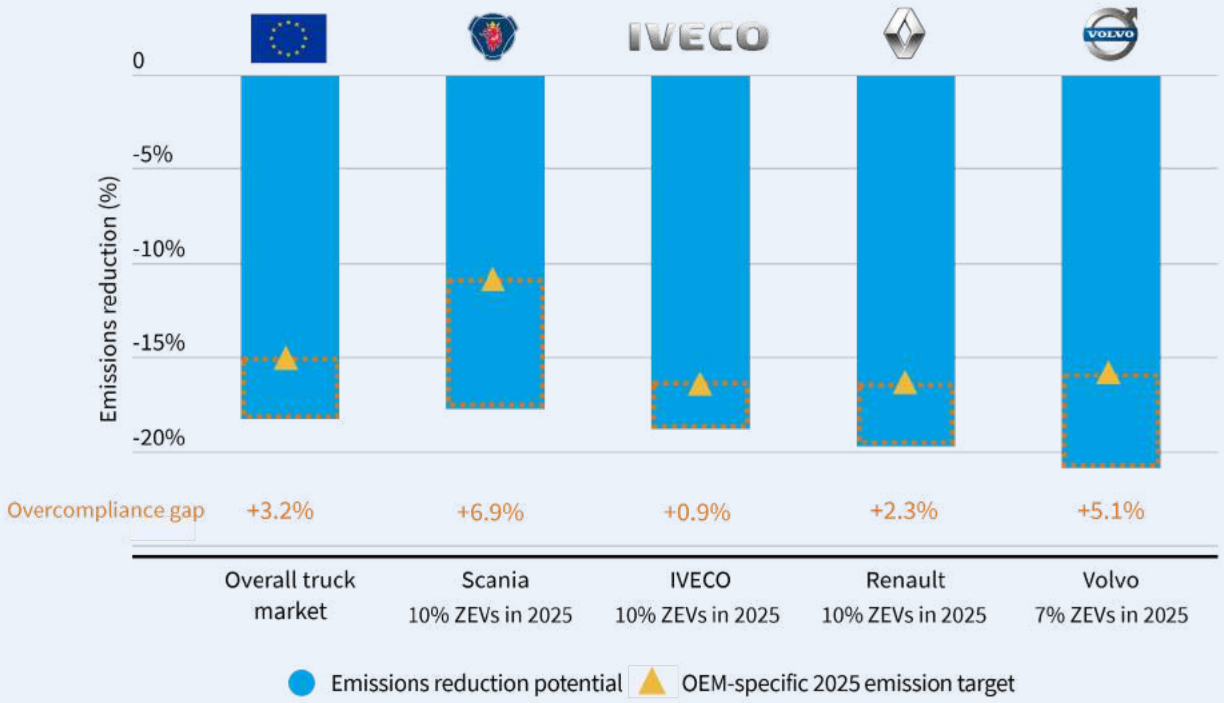


*Based on MAN's targets of 60% ZEV sales shares in the urban and regional delivery and 40% in the long-haul segment and a 20%/80% split based on the manufacturer's vehicle registrations during the baseline period.

Source: T&E analysis, data from public OEM announcements and ACEA sales shares (EU27, 2019)

Truckmakers announce close to half of their sales to be ZEVs by 2030

Taking into account voluntary commitments, in addition to models already available on the market today and regulatory flexibilities, **the 2025 CO_2 target could even be overachieved by 3.2 percentage points overall.** For the four truckmakers who made public announcements for 2025, this could go from 0.9 percentage points (IVECO) to 6.9 percentage points (Scania) above their respective CO_2 target.



Source: T&E analysis of the CO2 emissions from heavy-duty vehicles during the reference period (July 1st 2019 to June 30th 2020), published by the EEA in June 2021.

Based on recent announcements, current technologies and flexibilities truckmakers could overachieve their 2025 CO_2 target.

Recommendations for the 2022 review of the CO_2 standards

The current regulation lacks ambition to drive the supply of ZEVs necessary to reach the EU climate goals. **The 2022 review of the CO_2 standards should significantly increase the level of ambition of the targets and improve the design of the regulation already from the second half of the 2020s.**

Intermediate target in 2027/2028.

Under its current design, the truck CO_2 regulation doesn't require truckmakers to reduce their emissions between 2025 and 2029 - which could be reached without selling any zero-emission vehicles. However, current voluntary announcements from truckmakers show that - under the right regulatory framework - 43% of ZEVs can be expected in 2030. Therefore, an ambitious intermediate CO_2 target should be set for 2027/2028 in order to ensure significant emissions reduction across the market before 2030 and secure the supply of ZEVs already in the 2020s. Allowing OEMs to spread their efforts across several years, the existing banking and borrowing mechanism would help truckmakers accommodate the additional intermediate target.

Higher ZLEV benchmark in the 2020s.

The current voluntary ZLEV benchmark lags behind market potential. As highlighted above, based on OEMs voluntary announcements, a 30% benchmark in 2028 would be an adequate level. Furthermore, a malus should be considered to increase the effectiveness of such a mechanism and the calculation of ZLEV credits should be based on the electric range.

100% CO_2 target for the vast majority of HDVs in 2035

Similarly as for light-duty vehicles, a 100% CO_2 reduction target by 2035 should be set for the vast majority of new HDVs and the 2030 CO_2 reduction target should be significantly increased in order for the road freight sector to play its fair share in the EU's Green Deal climate framework. T&E will present the potential for higher targets in 2030 and a trajectory for the optimal phase-out of combustion trucks in an upcoming report.

Table of contents

1. Introduction

Responsible for around three quarters of inland freight activity [1], trucks are an integral part of the European economy and European truckmakers produce vehicles worldwide. Accounting for less than 2% of the vehicles on the road in Europe [2], trucks also represent around a quarter of CO_2 emissions from road transport (23% in 2019) [3].

In order to reduce CO_2 emissions from heavy-duty vehicles (HDVs) and meet its climate objectives, the European Union adopted in 2019 its first CO_2 emissions performance standards for new trucks. Under these standards, truck manufacturers are required to reduce their average fleet emissions by 15% in 2025 and by 30% in 2030 compared to the reference period (2019-2020)[1]. In 2022, the Regulation will be reviewed in order to reassess the incentive mechanism for zero- and low-emission vehicles (ZLEVs) and the 2030 reduction target, to introduce subsequent targets beyond 2030 and to extend the scope to currently non-regulated vehicles categories.

Truck emissions are certified based on the Vehicle Energy Consumption Calculation Tool (VECTO) [4], which simulates the CO_2 emissions of individual vehicles depending on their technical specifications. For each reporting period, truck registrations are monitored and reported by manufacturers and Member States and processed by the European Environmental Agency (EEA). Registration data for the reference period (01 July 2019 - 30 June 2020) was published in June 2021 by the EEA [5] and serves as the basis for calculating the average reference CO_2 emissions for the so-called baseline.

In this report, T&E analyses the registration data for the reference period and assesses truckmakers' overall emissions performance as well as possible compliance scenarios for the 2025 target. This report is the first of a series of annual T&E reports which will closely monitor and analyse CO_2 emissions from HDVs. Section 2 of this report presents an analysis of the truck market by looking at the emissions in the different regulated sub-groups and per Member State.

Section 3 examines the best-in-class emissions reduction technologies which are available today as well as the different flexibilities in the Regulation, such as the zero- and low-emission vehicle (ZLEV) factor and the banking and borrowing mechanism. A modelling of the compliance with the CO_2 emissions reduction targets and a comparison with the public announcements made by original equipment manufacturers (OEMs) are also presented. Finally, Section 4 lays out T&E's conclusions and policy recommendations to increase the stringency of the CO_2 standards. Additional methodological details are presented in Section 5, including national findings for six countries.

[1] Although the EU CO_2 standards are for all new heavy-duty vehicles, during the first reporting period only truck registrations from specific regulated vehicle sub-groups have been effectively reported (trailers, buses and coaches will be covered by the upcoming extension of the Regulation). Therefore, in this report HDVs only refer to trucks.

2. Analysis of the reference period

For the first reporting period, also called the reference period, certified emissions of new HDVs were monitored and reported according to EU Regulations 2017/2400 [6] and 2018/956 [7]. Emissions from vehicles registered in the European Union between 01 July 2019 and 30 June 2020 constitute the baseline for the average fleet reduction targets. The reference CO_2 emissions of the reference period are based on the monitored and reported vehicle registrations from Member States and truck manufacturers, which are processed and managed by the EEA [5]. The analysis presented hereafter is derived from the matched dataset published by the EEA in June 2021.

2.1. Overview of the regulated truck market

In order to regulate HDV emissions, the EU truck market has been segmented in 17 vehicle groups based on different parameters such as the axle configuration, the gross vehicle weight, the engine power and the mission profile. Out of these 17 vehicle groups, 4 vehicle groups are currently regulated under EU Regulation 2019/1242 [8]. As shown in Table 1 below, these 4 groups are subdivided into 9 vehicle sub-groups.

Description	Group	Sub-group	Cabin type	Engine power	Annual mileage
Rigid, 4x2 axle, GVW > 16 t	4	4-UD	All	< 170 kW	60,000 km
		4-RD	Day cab	≥ 170 kW	78,000 km
			Sleeper cab	≥ 170 kW & < 265 kW	
		4-LH	Sleeper cab	≥ 265 kW	98,000 km
Tractor, 4x2 axle, GVW > 16 t	5	5-RD	Day cab	All	78,000 km
			Sleeper cab	< 265 kW	
		5-LH	Sleeper cab	≥ 265 kW	116,000 km
Rigid, 6x2 axle	9	9-RD	Day cab	All	73,000 km
		9-LH	Sleeper cab		108,000 km
Tractor, 6x2 axle	10	10-RD	Day cab	All	68,000 km
		10-LH	Sleeper cab		107,000 km

Table 1: Regulated vehicle sub-groups

2.1.1. A market dominated by long-haul trucks

About 170,000 trucks have been registered during the reference period (2019-2020) for the nine sub-groups highlighted in Table 1. As shown in Figure 1, 5-LH vehicles belonging to the sub-group 5 long-haul (LH) make up about 61.9% of all regulated trucks. Combined, all LH trucks account for 85.8% of total registrations, followed by regional delivery (RD) trucks with 13.8% and urban delivery (UD) trucks with only 0.4%.

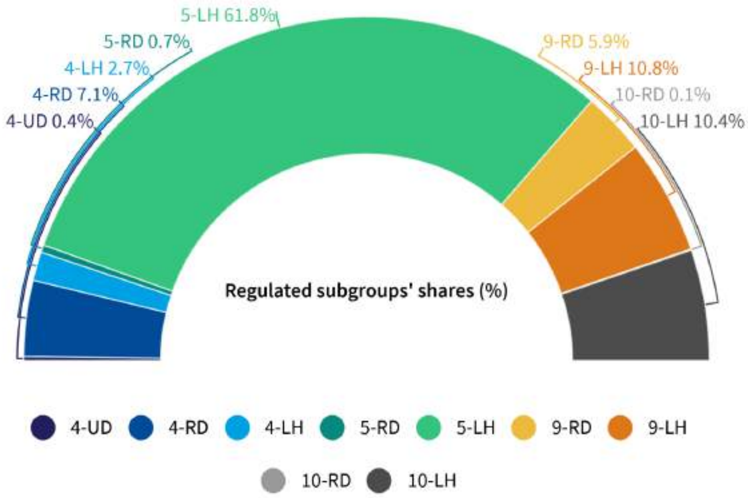


Figure 1: Truck registrations per sub-group during the reference period (2019-2020)

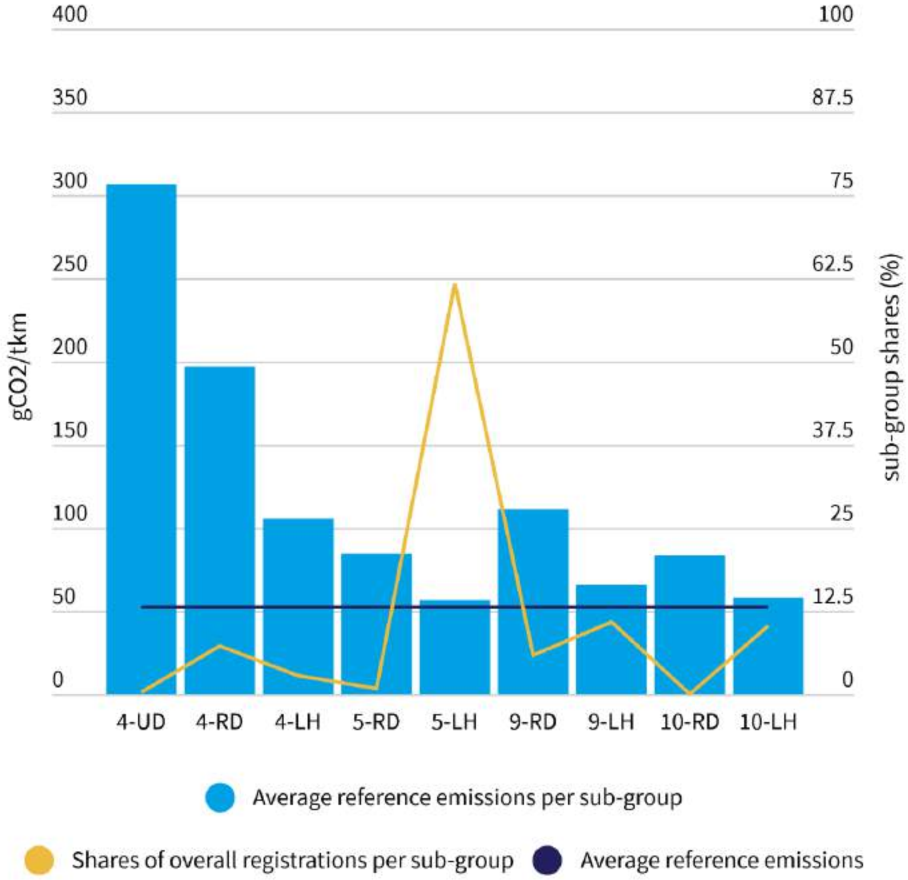
2.1.2. CO_2 emissions from new trucks

For each truck registered in the reference period, emissions have been determined thanks to the VECTO simulation tool [4]. This tool takes as inputs different technical parameters such as rolling resistance, air drag, masses and inertia, gearbox friction, auxiliary power and engine performance in order to simulate the fuel consumption and CO_2 emissions on standardised driving cycles. A weighted combination of different mission profiles (urban delivery, regional delivery and long haul) and payload values is subsequently applied to obtain specific emissions in grams of CO_2 per tonne-kilometre (gCO_2/tkm)[2] for each sub-group.

As shown in Figure 2, trucks from the LH sub-groups have much lower emissions per tonne-kilometre (tkm) compared to UD and RD sub-groups. For instance, 5-LH trucks emit on average 56.6 gCO_2/tkm while 5-RD emit 84.0 gCO_2/tkm. This is explained by the fact that LH trucks have higher freight activity since they carry higher payloads (e.g. 5-LH: 13.8 t average payload vs 5-RD: 10.3 t) over longer driving cycles with more constant speeds, as shown for instance by the ICCT in its analysis of VECTO driving cycles [9].

[2] The methodology used to assess these emissions is presented in greater details in Annex 1.

For the same reason, the 4-UD sub-group has the highest emissions across all sub-groups because of lower payload and mileage compared to RD and LH.



Notes: The average reference emissions are weighted on the shares of each sub-group and on mileage and payload (MPW factor, normalized on 5-LH) as described in the Regulation.

Source: T&E analysis of the CO2 emissions from heavy-duty vehicles during the reference period (July 1st 2019 to June 30th 2020), published by the EEA in June 2021.

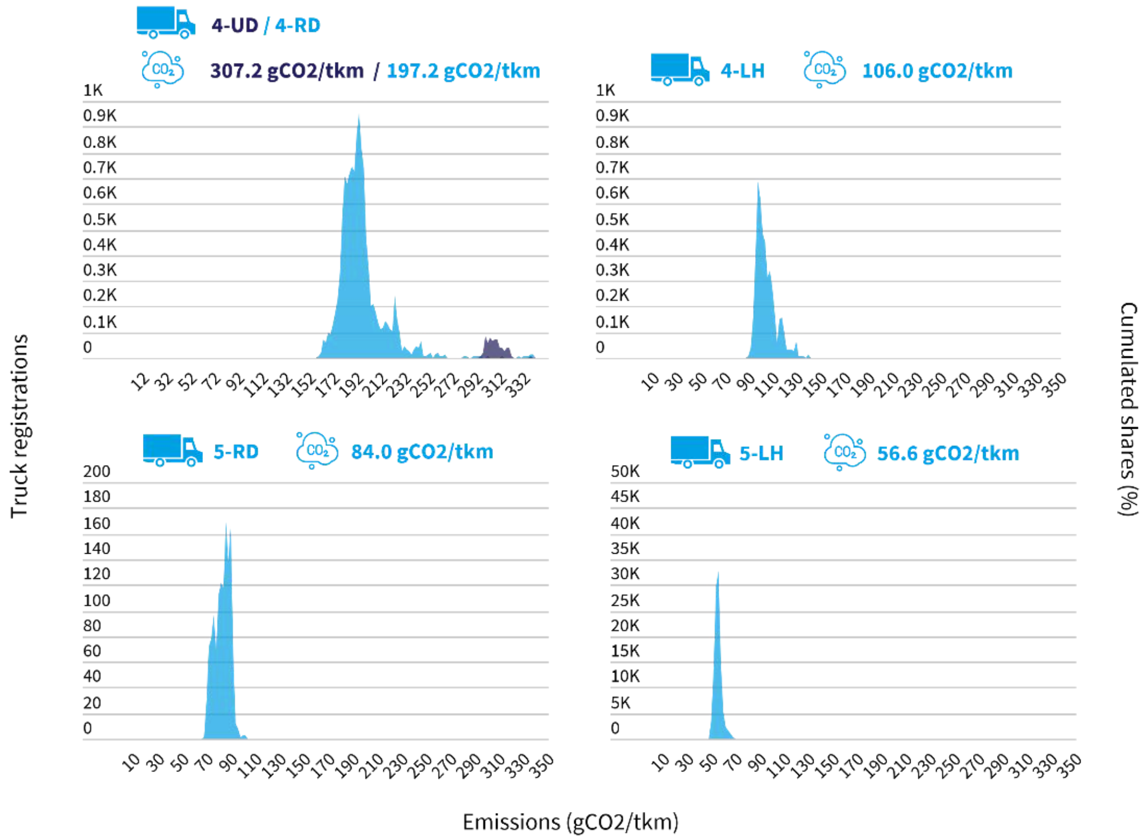
Figure 2: Average reference CO_2 emissions per sub-group (2019-2020)

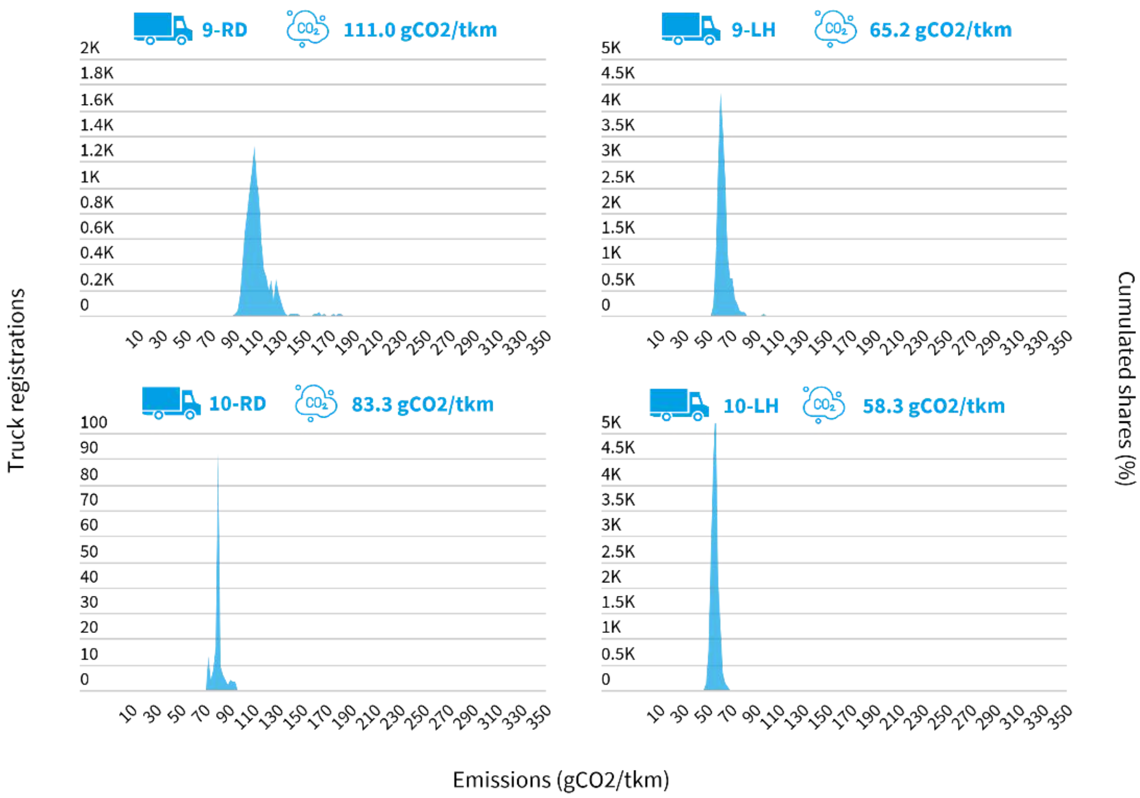
The average reference CO_2 emissions are calculated by multiplying the weighted average CO_2 emissions of each sub-group by their respective mileage and payload weighting (MPW) factors. MPW factors vary between 0.1 and 1, with low mileage, low sales volumes trucks allocated low MPWs (e.g. 4-UD) while the inverse is true for high mileage, high sales volumes trucks (e.g. 5-LH). The calculated average reference CO_2 emissions during the reference period is 52.7 gCO_2/tkm (dark blue line in Figure 2), which is corroborated by the Commission in its Implementing Decision (EU) 2021/781 in May 2021 [10].

This value falls below the average CO_2 emissions of all sub-groups as it is a theoretical, rather than a physical value. In the case of 4-UD, the MPW is 0.1, so the emissions contributing to the average reference

CO_2 emissions are 0.1 gCO_2/tkm, while for 5-LH the emissions contributing to the average are 35.0 gCO_2/tkm. Even though future CO_2 targets will be specific to each OEM, the average reference CO_2 emissions across the nine sub-groups indicates how the overall market performed in the reference period and how it should perform to comply with future standards. Figure 2 shows how this average emissions compares to the different sub-groups' averages.

Figure 3 presents the emissions distribution and the average emissions for each vehicle sub-group. It can be noted that RD and UD sub-groups have larger emission bands while LH sub-groups have their emissions more concentrated around the sub-group average. This indicates a more homogeneous truck market in the LH segments.





Source: T&E analysis of the CO2 emissions from heavy-duty vehicles during the reference period (July 1st 2019 to June 30th 2020), published by the EEA in June 2021.

Figure 3: Distribution of specific CO_2 emissions per sub-group (2019-2020)

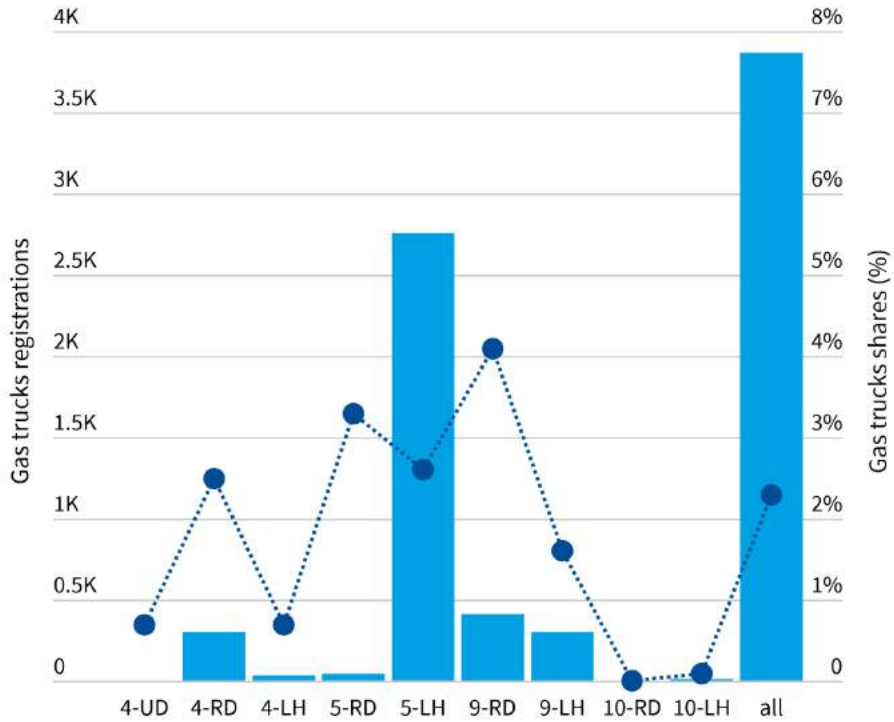
2.1.3. Alternative vehicle technologies

Preliminary registration data shows that 97.6% of trucks reported during the reference period are diesel trucks, while gas trucks reached 2.3% of registrations. Other alternative fuels and technologies (e.g. battery electric, hybrid, hydrogen etc.) only account for 0.1% of all regulated vehicles.

More precisely, in the reporting period only 3 zero-emission vehicles have been reported. This very low number can be explained by the fact that most zero-emission trucks are not yet covered by the certification regulation or are part of the non-regulated categories and therefore not yet included in the dataset. Indeed, zero-emission trucks are likely to be currently more prevalent in the non-regulated sub-groups, as ACEA reported about 1,000 electrically chargeable trucks sold in 2020, an increase of 32% compared to 2019 [11].

Regarding the adoption of gas trucks, Figure 4 shows the number of gas vehicles and their shares in each regulated sub-group. It can be seen that most gas trucks were sold in the 5-LH sub-group where they represented 2.6% of total registrations. On the other hand, gas truck registrations reach up to 4.1% of the

9-RD sub-group, but with only 400 vehicles. Overall gas trucks represent about 3,900 registrations and 2.3% of all regulated trucks.



Source: T&E analysis of the CO2 emissions from heavy-duty vehicles during the reference period (July 1st 2019 to June 30th 2020), published by the EEA in June 2021.

Figure 4: Gas trucks registered per sub-group (2019-2020)

The gas truck registrations shown in Figure 4 do not yet include dual-fuel gas trucks which are powered by both methane and diesel. As it is the case for ZLEV technologies, these vehicles can currently not be simulated and certified under VECTO and their specific CO_2 emissions remain therefore unknown. However, there are about 1,200 of these trucks included in the database which are currently not considered but will be retroactively added to the reference period once the certification is possible.

Compared to regulated diesel trucks, gas trucks reported in the reference period have lower emissions but this differs per sub-group and ranges from -12% for 5-RD to +4% for 4-RD and +6% for 9-RD with a -4% difference in the largest sub-group (5-LH). This shows that in some sub-groups gas trucks can actually emit more CO_2 than diesel trucks. Weighted across sub-groups and manufacturers, gas trucks appear to emit only 4.5% less CO_2 than diesel trucks (50.4 gCO_2/tkm vs 52.8 gCO_2/tkm). However, gas-powered vehicles also emit other greenhouse gases such as methane which are neither accounted for when certified nor regulated under the CO_2 standards.

Differences in the CO_2 emissions performance of gas and diesel trucks

As explained above, weighted on sub-groups, payload, and mileage, gas trucks' average reference emissions per tonne-kilometre are 4.5% lower than diesel trucks' CO_2 emissions. However, T&E's recent report on gas trucks' greenhouse gas emissions [12] indicates that tailpipe CO_2 emissions of LNG trucks are between 11.9% and 10.6% lower *per kilometre*, depending on the duty cycle. These results were obtained from two specific truck models tested under real-world conditions: IVECO's Stralis diesel truck and IVECO's S-Way gas truck, registered in 2019 and 2020 respectively.

During the reference period, about 4,300 Stralis and 2,000 S-Way trucks were registered in the largest sub-group, 5-LH, of which 1,900 Stralis were gas-powered trucks while no gas versions of the S-Way trucks were registered. Looking at the certified CO_2 emissions of the Stralis trucks in the 5-LH sub-group over the long-haul representative mission profile (LHR), the gas version of this model emits 14.0% less CO_2 *per kilometre* than the diesel version (723 gCO_2/km vs 841 gCO_2/km). These CO_2 savings are rather close to the manufacturer's claims on CO_2 [13] and slightly higher than measured during the on-road tests. However, across all mission profiles in the sub-group 5-LH, the difference in emissions *per tonne-kilometre* goes down to 5.8% (55.7 gCO_2/tkm vs 59.2 gCO_2/tkm).

In addition, it can be noted that the specific emissions of the Stralis' diesel version are 4.4% higher than the average specific emissions of diesel trucks in the 5-LH sub-group (59.2 gCO_2/tkm vs 56.7 gCO_2/tkm), which means than the gas version of the Stralis is only 1.7% less emitting than the average 5-LH diesel truck. This also explains why gas trucks only deliver negligible CO_2 emissions savings compared to the average diesel emissions in the same sub-group.

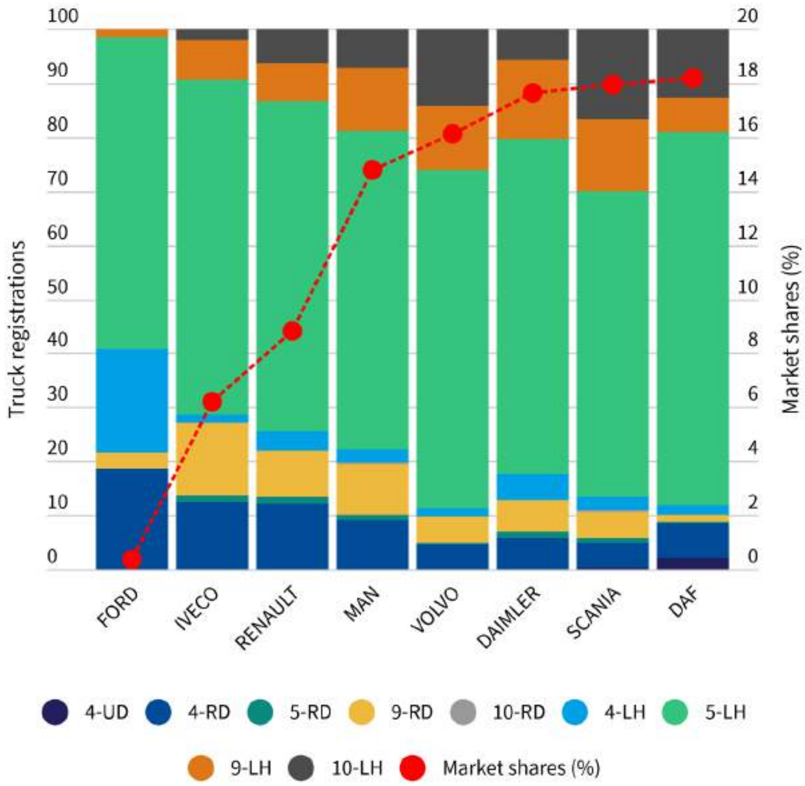
To conclude, the difference in the CO_2 emissions performance between gas and diesel trucks can be explained by differences in the scope of the analysis (driving cycle, units) and by the comparison perspective used (low-performance diesel truck as the benchmark). Even though on a specific mission profile and for specific models, gas trucks can have around 11% lower emissions, averaged over different mission profiles, sub-groups and on the overall truck market, this goes down to below 5%.

2.2. Analysis of individual truckmakers

In contrast to the European light-duty vehicle (LDV) market where several dozen manufacturers are present, the HDV market comprises only 8 brands from 5 manufacturers. This section gives an overview of the truck market and the average specific CO_2 emissions per OEM.

2.2.1. Market shares

Among the 170,000 regulated trucks registered in the reference period, DAF is leading with a market share of 18.2%, followed closely by Scania and Daimler with 17.9% and 17.6% respectively. As presented in Figure 5, Volvo (16.1%) and MAN (14.8%) come next, while Renault Trucks and IVECO registered about half as many vehicles with 8.8% and 6.1% respectively. Ford represents 0.4% of the regulated truck market through its Turkish subsidiary Ford Otosan with only 600 vehicles registered.



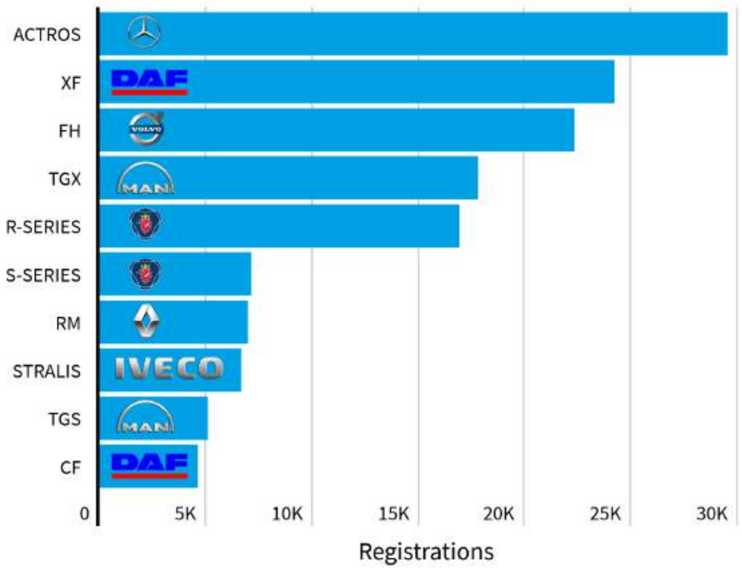
Source: T&E analysis of the CO2 emissions from heavy-duty vehicles during the reference period (July 1st 2019 to June 30th 2020), published by the EEA in June 2021.

Figure 5: Truck registrations per OEM and sub-group (2019-2020)

Even though 5-LH trucks are the dominant sub-group for all truckmakers, the share of each sub-group can vary as OEMs usually specialize in different vehicle segments. For instance, about 90% of Volvo's and Scania's sales are long-haul vehicles, while these trucks only represent 73% of IVECO's sales. Similarly, IVECO and Renault Trucks are more focused on the regional delivery segment with 27% and 22% of their respective sales being registered in one of the RD sub-groups, while Volvo and DAF only have 10% and 8% respectively.

In addition, 42 different truck models can be identified in the registrations during the reference period. As shown in Figure 6, Daimler's Actros is leading with almost 30,000 registrations, making up 98% of Daimler's regulated vehicles sales and 17% of the total regulated truck market. DAF's XF truck comes in second position with 24,000 sales but only represents 78% of DAF's overall registrations as this OEM registered 6 different models. The top 10 most sold models account for 83% of all regulated truck registrations, showing a high concentration of the truck market around these models.

The analysis of these OEMs indicate two different strategies. On one hand, Daimler has one main model accounting for almost all of its sales and which can be offered in different versions for different mission profiles (UD, RD and LH). On the other hand, DAF has 6 different models for different mission profiles with, for instance, its XF exclusively registered for LH applications.



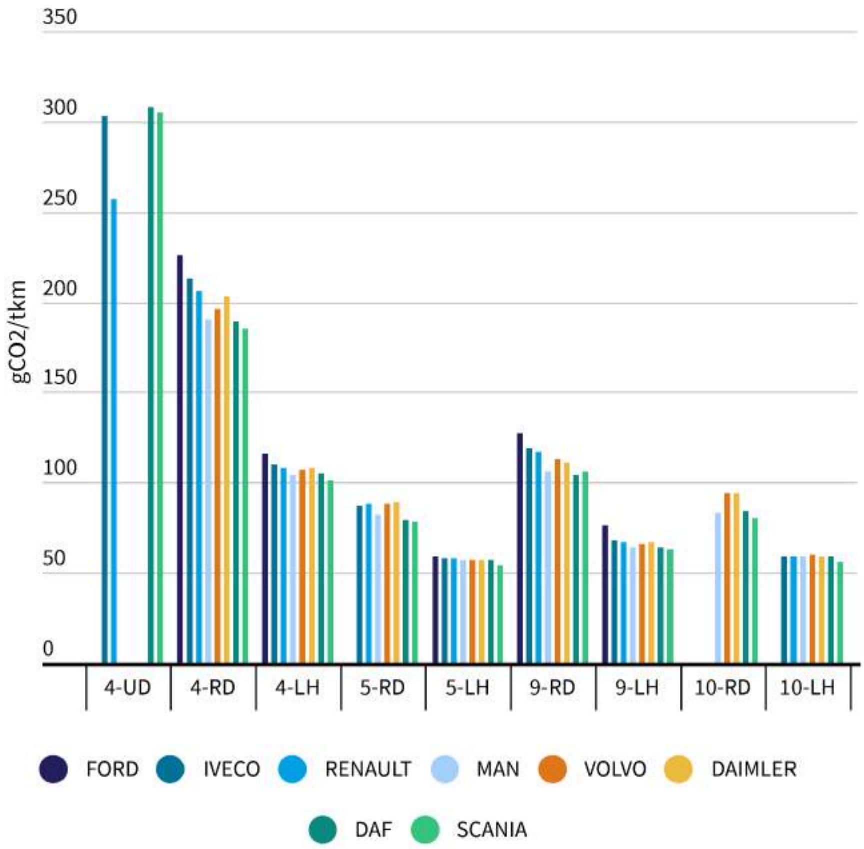
Source: T&E analysis of the CO2 emissions from heavy-duty vehicles during the reference period (July 1st 2019 to June 30th 2020), published by the EEA in June 2021.

Figure 6: Top 10 most sold truck models (2019-2020)

2.2.2. Average specific CO_2 emissions

For each regulated sub-group and each truckmaker, average specific CO_2 emissions are shown in Figure 7. As already described above, it is evident that RD and UD sub-groups have a much wider distribution in emissions compared to the LH sub-groups, showing again a more homogeneous adoption of fuel efficiency technologies in those segments.

Scania has the lowest emissions across all sub-groups except for 4-UD and 9-RD. Scania's vehicles also performed significantly better than the market average across all sub-groups: from 0.7% below the average emissions for 4-UD to 7.5% below for 5-RD.

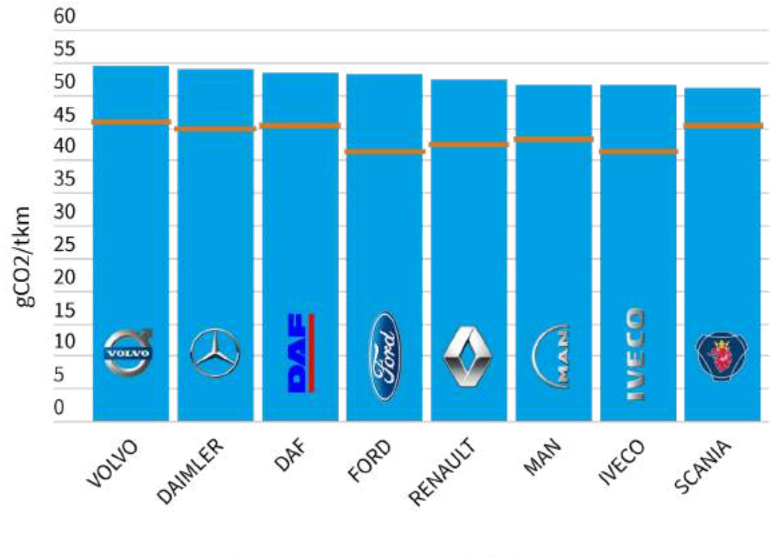


Source: T&E analysis of the CO2 emissions from heavy-duty vehicles during the reference period (July 1st 2019 to June 30th 2020), published by the EEA in June 2021.

Figure 7: Specific CO_2 emissions per OEM and sub-group (2019-2020)

As mentioned, a manufacturer's average specific CO_2 emissions are calculated based on its sales distribution across the nine regulated sub-groups, its specific CO_2 emissions per sub-group and the mileage and payload weighting of each sub-group, as described in EU Regulation 2019/1242 [8] and detailed in Annex 1. The average specific CO_2 emissions of a manufacturer will then be compared against its specific CO_2 emissions reduction trajectory which is linearly extrapolated based on the average reference CO_2 emissions and the specific CO_2 emissions targets for 2025 and 2030 (see Section 2.4)

The calculated average specific CO_2 emissions for each truckmaker are shown in Figure 8. As expected from the specific emissions per sub-group, Scania achieved the lowest emissions, with 3.2% below the average. IVECO, MAN and Renault Trucks also do better than the average (-2.4%,- 2.3% and -1.0% respectively), while Ford, DAF, Daimler and Volvo sold more emitting vehicles, with their emissions 0.6%, 1.3%, 2.4% and 3.1% above the average respectively.



Notes: The average specific emissions are weighted on the shares of each sub-group per OEM and on mileage and payload (MPW factor, normalized on 5-LH) as described in the Regulation.

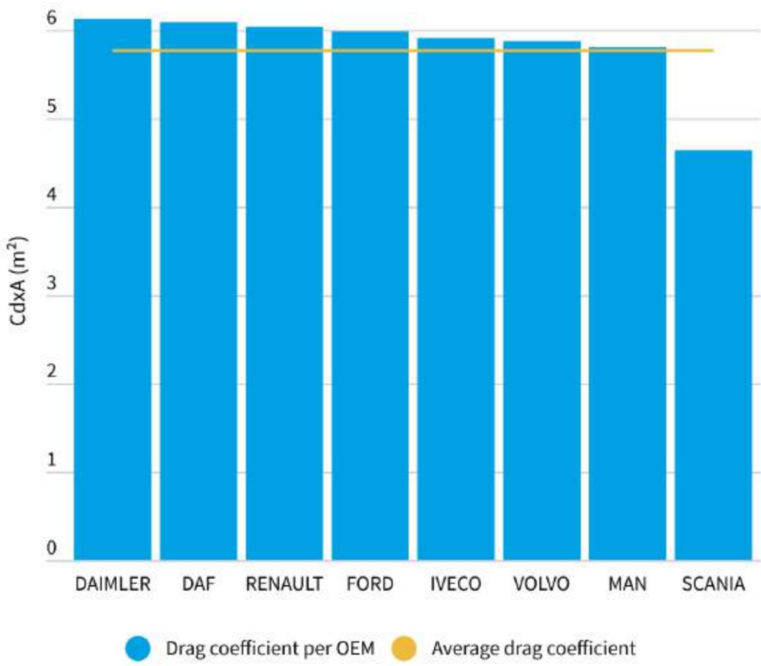
Source: T&E analysis of the CO2 emissions from heavy-duty vehicles during the reference period (July 1st 2019 to June 30th 2020), published by the EEA in June 2021.

Figure 8: Average specific CO_2 emissions per OEM (2019-2020)

Scania's lower emissions can be explained by looking at the technical parameters of its truck registrations. The analysis of the air drag coefficient for all truckmakers across all sub-groups shows that Scania has significantly lower air drag values. The air drag coefficient defines the aerodynamics of a truck and more precisely the air drag force which directly affects the vehicle energy consumption [14]. In the Regulation, the reported air drag area ($C_D{\cdot}A$ in m^2) is defined as the product of the drag coefficient (C_D) and the cross-sectional area of the truck (A). Under the scope of the Certification Regulation, this value is reported as a range of about 0.15 m^2 labelled from A1 to A24 and serves as an input in VECTO simulations. In this report, we used the median value for each air drag category.

Figure 9 shows the average air drag value for each OEM in the sub-group 5-LH. Scania has lower values compared to the other truckmakers, with an average air drag coefficient that is about 20% lower than the market average (4.6 m^2 vs 5.8 m^2). This trend can be observed in all sub-groups (except in 9-RD where Scania only registered 51 trucks), with $C_D{\cdot}A$ ranging from 6% (10-LH) to 20% (5-LH) below the respective sub-groups' averages.

With such lower air drag values, the aerodynamics of Scania's trucks appears to be more advanced than the market average, leading to a lower energy consumption and therefore to lower emissions. This also demonstrates the huge potential to leverage energy efficiency by improving the aerodynamics of trucks.



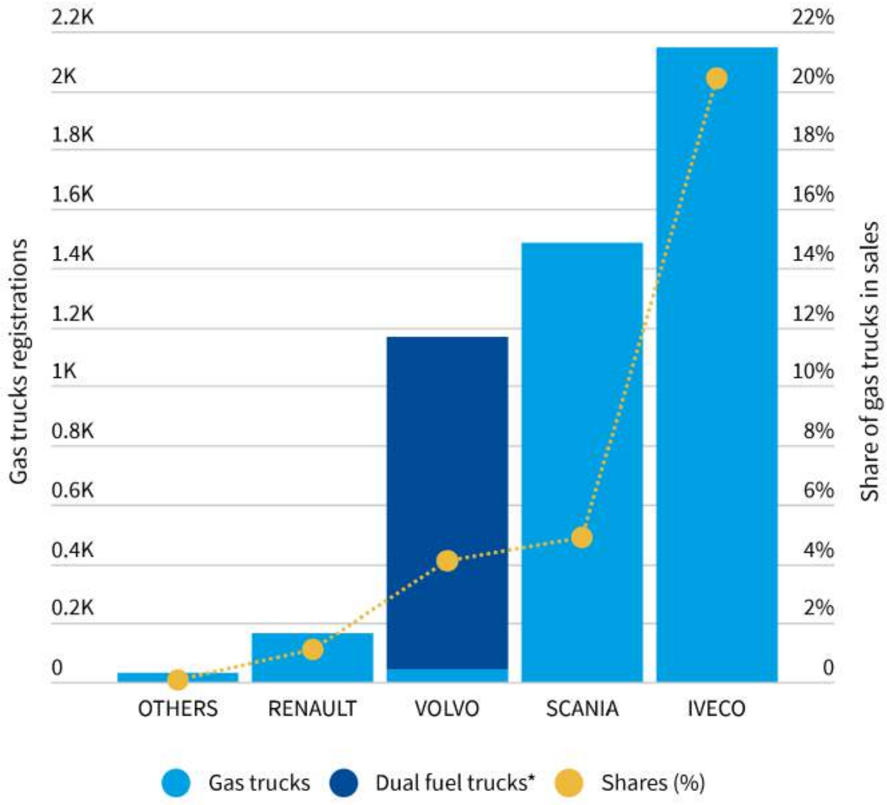
Source: T&E analysis of the CO2 emissions from heavy-duty vehicles during the reference period (July 1st 2019 to June 30th 2020), published by the EEA in June 2021.

Figure 9: Average drag coefficient per OEM in the sub-group 5-LH (2019-2020)

2.2.3. Alternative vehicle technologies

Of the 3,900 gas trucks registered in the reference period, 55% have been sold by IVECO, 38% by Scania, 4% by Renault Trucks and 1% by Volvo. With up to 29% gas trucks in its 5-LH sales and 22% across all sub-groups, IVECO has the highest share of gas truck sales and clearly adopted this technology.

As shown in Figure 10, Scania also sold a large number of gas trucks but those only accounted for 5% of its overall sales. New gas trucks by Renault Trucks and Volvo represent only 1.1% and 0.2% of their regulated truck registrations respectively. However, as mentioned in Section 2.1.3, dual-fuel vehicles are not yet covered by the certification process and therefore not yet considered as part of the baseline, but are already included in the registrations data. Therefore, once the 1200 dual fuel trucks sold by Volvo are certified and added retroactively, gas trucks would make up 4% of its registrations, as indicated in Figure 10.



Source: T&E analysis of the CO2 emissions from heavy-duty vehicles during the reference period (July 1st 2019 to June 30th 2020), published by the EEA in June 2021.

*Dual fuel trucks (diesel - natural gas) are shown here for indicative purposes as they are not yet covered in the current version of VECTO and therefore not reported in the baseline.

Figure 10: Gas truck registrations per OEM (2019-2020)

Finally, the three zero-emission vehicles registered were produced by DAF, Volvo and MAN. These were DAF's CF Electric, Volvo's FL Electric and MAN's TGM electric truck, and they were all registered in long-haul sub-groups (5-LH, 4-LH and 9-LH respectively). As mentioned, these very few ZEVs reported in the reference period likely do not include small-scale series productions of ZEVs which do not yet fall under the monitoring and reporting obligations.

2.3. New truck CO_2 emissions per country

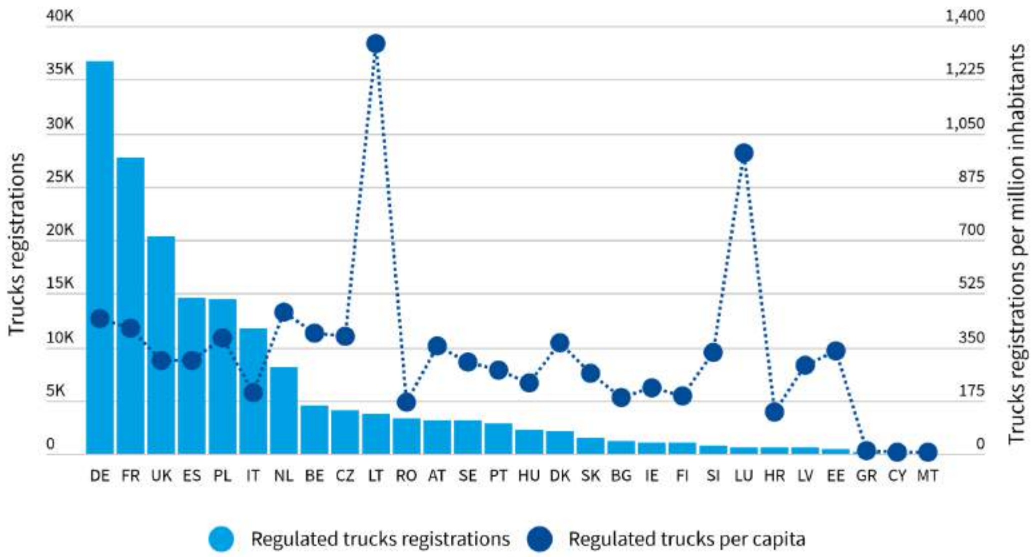
In this section, an analysis of the registration data is presented from a Member States' perspective, giving again an overview of the truck market and the reference emissions for the 28 countries which reported their truck registrations (EU27+UK) and are included in the reference period[3]. The United Kingdom is

[3] Norway is covered by (EU) 2018/956 regarding monitoring and reporting of HDVs emissions but not by (EU) 2019/1242 regarding HDV CO_2 standards and is therefore not part of the reference period.

included in the reference period despite it not being an EU Member State anymore; the UK will therefore not have to comply with the 2025 and 2030 CO_2 targets imposed by the EU [15].

2.3.1. European market overview

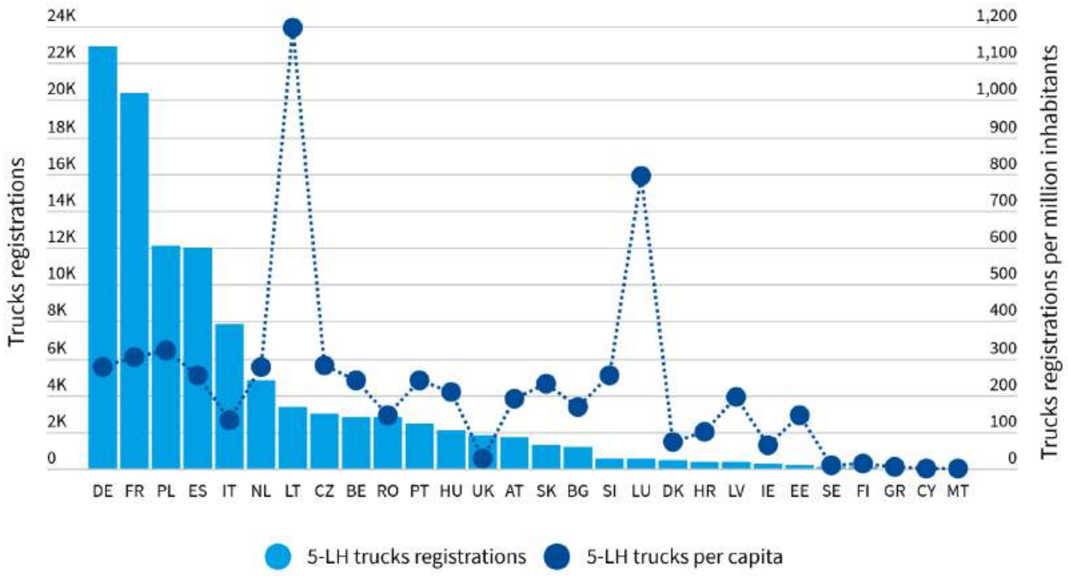
Germany is the leading country for truck sales with a market share of 22%, followed by France (16%) and the UK (12%), as it can be seen in Figure 11. However, if we look at the number of new trucks per capita, the outcome differs with Lithuania and Luxembourg leading by far. These countries registered about 4 and 3 times the number of trucks per million inhabitants compared to the European average.



Source: T&E analysis of the CO2 emissions from heavy-duty vehicles during the reference period (July 1st 2019 to June 30th 2020), published by the EEA in June 2021. Population data from Eurostat (2019).

Figure 11: Truck registrations per Member State (2019-2020)

Focussing on the sub-group 5-LH (see Figure 12), the ranking changes slightly. Germany and France are still leading with 22% and 19% market shares respectively, but Poland comes third with a share of 12%, followed closely by Spain (11%). It can also be noted that out of the 10 countries selling the most 5-LH trucks, 4 are from Central and Eastern Europe (Poland, Lithuania, Czech Republic and Romania). The UK drops down the list as there are incentives to purchase the 6-axle 10-LH, rather than the 4-axle 5-LH, tractors there.



Source: T&E analysis of the CO2 emissions from heavy-duty vehicles during the reference period (July 1st 2019 to June 30th 2020), published by the EEA in June 2021. Population data from Eurostat (2019).

Figure 12: 5-LH truck registrations per Member State (2019-2020)

Finally, the sales composition, or the share of registrations in each sub-group, can vary significantly from one country to another. For instance, almost all trucks registered in Lithuania were LH (99%) while Greece and Finland only reported 50% and 66% of their vehicles in LH sub-groups.

2.3.2. Average emissions per Member State

When looking at the emissions of new trucks registered per country for the largest sub-group 5-LH, six out of the top ten least emitting countries are located in Central and Eastern Europe[4] (Estonia, Bulgaria, Latvia, Hungary, Slovakia and Czech Republic). For instance, Estonia's 5-LH emissions are 2.5% below the EU average, while Germany's 5-LH emissions are 0.9% above. This could be explained by the location of major trans-European transport operators in Eastern Europe.

Because of the major differences in the sales composition, the average emissions per country cannot be compared directly. As an example, Member States selling more 5-LH trucks achieve better than average performance since reference CO_2 emissions are typically lower in this sub-group (see Figure 2). To provide a fair comparison, Member State's reference CO_2 emissions per sub-group were averaged over LH sub-groups on one hand and UD/RD on the other, based on each Member State's shares per sub-group[5].

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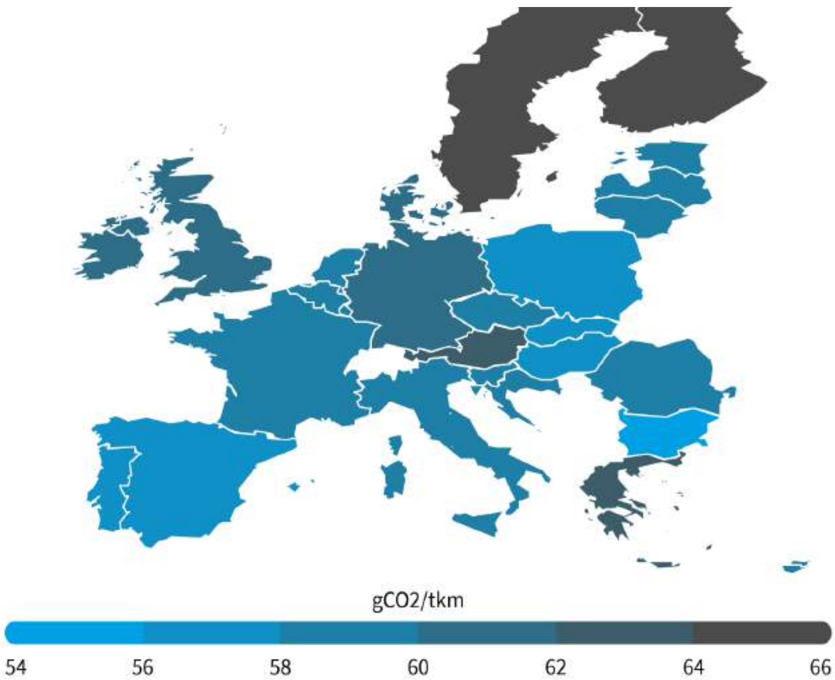
[4] Eastern and Central European countries refer to Member States that joined the EU after 2004 while Western European countries refer to countries that joined before (also called EU15, including the UK) [16].

[5] Even though this approach is not used in the Regulation, it allows to compare average emissions between countries on an equal footing since trucks are more similar within LH and UD/RD sub-groups respectively.

Figure 13 shows the average CO_2 emissions for LH trucks across the continent. Larger countries such as France, Germany and the United Kingdom are performing worse in terms of CO_2 emissions compared to the EU average, while smaller countries such as Bulgaria, Portugal and Slovakia perform significantly better. Sweden and Finland appear to have very high average emissions across LH sub-groups because most of their LH sales are in 9-LH, while most LH sales are in 5-LH across the EU, and this sub-group has 15% higher reference CO_2 emissions compared to 5-LH.



Source: T&E analysis of the CO2 emissions from heavy-duty vehicles during the reference period (July 1st 2019 to June 30th 2020), published by the EEA in June 2021.

Figure 13: Average CO_2 emissions per Member State across LH sub-groups (2019-2020)

While light-duty vehicles (vans) registration data shows a 26% difference between the maximum and the minimum average emissions from Member States [17], for long-haul trucks this difference is only 15%. In addition, the average emissions of Eastern and Central Europe countries appear to be 3% lower than Western European countries' emissions (58.0 gCO_2/tkm vs 59.9 gCO_2/tkm), while for vans it's the opposite: Western countries sell 9% less emitting vehicles than Eastern and Central European countries (154.4 gCO_2/km vs 168.9 gCO_2/km, NEDC). It shows that in contrast to vans, there is not an "emissions border" between the West and the East of Europe for long-haul trucks.

On the other hand, Figure 14 shows the CO_2 emissions per country, averaged on UD and RD sub-groups. As observed in Section 2.1, trucks registered in these sub-groups present much more heterogeneous emissions. From that perspective, Estonia, Denmark and Germany are the least-emitting countries while Romania, Greece and Croatia sold the most-emitting trucks. In the case of Romania, a significant difference in performance between LH and UD/RD sub-groups can be noted between Figure 13 and Figure

14. This could be explained by the fact that close to all trucks registered in this country were LH (93% LH vs 7% UD/RD).

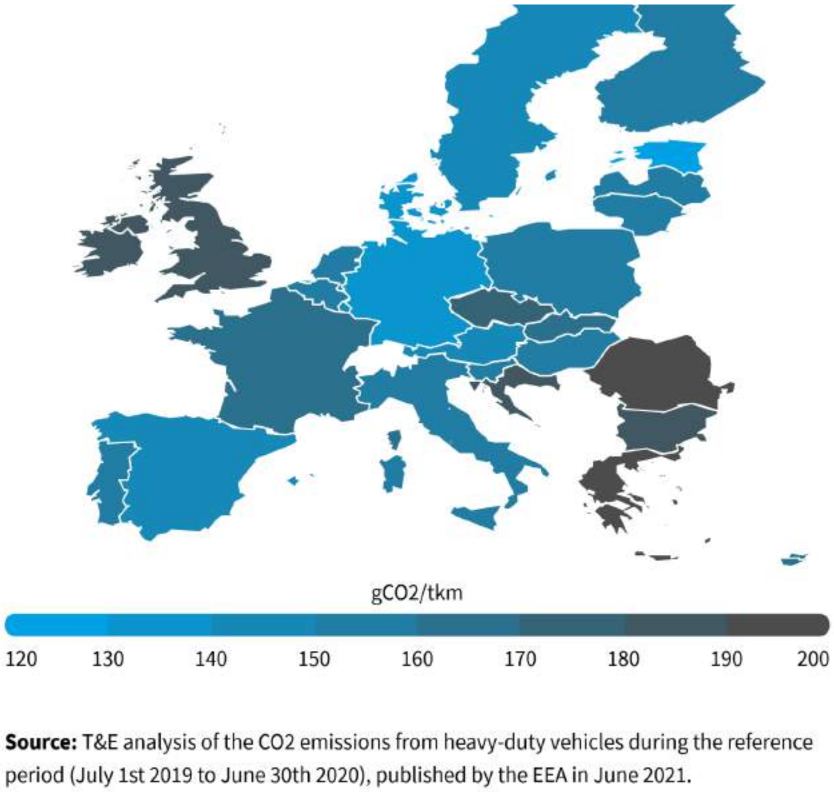


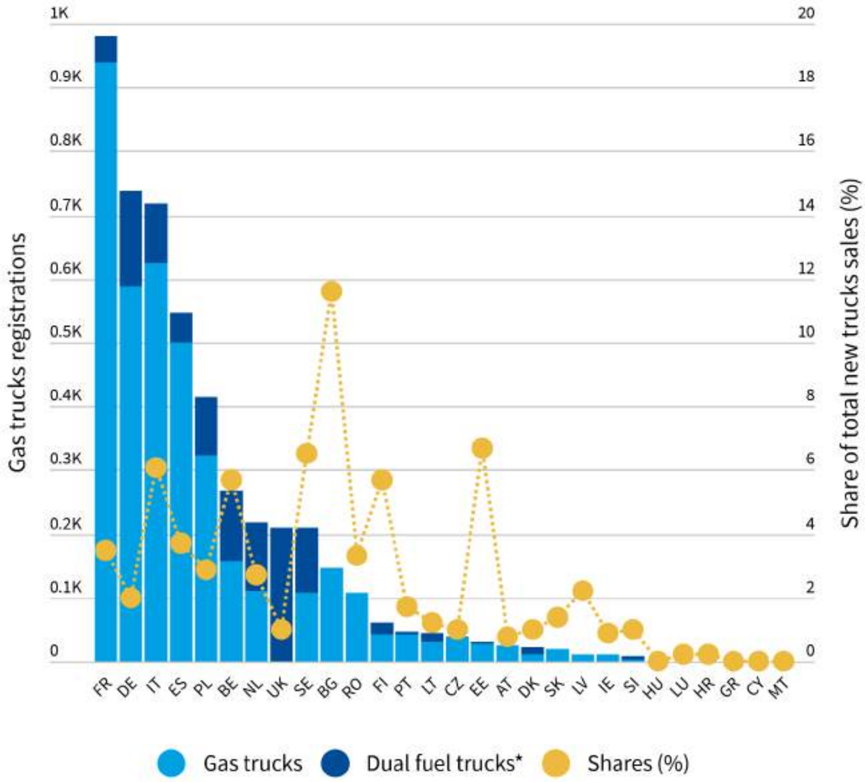
Figure 14: Average CO_2 emissions per Member State across UD/RD sub-groups (2019-2020)

Finally, UD and RD trucks registered in Eastern and Central European countries emit on average 5% more CO_2 than Western European countries (165.1 gCO_2/tkm vs 157.0 gCO_2/tkm). Eastern and Central countries also have more focus on LH trucks than Western countries (94% vs 84% LH shares, respectively).

2.3.3. Gas-powered trucks

Figure 15 shows the distribution of gas-powered vehicles across the Member States. It can be seen that France sold the highest number of gas trucks with almost 1,000 vehicles registered and these vehicles represented 24% for the overall EU gas truck market. Germany and Italy came second and third with about 620 and 590 registrations (16% and 15% market shares respectively).

The majority of dual-fuel trucks were registered in the UK with 200 units, or 17% of the total. When including dual-fuel vehicles, Bulgaria has the highest share of gas truck sales (11.6%), followed by Estonia (6.7%), Sweden (6.5%) and Italy (6.1%). Even though France and Germany account for the highest absolute number of gas truck sales, these vehicles only accounted for 3.5% and 2% of the two countries' total new truck registrations.



Source: T&E analysis of the CO2 emissions from heavy-duty vehicles during the reference period (July 1st 2019 to June 30th 2020), published by the EEA in June 2021.

*Dual fuel trucks (diesel - natural gas) are shown here for indicative purposes, as they are not yet covered in the current version of VECTO and therefore not reported in the baseline.

Figure 15: Gas trucks registered per Member State (2019-2020)

3. Compliance with the truck CO_2 targets

The CO_2 standards require truck manufacturers to reduce their emissions by 15% and 30% CO_2 in 2025 and 2030 compared to the reference period. To achieve this, truck manufacturers can improve the fuel efficiency of their conventional combustion trucks or sell ZLEVs. They can also benefit from different flexibilities such as the ZLEV factor, an incentive mechanism to encourage OEMs to sell more ZLEV vehicles, or the banking and borrowing scheme which makes it possible for OEMs to accumulate emission credits and debts.

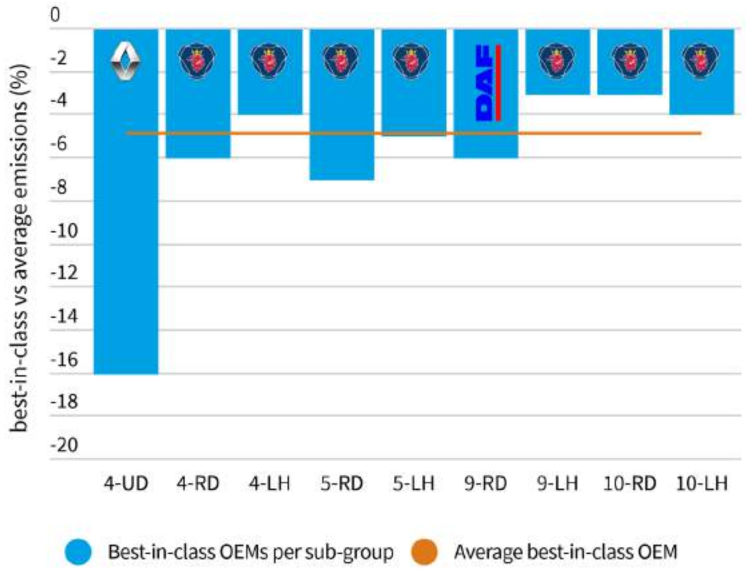
In this section, an analysis of the potential of these flexibilities will be presented in order to determine the remaining compliance gap which manufacturers have to close to reach their specific CO_2 emissions target in 2025.

3.1. Best available technologies

Based on the reference CO_2 emissions, an analysis of the best-in-class fuel efficiency technologies was conducted. This provides an insight into the currently available technologies which were deployed by at least one OEM and which can therefore be expected to be deployed at large scale by all manufacturers in the short-term. This helps to identify the current best-in-class technologies that could already be deployed at a larger scale. The following section presents these technologies both from the perspective of the individual manufacturer as well as from individual vehicle models.

3.1.1. Best-in-class truckmakers

From the manufacturer's side, the calculation of the average specific CO_2 emissions in Section 2.2.2 outlines the best performing OEMs (see Figure 8). Figure 16 compares for each individual sub-group the difference between the average CO_2 emissions of the best performing truckmaker and the average emissions of all truckmakers in the given sub-group.



Notes: The average best-in-class emissions are weighted on the shares of each sub-group and on mileage and payload (MPW factor, normalized on 5-LH) as described in the Regulation.

Source: T&E analysis of the CO2 emissions from heavy-duty vehicles during the reference period (July 1st 2019 to June 30th 2020), published by the EEA in June 2021.

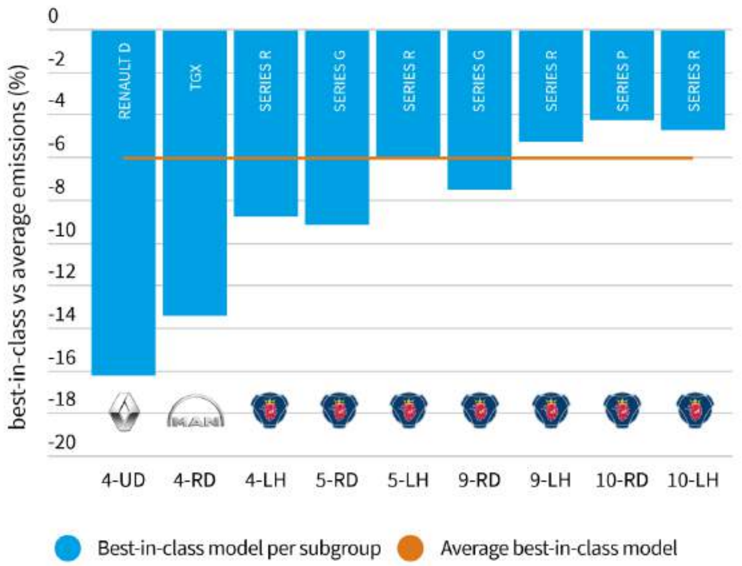
Figure 16: Best-in-class OEMs per regulated sub-group (2019-2020)

In line with the results presented in Section 2.2.2, Scania performs between 3% and 7% better than the sub-group average across most sub-groups thanks to significantly improved truck aerodynamics. In the 4-UD sub-group, Renault Trucks sold trucks which emitted 16% less than the average, while in 9-RD DAF did 6% better than the sub-group average.

Using the same mileage and payload weighting (MPW) as for the baseline emissions estimate (see Section 2.1.2 and Annex 1), the analysis of the best-in-class OEM per sub-group gives a best-in-class average of 50.1 gCO_2/tkm, 4.9% below the baseline average (52.7 gCO_2/tkm).

3.1.2. Best-in-class truck models

From the truck models perspective, it can be seen that in 7 out of 9 regulated sub-groups, Scania sold the least emitting heavy duty vehicles, with its Series R, Series G and Series P trucks. Only Renault Trucks' D truck and MAN's TGX trucks performed better in the 4-UD and 4-RD sub-groups respectively (see Figure 17).



Notes: The average best-in-class emissions are weighted on the shares of each sub-group and on mileage and payload (MPW factor, normalized on 5-LH) as described in the Regulation.

Source: T&E analysis of the CO2 emissions from heavy-duty vehicles during the reference period (July 1st 2019 to June 30th 2020), published by the EEA in June 2021.

Figure 17: Best-in-class models per regulated sub-group (2019-2020)

The weighted average then gives a best-in-class average of 49.5 gCO_2/tkm, or 6.1% below the baseline average (52.7 gCO_2/tkm). This shows how much emissions reduction could already be achieved with truck models and technology already available today, including better aerodynamics as detailed in Section 2.2, more efficient engines and lower tyre rolling resistance. In its recent report, the ICCT [18] analyses the engine performance of trucks in the reference period and indicates that DAF and MAN have the most efficient trucks with 42.6% thermal efficiency each, while the most efficient truck model was MAN's D38 15.3-liter engine (44.5% over WHTC[6] cycle). This shows that better engine efficiency is today achievable.

[6] World Harmonized Transient Cycle

3.2. ZLEV factor

In order to encourage truck manufacturers to produce and sell more zero- and low-emission vehicles (ZLEVs),[7] the Regulation introduces a bonus-only incentive mechanism, the so-called ZLEV factor. The ZLEV factor effectively reduces a manufacturer's average specific CO_2 emissions if a certain level of both regulated and unregulated ZLEVs are sold. The ZLEV factor is between 1 and 0.97 and is multiplied against an OEM's average specific CO_2 emissions, thus potentially decreasing emissions by a maximum 3% (see Annex 1 for more details on the methodology).

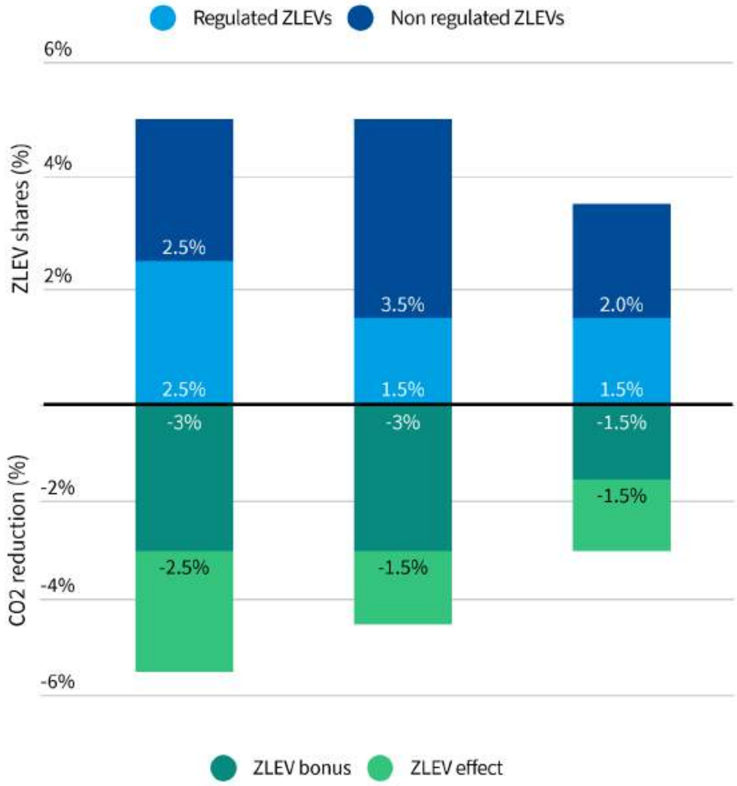
From 2019 to 2024, this bonus can be reached without a minimum number of newly registered ZLEVs as it is designed as a 'supercredit' mechanism. In practice, an OEM with 1% ZLEV registrations (in regulated categories) will be able to apply a ZLEV factor of 0.99, benefitting from both the sale of the ZLEV and the application of the ZLEV factor. An OEM with 4% ZLEV registrations will be able to reduce their emissions by 0.97.

From 2025 on, truck manufacturers need to sell at least 2% ZLEVs in order to benefit from the bonus and decrease their emissions by up to 3%. In practice, an OEM with 1% ZLEV registrations (in regulated categories) will apply a ZLEV factor of 1 to their average CO_2 emissions, which offers no additional benefit. An OEM with 4% ZLEV registrations will be able to apply a ZLEV factor of 0.98 to their average specific CO_2 emissions.

Under this mechanism, ZLEVs from non-regulated categories are included in addition to the ZLEVs from the regulated categories. This means that truck manufacturers can sell ZLEVs in non-regulated vehicle groups and still get the emission bonus for the regulated trucks' CO_2 targets. However, there is a cap of 3.5% on the total number of vehicles registered in the reporting period which can belong to the non-regulated groups.

Since non-regulated trucks also count towards the ZLEV bonus, the full 3% bonus (above the 2% benchmark) can be reached in a number of ways. For example, it could be reached with 2.5% regulated ZLEVs and 2.5% non-regulated ZLEVs, or alternatively with 1.5% regulated ZLEVs and 3.5% non-regulated ZLEVs. However, only ZLEVs registered in the regulated categories reduce the average specific CO_2 emissions of a truck maker, which means that the scenario with 2.5% regulated ZLEVs brings a higher overall CO_2 reduction than the one with 1.5%. This is illustrated by the 'ZLEV effect' in Figure 18 below.

[7] Low-emission vehicles are defined as vehicles emitting less than 50% of the reference CO_2 emissions in each regulated sub-group.



Notes: In dark green is shown the emission bonus potentially induced by the ZLEV factor and in light green the effect of regulated ZLEV shares on new trucks' emissions (assuming that all ZLEVs are ZEVs), resulting from the different ZLEV shares shown in blue above.

Source: T&E modelling

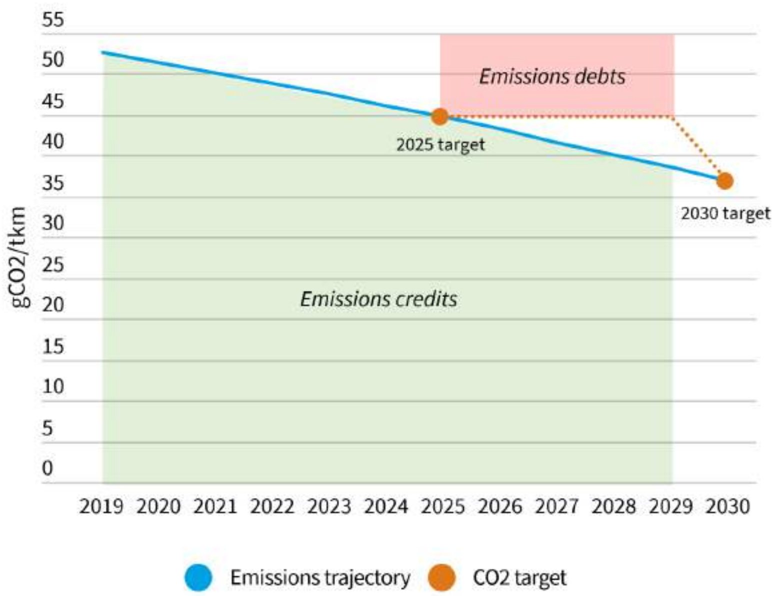
Figure 18: Three scenarios showing the effect of the ZLEV benchmark on the regulated trucks' emissions in 2025

3.3. Banking and borrowing mechanism

As part of the CO_2 standards, a banking and borrowing mechanism was introduced in order to take into account production cycles and to reward truck manufacturers for early action and emission savings. This takes the form of an emission credit and debt system where truckmakers can bank emission credits if they are below their individual emission trajectory and borrow emission credits if they are above it. The CO_2 emission trajectory of each truckmaker is calculated by combining the average reference CO_2 emissions per sub-group with each individual sales shares per sub-group (i.e. the sales composition of each OEM).

3.3.1. Definition

Figure 19 summarises the principle of this mechanism for the overall market, assuming that the number of trucks sold each year will remain the same. The green area represents the emissions where truckmakers would be performing better than the linear emission trajectory (in blue) and thus eligible to bank emission credits. The red area corresponds to the emissions where truckmakers emit more than the 2025 CO_2 target, and would therefore need to borrow emission credits (going into emission debt). The area between the emission trajectory and the CO_2 target does not lead to any emission credits or emission debts.



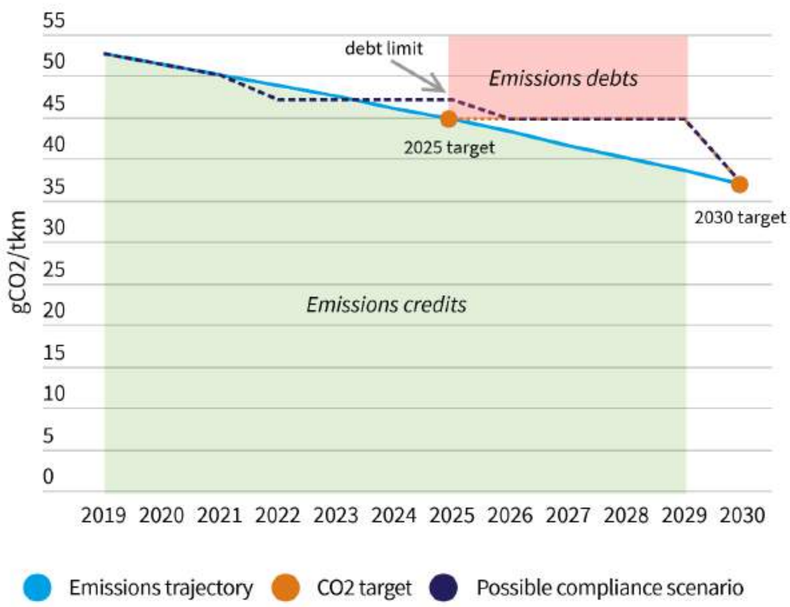
Notes: The light blue line corresponds to the emissions trajectory of a representative OEM which would be at the same level as the overall EU average.

Figure 19: Banking and borrowing mechanism

From 2019 to 2024, OEMs can only bank emissions if they are below the linear trajectory, the credits accumulated over this period can only be used for compliance in the year 2025. Truckmakers can only start to accumulate emissions' debts from 2025 but need to have their emission debts cleared by the end of the reporting period in 2029. Truckmakers' debts can not reach above the limit of 5% of the 2025 CO_2 target. Assuming that the number of vehicles registered each year remains constant and considering that the 2025 target would be around 44.8 gCO_2/tkm, the debt limit would amount to around 2.2 gCO_2/tkm (or about 375,000 gCO_2/tkm if multiplied by all registrations in the reference period).

3.3.2. Scenarios

Based on the banking and borrowing mechanism, different compliance scenarios could be followed by individual truckmakers. For instance, with the help of credits accumulated between 2019 and 2024, they would be able to comply with the CO_2 standards while being 5% above the official 2025 target, and still not accumulate any emission debts. Figure 20 illustrates this scenario when truck manufacturers maximise the flexibility from the banking and borrowing mechanism in the period before 2025. In practice, this would mean that slightly more fuel efficient vehicles or ZLEVs would need to be introduced in this initial period.

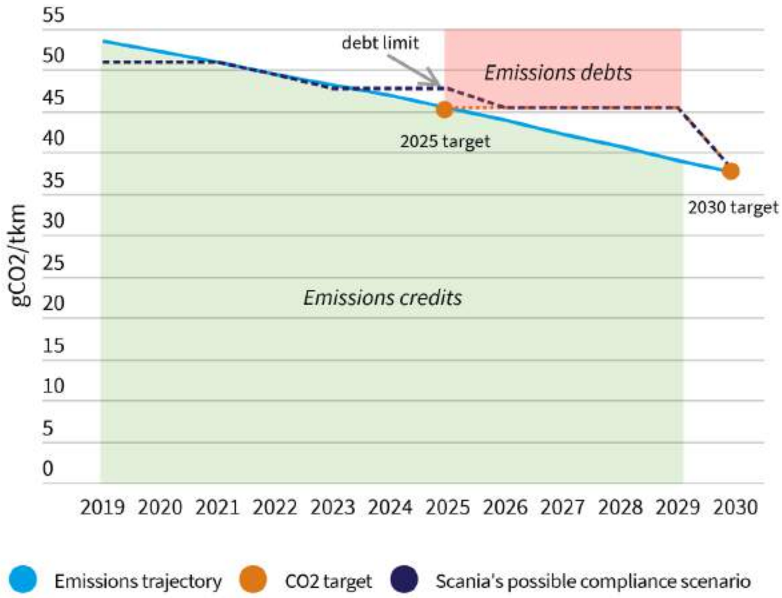


Notes: The blue lines correspond to the emissions trajectories of a representative OEM which would be at the same level as the overall EU average.

Figure 20: Illustrative compliance scenario with banking of early credits

The analysis of the baseline data also shows that Scania already achieved a 4.7% emissions reduction during the first reporting period compared to its individual linear emission trajectory, and thereby reaching already around a third of its 2025 CO_2 target. Thanks to this early emissions reduction, Scania was able to already bank 77,096 credits allowances, equivalent to 2.5 gCO_2/tkm on average, that can be used in 2025.

Figure 21 shows one of the hypothetical compliance scenarios for Scania. The company could benefit from its early emissions reductions for a couple of years before closing in on its reduction trajectory. From 2023, Scania could already reach its 2025 target with a 5% debt limit that would be compensated for by its credits acquired in 2019-2020.



Notes: The light blue line corresponds to Scania's emissions trajectory based on the reference period.

Figure 21: Possible compliance scenario for Scania

Given that emissions could be reduced with available technologies considering Scania's example, it is likely that truckmakers will attempt to accumulate credits in the early phase and benefit from the 5% debt limit in 2025, as presented above.

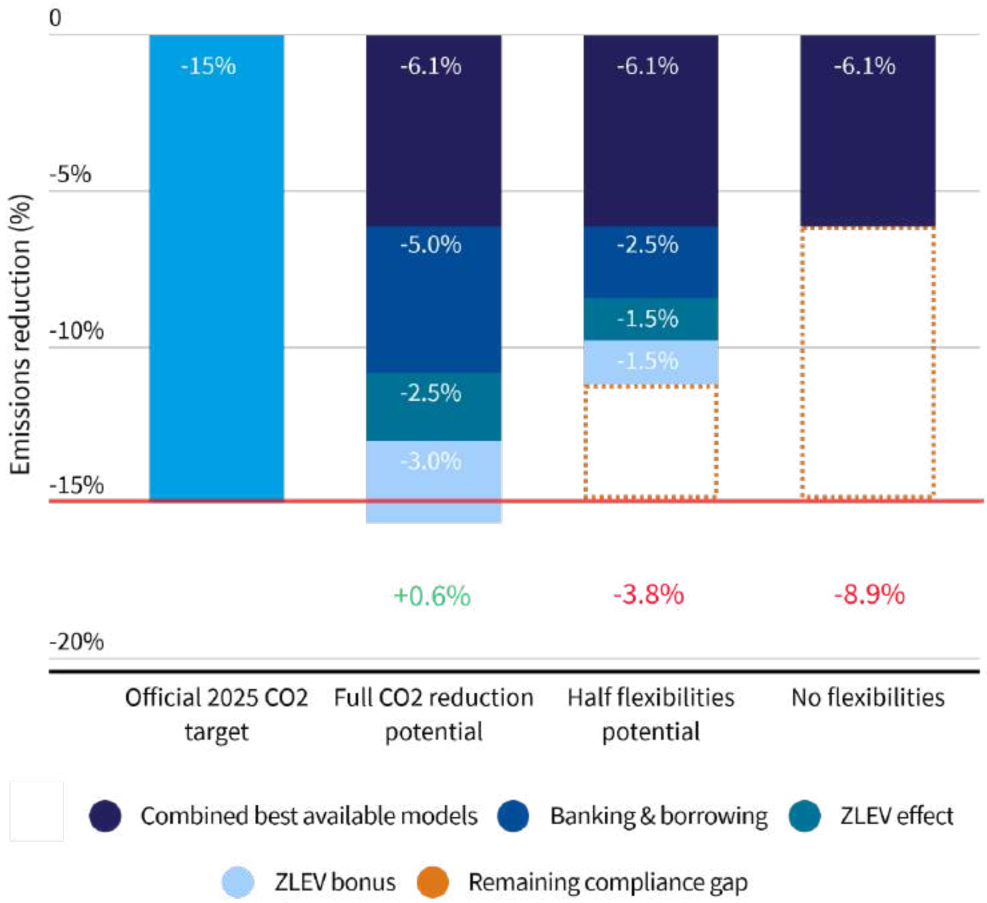
3.4. Compliance gap

Based on the analysis of the different flexibilities and both the best-in-class vehicle models and truckmakers, the remaining compliance gap was estimated, i.e. the actual emissions reduction efforts needed to comply with the 2025 CO_2 target.

3.4.1. Compliance with the 2025 CO_2 target

Figure 22 shows three conceivable compliance scenarios depending on to what extent truckmakers would make use of the different flexibilities. In all scenarios, the potential of combined best available models is assumed to be at the same level (6.1% CO_2 reduction) because it corresponds to the emissions reduction that could be already reached with today's available technologies (enhanced aerodynamics, improved engine efficiency, etc.)

In the "Full CO_2 reduction potential" scenario, the maximum potential of the ZLEV bonus and of the banking and borrowing mechanism is reached. This means that OEMs would sell 2.5% regulated ZLEVs and 2.5% non-regulated ZLEVs and get the maximum ZLEV bonus of 3% which would be combined with the actual reduction effect of these ZLEVs on the fleet emissions (2.4% additional CO_2 reduction). In addition, this scenario also assumes that OEMs would be able to bank some early emissions reductions from 2019 until 2024 and use the accumulated emission credits in 2025 up to the 5% maximum debt limit. In the two other scenarios presented below, half and none of this flexibility potential is considered.



Notes: In the full reduction potential scenario, the maximum ZLEV bonus and emission debts are reached in 2025, while only half of this potential is reached in the half-flexibilities scenario and no bonus is granted in the worst-case scenario. Combined best available models correspond to the emission reduction potential that could today be reached if all trucks were as efficient as current best-in-class models. Bar labels are not additive, each bar is scaled with the percentage points induced by each emission reduction percentages.

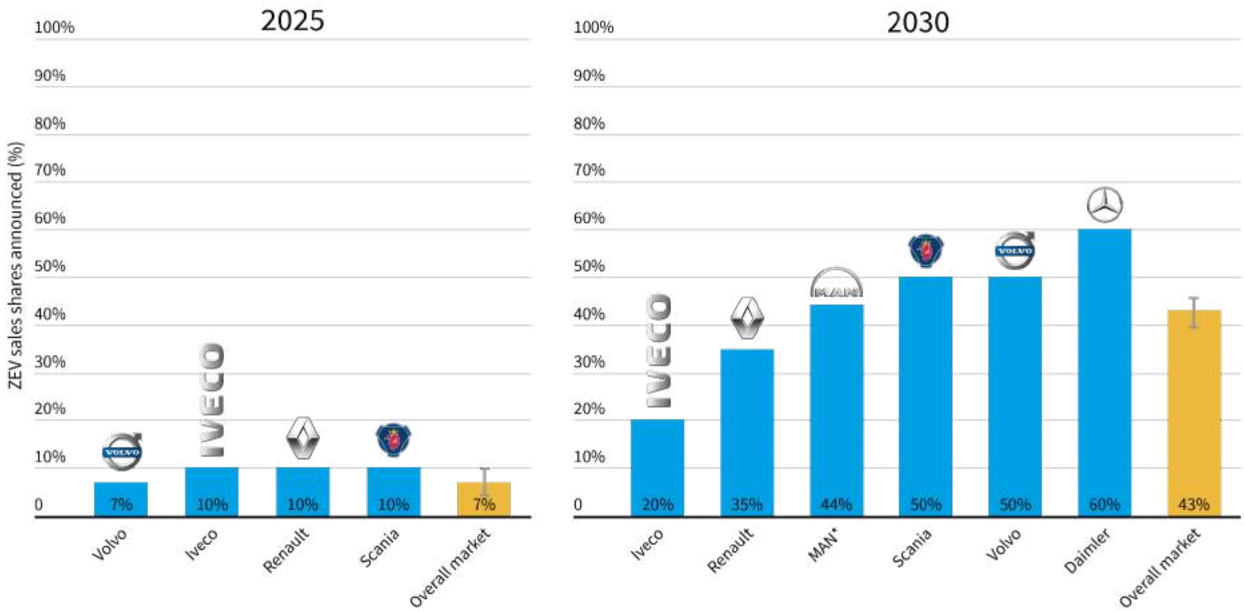
Source: T&E analysis of the CO2 emissions from heavy-duty vehicles during the reference period (July 1st 2019 to June 30th 2020), published by the EEA in June 2021.

Figure 22: Possible compliance scenarios based on flexibilities and combined best available models

In the full potential scenario, the 2025 CO_2 target would be reached without any additional effort from truckmakers, apart from reducing their emissions thanks to currently available technologies and minimum ZLEV benchmark requirements. In the second scenario, the remaining compliance gap would be about 3.8 percentage points, or 0.8 pp per year and in the scenario with no flexibilities and no ZLEV considered this gap would be around 8.9 percentage points, or 1.8 pp per year. In these scenarios the additional emissions reduction needed is therefore not enough to drive any additional ZEV uptake since these small annual emissions decreases could be reached thanks to efficiency improvements.

3.4.2. Comparison with truck manufacturers' official announcements

Based on recent announcements from truckmakers for 2025 and 2030, it is possible to have an overview of the potential uptake of ZEVs in the overall truck market. As shown in Figure 23, zero-emission sales shares are projected to be around 7% in 2025 (4.2% in the worst case scenarios and 9.2% in the best case scenario) and around 43.3% in 2030 (40.8% in the worst case scenario and 46.5% in the best case scenario). This indicates that most of the OEMs are expected to reach the full ZLEV bonus in 2025. The details of all these announcements and the assumptions used for the different scenarios can be found in Annex 4.2.



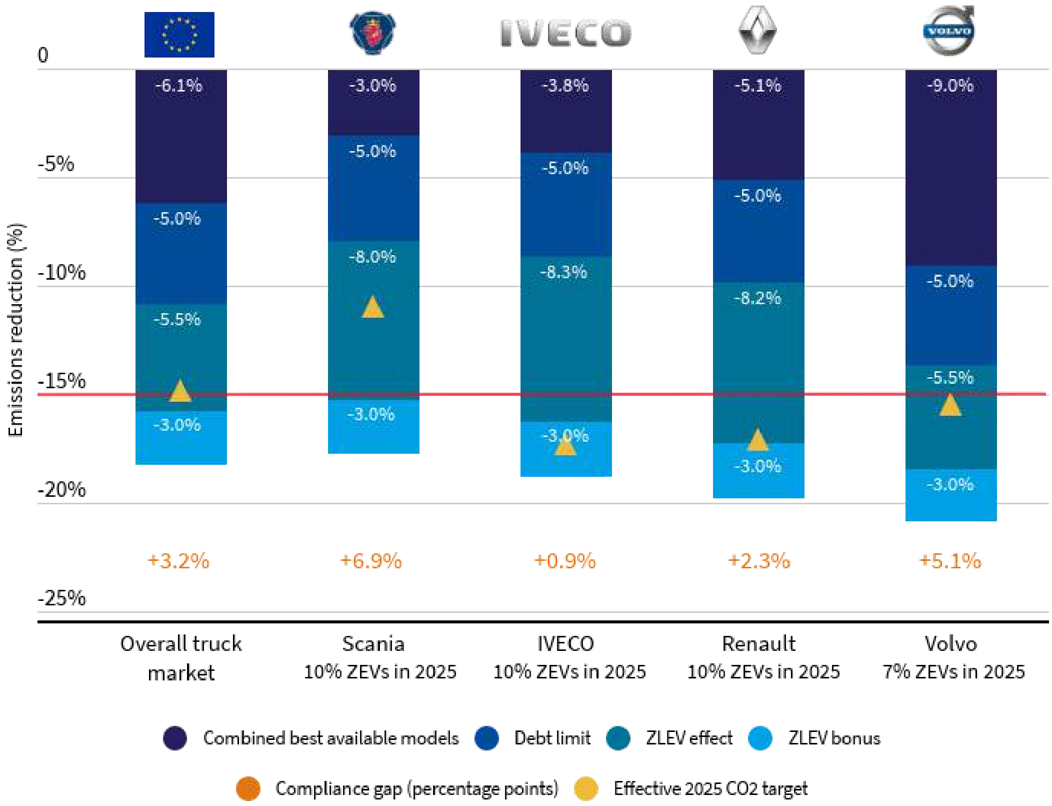
Notes: The overall market averages have been estimated based on the 2019 sales shares of each OEM in the EU. The value represents an intermediate scenario, half-way between a best-case and a worst-case scenario. The best-case scenario assumes that those OEMs, which have not yet made any announcement, perform as well as the average of OEMs that have made announcements. The worst-case scenario assumes that OEMs with no announcement will not sell any ZEVs at all.
*Based on MAN's targets of 60% ZEV sales shares in the urban and regional delivery and 40% in the long-haul segment and a 20%/80% split based on the manufacturer's vehicle registrations during the baseline period.

Source: T&E analysis, data from public OEM announcements and ACEA sales shares (2019)

Figure 23: Truckmakers' announcements and their impact on the overall truck market (EU27)

In all of the compliance scenarios presented previously, CO_2 standards do not appear to be sufficient to drive any major ZEV uptake in the short-term. This seems quite contradictory compared to the truckmakers' announcements presented above. The expected 2025 ZEV sales are indeed up to 2 times more than what the ZLEV benchmark will bring in the most optimistic scenario. However, these announcements being for truckmakers' overall sales, there is still some uncertainty in the distribution of these ZEV sales expected across regulated and non-regulated sub-groups.

Adding the full potential flexibilities analyzed in Section 3.4.1 and the potential of current best-in-class models with the announcements from truckmakers, the 2025 CO_2 target could be overachieved by 3.2% in an intermediate case scenario (between 2.0% and 4.4% depending on the shares of ZEVs in LH sub-groups).



Notes: Combined best available models refers to the difference between OEMs' average specific emissions in the reference period and average emissions from best-in-class models. The effective 2025 CO2 target corresponds to the level of CO2 emissions reduction needed for each OEM compared to their specific emissions in the reference period.

Source: T&E analysis of the CO2 emissions from heavy-duty vehicles during the reference period (July 1st 2019 to June 30th 2020), published by the EEA in June 2021.

Figure 24: Based on public announcements, current technologies and flexibilities, OEMs could overachieve their 2025 CO_2 target

Figure 24 shows the compliance gap for the overall truck market and for the four truckmakers who made announcements for 2025. The effect of announcements on new sales emissions ("ZLEV effect") depends on the distribution of the zero-emission vehicles announced across LH and UD/RD sub-groups, since the mileage and payload weighting (MPW) factor used in the Regulation advantages LH sub-groups. That's why, as an intermediate case assumption, ZEVs shares in LH sub-groups are estimated to be around 50% of the overall ZEVs objectives announced by OEMs. For instance, 10% ZEVs in 2025 announced by IVECO will result in emissions reduction between -6.6% (0% ZEVs in LH sub-groups) and -10% (as much ZEVs in

LH sub-groups as overall, i.e. 10% ZEVs in LH), with an intermediate case around -8.3% CO_2 reduction as shown above (half of the overall ZEVs share announced in LH sub-group, i.e. 5% ZEVs in LH).

Because Scania performed well in the reference period already, this OEM only needs to reduce its emissions by 10.8% to reach its 2025 CO_2 target. For the same reason, Scania has a limited additional potential from best available technologies (3% CO_2 emissions reduction). Finally, because this truckmaker announced 10% ZEVs in 2025, it could overachieve its 2025 CO_2 target by 6.9%.

On the other hand, and following the same methodology, IVECO and Renault could overachieve their target by 0.9% and 2.3% respectively, thanks to their 10% ZEVs announced for 2025. Volvo could overachieve its CO_2 target by 5.1% thanks to a significant untapped fuel efficiency potential from current best models, but also thanks to its objectives of 7% ZEVs in 2025.

4. Conclusions and policy recommendations

We analysed the truck registration data reported during the reference period (1st July 2019 - 30th June 2020) and showed that across the nine regulated sub-groups, LH vehicles made up most of the registrations. Looking at specific emissions reported by truckmakers, Scania performed particularly well thanks to improved aerodynamics. Finally, at Member State level, long-haul trucks registered in Central and Eastern European countries were as fuel efficient, if not better, as Western European ones.

We showed that truckmakers could reach the 2025 CO_2 target already today thanks to current best-in-class models and regulatory flexibilities, which is corroborated by ICCT's study on truck fuel efficiency potential [19]. Considering recent voluntary announcements, truckmakers are likely going to overachieve their 2025 target and easily comply with the targets up to 2029 without using the banking and borrowing mechanism. The current regulatory ambition is too weak to drive the CO_2 emissions reductions necessary to reach the EU climate goals. The 2022 review of the CO_2 standards therefore needs to significantly increase the level of ambition and improve the design of the regulation.

The current regulation is also wholly insufficient to drive the supply of zero-emission vehicles in the 2020s. The EU cannot rely on voluntary commitments from truckmakers to ramp up ZEV sales. **A significantly higher emissions reduction target can and should be set already from the second half of the 2020s.**

To do so, the stringency of the CO_2 standards should be increased in 2027/28. Several options should be considered, including introducing an intermediate target, setting a much higher ZLEV benchmark and improving the banking and borrowing mechanism.

Intermediate target in 2027/28
An intermediate CO_2 target between the years 2025 and 2030 should be considered in order to compensate for the weak 2025 CO_2 target, tap on the cost effective emissions reduction available in the second half of the 2020s (in particular the mass market penetration of battery electric trucks) and thus ensure a steady roll-out of zero-emission vehicles over the decade rather than a stagnation around

5%-7% up to 2029. Current voluntary announcements from truckmakers show that - under the right legislative framework - 30% of ZEVs can be expected in 2028. Therefore, an ambitious intermediate CO_2 target should be set for 2027/2028 in order to ensure significant emissions reduction across the market before 2030.

Higher ZLEV benchmark in the 2020s

The current voluntary ZLEV benchmark lags behind market potential. The European Commission should set a much higher ZLEV benchmark threshold to provide the right incentive for OEMs to produce and sell zero-emission trucks rather than just weakening the stringency of the regulation by setting a level far below the business-as-usual potential as it is currently the case. As highlighted above, based on OEMs voluntary announcements, a 30% benchmark in 2028 would be an adequate level. Furthermore, a malus should also be considered to increase the effectiveness of such a mechanism and the calculation of ZLEV credits should be based on the electric range.

Improving the banking and borrowing mechanism

Under its current design, the banking and borrowing mechanism allows OEMs to stay far above their linear emission trajectory while still complying with the 2025-2029 target of -15%. The banking and borrowing mechanism is designed to provide flexibility for truckmakers with regards to their investments and product or technology launches by those over the years. Under such a mechanism, targets can be more gradually improved with a higher frequency in the increase of the stringency of the target given that truckmakers have the flexibility to miss or overachieve the target while compensating for the previous or following years.

The European Commission should improve the current weak and generous banking and borrowing mechanism. Several solutions could be considered. The flat 2025-2029 debt limit (or target) should be aligned with the credit limit (linear trajectory between the 2025 and 2030 target) from 2027/28. Alternatively, a new debt limit could be set for 2028-2029, in line with the 2028 credit limit in order to support the intermediate CO_2 target needed in 2027/28

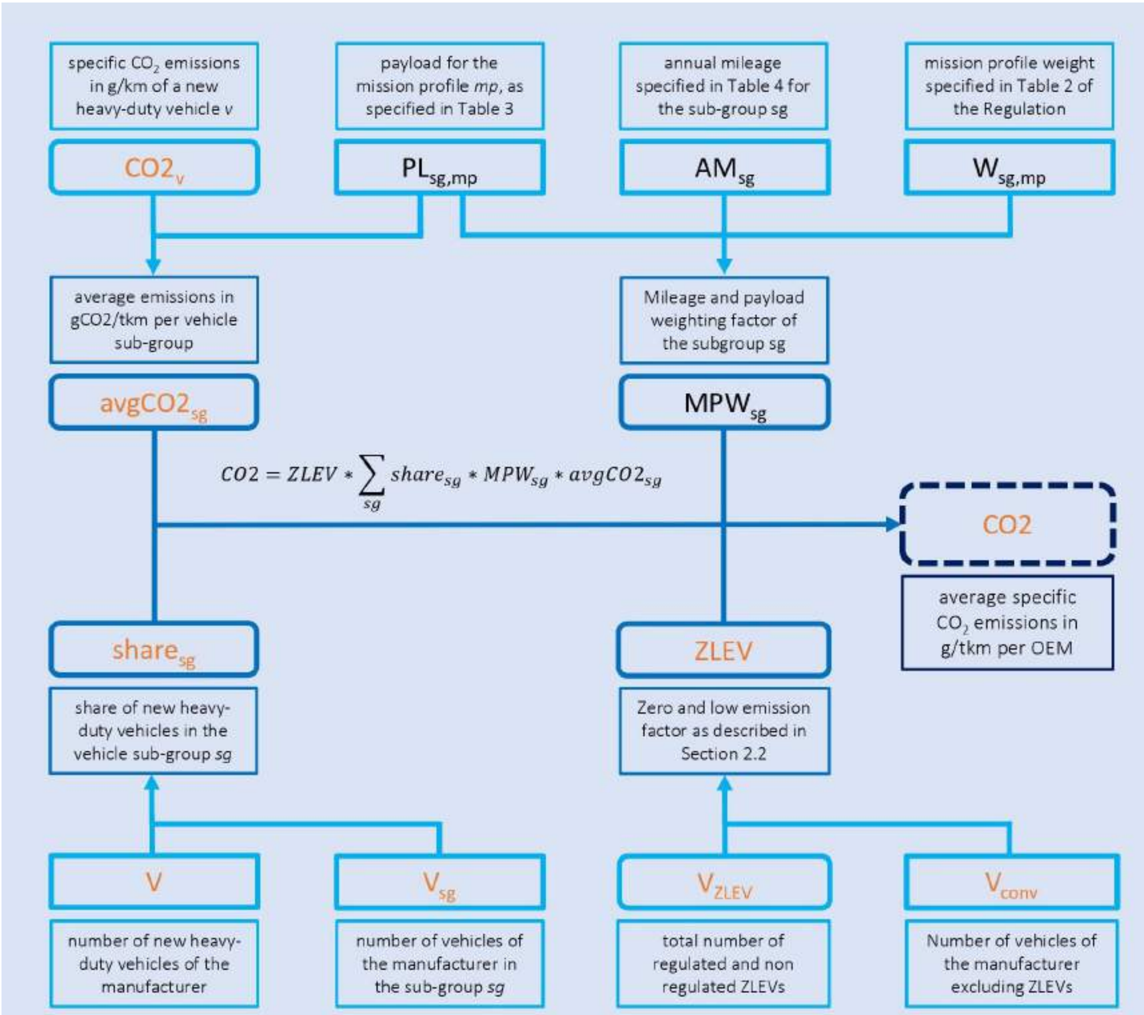
100% CO_2 target for the vast majority of HDVs in 2035

A 100% CO_2 reduction target by 2035 should be set for the vast majority of new HDVs and the 2030 CO_2 reduction target should be significantly increased in order for the road freight sector to play its fair share in the EU's Green Deal climate framework. The potential for higher targets in 2030 and a trajectory for the optimal phase-out of combustion trucks will be presented in an upcoming report.

5. Annexes

5.1. Emissions averaging methodology

The EU Regulation 2019/1242 details a methodology to calculate average specific CO_2 emissions for each OEM. As presented in Figure 25, this methodology uses four different components: the ZLEV factor, the share of regulated trucks registered in each vehicle sub-group, the mileage and payload weighting and the specific emissions per sub-group.



Notes: Parameters in orange are specific to each OEM, while other parameters are common to all of them.

Source: T&E, from Regulation (EU) 2019/1242

Figure 25: Methodology used in the Regulation to estimate truckmakers' emissions

5.1.1. Mileage and payload weighting factor

The mileage and payload weighting factor is calculated from average values given in the Regulation such as average payload and mileage per sub-group. These values are then normalized based on the 5-LH values, using the following equation:

$$MPW_{sg} = \frac{AM_{sg} * PL_{sg}}{AM_{5-LH} * PL_{5-LH}}$$

Table 2 gives the resulting MPW factors for each sub-group:

	4-UD	4-RD	4-LH	5-RD	5-LH	9-RD	9-LH	10-RD	10-LH
AM_{sg}	60,000	78,000	98,000	78,000	116,000	73,000	108,000	68,000	107,000
PL_{sg}	2.7	3.2	7.4	10.3	13.8	6.3	13.4	10.3	13.8
MPW_{sg}	0.10	0.15	0.45	0.50	1.00	0.29	0.90	0.43	0.92

Table 2: Mileage and payload weighting factors

5.1.2. ZLEV factor

From 2025 onwards, the ZLEV factor is calculated following the methodology presented below:

$$ZLEV_{factor} = 1 - (y - x)$$

Where:

$y = (V_{in} + V_{out})/V_{total}$

$x = 0.02$

V_{in} is the total number of ZLEVs registered in regulated sub-groups,

V_{out} is the total number of ZLEVs registered in non-regulated sub-groups, capped at 3.5% of V_{total},

V_{total} is the total number of regulated vehicles registered in the reporting period,

And where V_{in} is smaller than 0.75% of V_{total}, the ZLEV factor should be at 1.

5.2. Market uptake of zero-emission trucks - T&E calculations

5.2.1. Truckmakers' announcements

The different announcements made by European truckmakers are presented below and summarized in Table 2:

- Daimler foresees up to 60% of its trucks to be zero-emission vehicles in 2030 [20].
- MAN announced that 40% of long-haul trucks and 60% urban and regional delivery vehicles will be zero-emission in 2030 [21].
- Scania aims at 10% and 50% of its sales to be electric in 2025 and 2030 [22].
- Renault Trucks predicts that electric vehicles will represent 10% of its sales volume by 2025 and 35% by 2030 [23].
- IVECO expects to sell 8%-10% zero-emissions trucks (>16t) by 2025 and 20% by 2030 [24].
- Volvo sees 7% and 50% of its trucks being zero-emissions by 2025 [25] and 2030 [26].
- Finally, Daimler, IVECO, Scania, Volvo Group, DAF and MAN all announced their commitment to sell 100% fossil-free trucks in 2040 [27].

OEM	2019 market shares (EU27+UK) [28]	2025 ZEV sales shares announced	2030 ZEV sales shares announced
Daimler	22.4 %	No announcement	60 %
MAN	16.1 %	No announcement	44 %[8]
Scania	13.5 %	10 %	50 %
Volvo	11.9 %	7 %	50 %
DAF	11.0 %	No announcement	No announcement
IVECO	9.9 %	10 %	20 %
Renault Trucks	7.3 %	10 %	35 %
Volkswagen	0.4 %	No announcement	No announcement

Table 3: Detailed OEMs' announcements

5.2.2. Detailed scenarios

From the announcements described above, three scenarios have been built in order to get a better overview of the impact of these announcements on the overall truck market.

[8] A 20%/ 80% split was used to differentiate UD/RD and LH trucks based on the analysis of MAN's registrations in the reference period data (see Section 1).

Worst-case scenario

Globally, the announcements presented above suggest that in this most conservative scenario, average sales share for zero-emission trucks would be **at least 4.2% in 2025 and 40.8% in 2030**. In this conservative scenario, OEMs that did not announce any target are considered to be selling 0% of zero-emission trucks. This translates into 50,000 trucks on the road in 2025 and 480,000 trucks in 2030 in the EU27.

This is already much higher than what ACEA, the automotive industry lobby group, has announced for the EU27+UK: 20,000 zero-emission trucks on the road in 2025 and 200,000 in 2030 (above 16t). Which would mean that the European average sales market share for zero-emissions trucks would be at 1.3% in 2025 and 15% in 2030 [29].

Intermediate scenario

Assuming that OEMs that did not make an announcement would at least sell 5% of zero-emission trucks in 2025 and 20% in 2030, this leads to a scenario with respectively **6.9% zero-emission trucks sales in 2025 and 43.3% in 2030**. Cumulatively, this scenario would in total represent 80,000 ZEVs in 2025 and 560,000 in 2030 in the EU27.

Best-case scenario

Assuming that all OEMs would do as well as announced by the most ambitious OEMs, in this scenario, **9.2% of truck sales in 2025 would be zero-emission and 46.3% in 2030**. Cumulatively this would amount to about 106,000 ZEVs in 2025 and 630,000 in 2030 in EU27.

These three scenarios of the zero-emission truck adoption are summarized below:

Scenarios - EU27	2025		2030	
	Sales shares	ZEVs on the road	Sales shares	ZEVs on the road
Worst-case scenario	4.2 %	50,000	40.8 %	480,000
Intermediate scenario	6.9 %	80,000	43.3 %	560,000
Best-case scenario	9.2 %	106,000	46.5 %	630,000

Table 4: Summary of the zero-emission truck uptake scenarios based on OEMs' announcements

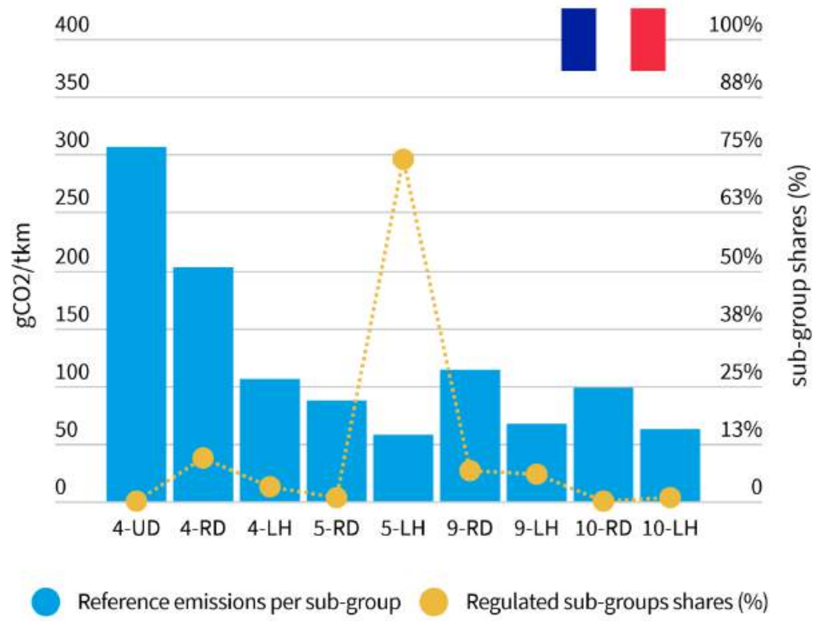
Therefore, even in the most conservative scenario, at least 6 times more zero-emissions trucks are expected on the roads compared to what the European Commission foresees: 170,000 ZEVs in 2030 (110,000 battery-electric trucks and 60,000 fuel-cell electric trucks), as described in Table 4 of the impact assessment of the Alternative Fuel Infrastructure Regulation (AFIR) [30].

5.3. National fiches

5.3.1. France

With about 28,000 trucks registered during the reference period (2019-2020), France is the 2nd biggest truck market in the EU after Germany: regulated trucks sold in France represent 16% of the EU market. LH trucks make up 83% of French sales (vs 86% in the EU), with about 75% of trucks registered in the 5-LH sub-group.

Figure 26 shows the distribution of emissions and registrations across all sub-groups. 5-LH trucks registered in France emit on average 57.1 gCO_2/tkm (21st out of 28 countries). Weighted across LH sub-group shares, as explained in Section 2.3.2, France's average truck emissions are around 59.6 gCO_2/tkm, which makes France just above the EU average (59.5 gCO_2/tkm). Looking at UD and RD sub-groups only, trucks sold in France emit around 163.1 gCO_2/tkm, 3.4% above the EU average.



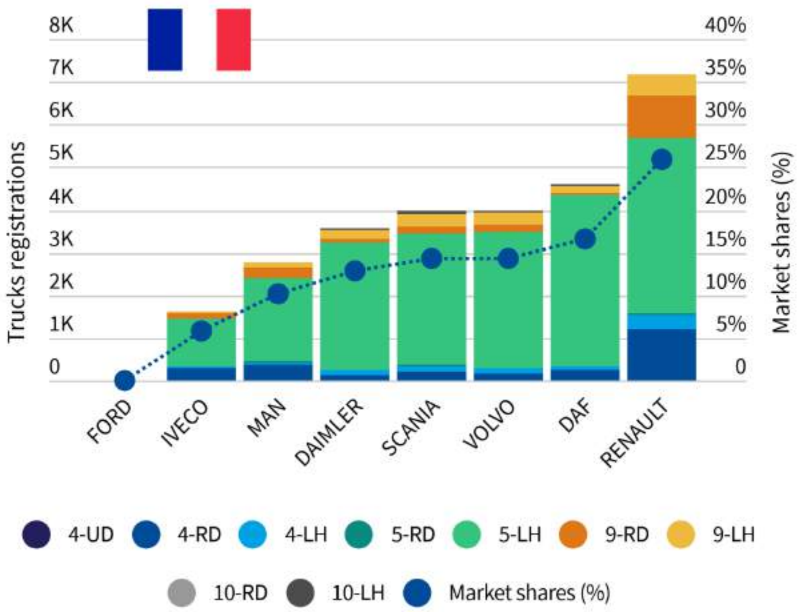
Source: T&E analysis of the CO2 emissions from heavy-duty vehicles during the reference period (July 1st 2019 - June 30th 2020), published by the EEA in June 2021.

Figure 26: Average emissions per sub-group (France, 2019-2020)

France is also the biggest gas market in the reference period with about 940 gas trucks registered. These vehicles represent 3.3% of sales across all sub-groups, while the EU average is around 2.3%. In UD and RD sub-groups, the share of gas trucks makes up to 6.0% while in LH sub-groups it gets down to 2.9%.

From the truckmakers perspective, Renault is leading the French market with more than 7,000 vehicles registered in the reporting period - about 26% of the overall regulated truck market in France - of which

31% are UD and RD vehicles (vs 14% on average in the EU). As shown in Figure 27, DAF, Volvo and Scania come next with 17%, 14% and 14% market shares respectively.



Source: T&E analysis of the CO2 emissions from heavy-duty vehicles during the reference period (July 1st 2019 - June 30th 2020), published by the EEA in June 2021.

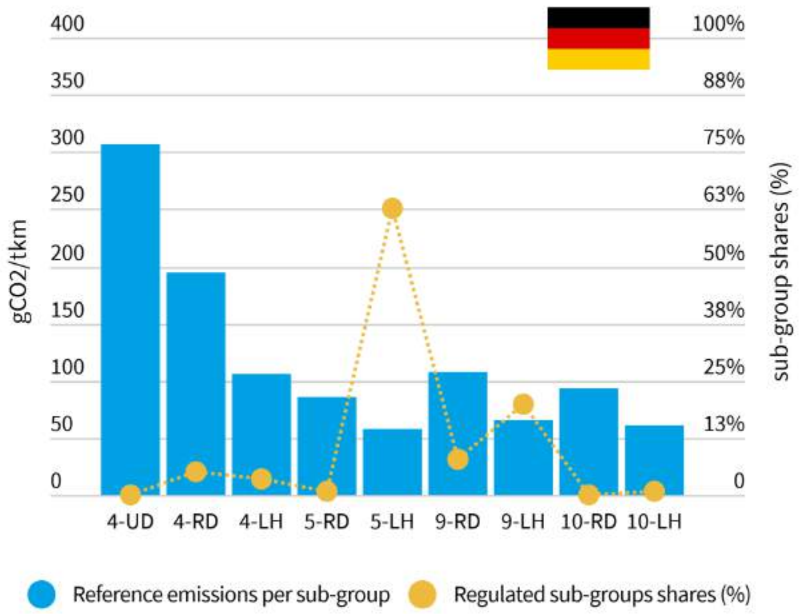
Figure 27: Truck registrations per OEM and sub-group (France, 2019-2020)

5.3.2. Germany

Germany is leading the EU truck market with about 37,000 vehicles reported during the reference period, making up 22% of the overall truck market. With about 62% of trucks registered in the 5-LH sub-group, LH trucks account for 86% of all regulated vehicles reported in Germany.

Figure 28 shows the distribution of emissions and registrations across all sub-groups. 5-LH trucks registered in Germany emit on average 57.1 gCO_2/tkm (22nd out of 28 countries). Weighted across LH sub-groups, as explained in Section 2.3.2, average truck emissions are around 60.7 gCO_2/tkm, which puts Germany at the 22nd place out of 28 countries (2.2% above the EU average). In UD and RD sub-groups, Germany's average emissions are around 139.1 gCO_2/tkm, just behind the two least-emitting countries, Estonia and Denmark.

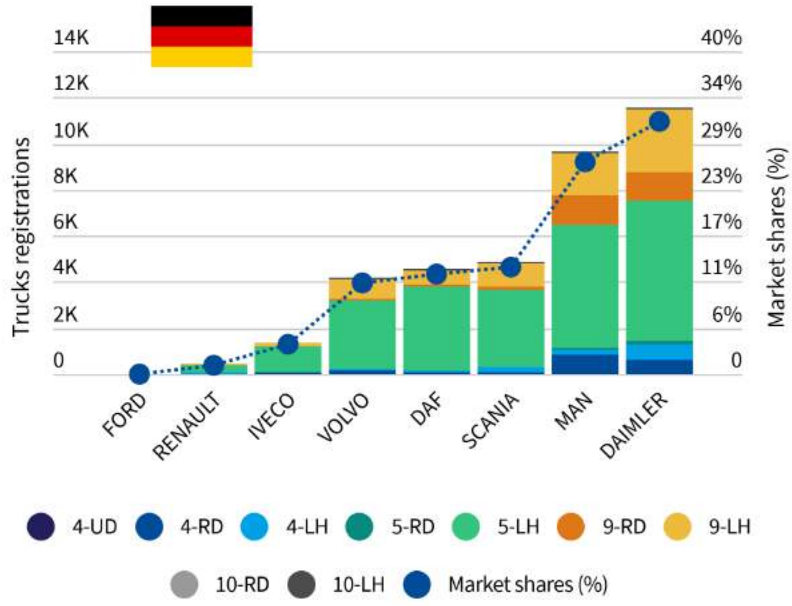
With about 590 gas trucks sold in the reference period, Germany is the third biggest market for gas trucks. These vehicles represent 1.6% of sales across all sub-groups, while the EU average is around 2.3%. In UD and RD sub-groups, gas trucks account for 0.4% of sales while in LH sub-groups it gets up to 1.8%.



Source: T&E analysis of the CO2 emissions from heavy-duty vehicles during the reference period (July 1st 2019 - June 30th 2020), published by the EEA in June 2021.

Figure 28: Average emissions per sub-group (Germany, 2019-2020)

From the truckmakers perspective, Daimler is leading the German market with almost 12,000 vehicles registered in the reporting period - about 32% of the overall regulated truck market in Germany - of which 83% are LH vehicles. As shown in Figure 29, MAN, Scania and DAF come next with 26%, 13% and 12% market shares respectively.



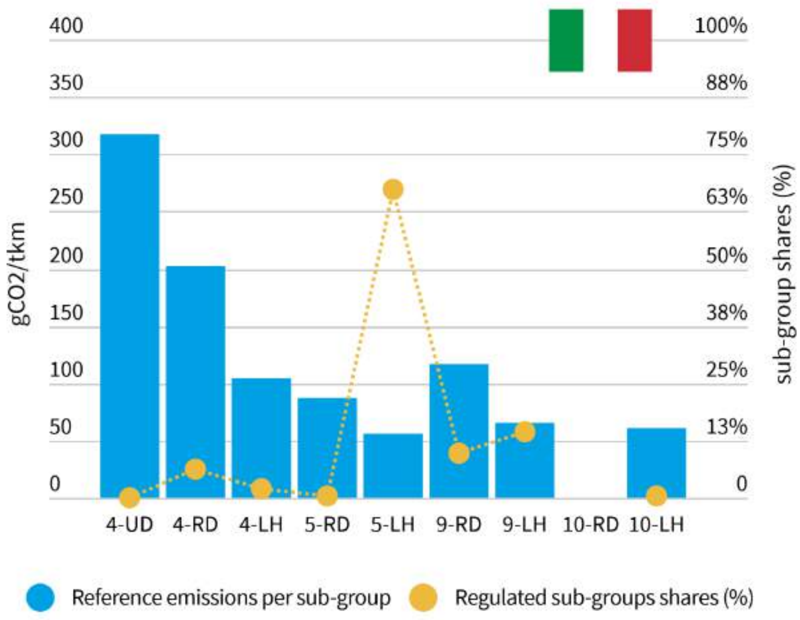
Source: T&E analysis of the CO2 emissions from heavy-duty vehicles during the reference period (July 1st 2019 - June 30th 2020), published by the EEA in June 2021.

Figure 29: Truck registrations per OEM and sub-group (Germany, 2019-2020)

5.3.3. Italy

With about 12,000 trucks registered during the reference period (2019-2020), Italy is the 6th biggest truck market in the EU: regulated trucks sold in Italy represent 7% of the EU market. LH trucks account for 84% of Italian sales (vs 86% in the EU), with about 75% of trucks registered in the 5-LH sub-group.

The distribution of emissions and registrations across all sub-groups can be seen in Figure 30. 5-LH trucks registered in Italy emit on average 56.7 gCO_2/tkm (20th out of 28 countries). Weighted across LH sub-groups, as explained in Section 2.3.2, Italy's average truck emissions are around 59.2 gCO_2/tkm, 0.5% below the EU average (15th out of 28 countries). Looking at UD and RD sub-groups only, trucks sold in Italy emit around 151.0 gCO_2/tkm, 4.2% below the EU average.

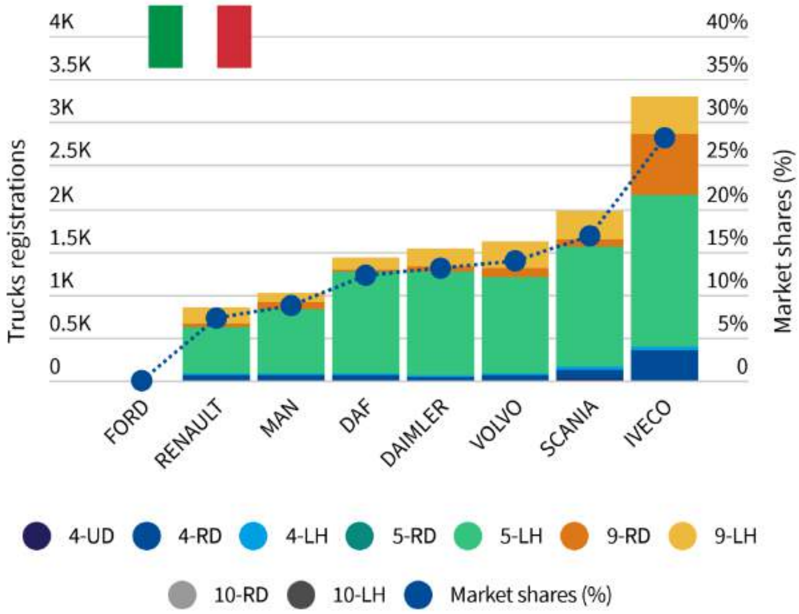


Source: T&E analysis of the CO2 emissions from heavy-duty vehicles during the reference period (July 1st 2019 - June 30th 2020), published by the EEA in June 2021.

Figure 30: Average emissions per sub-group (Italy, 2019-2020)

Italy is also the second biggest gas truck market, after France, in the reference period with about 620 gas trucks registered. These vehicles represent 5.3% of sales across all sub-groups, while the EU average is around 2.3%. In UD and RD sub-groups, gas trucks represent 2.3% of registrations while in LH sub-groups they make up to 5.9%.

From the truckmakers perspective, IVECO is leading the Italian truck market with more than 3,000 vehicles registered in the reporting period - about 28% of the overall regulated truck market in Italy - of which 32% are UD and RD vehicles (vs 14% on average in the EU). As shown in Figure 31, Scania, Volvo and Daimler come next with 17%, 14% and 13% market shares respectively.



Source: T&E analysis of the CO2 emissions from heavy-duty vehicles during the reference period (July 1st 2019 - June 30th 2020), published by the EEA in June 2021.

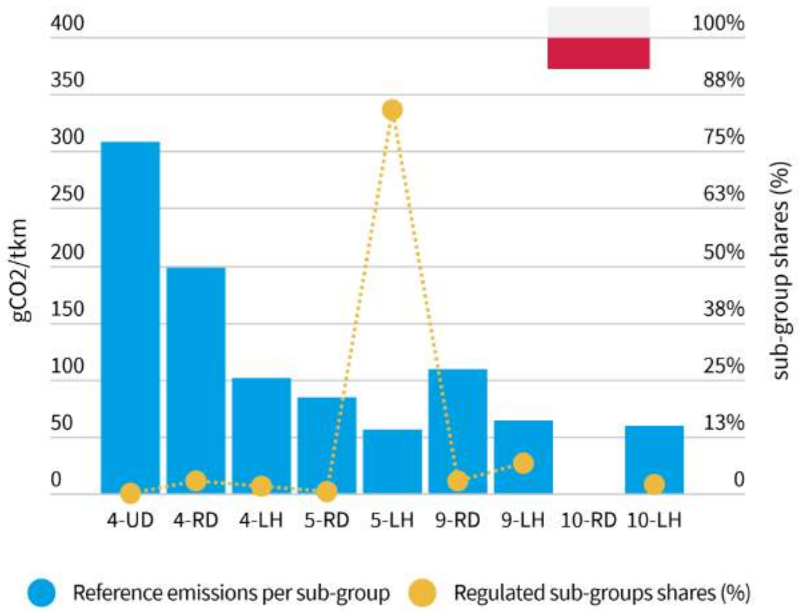
Figure 31: Truck registrations per OEM and sub-group (Italy, 2019-2020)

5.3.4. Poland

Poland is the 5th largest EU truck market with about 14,000 vehicles reported during the reference period, making up 8% of the overall truck market. With about 84% of trucks registered in the 5-LH sub-group, LH trucks account for 94% of all regulated vehicles reported in Poland (vs 86% on average in the EU).

Figure 32 shows the distribution of emissions and registrations across all sub-groups. 5-LH trucks registered in Poland emit on average 56.0 gCO_2/tkm (12th out of 28 countries). Weighted across LH sub-groups, as explained in Section 2.3.2, average truck emissions are around 57.4 gCO_2/tkm, which puts Poland at the 6th place out of 28 countries (3.5% below the EU average). In UD and RD sub-groups, Polish trucks are around 151.9 gCO_2/tkm, 3.4% below the EU average.

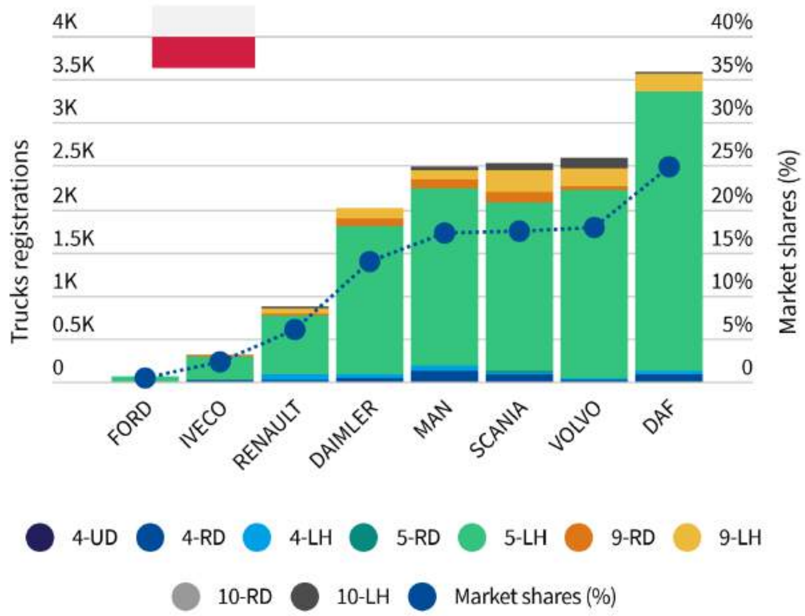
With about 320 vehicles sold in the reference period, Polish gas trucks account for 2.2% of registrations across all sub-groups, while the EU average is around 2.3%. In UD and RD sub-groups, gas trucks account for 7.6% of sales while in LH sub-groups it gets down to 1.9%.



Source: T&E analysis of the CO2 emissions from heavy-duty vehicles during the reference period (July 1st 2019 - June 30th 2020), published by the EEA in June 2021.

Figure 32: Average emissions per sub-group (Poland, 2019-2020)

From the truckmakers perspective, DAF is leading the Polish truck market with more than 3,500 vehicles registered in the reporting period - about 25% of the overall regulated truck market in Poland - of which 98% are LH vehicles. As shown in Figure 33, Volvo, Scania and MAN come next with 18%, 18% and 17% market shares respectively.



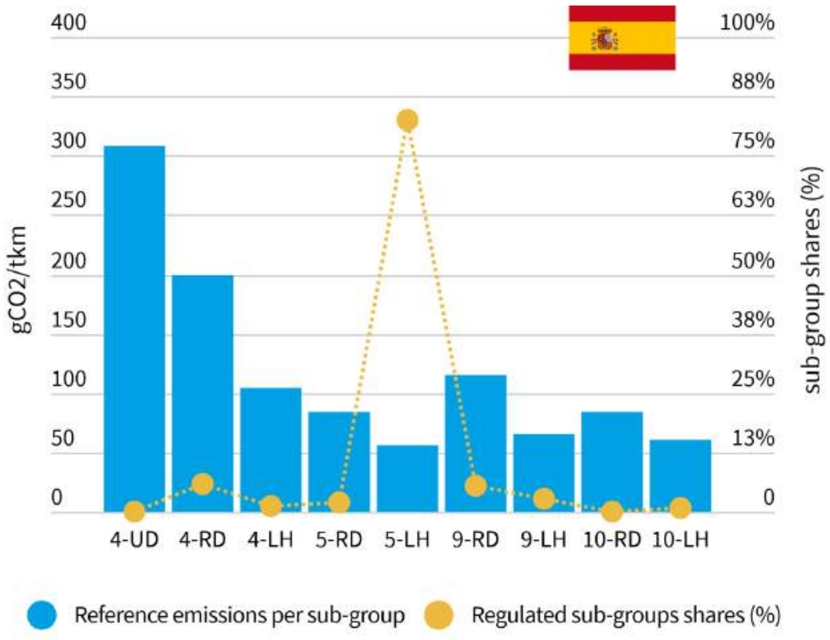
Source: T&E analysis of the CO2 emissions from heavy-duty vehicles during the reference period (July 1st 2019 - June 30th 2020), published by the EEA in June 2021.

Figure 33: Truck registrations per OEM and sub-group (Poland, 2019-2020)

5.3.5. Spain

With about 15,000 trucks registered during the reference period (2019-2020), Spain is the 5th biggest truck market in the EU: regulated trucks sold in Spain represent 9% of the EU market. LH trucks account for 87% of Italian sales (vs 86% in the EU), with about 82% of trucks registered in the 5-LH sub-group.

The distribution of emissions and registrations across all sub-groups can be seen in Figure 34. 5-LH trucks registered in Spain emit on average 56.3 gCO_2/tkm (16th out of 28 countries). Weighted across LH sub-groups, as explained in Section 2.3.2, average truck emissions are around 57.2 gCO_2/tkm, which puts Spain at the 5th place out of 28 countries (3.8% below the EU average). In UD and RD sub-groups, average emissions in Spain are around 146.4 gCO_2/tkm, or 7.2% below the EU average.

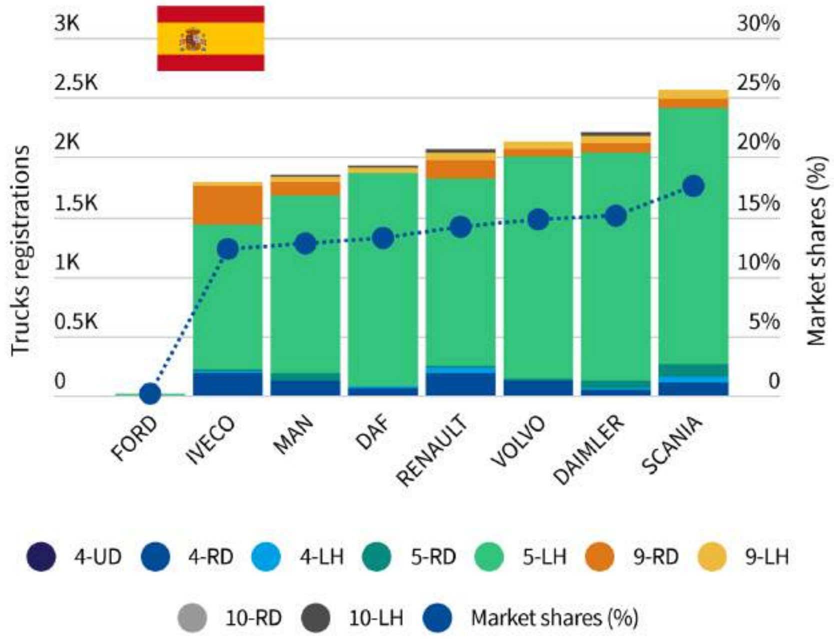


Source: T&E analysis of the CO2 emissions from heavy-duty vehicles during the reference period (July 1st 2019 - June 30th 2020), published by the EEA in June 2021.

Figure 34: Average emissions per sub-group (Spain, 2019-2020)

Spain is also the fourth biggest gas truck market in the reference period with about 500 gas trucks registered. These vehicles represent 3.4% of sales across all sub-groups, while the EU average is around 2.3%. In UD and RD sub-groups, gas trucks represent 5.9% of registrations while in LH sub-groups they account for 3.1%.

From the truckmakers perspective, Scania is leading the Spanish truck market with about 2,500 vehicles registered in the reporting period - about 18% of the overall regulated truck market in Spain - of which 88% are LH vehicles (vs 86% on average in the EU). As shown in Figure 35, Daimler, Volvo and Renault come next with 15%, 15% and 14% market shares respectively.



Source: T&E analysis of the CO2 emissions from heavy-duty vehicles during the reference period (July 1st 2019 - June 30th 2020), published by the EEA in June 2021.

Figure 35: Truck registrations per OEM and sub-group (Spain, 2019-2020)

5.3.6. United Kingdom

The United Kingdom registered about 20,000 vehicles during the reference period and is therefore the 3rd biggest truck market in the EU27+UK. With only 9% of its trucks being registered in the 5-LH sub-group and up to 63% in 10-LH, the UK truck market is very particular. Because most LH trucks have a 6x2 axle configuration in the UK, most LH are indeed registered in the 10-LH sub-group rather than 5-LH (4x2 axle configuration). In total LH trucks account for 82% of all regulated vehicles reported in Germany.

Figure 36 shows the distribution of emissions and registrations across all sub-groups. 5-LH trucks registered in the UK emit on average 57.4 gCO_2/tkm (and 57.8 gCO_2/tkm in 10-LH). Weighted across LH sub-groups, as explained in Section 2.3.2, average truck emissions are around 60.5 gCO_2/tkm, 2.8% above the EU average, while in UD and RD sub-groups average emissions are around 189.0 gCO_2/tkm, 19.8% above the EU average.

With no regulated gas trucks sold in the reference period, the UK is once again a very specific truck market compared to other European countries. However, looking at truck registrations out of the reference period scope, it can be noticed that about 200 dual fuel trucks (natural gas - diesel) are registered in the UK. Not yet certified as part of the VECTO simulation tool, these trucks will be retroactively added to the reference emissions once they will be covered by the Regulation.

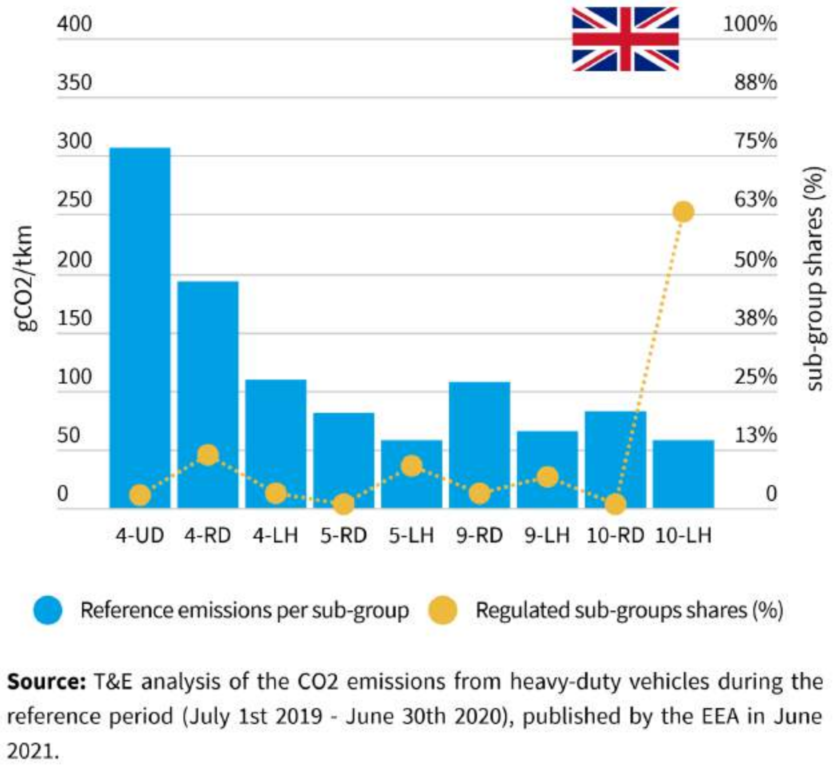
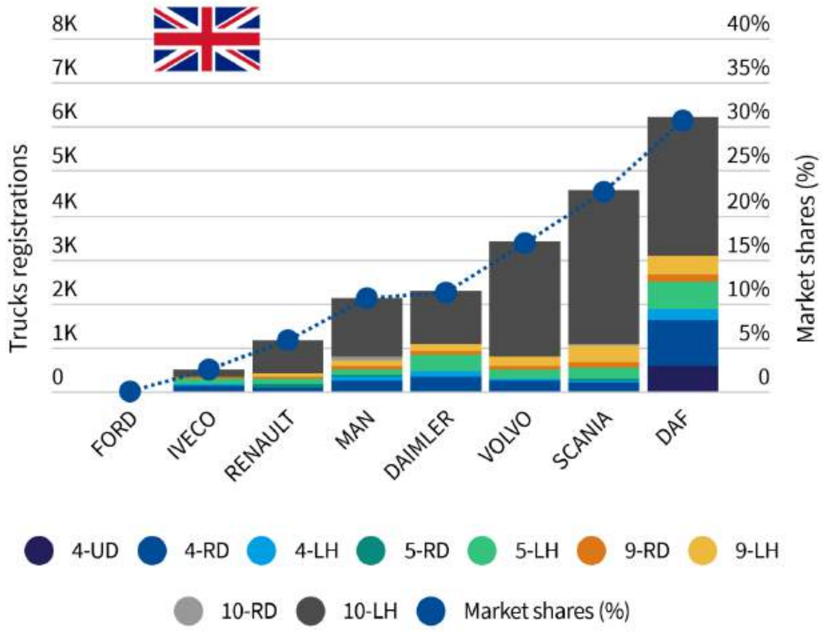


Figure 36: Average emissions per sub-group (UK, 2019-2020)

Finally, from the truckmakers perspective, DAF is leading the UK truck market with about 6,000 vehicles registered in the reporting period - about 31% of the overall regulated truck market in the UK - of which 71% are LH vehicles (vs 86% on average in the EU). As shown in Figure 37, Scania, Volvo and Daimler come next with 23%, 17% and 11% market shares respectively.



Source: T&E analysis of the CO2 emissions from heavy-duty vehicles during the reference period (July 1st 2019 - June 30th 2020), published by the EEA in June 2021.

Figure 37: Truck registrations per OEM and sub-group (UK, 2019-2020)

Endnotes

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