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COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT AND THE COUNCIL

on the technological and market readiness of heavy-duty road transport vehicles

1 Introduction

The amended CO_2 emission performance standards for new heavy-duty vehicles[1] set ambitious emission reduction targets for new lorries, buses and coaches for 2030 and beyond. Meeting those targets will require rapid market uptake of zero-emission vehicles (ZEVs). In order to provide the conditions to enable those zero-emission vehicles to enter the market, Regulation (EU) 2023/1804[2] on the deployment of alternative fuels infrastructure (AFIR) sets mandatory deployment targets for sufficient minimum dedicated publicly accessible recharging and hydrogen refuelling infrastructure along the TEN-T road network, in urban nodes and in safe and secure parking areas.

To reflect the rapid developments in demand for alternative fuels, Article 24(1) of that Regulation requires the Commission to adopt a technology and market-readiness report dedicated to heavy-duty vehicles (HDVs). The article further specifies that the report should take into account the initial indications of the preferences of the market. It should also consider technological developments in the short term, in particular regarding recharging and refuelling standards and technologies, such as high-power recharging standards and electric road systems (ERS), and the use of liquid hydrogen. In relation to hydrogen refuelling stations, the report should analyse the extent to which the technical requirements referred to in Article 6 of Regulation (EU) 2023/1804 are in line with technological and market developments.

Accordingly, this report provides an analysis of the technology and market readiness of zero-emission heavy-duty vehicles, taking into account observed powertrain technological developments and market trends as well as corresponding recharging and refuelling infrastructure deployment since political agreement was reached on Regulation (EU) 2023/1804. The assessment presented in this report draws on information received from discussions in the Commission Sustainable Transport Forum expert group as well as an external support study[3] in which relevant market actors were also consulted.

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1 Regulation (EU) 2024/1610 of the European Parliament and of the Council of 14 May 2024 amending Regulation (EU) 2019/1242 as regards strengthening the CO_2 emission performance standards for new heavy-duty vehicles and integrating reporting obligations, amending Regulation (EU) 2018/858 and repealing Regulation (EU) 2018/956 (Text with EEA relevance), OJ L, 2024/1610, 6.6.2024, ELI: http://data.europa.eu/eli/reg/2024/1610/oj.

2 Regulation (EU) 2023/1804 of the European Parliament and of the Council of 13 September 2023 on the deployment of alternative fuels infrastructure, and repealing Directive 2014/94/EU (Text with EEA relevance),
OJ L 234, 22.9.2023, p. 1, ELI: http://data.europa.eu/eli/reg/2023/1804/oj.

3 Transport & Mobility Leuven, Ramboll & University of Antwerp, *Market Readiness Analysis: Expected uptake of alternative fuel heavy-duty vehicles until 2030 and their corresponding infrastructure needs*, European Commission Publications Office, 2025.

2 Regulatory background

In line with the EU's commitment to become climate-neutral by 2050, the revised CO_2 emission performance standards for new heavy-duty vehicles[4] set emission reductions targets for new lorries, city buses and coaches. A summary of the legally binding targets to be met by manufacturers for new registrations set in the amended CO_2 emission performance standards is presented in Table 1.

Scope	Target year	CO_2 emission reduction target compared to 2019 levels
Fleet wide new motor vehicles (lorries > 5 tonnes; buses and coaches > 7.5 tonnes)	2030	45%
	2035	65%
	2040	90%
Urban buses > 7.5 t (ZEV mandate)	2030	90% (ZEV mandate)
	2035	100% (ZEV mandate)

Table 1: Overview of the targets set in the revised HDV CO_2 standards

In order to meet the 2030 reduction targets[5], manufacturers will have to address almost all categories of vehicle, in particular almost all lorries of more than 16 tonnes, which account for 75% of HDV sales in the EU.

In order to ensure that the lack of publicly accessible recharging and hydrogen refuelling infrastructure does not create a bottleneck in the necessary market uptake of zero-emission heavy-duty vehicles, Regulation (EU) 2023/1804 sets mandatory deployment targets for dedicated infrastructure for heavy-duty vehicles. With initial electric recharging targets set for this year, 2025, and 2027, full coverage of the EU's main transport network (the TEN-T road network)[6] with dedicated recharging and hydrogen refuelling infrastructure is set to be achieved by 2030. This should allow zero-emission road vehicles to be used throughout the EU. A summary of the recharging and H_2 refuelling infrastructure requirements is presented in Table 2.

[4] Regulation (EU) 2019/1242 of the European Parliament and of the Council of 20 June 2019 setting CO2 emission performance standards for new heavy-duty vehicles and amending Regulations (EC) No 595/2009 and (EU) 2018/956 of the European Parliament and of the Council and Council Directive 96/53/EC, OJ L 198/202, 25.7.2019, p. 202, ELI: http://data.europa.eu/eli/reg/2019/1242/oj.

[5] Vocational and some smaller VECTO groups are not included in the CO_2 emission performance standards.

[6] Regulation (EU) 2024/1679 of the European Parliament and of the Council of 13 June 2024 on Union guidelines for the development of the trans-European transport network, amending Regulations (EU) 2021/1153 and (EU) No 913/2010 and repealing Regulation (EU) No 1315/2013 (Text with EEA relevance), OJ L 2024/1679, 28.6.2024, ELI: http://data.europa.eu/eli/reg/2024/1679/oj.

Target year	Scope	Minimum capacity requirements	Distance requirements
2030	TEN-T core	One dedicated HDV recharging pool with at least 3 600 kW of aggregated power output with at least two points of minimum 350 kW	Every 60 km in each direction of travel
		H_2 refuelling stations for cars and lorries with a minimum capacity of 1 tonne per day and equipped with at least a 700 bar dispenser	Every 200 km
	TEN-T comprehensive	One recharging pool with at least 1 500 kW of aggregated power with at least one point of min. 350 kW	Every 100 km in each direction of travel
	Urban nodes	Recharging points with a minimum of 150 kW each and with an aggregated power output of at least 1 800 kW	
		One hydrogen refuelling station for cars and lorries	
	Safe and secure parking	At least four recharging stations of at least 100 kW in all safe and secure parking areas	

Table 2: AFIR requirements for dedicated recharging infrastructure for HDVs by 31 December 2030

3 Assessment of market readiness of zero-emission heavy-duty vehicles

In 2023 a total of just below 6.7 million heavy-duty vehicles, such as lorries, city buses and long-distance coaches, were registered in the EU, around 6 million of which were lorries above 3.5 t[7]. In the same year, about 380 000 new HDVs were registered. Those vehicles are responsible for 28% of greenhouse gas (GHG) emissions from road transport in the EU and account for over 6% of total EU-27 GHG emissions[8].

Zero-emission heavy-duty vehicles are defined under the CO_2 emission performance standards for heavy-duty vehicles as vehicles without a combustion engine, or with a combustion engine emitting very little CO_2[9].

There are currently two groups of technologies that can meet these requirements: battery electric vehicles (BEVs) and hydrogen (H_2)-fuelled vehicles. Hydrogen-fuelled vehicles include both fuel cells (H_2 FCs) and internal combustion engines (H_2 ICEs). Figures for low-emission plug-in hybrid vehicles (PHEVs) – although they do not qualify as zero-emission vehicles – are also, where relevant, presented in this section, as they contribute to the demand for recharging infrastructure[10].

[7] https://www.acea.auto/files/ACEA_Report_-_Vehicles_on_European_roads_2025.pdf
[8] https://www.eea.europa.eu/data-and-maps/data/data-viewers/greenhouse-gases-viewer.
[9] No more than 3 g CO_2/(tkm) or 1 g CO_2/(pkm) as determined in accordance with Regulation (EU) 2017/2400, or no more than 1 g/kWh of CO_2 as determined in accordance with Regulation (EC) No 595/2009 or no more than 1 g/km of CO_2 as determined in accordance with Regulation (EC) No 715/2007.
[10] Other alternative powertrain and fuel technologies (LNG, CNG, biofuels, e-fuels) have not been part of the required focus of this report.

3.1 Status quo and latest market developments

Although the share of the overall HDV fleet accounted for by zero-emission vehicles is still very small, it has been growing quickly over the last few years, mainly due to growth in battery electric vehicles, models of which are now available for all use cases. In other words, vehicles with various ranges can be deployed for different types of services for both freight and passenger transport.

3.1.1 Lorries

At the end of 2024, the fleet of zero-emission lorries registered in the EU consisted of more than 15 000 battery electric lorries and 170 hydrogen lorries. Additionally, more than 300 low-emission plug-in hybrid lorries had been registered across the EU[11].

More than 7 500 battery electric lorries were newly registered during 2024, accounting for 2.3% of all registrations. Of the lorries registered in that period, only 106 were hydrogen lorries. The highest share of battery electric lorries reported was in the category of medium lorries with a technically permissible maximum laden mass exceeding 5 t but not exceeding 7.4 t (5.4% of total registrations)[12].

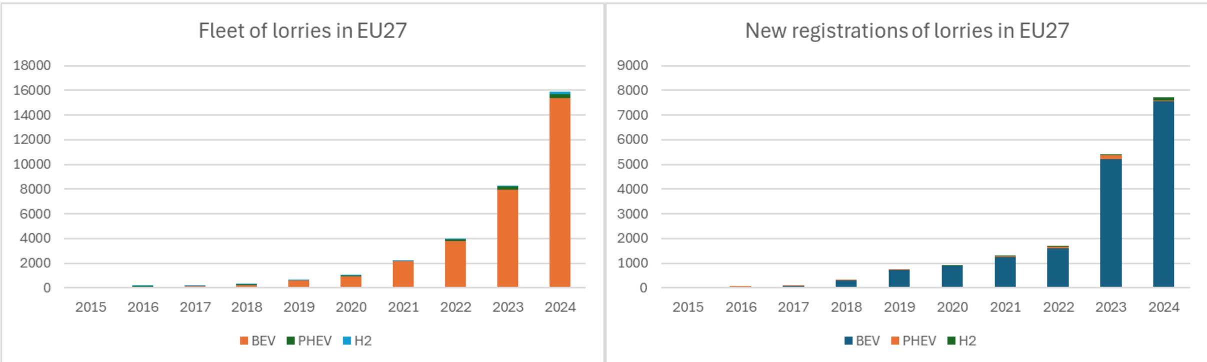

Figure 1: Lorry fleet and new registrations. Source: EAFO, end of 2024

3.1.2 Buses and coaches

Although zero-emission buses and coaches (M2 and M3 vehicles)[13] accounted for a significantly larger share, they were driven almost exclusively by the urban bus segment, whereas there are only a few zero-emission coaches in the market. The total stock of battery electric buses and coaches reached 23 000 in 2024 while the number of hydrogen buses and coaches was close to 500. Low-emission plug-in hybrid vehicles played a slightly bigger role

[11] Unless specified otherwise, all numbers used in this document are taken from the European Alternative Fuels Observatory (EAFO), www.eafo.eu.

[12] Transport & Mobility Leuven, Ramboll & University of Antwerp, *Market Readiness Analysis: Expected uptake of alternative fuel heavy-duty vehicles until 2030 and their corresponding infrastructure needs*, European Commission Publications Office, 2025.

[13] Annex II to Directive 2007/46/EC of the European Parliament and of the Council of 5 September 2007 establishing a framework for the approval of motor vehicles and their trailers, and of systems, components and separate technical units intended for such vehicles (Framework Directive) (Text with EEA relevance), OJ L 263, 9.10.2007, p. 1, ELI: http://data.europa.eu/eli/dir/2007/46/oj.

in the bus segment than in the lorry segment, with a vehicle stock reaching 1 000 vehicles at the end of 2024.

Approximately 6 600 new BEVs were sold in 2024, almost all of them urban buses. 18.4% of all buses and coaches – and 40% of all urban buses – newly registered in 2024 were BEVs. A total of 113 H_2 buses and coaches were registered over the same period.

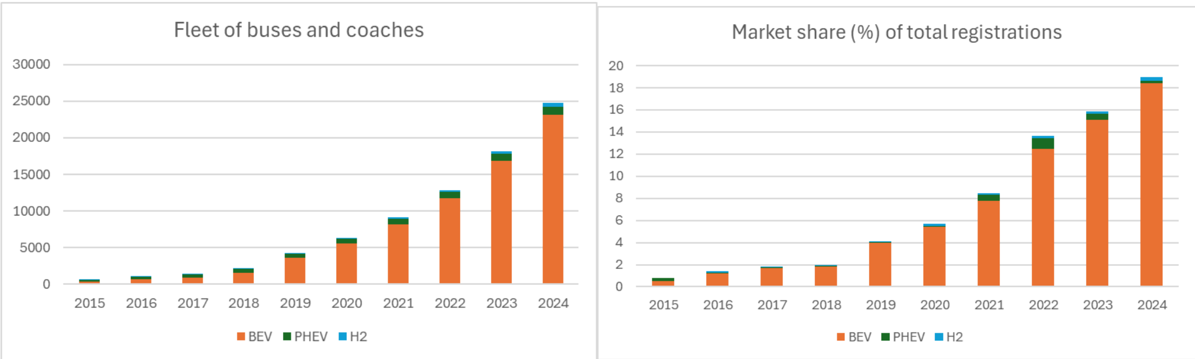

Figure 2: Fleet and market share of total registrations of buses and coaches. Source: EAFO, end of year 2024

3.2 Market availability of zero-emission vehicles

According to publicly available data and a survey carried out by the support study to this report, vehicle manufacturers, commonly referred to as original equipment manufacturers (OEMs), are developing and investing in a wide range of technologies and drivetrains to decarbonise their fleet. In terms of the number of models available on the market, however, battery electric vehicles are clearly the predominant investment choice of manufacturers. More than 100 models were available in 2024 compared to around 20 models of fuel cell electric vehicles (FCEVs) while first models of H_2 ICEs are entering the market in 2025 in small series production. In the market segments of lorries above 7.4 tonnes, there are around 40 heavy-duty BEV models and 6 FCEV models available. Medium lorries include around 15 BEV models and one FCEV model. The bus segment accounts for the largest part of the overall range of zero-emission models, with around 60 BEV bus models and around 15 FCEV bus models available. The range of zero-emission models in the coach segment remains limited, with three BEV models and one FCEV model currently available[14]. EU funded Research & Innovation has supported technological developments towards zero-emission HDV powertrains since FP7 with topics focused on both truck and buses, and more recently on HDV long-haul operations and megawatt charging system.[15]

[14] CALSTART, 'ZETI Data Explorer.' 2024. Accessed: 11 Sep. 2024. [Online]. Available: https://globaldrivetozero.org/tools/zeti-data-explorer/.

[15] As examples, see EGVI and 2Zero partnership projects ZeEUS, TRANSFORMERS, LONGRUN, AEROFLEX, NextETRUCK, ESCALADE, EMPOWER, ZEFES, EBRT2030, MACBETH, FLEXMCS; and FCH JU and Clean Hydrogen partnership projects StaSHH, CoacHyfied, H2Haul, H2Accelerate in https://cordis.europa.eu/

Investment planning published by all major OEMs shows that battery electric solutions are set to remain strongly predominant among zero-emission powertrains for heavy-duty road transport for at least the rest of the current decade. New models are announced for series production in all categories between 2025 and 2030, widening the range of models in the long-haul and interurban coach segments, in particular. Most vehicle manufacturers have, however, also announced future investment in hydrogen models for all segments. These include new hydrogen fuel cell vehicles and liquid hydrogen fuel cell solutions, but also vehicles powered by hydrogen combustion.

3.3 Availability and performance of current zero-emission technologies

Battery electric

BEV models are available for all use cases of passenger and freight transport services. Current battery electric city buses typically have ranges of around 300-400 km. Battery electric trucks for urban delivery typically have a range of around 100 km, while battery electric trucks for regional distribution have ranges of 300-400 km. Current battery electric long-haul trucks typically have a range of around 500 km, but demonstration tests have already reached ranges of up to 800 km and more. Most lorry transport services cover a distance of 600 km or less. These ranges already allow the operational needs of the vast majority of operators to be met, depending on the availability of recharging infrastructure and taking account of driving time rules and mandatory rest breaks. Battery electric long-haul truck models with ranges of 700-800 km are announced for serial production in 2025 and subsequent years.

From a total cost of ownership (TCO) perspective, battery electric vehicles are already able to compete with conventional vehicles in some use cases. This is the case for urban buses and urban delivery trucks, in particular. Their significantly higher purchase costs – which can be more than twice as high as those of a comparable combustion engine vehicle – still present a significant barrier to their adoption, however, especially by SMEs with limited access to finance.

The combined charging standard (CCS) is the charging technology currently available for recharging battery electric vehicles. The megawatt charging system (MCS) standard should be finalised and adopted by international standardisation organisations in 2025. The CCS is the direct-current (DC) charging standard currently applied to all DC charging of battery electric vehicles in the EU. The MCS standard enables much higher charging power of up to more than 1 MW[16] and additional safety features. Several OEMs and charging point operators indicate that they expect the MCS standard to fully replace the CCS over time, in both vehicle inlets and recharging infrastructure. In the long term, these stakeholders expect all new heavy-duty vehicles to be equipped with MCS inlets and the HDV charging market to develop fully towards the MCS, including for recharging points with a power of below 400 kW. It is not, however, clear how long this transition will take. At least in the short and medium terms, both the CCS

[16] Although the MCS standard will allow charging of up to 3 MW, such a high charging power is currently not considered necessary for road vehicles. Power output of up to 1 MW is considered sufficient to meet the needs for recharging during the mandatory rest times of drivers of such vehicles.

and the MCS are widely expected to coexist as standards for the recharging of battery electric vehicles.

Hydrogen

In general, hydrogen heavy-duty vehicles have longer driving ranges than most battery electric heavy-duty vehicles. One H_2 FC truck available in series production has a range of up to 800 km and one prototype is expected to reach a range of 1 000 km. Current FCEV urban buses have a range of around 400 km, which is comparable to similar BEV buses.

As stated in Section 3.2, there are currently far fewer hydrogen than battery electric HDVs on the market. Although there are, in general, more hydrogen vehicles in the bus segment than in the lorry segment, prices remain high and production capacity limited in all segments. Most existing vehicles are fuel cell vehicles that run on compressed hydrogen at either 350 or 700 bar. In order to increase range and reduce refuelling times, however, some manufacturers have said that they plan to develop HDVs running on liquid hydrogen. At the same time, some manufacturers have announced that they will produce hydrogen internal combustion vehicles. Although much less efficient than fuel cell vehicles, hydrogen internal combustion vehicles are cheaper to produce and the technology is considered easier to manage. The market uncertainty about technology choices for hydrogen vehicles has not decreased since political agreement was reached on Regulation (EU) 2023/1804. This continues to present problems to the deployment of corresponding refuelling infrastructure as the different technologies require different infrastructure configurations.

The initial purchase cost and operational costs of hydrogen fuel cell vehicles are at present much higher than both conventional vehicles and battery electric ones, resulting in a higher TCO under all use cases. Hydrogen internal combustion engine vehicles are expected to have lower purchase costs, but significantly higher operational costs, with the exact level depending on hydrogen production costs and market prices. Hydrogen vehicles may, however, be able to offer operational advantages that might make them preferable to BEVs in specific use cases, such as greater torque power, which is essential in the context of transporting very heavy goods.

Electric road systems (ERSs) and battery swapping

Electric road systems are designed to provide vehicles with electricity while in motion. This allows vehicles to have smaller batteries and reduces the need for stationary charging. There are at least three different ERS technologies: catenary systems, inductive charging and ground contact charging (e.g. through a rail). On the basis of pilot projects in various Member States (Germany, France, Italy, Sweden), the technology has been demonstrated but a broad use case is not expected in the short term. There are at present no concrete plans in Germany to expand the pilots, and the planned electric road procurement programme in Sweden was stopped since the technology-, investment-, operation- and maintenance-related risks were considered too high.

Furthermore, given the long planning and construction time required to cover even relatively short road segments, it would be impossible for this technology to cover more than a very small part of the European TEN-T road network – which extends over more than 100 000 km – in the short or medium term. The ERS is therefore not expected to make a significant contribution to the decarbonisation of HDV transport in Europe by 2030.

In China, battery swapping has gained momentum in heavy-duty vehicles, in particular, with major battery manufacturers investing in this technology. Battery swapping can have significant benefits: it facilitates the integration of battery electric vehicles into the electricity system by increasing flexibility, as charging the batteries requires less power from the electricity grid overall. Despite the existence of a standardisation mandate, European car manufacturers have not, however, shown any interest in the technology because of operational problems in swapping and vehicle design, with batteries often being fully integrated into the vehicle structure. Nor have European HDV manufacturers so far shown any interest in developing battery swapping for HDVs. Under the review of Regulation (EU) 2023/1804, the Commission will further examine this technology and the relevance and maturity of setting further common technical specifications in the EU.

3.4 Expected zero-emission fleet development

Manufacturers have stated publicly that they will both make use of a growing share of zero-emission vehicles and improve the energy efficiency of their conventional models in order to meet the 2025 and 2030 CO_2 emission performance standards for heavy-duty vehicles. In this context, manufacturers indicated, in the stakeholder consultation carried out under the support study, that approximately one in three new heavy-duty vehicles could be expected to be zero-emission by 2030.

Estimates from various sources indicate that by 2030 the zero-emission vehicle fleet will comprise in total between 410 000 and 600 000 vehicles (equivalent to between 5% and 9% of the HDV fleet). A clear majority of these will be battery electric vehicles: market development estimates vary from 65% to more than 90%, with most studies and recent analyses now seeing the market at the upper end of the range. Current market shares and announced zero-emission vehicle models therefore suggest that manufacturers will rely heavily on battery electric vehicles in order to reach their 2030 targets.

4 Infrastructure requirements

4.1 Current development of recharging and hydrogen refuelling infrastructure

Existing infrastructure

By the end of 2024, about 140 000 publicly accessible DC recharging points were deployed in the EU, of which more than 65 000 were between 150 kW and 350 kW and more than 16 000 above 350 kW. While most of that recharging infrastructure is designed to serve cars and vans, electric HDVs can also use it when the dimensions of the recharging point and the space surrounding it allow them to. This may be possible for smaller lorries, in particular, but not for most larger ones. Several manufactures have demonstrated that it is already possible to drive heavy battery electric trucks across the EU, although it requires a lot of flexibility in terms of charging and trailer parking, which is not conducive to real mass-market operation.

What is required for mass-market operation is a dedicated publicly accessible recharging infrastructure network for heavy-duty vehicles as envisaged by Regulation (EU) 2023/1804. Although no such network currently exists, the situation is expected to change quickly in the coming years. A large number of recharging infrastructure installation projects have already started or are about to start, many of them assisted by the Alternative Fuels Infrastructure Facility (AFIF) under the Connecting Europe Facility (CEF)[17] (see next section), while others with the help of public funding by the respective Member State and under the applicable State aid laws[18].

By the end of 2024, more than 250 hydrogen stations, serving a total of 4 700 cars, 320 vans, 140 lorries and 320 buses, had been deployed in the EU. The existing H_2 refuelling infrastructure is broadly sufficient for the current H_2 HDV vehicle fleet. Current market trends and the latest time frames announced for the series production of new H_2 vehicle models by OEMs indicate that before 2030 the number of hydrogen heavy-duty vehicles on the market is unlikely to reach a level that would require significantly higher capacity than already provided for under Regulation (EU) 2023/1804 to ensure network coverage. Limited vehicle availability and lack of availability and affordability of hydrogen – rather than infrastructure deployment – are currently the main obstacles to market uptake of hydrogen fuelled road transport vehicles.

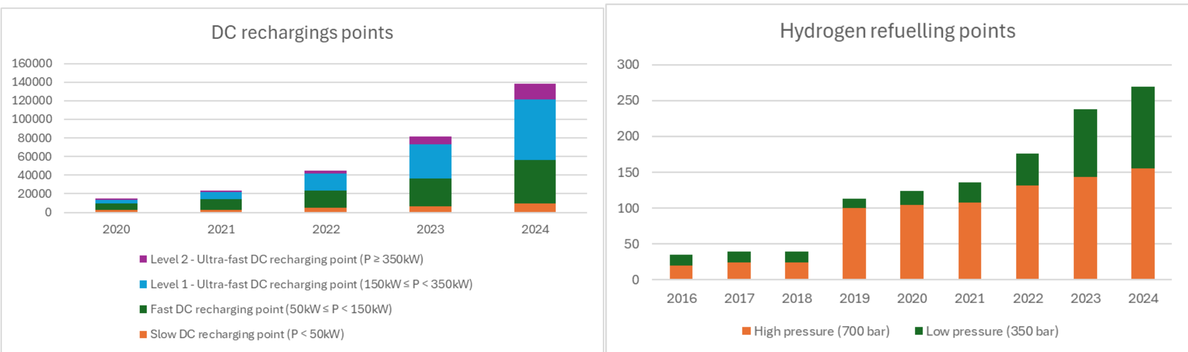

Figure 3: Existing DC recharging and hydrogen refuelling infrastructure. Source: EAFO, end of 2024

Short-term trends and EU support

In response to the CO_2 emission performance standards for heavy-duty vehicles and the requirements for dedicated recharging infrastructure under Regulation (EU) 2023/1804, a range of different companies are investing in both dedicated truck recharging and hydrogen refuelling

17 Regulation (EU) 2021/1153 of the European Parliament and of the Council of 7 July 2021 establishing the Connecting Europe Facility and repealing Regulations (EU) No 1316/2013 and (EU) No 283/2014 (Text with EEA relevance), OJ L 249, 14.7.2021, p. 38, ELI: http://data.europa.eu/eli/reg/2021/1153/oj.

18 The relevant State aid instruments, most commonly used to assess compatibility of investments in charging infrastructure, are the Guidelines on State aid for climate, environmental protection and energy 2022, C/2022/481, *OJ C 80, 18.2.2022, p. 1–89,* Section 4.3; as well as the Green Deal General Block Exemption Regulation, Regulation (EU) No 651/2014 of 17 June 2014 declaring certain categories of aid compatible with the internal market in application of Articles 107 and 108 of the Treaty, Articles 36a and 36b.

infrastructure. Under the AFIF, the European Commission supports the deployment of this infrastructure[19].

Under the second (2024-2025) phase, AFIF support is specifically targeted at high-power recharging for battery electric trucks. Under the first cut-off date, there was particularly great interest in investments in electric recharging infrastructure dedicated to HDVs. It is expected that grant agreements will be signed for up to 2 070 recharging points (up to 1 540 points of 350 kW and up to 530 of at least 1 MW) at around 600 locations in 17 Member States. This represents around 20% of locations and around 15% of the aggregated power output required under Regulation (EU) 2023/1804 by 2030. There will be two further cut-off dates under the second AFIF call. Many Member States have started national programmes to support industry in building up the required dedicated HDV recharging infrastructure. This dedicated infrastructure will supplement more than 2 000 existing fast recharging points of at least 360 kW financed under the first phase of the AFIF. This could support smaller lorries, in particular. The AFIF is already supporting the deployment of 178 hydrogen refuelling stations across the EU under the first (2022–2024) phase, with around an additional 30 to be financed under the first cut-off date of the second phase.

While industry interest in investing in recharging infrastructure is growing, many projects at present face delays because of lengthy permission and grid connection procedures. In fact, both the support study and stakeholder consultations indicate that the primary barrier to deploying a widespread charging network for heavy-duty vehicles is access to the electricity grid, not the cost of deploying the recharging infrastructure. In order to accelerate the deployment of zero-emission heavy-duty vehicles, it will be crucial to prepare electricity grids for increased demand at charging hubs and depots by strengthening the grid and addressing permission processes to reduce lead times for grid connections. It will also be important to make plans to enable recharging sites to meet the requirements for recharging points and pools laid down in Regulation (EU) 2023/1804, including safe and secure parking areas for trucks. The need for accelerating permitting procedures and provisions for specific grid priority areas will be addressed as part of the pilot European Transport Corridor initiative developed under the Competitiveness Coordination Tool, as announced in the Industrial Action Plan for the European automotive sector[20].

4.2 Recharging infrastructure needs up to 2030

According to all market actors and the information gathered through the support study for this report, battery electric HDVs will rely on a combination of depot charging, using primarily 100-

[19] Article 9 of Regulation (EU) 2021/1153 of the European Parliament and of the Council of 7 July 2021 establishing the Connecting Europe Facility and repealing Regulations (EU) No 1316/2013 and (EU) No 283/2014 (Text with EEA relevance), OJ L 249, 14.7.2021, p. 38, ELI: http://data.europa.eu/eli/reg/2021/1153/oj.

[20] Communication from the Commission to the European Parliament, the Council, European Economic and Social Committee and the Committee of Regions of 5 March 2025. Industrial Action Plan for the European automotive sector, COM(2025) 95 final. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:52025DC0095

150 kW chargers, and publicly accessible high-power charging of likely up to 1 MW and overnight charging at around 100 kW. Operators will maximise the share of depot charging wherever possible, because of lower cost per kWh.

Depending on their operational needs, different use cases will result in different charging strategies and different shares of depot and public charging. Urban delivery trucks will typically charge overnight at the depot and may not need to charge during the day. Similarly, urban buses will rely almost exclusively on private recharging at the depot or scheduled private opportunity charging en route. Regional delivery trucks will typically charge overnight but may need an additional recharge during their journey, which can be either during a scheduled stop at a warehouse or at a publicly accessible recharging point en route. On the other hand, long-haul HDVs (trucks and coaches), which travel beyond the range of depot-based charging, will regularly make use of recharging en route. They will require a publicly accessible recharging network with high-power chargers allowing drivers to recharge their vehicle during their mandatory rest times, or overnight in the case of multiple-day itineraries.

Regulation (EU) 2023/1804 sets mandatory targets for complete EU-wide coverage of recharging infrastructure along the TEN-T road network – for both high-power recharging and overnight recharging at safe and secure parking areas – and in urban nodes. Those targets are meant to provide only basic infrastructure along the EU's main transport network, while additional infrastructure is expected to develop through market forces where additional demand exists. According to the analysis carried out under the support study, dedicated HDV recharging stations mandated should be sufficient to meet at least 47% of the total energy demand for publicly accessible recharging by the electric HDV fleet expected in 2030. The exact share will be highly dependent on a number of factors, including the share of long-distance battery electric trucks, their driving patterns and the possibility of charging at the depot.

4.3 Hydrogen refuelling infrastructure needs up to 2030

Unlike electric vehicles, hydrogen vehicles will rely largely on publicly accessible refuelling for all use cases. The costs of installing and operating hydrogen refuelling infrastructure and related safety requirements are prohibitively high for private infrastructure operation.

Regulation (EU) 2023/1804 requires hydrogen refuelling stations to be deployed every 200 km along the TEN-T core network to support long-haul transport and in urban nodes for destination refuelling. According to the analysis carried out under the support study, those hydrogen refuelling stations should, depending on the availability of private refuelling and the technology chosen for the vehicles, by 2030 supply at least 48% of the total demanded from publicly accessible infrastructure. There are, however, further technological complications since the market is, as stated in Section 3.3, not currently converging towards a single approach to refuelling technology. Moreover, the specification of the capacity of refuelling stations – currently set at 1 t/day for refuelling stations along the TEN-T road network – may need to be further adjusted in order to take account of the need for fast back-to-back refuelling. The Commission will continue to work with stakeholders on those technical aspects under the Sustainable Transport Forum.

There are still great uncertainties regarding the uptake of hydrogen heavy-duty vehicles and the technology choices and technical requirements that it will impose on the refuelling infrastructure. Given that Article 24(1) of Regulation (EU) 2023/1804 requires an assessment of whether it is relevant to extend the scope of targets, it appears premature, at this stage of market development, to further widen the scope of mandatory requirements under that Regulation to infrastructure for liquid hydrogen or other new technologies. It seems equally premature – given the slow uptake of hydrogen heavy-duty vehicles and the limited overall availability of hydrogen vehicle models in series production – to broaden the scope of hydrogen refuelling infrastructure targets to the TEN-T comprehensive network. Further observation of market development is needed in order to draw any conclusions regarding further policy needs. This will be addressed in the review of Regulation (EU) 2023/1804.

5 Conclusions

The vehicle market analysis highlights that the transition to zero-emission heavy-duty vehicles is progressing rapidly, though challenges remain. To reach the 2030 targets under the CO_2 emission performance standards for heavy-duty vehicles, manufacturers expect by 2030 to put one in three new zero-emission lorries on the market across all segments. Even though prices of zero-emission heavy-duty vehicles are expected to fall in the coming years and TCO will become significantly more favourable, this would be a sharp market increase in a very short period of time in a market characterised by small profit margins and many SME operators with limited capital to invest and a very small share of zero-emission vehicles in 2025. At the end of 2024, the share of zero-emission vehicles in new sales in the EU was 2.09%, almost all of them battery electric vehicles. Facilitating this market ramp-up will require extended support for the deployment of recharging infrastructure and grid modernisation.

Current developments show marked differences in terms of technological maturity and market investment between battery electric technology, on the one hand, and hydrogen fuel cell and combustion technologies, on the other. Current market shares and announced vehicle models indicate that the contribution of H_2 FCs and H_2 ICEs to emission reductions by 2030 will be limited and that OEMs will rely mostly on BEVs for reaching their 2030 targets. Estimates from various sources indicate that by 2030 the zero-emission HDV fleet in the EU will comprise in total between 410 000 and 600 000 vehicles. A clear majority of these will be battery electric vehicles, which are expected to make up around 90% of the zero-emission HDV fleet.

The overall targets laid down in Regulation (EU) 2023/1804 will lead to EU-wide coverage of dedicated HDV recharging and hydrogen refuelling infrastructure along the TEN-T core – and, in the case of electric recharging, the TEN-T comprehensive – road network as well as in urban nodes. Significant investments will have to be made in the next five years in order to meet those targets. The targets are, however, set to provide basic infrastructure along the EU's main transport network. Additional demand – especially along heavily used network segments – will require additional infrastructure, which will be delivered by the markets. According to the analysis carried out under the support study, the requirements under Regulation (EU) 2023/1804 are, however, estimated already to supply almost 50% of the publicly accessible infrastructure demanded by 2030. This provides a solid basis for further market-driven investments.

At the end of 2024, more than 16 000 publicly accessible recharging points above 350 kW are already deployed. Only a small portion of them is dedicated and fully accessible to HDVs. Nevertheless, a wide range of companies have made significant investment plans and, under the first AFIF call, up to 2 070 dedicated recharging points are being funded under the first AFIF cut-off date. As regards technology choices, it is expected that the CCS and the MCS will coexist, at least in the coming years. It remains to be seen if the sector will converge towards the MCS for all recharging in the future. The primary barriers to battery electric HDV adoption are high TCO and limited coverage of publicly accessible recharging infrastructure in relation to the number of vehicles expected on the road by 2030. The roll-out of dedicated recharging infrastructure will have to be sped up considerably, in accordance with Regulation (EU) 2023/1804, between now and 2030. The main obstacles to this necessary deployment of additional recharging infrastructure are limited grid hosting capacity and deficiencies in related administrative grid connection procedures. Grid capacity constraints present the main bottleneck to unlocking recharging infrastructure development, as they limit the potential size of charging locations, directly affecting the deployment rate of recharging stations along key transport corridors. Grid capacity constraints not only hinder the deployment of publicly accessible infrastructure. They may also affect the deployment of private recharging at depots. Bi-directional charging might be of help in this context, but economic and regulatory hurdles still prevail.

There are already 270 hydrogen refuelling stations operational in the EU: more than enough for the approximately 500 hydrogen HDVs and 5 000 hydrogen cars registered in the EU. Vehicle availability as well as availability and cost of hydrogen, rather than infrastructure deployment, presents the main bottleneck to hydrogen use in road transport, and uncertainty about vehicle uptake and technology choices makes investments in hydrogen refuelling risky. Various hydrogen vehicle technologies are being developed, and there is currently no clear market convergence across manufacturers. This raises questions about future refuelling requirements and the technologies that should be available at publicly accessible refuelling points (700 bar, 350 bar, liquid hydrogen). The costs of deploying parallel hydrogen refuelling infrastructure for these various technologies would be very high, and subject to significant risk of stranded assets. In light of the limited availability of models expected by 2030, the very high vehicle costs and uncertainty about hydrogen pricing and technologies, the required pace of hydrogen infrastructure deployment is not expected to speed up significantly between now and then.

Although some ERS pilot projects have been concluded, the most developed initiatives highlighted the high investment, operational and maintenance risks, calling into question the overall economic viability of the technology at this stage. Furthermore, the long planning and construction time required to cover even relatively short road segments means that it would be impossible to cover more than a very small part of the European TEN-T road network in the short or medium term. ERSs are therefore not expected to provide a solution for the decarbonisation of HDV transport in the EU by 2030. Furthermore, in China investments are being made in battery swapping, and it appears relevant for industry to determine whether that technology will play a role in HDVs in the EU in the future. Pursuing such an approach to technology would, however, require broad alignment between vehicle manufacturers.