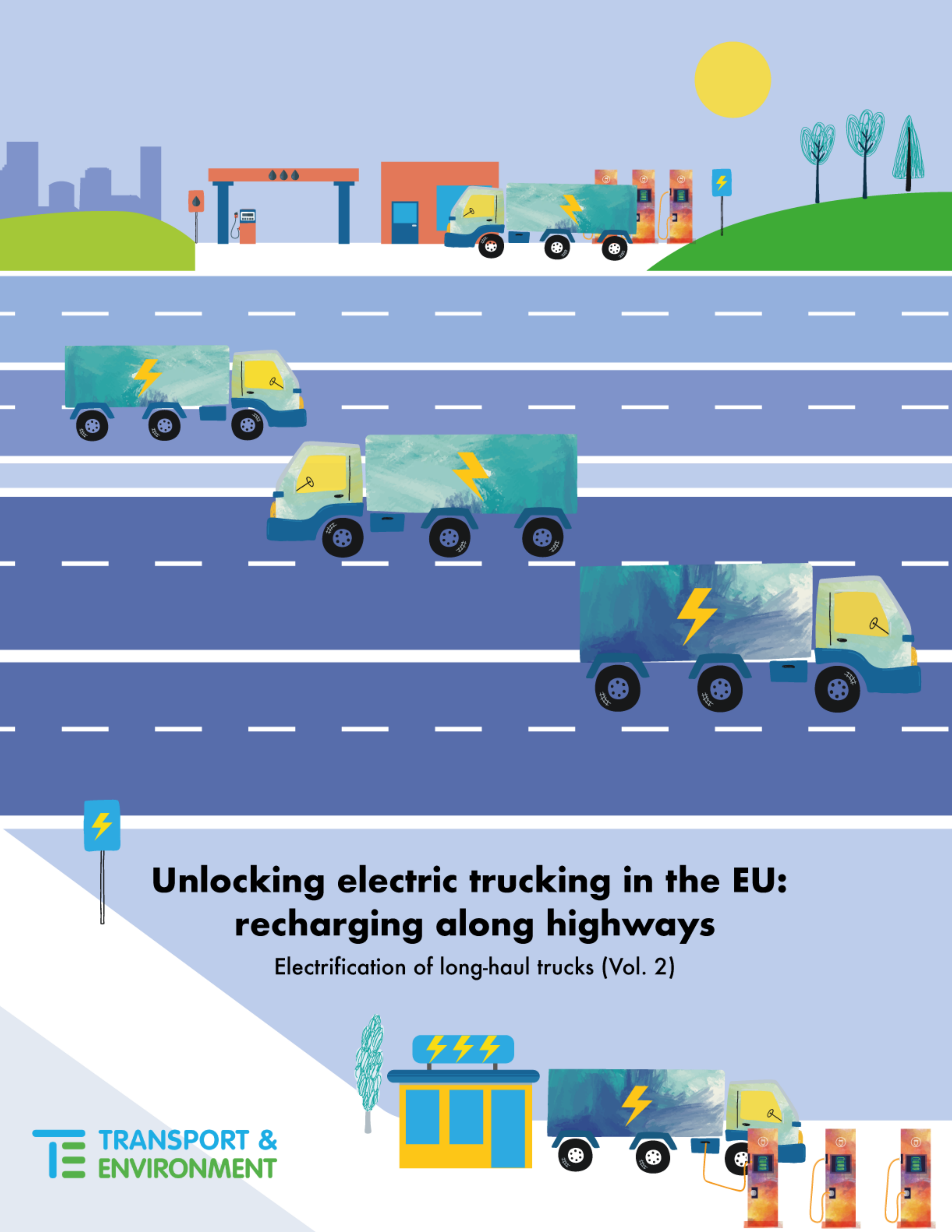

Unlocking electric trucking in the EU: recharging along highways

Electrification of long-haul trucks (Vol. 2)

TRANSPORT & ENVIRONMENT

Transport & Environment

Published: April 2021
In house analysis by Transport & Environment

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To cite this study:

Transport & Environment (2021). *Unlocking Electric Trucking in the EU: long-haul trucks*

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Acknowledgements

The authors kindly acknowledge the external peer reviews by Dr. Patrick Plötz and Steffen Link from Fraunhofer ISI, and other external reviewers who gave valuable feedback. The findings and views put forward in this publication are the sole responsibility of the authors listed above. The same applies to any potential factual errors or methodological flaws.

Executive Summary

The potential of battery electric heavy-duty trucks to mitigate climate change and reduce air pollution is commonly underestimated. This is especially true for the current European policy frameworks, notably the EU Smart and Sustainable Mobility Strategy, which is extremely shy on its ambitions for zero emission trucks (80,000 vehicles on the road in 2030). While most of the urban and regional delivery applications could already be covered by battery electric trucks today, long-haul battery electric trucks are only a few years behind. Just as the European Commission is preparing its climate law package of the generation, this report shows that most long-haul road freight can be directly electrified and explains what's needed to do so.

Trips over more than 400 km make about 5% of all trips in Europe but represent 40% of the EU's total truck activity (in tonne-km or tkm) and are estimated to account for 20% of trucks' emissions. Battery electric trucks with ranges beyond 400 km will come to the market before mid of the decade and are likely to represent the most cost-competitive option, and hence the dominant pathway, to decarbonise long-haul trips. Hydrogen fuel cell trucks will be offered by some truck makers only in the second half of the 2020s, and can be expected to play a role at ports and industrial clusters where they can benefit from synergies with other hydrogen applications.

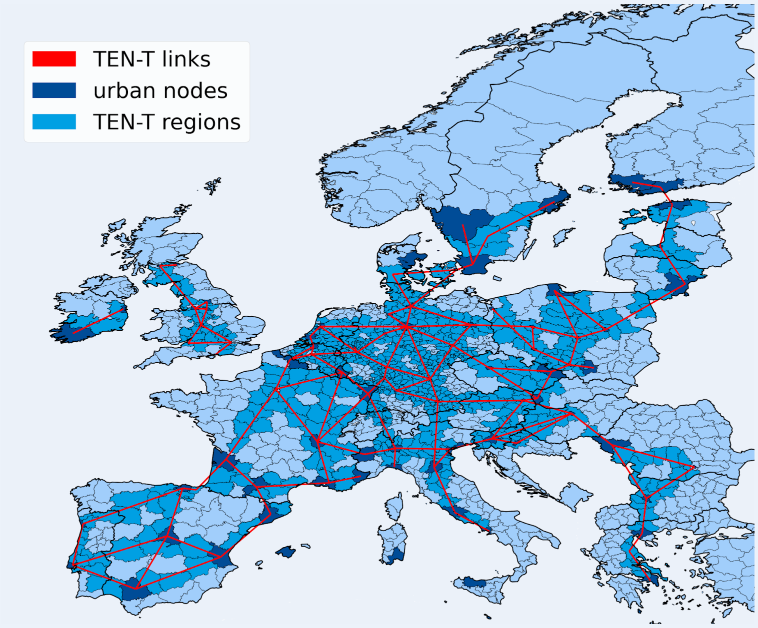
The report provides a quantitative analysis of how much charging infrastructure for electric trucks will be required in the next decade to electrify main highway corridors based on European truck traffic flows.

Findings

Based on a novel methodology, this report shows that electric truck adoption and deployment of the associated charging infrastructure should be prioritised alongside Europe's largest highway corridors - e.g. between Hamburg and Berlin. The analysis finds that targeting the core network of the Trans-European Transport Network (TEN-T) is the optimal strategy for the coming decade to achieve zero-emission long-haul road freight. In particular, deployment of truck charging infrastructure should start from the regions identified here as 'TEN-T regions':

- These regions are 'hotspots' for long-haul freight activity as they connect all major urban areas in Europe.
- Trips coming to or from one of these regions make up 80% of the total EU road freight activity (tkm) and 88% of the total long-haul activity.

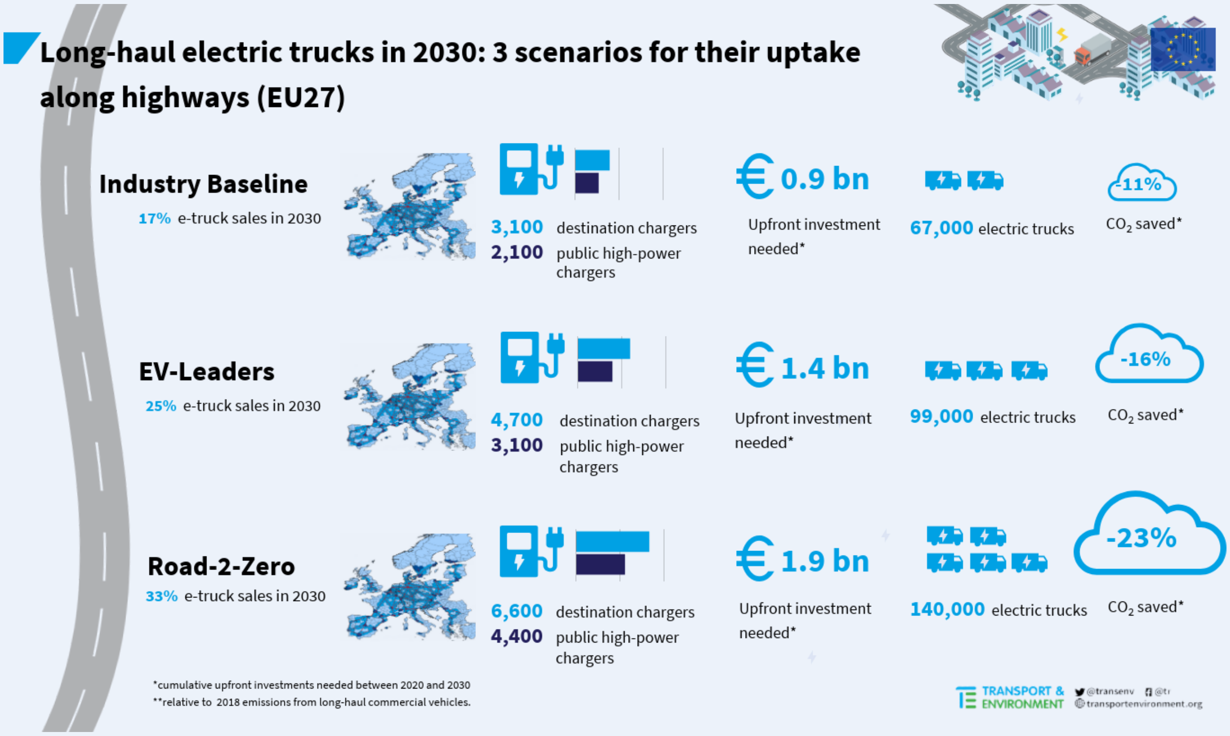
Based on OEMs' announcements, three scenarios for battery electric truck uptake have been considered: the Baseline scenario based on existing zero-emission truck targets from truck makers; the EV-Leaders scenario which assumes the market follows the leading truck makers; and the Road-2-Zero scenario: T&E's scenario compliant with mid-century climate neutrality.



T&E's approximated TEN-T network used in this study

Prioritising charging infrastructure roll-out at the 25,000 km of main TEN-T's corridors is demonstrated to be an effective strategy in which electric trucks cover 12%, 18% and 25% of the total long-haul road freight activity in 2030 respectively in the Baseline, EV-Leaders and Road-2-Zero scenarios. As a result, CO_2 emissions from long-haul road freight would be reduced by 11%, 16% and up to 23% in 2030.

T&E calculates that in 2030 there should be a total of 4,400 high-power public chargers in the EU27 and 6,600 destination chargers (at the distribution center) in the scenario compatible with climate neutrality. This translates into a need of about one public charger for every 35 electric trucks and one destination charger for every 21 electric trucks. Total cumulative upfront investments in destination and public high-power chargers would amount to €1.9 billion over the next decade, or an average annual investment of €190 million, which is only 0.2% of the annual EU €100 billion investment in transport infrastructure.



Long-haul electric trucks in 2030: 3 scenarios for their uptake along highways (EU27)

Industry Baseline
17% e-truck sales in 2030
3,100 destination chargers
2,100 public high-power chargers
€ 0.9 bn Upfront investment needed*
67,000 electric trucks
-11% CO$_2$ saved*

EV-Leaders
25% e-truck sales in 2030
4,700 destination chargers
3,100 public high-power chargers
€ 1.4 bn Upfront investment needed*
99,000 electric trucks
-16% CO$_2$ saved*

Road-2-Zero
33% e-truck sales in 2030
6,600 destination chargers
4,400 public high-power chargers
€ 1.9 bn Upfront investment needed*
140,000 electric trucks
-23% CO$_2$ saved*

*cumulative upfront investments needed between 2020 and 2030
**relative to 2018 emissions from long-haul commercial vehicles.

Combined results from T&E's urban, regional and long-haul truck analyses

When combining all truck trips (urban, regional and long haul), T&E scenarios indicate between 236,000 and 617,000 battery electric trucks on EU27 roads in 2030. These trucks will need up to 31,400 destination chargers and 17,400 public chargers, cumulating €23 billion upfront investments between 2020 and 2030. Finally, both short- and long-haul electric trucks will avoid up to 59 MtCO$_2$ emissions in 2030, representing a 32% reduction compared to current heavy-duty trucks emissions in the EU27.

EU27 - 2030	Industry-Baseline	EV-Leaders	Road-2-Zero
Battery electric trucks	236,000	389,000	617,000
Public HPC*	6,700	11,000	17,400
Destination chargers + Public HPC	18,700	30,800	48,900
BET** / Public HPC	35	35	35
BET / Destination + HPC	12.6	12.6	12.6

Source: T&E analysis, data from the ETIS Plus project and Eurostat
* High power chargers, ** battery electric trucks

Recommendations

With the right policy and charging infrastructure deployment, road freight can be decarbonised to a great extent in the 2020s. To achieve this, a number of legislative and policy changes will be necessary to accelerate both the supply of electric trucks and the deployment of charging infrastructure at the depot (overnight charging), at the distribution center (destination charging or semi-public charging) and at publicly accessible locations (public charging). Policymakers should start this today and bring about a comprehensive strategy to rapidly electrify all deliveries.

First, **the revision of the Alternative Fuels Infrastructure Directive** (AFID), planned for June 2021 as part of the EU Green Deal, should finally cover electric trucks and recognise direct electrification as the dominant pathway to decarbonise urban, regional and long-haul deliveries. The **AFI Directive should be turned into a Zero Emission Infrastructure Regulation (ZEIR)**, **focusing exclusively on electricity and green hydrogen**:

- Moving from 'alternative fuels' to 'zero emissions' effectively removes natural gas from the scope of the 'alternative fuels' that currently get preferential EU treatment and funding.
- An EU regulation, rather than a directive, is essential to ensure a harmonised framework and implementation across the EU and a swift adoption.

The new ZEI Regulation should set the following targets for electric truck charging to ensure the minimum and essential coverage of the road network:

- **Urban areas:** binding targets for public charger roll-out at urban nodes with a minimum of four public chargers per urban node in 2025, increasing to ten public charge points in 2030 (at least 350 kW).
- **Destination charging:** all medium and large logistics hubs should have at least one opportunity charger (350 kW or higher) from 2025.
- **Highway**: at least one public charging station with a minimum of 4 charging points every 100 km of the TEN-T Core network by 2025 and at least one every 50 km by 2030. These should be equipped with high power chargers (HPC) with at least 700-800 kW.

Overall the revised AFID should aim at a total of **around 10,000 public and destination chargers in 2025** (EU27) increasing to **40,000-50,000 public and destination chargers in 2030**. To ensure these targets are effectively reached, the EU should set minimum binding targets per Member State.

The revised AFID should recognise that grid preparation is key for the future roll out of truck charging infrastructure and ensure that **charging locations** (public parking and distribution centers) **are prepared with sufficient grid connections as early as possible**. Moreover, the EU should ensure that when a truck parking site is built or renovated under the Safe and Secure Truck Parking Areas framework, the grid connection is sufficient for the future truck charging demand.

With regard to the deployment of refuelling infrastructure for hydrogen trucks, it is crucial to follow the hydrogen truck market, to ensure investment is balanced to the actual needs of the fleet. Sea ports should be prioritised for initial pilot projects, and should be targeted under the revision of the AFID. Ports and industrial clusters represent a no-regret starting point to roll out hydrogen refuelling stations for trucks as this will create synergy effects with hydrogen's future application in the shipping and industry sectors. Sea ports will also serve as major landing terminals for hydrogen imports from offshore or overseas production sites.

Second, the **revision of the TEN-T Regulation**, which is set to take place in parallel of the AFID revision, should double the number of TEN-T urban nodes (from 88 today) with another set of complementary ‘freight’ nodes and clearly identify the main TEN-T Core networks where deployment of truck charging should be prioritised. The revision should also strengthen the ‘low carbon urban delivery’ requirement at urban nodes to make them EU’s leaders for zero emission mobility. This should be complemented with a strategy from **local and national authorities** to set a clear path towards zero-emission freight deliveries by extending vehicle **zero emission zones to freight** and engage the transition with the various stakeholders.

The future of trucks is electric. The EU stands a chance to become a world leader in the transition to zero-emission road freight. With the revision of the AFID, it can enable electric trucking to become the new norm in Europe, staying on track with its Green Deal ambition.

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Abbreviations

AFID	Alternative Fuels Infrastructure Directive
BET	Battery Electric Truck
GVW	Gross Vehicle Weight
HDV	Heavy Duty Vehicle
HPC	High Power Charging
MCS	Megawatt Charging System
OEM	Original Equipment Manufacturer
TEN-T	TransEuropean Transport Network
TTW	Tank-to-Wheel
WTW	Well-to-Wheel
ZEV	Zero-Emissions Vehicle

Introduction

While heavy-duty trucks account for less than 2% of the vehicles on the road in Europe [1], they represented 22% of CO_2 emissions from road transport in 2019 [2] and their emissions are growing fast (+9% between 2014 and 2019). The EU CO_2 emission reduction targets for new heavy duty vehicles will drive the electrification of new vehicles and will open new opportunities for the EU's industry. Major European truck-makers have already committed to sell 100% fossil-free trucks by 2040 [3] and some of them have ambitious electric truck sales targets for the next decade.

In February 2020, T&E published a roadmap for electric truck charging [4] which outlines a policy strategy for the EU to decarbonise the road freight sector and bring it in line with the EU's Green Deal commitments. Following this roadmap, T&E published the first volume of the *Unlocking electric trucking in the EU* series (hereinafter referred to as Vol. 1) [5], focusing on urban and regional electric trucking, analysing charging infrastructure requirements based on in-house modelling of European truck flows.

In this report, we carry out a similar quantitative analysis as done in Vol. 1 but with a focus on long-haul truck flows[1]. The objective of this study is to provide analytical evidence on how much charging infrastructure is needed in the EU to support the deployment of long-haul electric trucks up to 2035. The analysis focuses on the Trans-European Transport Network (TEN-T) core network [6] where most road freight is taking place across the EU. This new evidence shall contribute to creating a better understanding of what can be expected in the next decade with regards to the uptake of electric heavy-duty vehicles as well as providing a solid basis for future policy and regulation, in particular for the revision of the Alternative Fuels Infrastructure Directive (AFID) [7] in 2021.

Section 1 of this report gives a brief summary of the main findings from Vol. 1 and provides an overview of T&E's roadmap for electric truck adoption in the EU. Section 2 investigates long-haul truck flows across the TEN-T network while Section 3 presents three scenarios for battery electric truck adoption, based on OEM's new announcements. Section 4 describes the outcome of the analysis and assesses the impact of the electrification of long-haul trips in terms of energy requirements, charging infrastructure and CO_2 emissions avoided. Section 5 details T&E's views on potential roles for hydrogen in decarbonizing road freight. Finally, Section 6 lays out T&E's policy recommendations to accelerate the deployment of electric heavy-duty vehicles charging infrastructure, focusing on the revision of the Alternative Fuels Infrastructure Directive.

As for Vol. 1, this study is based on a database of European freight movements which is the result of the ETIS Plus project [8], a European Commission DG MOVE research project. **This analysis has been conducted for EU27+UK+NO+CH road freight movements. We provide EU27 specific figures only**

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[1] Long-haul trips are defined in this study as trips above 400 km.

in the policy recommendations section. For more details on the database, the methodology and the modelling of this project, please see the separate methodology note [9].

1. Roadmap for e-truck charging

1.1. Urban and regional deliveries: a low hanging fruit

As modelled and analysed in Vol. 1 [5], battery electric trucks are the most promising solutions to decarbonise urban and regional deliveries. Half of the EU's total truck activity (in tonne-kilometres, or tkm) is driven over distances of less than 300 km. These trips could be covered by battery electric trucks coming to market today, thanks to new models coming to the market with about 300 km range (enough to cover nine trips out of ten). But limited supply and the lack of charging infrastructure currently slows down the uptake.

This analysis found that targeting charging infrastructure deployment in the EU's largest urban areas is essential for the uptake of battery electric trucks in the next few years. Based on a novel methodology, the report showed that the roll-out of battery electric trucks and the associated charging infrastructure should be prioritised in 173 medium and large urban areas in the EU, so-called 'urban nodes'. These urban nodes combine three factors that justify their prioritisation:

- They are 'hotspots' for freight activity: trips coming to or from the urban nodes make up half of the total EU freight activity (tkm) and 39% of trips[2].
- Trips include a large share of short trips: 15% of total freight activity occurs within urban nodes

Finally, this report demonstrates that prioritising charging infrastructure roll-out at the 173 urban nodes could be a cost-effective strategy in which electric trucks cover 9%, 14% and 24% of the total EU road freight activity in 2030 respectively in the Industry-Baseline, EV-Leaders and Road-2-Zero scenarios (or 16%, 30% and 43% of the trips). As a result, CO_2 emissions from road freight would be reduced by 8%, 13% and up to 22% in 2030.

1.2. Long-haul trucks: the next milestone

All truck makers are starting to offer battery electric trucks with up to 300 km range in the long-haul vehicle segment (typically above 26 tonnes gross vehicle weight, GVW) and most have committed to battery electric vehicles as the future for urban and regional deliveries but also for the long-haul segment. As shown in Figure 1, it is expected that the range of the battery electric trucks available will

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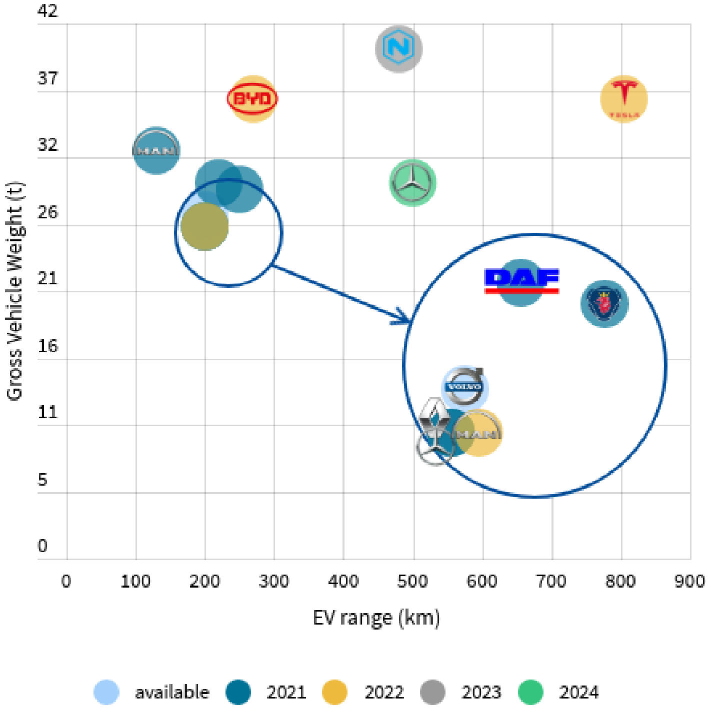
[2] Trips are defined as tonnes transported divided by the average truck payload (the payload considered was 10 tonnes per truck for Vol. 1 and will be 12.5 tonnes per truck for this study)

increase to 500 km in the coming years, covering about two thirds of kilometers and 19 trips out of 20; and then include the tractor-trailer segment (40/44 tonnes GVW).



Source: T&E analysis, data from ICCT and OEMs

*all years presented are years of starting series production for Europe

Figure 1: Battery electric truck models above 25 tonnes GVW expected in the coming years

The recent announcement of ACEA to only sell fossil-free trucks by 2040 [3] as well as recent individual truck manufacturer announcements like Scania [10], MAN[3] [11] and Renault [12] will deliver even more zero-emission trucks on the roads in the next decade. Furthermore, new manufacturers are coming to the market, such as Nikola Motors which announced they will start producing the first long-haul battery electric truck in Europe starting in 2021 in a joint venture with Iveco (range up to 480 km) [13] or Tesla's semi truck which is expected to be launched in 2022 with an 800 km range [14]. Table 1 gives an overview of the announced battery electric models in the long haul segment.

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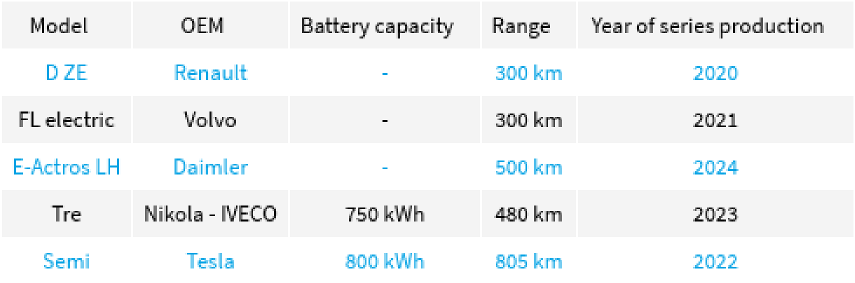
[3] MAN announced that 40% of long-haul trucks and 60% urban and regional delivery vehicles will be zero-emission in 2030 when Scania aims at 50% of its sales to be battery-electric in 2030.



Model	OEM	Battery capacity	Range	Year of series production
D ZE	Renault	-	300 km	2020
FL electric	Volvo	-	300 km	2021
E-Actros LH	Daimler	-	500 km	2024
Tre	Nikola - IVECO	750 kWh	480 km	2023
Semi	Tesla	800 kWh	805 km	2022

Table 1: Battery electric models with a range above 300 km expected before 2025

2. Analysis of long-haul truck flows

2.1. Overview of the database

As for the first volume of this series, this report is built on the analysis of European road freight movements that was the result of the ETIS Plus project [8] (see Info box). As the ETIS Plus project was calibrated with 2010 data, T&E updated the freight volumes and trip lengths based on Eurostat data [15], to the year 2018. The methodology [9] that accompanies Vol. 1 describes in greater detail how the calibration was undertaken, the data treatment utilised, and the scope of analysis.

ETIS Plus database: a brief overview

ETIS Plus was a research project in the 7th Framework Programme lasting from 2009 to 2012. The underlying database is a granular origin-destination (O/D) matrix of goods transported by road, inland waterways, and rail, by freight type. It covers all countries of the European Union, at the NUTS3 region level (see below for more). The resulting map (see Figure 2) shows the traffic flows throughout Europe resulting from the freight flows. The roads with the busiest traffic match closely with the TEN-T core network and are heavily concentrated around and between the key urban areas. As detailed in T&E's Methodology note [9], this database has been calibrated with Eurostat 2018 data.

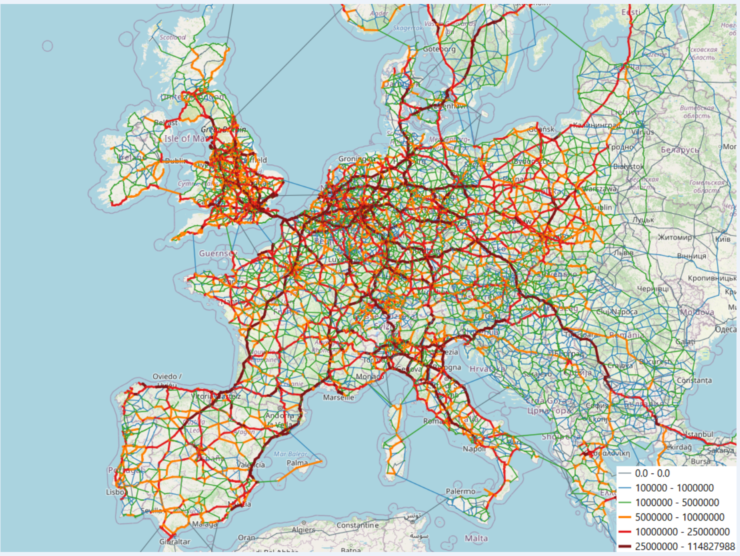


Figure 2: Map of truck flows based on the ETIS project O/D matrix

The geographical granularity of the data goes down to the level of a small region based on the Eurostat NUTS3 classification used for official EU statistics [16]. The origin and destination of trips are thus one of the 1,348 small regional level entities called NUTS3 regions, or simply referred to as ‘regions’ in this paper. Although the size of the regions can vary slightly from one country to another based on national administrative territorial division, the average size of a NUTS3 region is 3,500 km^2, which can be approximated by a disk with a radius of about 33 km.

2.2. Key corridors for long-haul freight in the EU

As defined in the EU Regulation (1315/2013) [6], the Trans-European Transport Network (TEN-T network) includes all the main freight routes in the EU, as it can be seen in Figure 3. These key corridors interconnect the 88 urban nodes that were analysed in Vol. 1. While electrifying the urban nodes is a logical starting point for the decarbonization of road freight, the next milestone is to electrify main long-haul routes in Europe, in other words electrifying the most frequented highways.

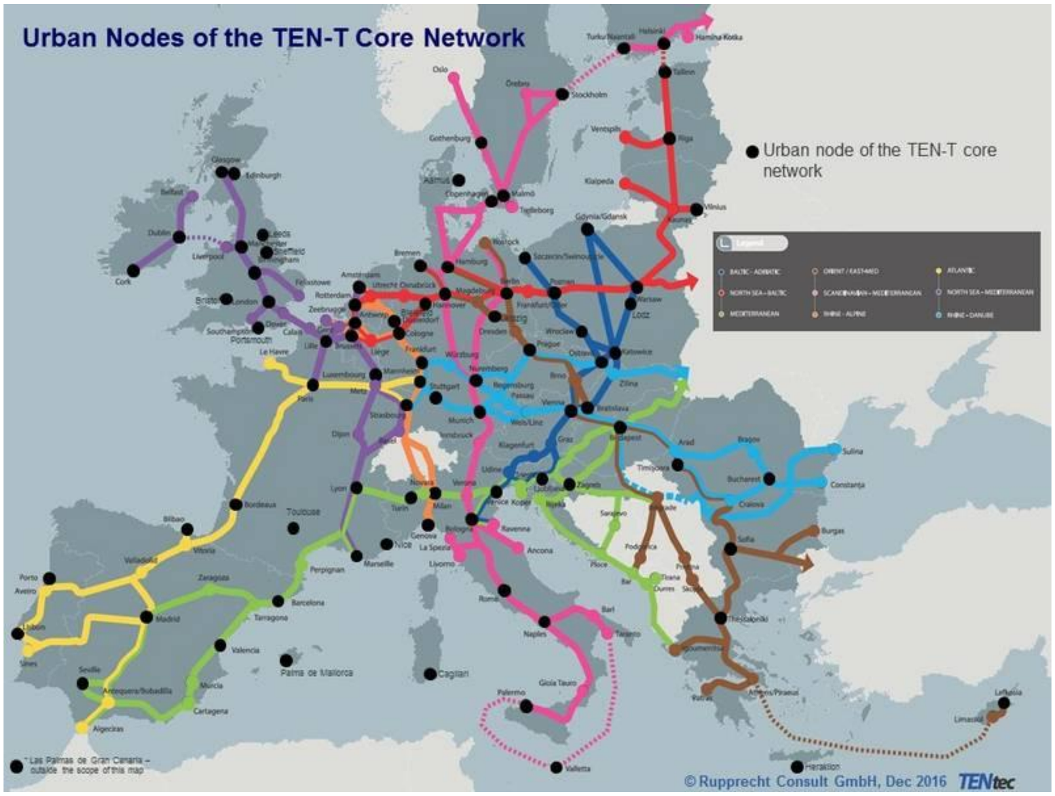


Figure 3: TEN-T corridors as defined in the EU TEN-T regulation [17]

In this report, the TEN-T core network has been approximated as the busiest connections between the 88 urban nodes defined in the Regulation. This network modelled by T&E is a combination of regions making up the TEN-T core network, meaning that these regions are crossed by TEN-T freight routes (i.e. highways). **These regions are named TEN-T regions and include urban nodes**. Further information on the network modelling can be found in Annex 1.

Applying the methodology mentioned above resulted in the network show in Figure 4, which has been used as the basis for the analysis of long-haul truck activity.

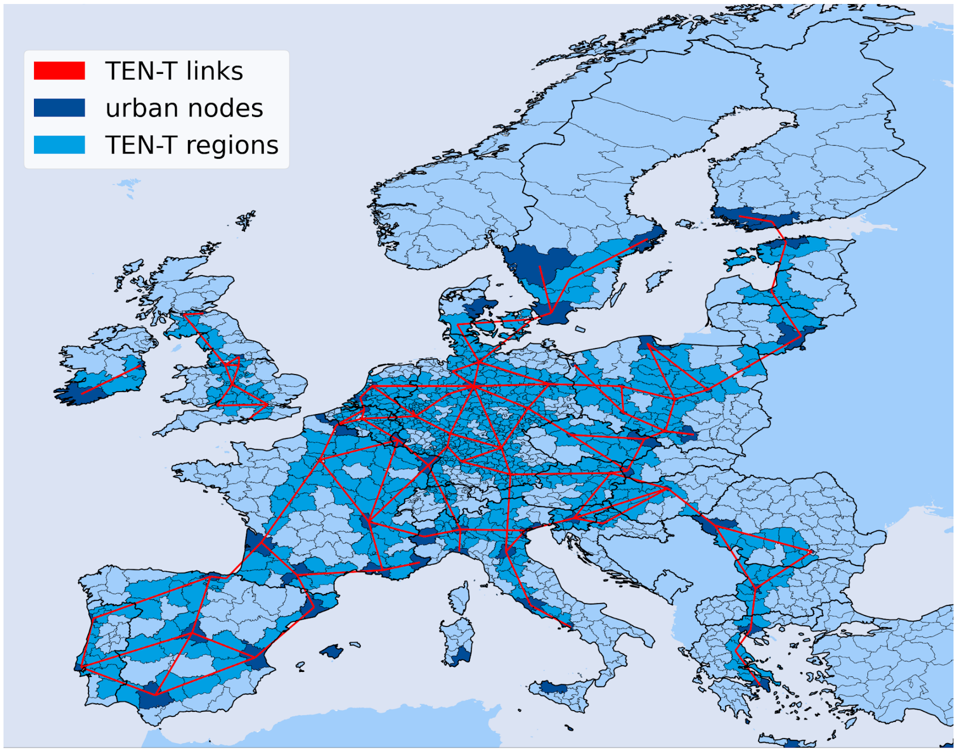


Figure 4: Approximated TEN-T network used in this study

The total length of this approximated network is about 30,700 km, slightly above the 24,500 km length of the 9 main corridors covering the core network [18].

Finally, this model showed that the average mass of freight carried on the network is about 540,000 t per section per year, with the busiest sections of the network presented in Figure 5[4].

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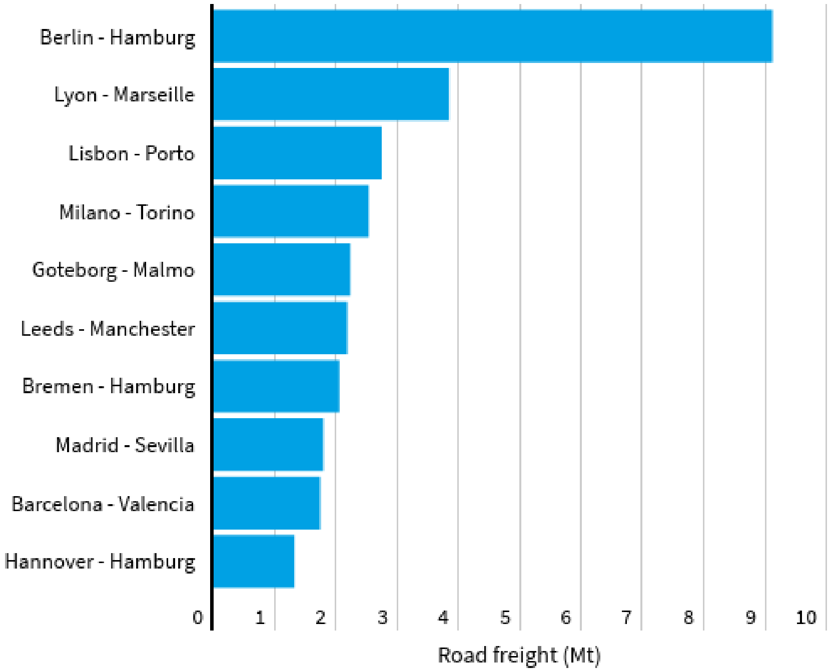
[4] Since the dataset from the ETIS Plus project only takes into account truck activity from a region to another, it is not possible to quantify truck flows from a subsection of a trip (i.e. truck flows from a region A to a region B do not include trucks flows from a region C to a region D passing through the connection between A and B).



Source: T&E analysis, data from the ETIS Plus project and Eurostat

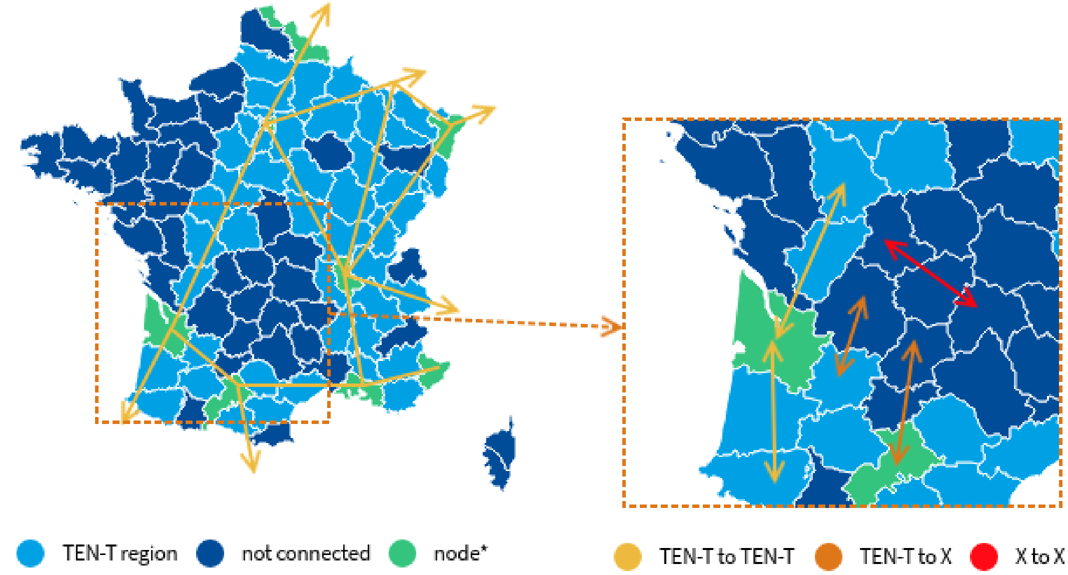
Figure 5: Most frequented sections of the TEN-T core network

2.3. Truck activity along the TEN-T core network

In the previous section, the TEN-T core network has been approximated as a set of TEN-T regions. Thanks to this approximated network, it has been possible to analyse truck flows with new trips types:

- **TEN-T to TEN-T trips** have their origin and destination in a region connected to the network.
- **TEN-T to X (same as X to TEN-T) trips** have their origin in a region connected to the network and destination in a region not connected to the network, or vice-versa.
- **X to X trips** are trips between regions not connected to the network

These trip types are shown schematically in Figure 6, with the example of France. The green shaded urban nodes are connected by the straight line modelled TEN-T network. The regions which fall under these network branches, or are within a certain distance of them, are defined as being TEN-T regions; all other non connected regions are shaded in dark blue. In the right hand side of Figure 6, the different trip types as listed above are shown.

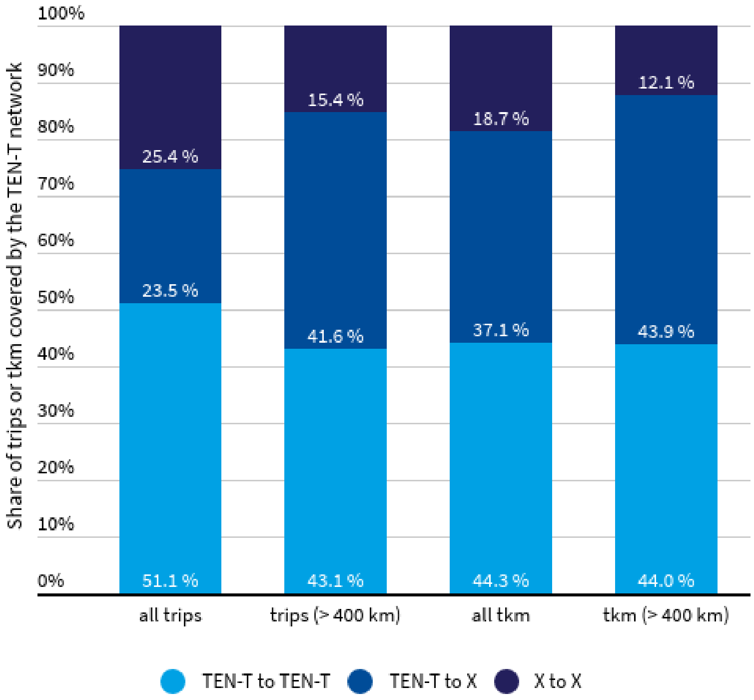


*urban nodes are also TEN-T regions. They are highlighted here to show how TEN-T connections are designed between main urban areas.

Figure 6: Illustration of TEN-T to TEN-T, TEN-T to X and X to X trips

About 7 trips out of 10 in Europe either leave or arrive (or both) at a region connected to the TEN-T network. Trips connecting two regions on the network (TEN-T to TEN-T) account for about 5 trips out of 10, while trips between a TEN-T region and a region not connected to the network account for 2 out of 10 (TEN-T to X).

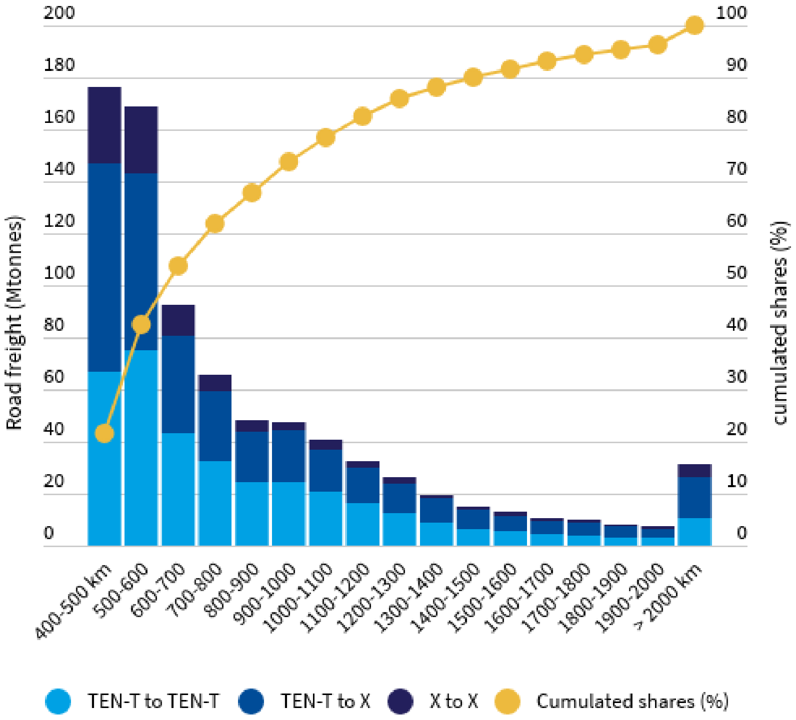
Long-haul trips (defined as above 400 km), which are the main focus of this study, account for 38% of Europe's truck activity but 41% of the total TEN-T truck activity (TEN-T to TEN-T and TEN-T to X), as shown in Figure 7. At least 8 out of 10 long-haul trips have an origin or destination on the network, resulting in only 12% of long-haul activity not being carried over the network. This explains why the TEN-T network is a key target for the decarbonization of long-haul trucks.



Source: T&E analysis, data from ETIS Plus and Eurostat

Figure 7: Breakdown of trips and truck activity among the TEN-T network

Finally, the observation of the long-haul truck activity (in tonne-kilometer) breakdown per distance band shows that 53% of truck activity are made between 400 km and 1000 km, with an average trip length of 652 km in this distance band. Figure 8 shows the road freight (in Mtonnes) breakdown per distance bands and per trip type. It highlights that about 74% of tonnes carried over more than 400 km are transported between 400 km and 1000 km. Trips above 1000 km are very likely to last multiple days, which therefore explains why road freight can be observed in the 2000 km distance band.



Note: Distribution of road freight activity across vehicle trip distance bands in the EU. Trips can last multiple days.

Source: T&E analysis, data from the ETIS Plus project and Eurostat

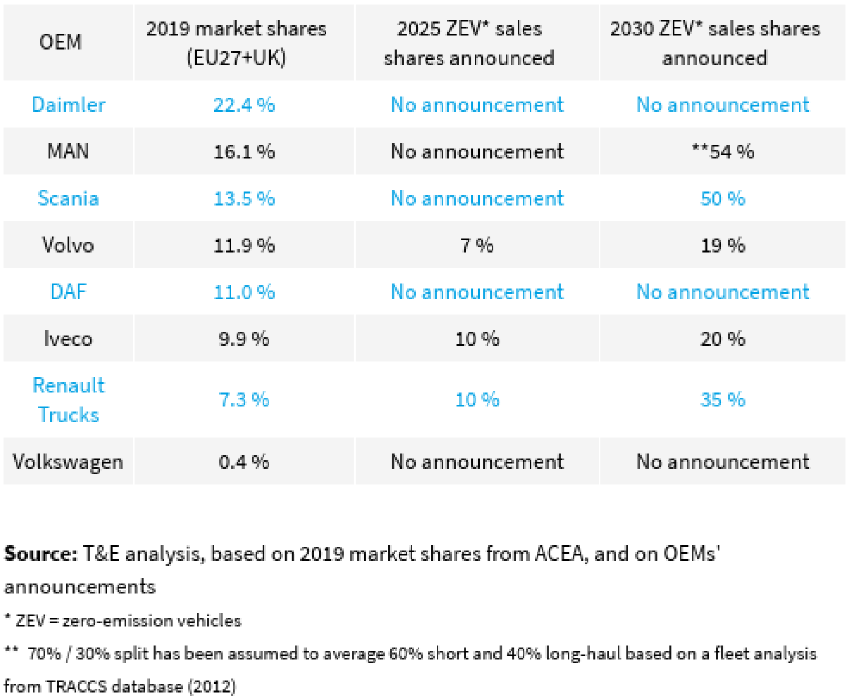
Figure 8: Breakdown of road freight above 400 km

3. Uptake of electric trucks

3.1. Scenarios

In this section, three scenarios for battery electric truck sales up to 2035 are presented. The first two are based on industry announcements and the last one is based on a trajectory compatible with reaching a zero-emission road freight sector by 2050. These scenarios slightly differ from Vol. 1 because of recent announcements made by major truck makers and now differentiate between short and long-haul truck sales, short-haul being trips below 400 km (regional and urban deliveries) and long-haul being trips above 400km.

As already mentioned in Section 1.2, MAN [11] announced that 40% of their long-haul trucks and 60% urban and regional delivery new sale vehicles will be zero-emission in 2030 when Scania [10] aims at 50% of its sales to be electric in 2030. Renault Trucks predicts that electric vehicles will represent 10% of its sales volume by 2025 and 35% by 2030 [19] [12] while Iveco expects to sell 8%-10% zero-emissions trucks (>16t) by 2025 and 20% by 2030 [20] and Volvo foresees 7% and 19% electric trucks in 2025 and 2030 respectively[5]. Finally, Daimler, Iveco, Scania, Volvo Group (Volvo Trucks and Renault Trucks), DAF and MAN all announced their commitment to sell 100% fossil-free trucks in 2040 [3]. These announcements are summarised in Table 2 and helped to build the scenarios presented below.



OEM	2019 market shares (EU27+UK)	2025 ZEV* sales shares announced	2030 ZEV* sales shares announced
Daimler	22.4 %	No announcement	No announcement
MAN	16.1 %	No announcement	**54 %
Scania	13.5 %	No announcement	50 %
Volvo	11.9 %	7 %	19 %
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

Source: T&E analysis, based on 2019 market shares from ACEA, and on OEMs' announcements

* ZEV = zero-emission vehicles

** 70% / 30% split has been assumed to average 60% short and 40% long-haul based on a fleet analysis from TRACCS database (2012)

Table 2: Zero-emissions trucks objectives per OEM

Industry-Baseline scenario

Truck makers will need to comply with the EU CO_2 emission reduction targets of -15% in 2025 and -30% in 2030 on a fleet average, compared to a 2019/2020 baseline. In this first scenario, the Industry-Baseline, truck manufacturers would rely to a very large extent on fuel efficiency

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[5] This was presented by Volvo Trucks during a public event as an indicative value for where trucks needed to go to comply with CO_2 standards.

improvements to comply with the CO_2 regulation which leads to lower uptake of zero-emissions trucks.

The announcements presented above suggest that in this most conservative scenario, the average sales shares for battery electric trucks would be at least 2.8% in 2025 and 20% in 2030[6]. In 2035, we assumed the sales shares of electric trucks to be 40% in this scenario. Based on the new announcements presented above, the additional number of electric trucks compared to Vol. 1 have been extrapolated as long-haul trucks (electric trucks in Vol. 1 were assumed to be short haul). For 2030, based on a truck fleet comprising 70% short-haul trucks and 30% long-haul trucks according to the TRACCS database [21], this translates into 21.4% and 16.7% of short-haul and long-haul trucks sales being battery electric respectively; or 293,000 battery electric trucks on the road in 2030.

This is already higher than what ACEA, the automotive industry lobby group, has announced [22]: 20,000 battery electric trucks on the road in 2025 and 200,000 in 2030 (above 16t). Which would mean that the EU average sales market share for electric trucks would be at 1.3% in 2025 and 15% in 2030.

EV-Leaders

Assuming that OEMs that did not make any announcement would at least sell 5% of battery electric trucks in 2025 and 20% in 2030, this leads to a scenario with 6.2% battery electric trucks sales in 2025 and 27.5% in 2030. Cumulatively, this EV-Leaders scenario would in total represent 458,000 battery electric trucks on the road in 2030. In this scenario the assumed share of sales in 2035 is 70%.

Road-2-Zero

To be aligned with the Paris Agreement objectives and the European Green Deal commitments, the EU must have a zero-emission road transport sector by 2050. The scenario modelled here is based on T&E's 2050 transport decarbonisation strategy [23], where the last internal combustion truck (including PHEVs and HEVs) has to be sold between 2035 and 2040.

In this scenario, 12% of truck sales in 2025 would be battery electric, up to 40% in 2030 and 100% in 2035, including both short-haul and long-haul trucks. This is already quite close to the most ambitious announcements made by OEMs (see Table 2 above). Cumulatively this would amount to about 734,000 in 2030.

Figure 9 shows the total battery electric truck (BET) fleet for all scenarios and all trucks categories.

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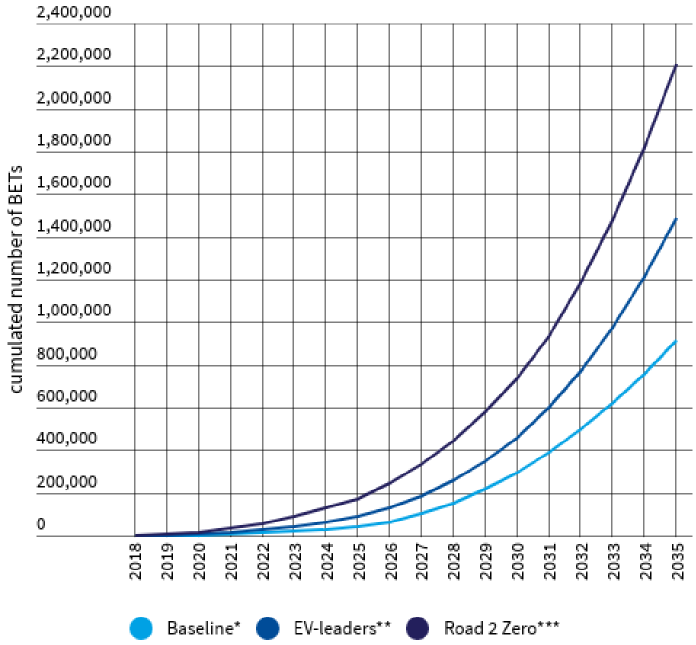
[6] In this conservative scenario, OEMs that did not announce any target are considered to be selling 0% of battery-electric trucks in 2025 and 2030.



BET = battery-electric trucks
* 20% BET sales in 2030, 40% in 2035
** 27.5% BET sales in 2030, 70% in 2035
*** 40% BET sales in 2030, 100% in 2035

Source: T&E analysis, based on OEM announcements

Figure 9: T&E battery electric truck fleet uptake scenarios, EU27+ UK

On the market sales side, the scenarios presented above are summarized in the following table:

Scenario		2025	2030	2035
Industry-Baseline	Short-haul (urban / regional)	2.9%	21.4%	42.9%
	Long-haul	2.7%	16.7%	33.3%
	Total	2.8%	20.0%	40.0%
EV-Leaders	Short-haul (urban / regional)	7.1%	28.6%	71.4%
	Long-haul	4.0%	25.0%	66.7%
	Total	6.2%	27.5%	70.0%
Road-2-Zero	Short-haul (urban / regional)	14.3%	42.9%	100.0%
	Long-haul	6.7%	33.3%	100.0%
	Total	12.0%	40.0%	100.0%

Table 3: Battery electric trucks sales shares for the different scenarios

Therefore, even in the most conservative scenario, much more zero-emissions trucks are expected on the roads compared to the European Commission target of 80,000 lorries in 2030, as described in the Smart and Sustainable Mobility Strategy (SSMS) [24].

3.2. Assumed electric trip shares

Since urban nodes will be electrified first and these nodes are the basis of the TEN-T network, trips which are carried out exclusively on the TEN-T network will have a higher uptake of battery electric trucks sales than trips from and to other regions. In practice, this means that a strong and comprehensive policy and investment strategy needs to be implemented along the main freight corridors (i.e. highways) to electrify long-haul deliveries, thanks to charging infrastructure at depots, distribution hubs and public locations.

In this report, public charging along highways is done based on the High Power Charging (HPC)[7] and on public overnight charging. In addition, destination and depot charging is assumed to be adequately deployed at the relevant locations along the network. This means that trucks are assumed to always leave with a full battery in the morning because they are always able to charge during the night (depot or public overnight charging). They can also charge between two trips while (un)loading (destination charging) or at public HPC chargers (short top-up or during mandatory rest periods). Importantly, public charging will be essential along the network to ensure that all trip lengths can be covered.

Truck activity modelling

The share of electrification for each trip type (as shown in Figure 10) has been calibrated to match the three electric truck uptake scenarios shown in Figure 10. For each distance band, the share of truck activity has been calculated in order to get the total truck activity targeted for each scenario.

For new electric trucks and for the first operating year, the activity is estimated to be around 1,450,000 tkm per truck and per year (average payload of 22.7 tonnes from TRACCS data [21], with 55% payload factor from Riccard-AEA [25], and an average mileage of 116,000 km from the EU Regulation [26]). This activity per new truck can be up to 3 times the current average activity per truck in the fleet as the fleet includes many old trucks having a very low annual mileage[8].

In order to properly estimate the truck activity of the BET fleet over time, a decreasing annual mileage in line with the ageing of trucks has been taken into account: the older a truck gets, the less it is driven.

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[7] In addition to highways, public charging thanks to HPC chargers can also be done in frequented regions with significant truck flows.

[8] The average activity per truck was 446,000 tkm in 2018 according to Eurostat and 540,000 tkm in 2010 for trucks above 20 tonnes according to TRACCS.

Based on T&E’s European Union Transport Roadmap Model (EUTRM) [27], it has been assumed that the annual mileage decrease rate would be similar for battery electric trucks and diesel trucks. In practice, battery electric trucks are expected to drive more than diesel trucks, especially for the first years, as it will make economic sense to operate them at the highest mileage possible.

Because the number of long-haul BETs increases over time, the average mileage and thus the average truck activity per truck only slightly decreases[9]. This is considered a conservative approximation, as BETs will be cheaper to run based on TCO analysis [28], and thus may be used more intensely than the ICE equivalents.

Electrification scenarios

The details of the truck electrification scenarios are presented in Figure 10. The share of electrification is higher for shorter trips and trips between TEN-T regions as the network will be first covered with charging infrastructure. Trips that connect a TEN-T region with another region which is not in the TEN-T network (noted ‘TEN-T to X’ in Figure 7), are less likely to be electric because either the trip origin, the trip destination or the route between both is lacking the sufficient charging infrastructure.

Finally a limited number of electric trips are assumed for X-X trips because of scarce charging locations within these regions and battery range limitations. In 2035 in the Road-2-Zero scenario, the maximum potential is reached for TEN-T to TEN-T trips: these trips will be 100% electrified. Detailed assumptions per trip type and distance bands can be seen in Annex 4.

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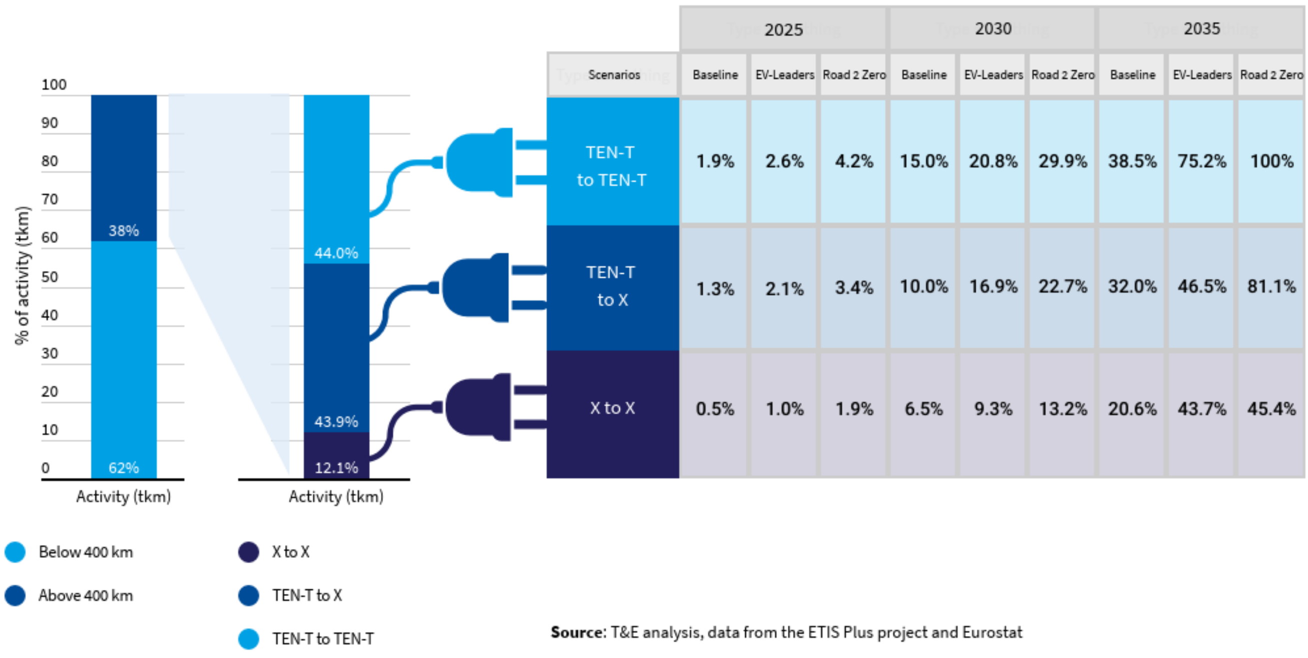
[9] From 1,450,000 tkm/truck/year for new BETs, the average truck activity in the fleet gets to 1,280,000 tkm/truck in 2025, 1,120,000 tkm/truck in 2030 and to around 1,000,000 tkm/truck in 2035.

Weighted average share of electrified truck activity per trip type



	2025			2030			2035		
Scenarios	Baseline	EV-Leaders	Road 2 Zero	Baseline	EV-Leaders	Road 2 Zero	Baseline	EV-Leaders	Road 2 Zero
TEN-T to TEN-T	1.9%	2.6%	4.2%	15.0%	20.8%	29.9%	38.5%	75.2%	100%
TEN-T to X	1.3%	2.1%	3.4%	10.0%	16.9%	22.7%	32.0%	46.5%	81.1%
X to X	0.5%	1.0%	1.9%	6.5%	9.3%	13.2%	20.6%	43.7%	45.4%

Source: T&E analysis, data from the ETIS Plus project and Eurostat

Figure 10: Electric long-haul truck uptake - scenarios illustration

4. Results: assessment of the electrification

In this section, the impact of the three scenarios presented above is analysed through different metrics: trips electrified, truck activity electrified, number of long-haul electric trucks, number and types of chargers needed, charging infrastructure costs and CO_2 emissions avoided.

4.1. Quantification of electric trips and electric truck activity

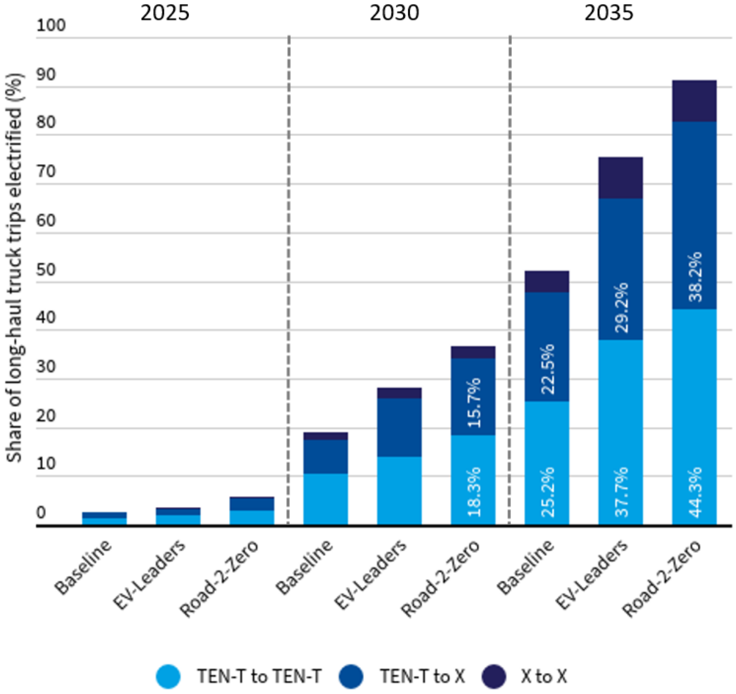
T&E EU road freight modelling from ETIS database

As detailed in Vol. 1, for every two NUTS3 regions of the EU, the O/D matrix provides information about the flow (in tonnes and tkm) of goods transported between the origin region and destination region. T&E's model allocates to each of these pairs a given share of electrified trips (see Figure 11), depending on the distance between the origin and the destination while taking into account higher electrification shares when the origin or destination (or both) is taking place on the TEN-T network. As a result of the model, the total volume of goods transported via long-haul electric trucks can be calculated as the sum of the volume of goods transported via electric trucks for all origin and destination pairs. This volume of goods transported via electric trucks is then compared to the overall volume of goods transported.

This approach does not take into consideration regional or trip disparities, but gives an overview of how road freight flows could be electrified. For more details on the limitations of this approach, see the sensitivity analysis investigated in Vol. 1 [5].

Applying this methodology, this gives for the Industry-Baseline scenario an electric trips coverage of 18.9% in 2030 compared to all European long-haul truck trips (Figure 11). In the EV-Leaders scenario, we find that 28.0% of long-haul truck trips are electric in 2030 in Europe, with TEN-T to TEN-T electric trips representing more than 5 trips out of 10 in this scenario.

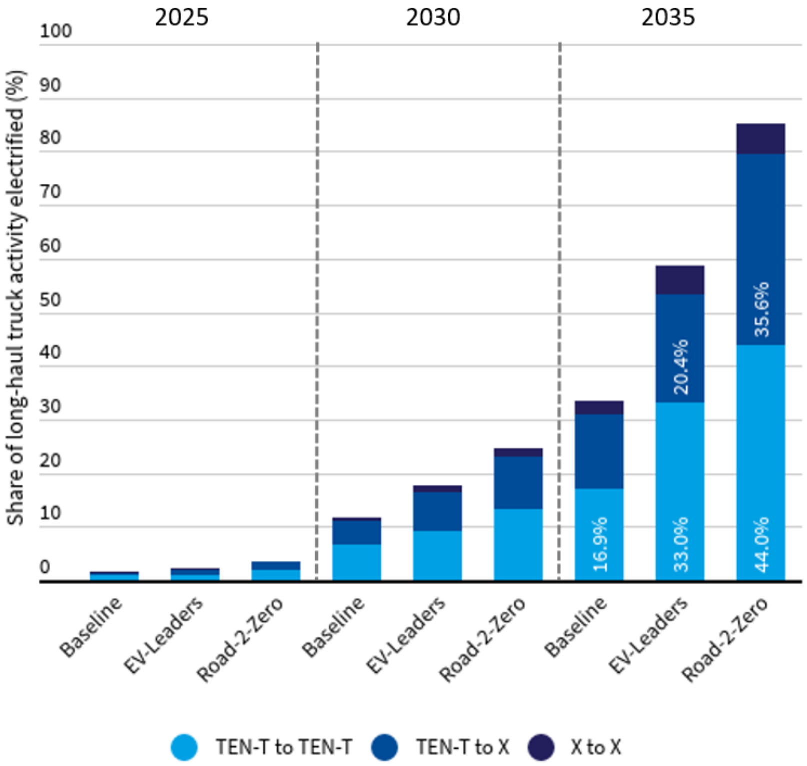
Finally, the Road-2-Zero scenario is a more ambitious scenario where the TEN-T network moves towards full electrification by 2035 where 100% of TEN-T to TEN-T trips and 81% of TEN-T to X are electrified. As a result, in this scenario, 36.7% of long-haul trips are electrified in 2030.



Source: T&E analysis, data from the ETIS Plus project and Eurostat

Figure 11: Share of long-haul truck trips electrified, EU27+UK+NO+CH

Looking at truck activity, in the Industry-Baseline truck activity electrified reaches 11.8% in 2030 in Europe. This corresponds to an average low level of electrified trips across the EU where electric truck uptake is focused on trips taking place on the TEN-T network. As shown in Figure 12, in the EV-Leaders scenario, we find that 17.7% of the long-haul truck activity is electrified in 2030. Finally, 24.7% of the EU truck activity would be electrified in 2030 in the Road-2-Zero scenario.



Source: T&E analysis, data from the ETIS Plus project and Eurostat

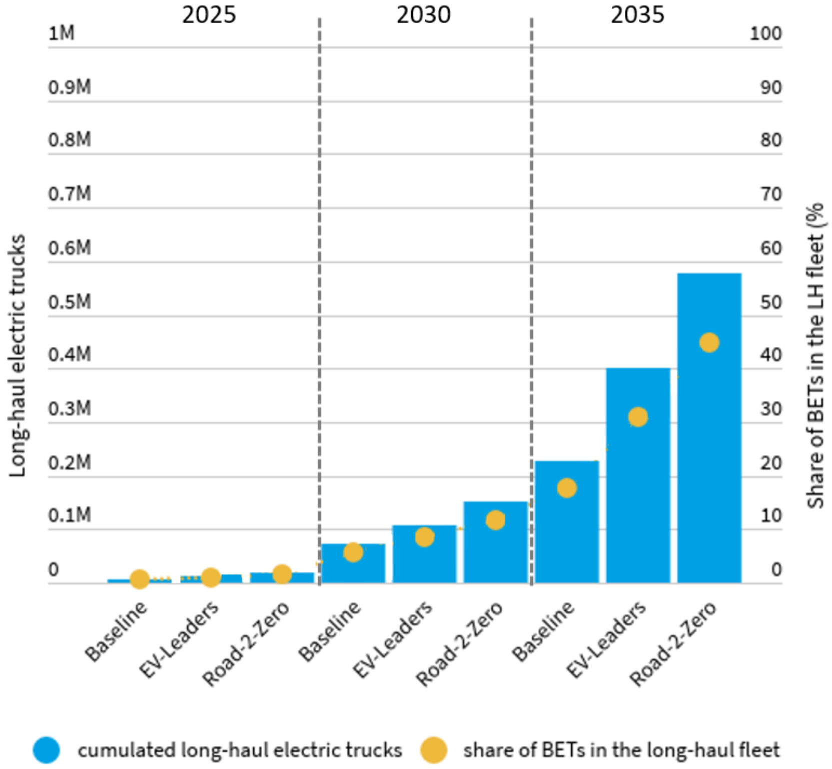
Figure 12: Share of long-haul truck activity electrified, EU27+UK+NO+CH

As the TEN-T core network moves more ambitiously on electrification of long-haul road freight, an increasing share of the trips going through the network are electrified. See figures in Annex 5 for an overview of the total volume of road freight activity electrified in each scenario.

4.2. Long-haul electric trucks

In the following section, the total volume of activity is calculated at the level of each region by looking at the total activity of trucks arriving in one region. This is then used to estimate the respective number of chargers and trucks, which is proportional to the volume of activity arriving in that given region.

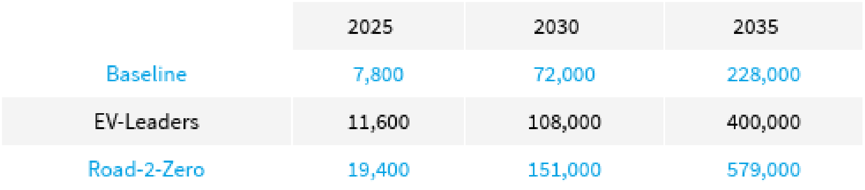
As explained in Section 3.2, the average truck activity of the BET fleet evolves over the year since the average fleet age increases from 0 years in 2022 (first long-haul BETs sold) up to 4.4 years in 2035. This results in a higher truck activity per truck for battery electric trucks compared to the current fleet, since new vehicles tend to drive much more than the average fleet. This is expected to hold true especially for electric trucks since they have lower utilisation costs and the economic incentive to use them is therefore higher.



Source: T&E analysis, data from the ETIS Plus project and Eurostat

Figure 13: Long-haul battery electric trucks uptake, EU27+UK+NO+CH

Long-haul electric trucks amount to 580,000 vehicles in Road-2-Zero 2035, which translates into about 45% of the long-haul fleet being electrified (see Figure 13). This compares to an approximate 85% of the tonne-kilometers being electrified in the same scenario (see Section 4.2). This again shows that electric trucks will be carrying much more goods than the average long-haul fleet. Table 4 summarizes the battery electric long-haul trucks required in each scenario.



	2025	2030	2035
Baseline	7,800	72,000	228,000
EV-Leaders	11,600	108,000	400,000
Road-2-Zero	19,400	151,000	579,000

Source: T&E analysis, data from the ETIS Plus project and Eurostat

Table 4: Number of electric long-haul trucks on the road in the different scenarios, EU27+UK+NO+CH

Looking at the EU27 only, we calculate that there would be 7,300, 67,000 and 209,000 long-haul electric trucks in 2025, 2030 and 2035 respectively in the Industry-Baseline scenario; 10,900, 100,000 and 370,000 electric trucks in the EV-Leaders scenario; and 17,900, 140,000 and 536,000 in the Road-2-Zero scenario.

4.3. Electricity consumption

This section aims to quantify how much energy will be required to recharge the long-haul electric trucks on the road for the different scenarios. This will subsequently be converted into charging infrastructure requirements.

In order to assess the truck energy consumption, the average energy needed per tkm has been used. This has been calculated from the average efficiency and the average mileage for each year. As for the truck activity presented in Section 3.2, the average kWh/km for the fleet has been estimated based on the energy efficiency of new trucks expected in the coming years[10]. From 1.52 kWh/km in 2020, the energy efficiency of new trucks entering the fleet is expected to reach 1.21 kWh/km in 2030 [29]. This translates into a fleet average of 1.39, 1.27 and 1.23 kWh/km in 2025, 2030 and 2035 respectively.

As expected, an important share of the total energy recharged by electric trucks is needed at regions connected to the TEN-T network given that this is where the majority of the activity takes place (Figure 14). In the Road-2-Zero scenario, the final energy consumption from long-haul electric trucks would reach about 17 TWh in 2030, which would represent about 1.7% of the total renewable electricity produced in the EU in 2018 [30]. In the EV-Leaders scenario, the total demand in 2030 would reach 12.4 TWh, while it would be 8.3 TWh in 2030 for the Industry-Baseline scenario.

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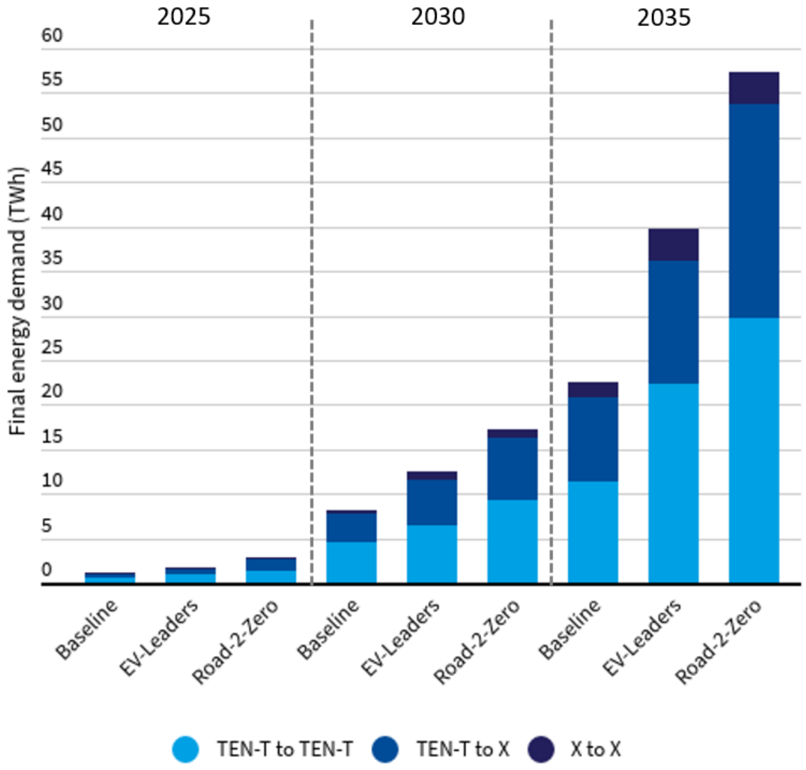
[10] These energy consumptions take into account 5% charging losses from the plug.



Source: T&E analysis, data from the ETIS Plus project and Eurostat

Figure 14: Energy requirements for charging long-haul electric trucks, EU27+UK+NO+CH

Finally, the average energy consumption needed for long-haul electric trucks along the TEN-T core network is estimated to be up to 4 times lower than the energy consumption needed for long-haul trucks in urban nodes. In the Road-2-Zero scenario and in 2030, this energy consumption would for instance be around 8.1 GWh per TEN-T region while it would be about 31.9 GWh per urban area connected to the network.

4.4. Charging infrastructure requirements

In this section we calculate the number of chargers of each type required: depot charger, destination charger, public fast charger (or high power chargers [HPC]) and public overnight charger.

4.4.1. Approach and assumptions

In order to estimate the number of chargers needed to fulfill the energy needs presented previously, several assumptions have been made to describe each charger type: the charging power (kW), the utilisation rate (number of operating hours per day) and the split between the different chargers (what proportion of energy is delivered by each type of charger). These assumptions are summarized in Table 5.

The actual average power required to charge the trucks' battery for each charger has been estimated from the average trip distance of the BET fleet. This results from the truck flow modelling in 2025, 2030 and 2035, the battery-capacity needed at each stop, the average charging time per charger and the average energy consumption per km. This approach takes into consideration the fact that in practice, most BETs will not arrive at the charging location with an empty battery and will therefore not need to fully charge at each stop, especially for the decade to come with trucks assumed not to be doing the longest distances. It has been therefore assumed that in 2025 only 60% of the battery capacity will be recharged at each stop, which will then increase to 70% in 2030 and 80% in 2035.

Given that long-haul trucks will cover longer distances than urban and regional delivery trucks, and thus will likely be away from their depot, the share of public chargers is expected to be higher than it was in Vol. 1. It was therefore assumed that 40% of the total energy consumed by electric trucks would be charged at public chargers, of which 20% will be public opportunity (HPC) chargers and 20% public overnight. The rest is expected to be covered by depot chargers (45%) and destination chargers (15%).

The formulas and calculations used to estimate the charging infrastructure requirements presented here are detailed in Annex 3.

Assumptions (averages)	Year	Depot	Public overnight	Destination	Public HPC
Average maximum charging power	2025	150 kW		350 kW	620 kW
	2030				730 kW
	2035				850 kW
Charging time	all	8 h/truck		1.5 h/truck	45 min/truck

Fleet average real world power during charging	2025	46 kW		246 kW	492 kW
	2030	55 kW		292 kW	585 kW
	2035	64 kW		339 kW	698 kW
Share of total energy delivered	2025	45%	20%	15%	20%
	2030				
	2035				
Utilization	2025	6 h/day		3 h/day	3 h/day
	2030	7 h/day		4 h/day	4 h/day
	2035	8 h/day		4 h/day	5 h/day

Table 5: Summary of key charging assumptions

4.4.2. Results

From the assumptions presented above and the energy needs detailed in Section 4.3, it has been possible to calculate the number of each charger type required to power the fleet of BETs. This has been determined by dividing the total energy needs in each scenario by the annual energy that can be delivered by each charger[11] and taking into account the share of each charger type in the total energy needs (see Annex 3 for more detailed information).

Destination chargers

Long-haul trucks tend to spend one hour or more at the distribution center (or logistics hub) to load and unload cargo [31]. T&E assesses that one destination charger would be required for every 21 long-haul electric trucks in 2030. This is based on assuming 350 kW maximum power charging but with an average 292 kW for the fleet with the methodology explained above, and a utilisation rate of 4 hours per day. As a result, in the Road-2-Zero scenario a total of 7,100 destination chargers would be needed in 2030. In the EV-Leaders scenario this amounts up to 5,100 chargers in 2030; and in the Industry-Baseline scenario, 3,400 chargers.

Depot chargers

Considering 150 kW maximum power chargers, 55 kW average power and 7 hours of utilization per day In 2030, as depot chargers are mostly overnight chargers and long-haul trucks do not charge at the depot every night, the average trucks per depot chargers is estimated to be around 2 in 2030. For the

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[11] We assume that all chargers are operational 6 days per week, 52 weeks per year, to consider potential downtime for maintenance work when chargers are not available to truck drivers.

Road-2-Zero scenario, this leads to a total of 65,000 depot chargers in 2030. In the EV-Leaders scenario, it amounts up to 46,500 in 2030; and 31,000 in the Industry-Baseline.

Public fast chargers (HPC)
As long-haul trucks cover trips greater than 400 km, public fast charging will be essential on highways, allowing trucks to drive longer distances than their battery range. These chargers need to be powerful enough to charge batteries during the 45 minute legal breaks that truck drivers need to take every 4.5 hours [32]. Assuming 20% of the total energy is delivered at public fast chargers, that the charger is used 4 hours per day on average in 2030 and given that we calculate average power of 585 kW for fast charging points (see above), there would be a need for one fast charger for every 32 long-haul electric trucks per charger in 2030.

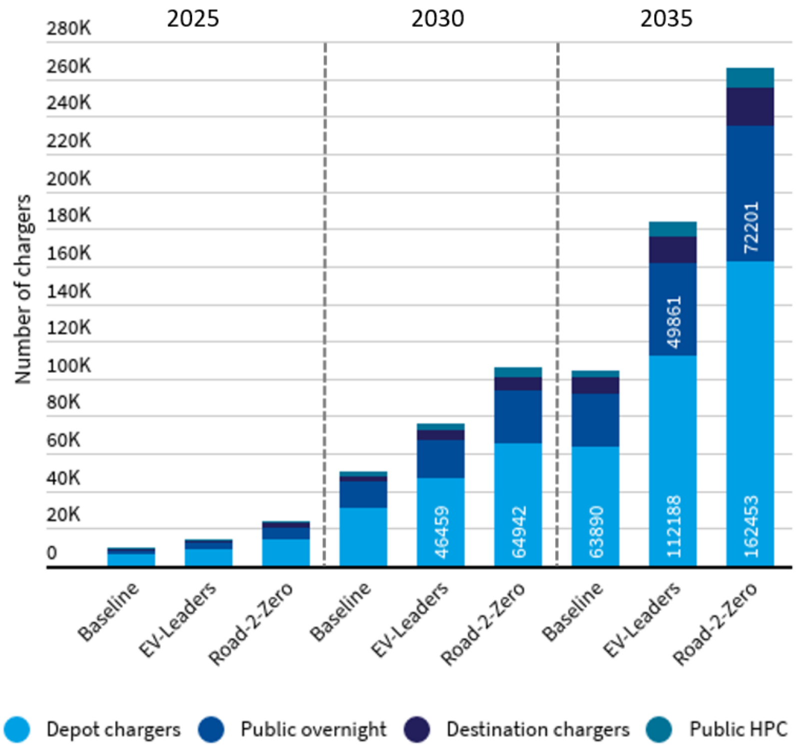
This translates into 2,300 HPC opportunity chargers in 2030 in the Industry-Baseline scenario, 3,400 in the EV-Leaders scenario and 4,800 in the Road-2-Zero scenario.

Public overnight chargers
As public HPC chargers, public overnight chargers will be essential for trucks driving longer trips over several days. These chargers will need to be installed on rest areas along highways where drivers are already used to spending their night in their sleep cabs. As for the depot, 150 kW maximum power, 55 kW average power and 7 hours of utilization per day are assumed in 2030. This gives an average ratio of 5 long-haul electric trucks per public overnight charger in 2030.

Looking at scenarios, the total number of public overnight chargers is expected to reach 13,800 in 2030 for the Industry-Baseline scenario. In the EV-Leaders scenario this will be 20,600 in 2030; and 28,900 in the Road-2-Zero scenario.

Figure 15 presents the total number of chargers needed in each scenario for the three periods considered. Table 5 summarizes the ratio of battery electric trucks per charger type, as described above. Moving towards, high power chargers and destination chargers could also be used as public overnight chargers in some cases, as it could optimize the chargers utilization.

Finally, looking at the EU27 only, 6,600, 4,700 and 3,100 destination chargers are calculated for 2030 in Road-2-Zero, EV-Leaders and Industry-Baseline respectively. On the other hand, 4,400, 3,100 and 2,100 high power chargers and 26,700, 19,000 and 12,700 public overnight chargers are needed for each scenario.



Source: T&E analysis, data from the ETIS Plus project and Eurostat

Figure 15: Long-haul electric truck chargers requirements per scenario, EU27+UK+NO+CH

Long-haul BET per charger	2025	2030	2035
Public HPC*	16	32	53
Public HPC + Destination	6.5	12.8	18.6
Public HPC + Destination + public overnight	2.1	3.7	5.6
Depot + public overnight	0.9	1.6	2.5
all types	0.8	1.4	2.2

Source: T&E analysis, data from the ETIS Plus project and Eurostat

*HPC = high power charger

Table 6: Ratio of long-haul battery electric trucks per charger

4.5. Charging infrastructure costs

Significant investments will be needed in charging infrastructure deployment to serve the growing BET market. To determine the magnitude of these investments, we conduct an upfront capital investments estimation[12]. These costs have been modelled assuming 500 €/kW for depot and public overnight chargers, 430 €/kW for destination chargers and 400 €/kW for HPC for 2020[13], and with a 1.5% cost reduction rate per year. This results in cost ranges of 60-70 k€/charger for depot and public overnight, 120-140 k€/charger for destination chargers and 230-260 k€/charger for HPC chargers.

Annual upfront investments in the deployment of all charging points would then increase from zero today, up to about €160-390 million per year for 2020-2025, increasing further to €630-1,260 million per year for 2025-2030 and €780-2,300 million per year for 2030-2035.

Looking at total cumulative upfront investments needed, this gets up to €800-2,000 million for 2020-2025, €3,900-8,200 million for 2020-2030 and €7,800-19,900 million for 2020-2035 in Europe (see Figure 16). The same upfront investment in the EU27 would represent €700-1,800 million for 2020-2025, €3,600-7,600 million for 2020-2030 and €7,200-18,400 million for 2020-2035.

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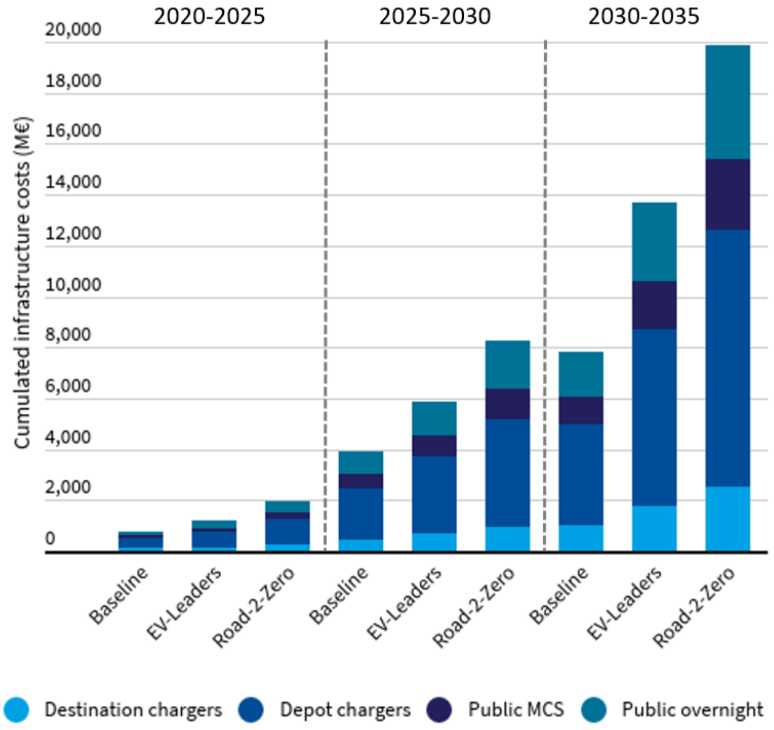
[12] These upfront investments do not include operational costs or grid connection costs. This will be the focus of a forthcoming study commissioned by T&E.
[13] These figures have been assumed based on bilateral exchanges with truck makers and literature references.



Source: T&E analysis, data from the ETIS Plus project and Eurostat

Figure 16: Cumulated upfront investment costs needed, EU27+UK+NO+CH

4.6. CO_2 savings

Greenhouse gas (GHG) emissions from medium and heavy duty trucks totalled 198 $MtCO_2$ in 2019 in the EU27+UK according to the UNFCCC emissions[14] [2]. Commercial vehicles emit roughly 100 gCO_2/tkm[15] (Tank-to-Wheel [TTW] emissions) on average. Looking more precisely at regulated trucks and according to ACEA [33], TTW emissions get down to around 59 gCO_2/tkm for long-haul because these trucks have much higher activity compared to the average truck. For regulated urban and regional deliveries, the average increases to 152 gCO_2/tkm. Here, to calculate the total emissions, the emission factors for regulated trucks are multiplied with the respective tkm for both short and long-haul trips.

We calculate that the heavy duty trucks emissions reach up to 211 $MtCO_2$ (40 $MtCO_2$ for trips above 400 km and 171 for trips below 400 km). These values are slightly higher than the UNFCCC, which could be

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[14] 232 $MtCO_2$ from heavy-duty vehicles and buses, where a 85 % / 15% split has been applied.
[15] CO_2 intensity per tonne-kilometer

explained by the fact that only regulated trucks have been taken into account. These estimates from ACEA's values serve as the basis for the emission comparison below as the UNFCCC global emissions do not give the split between short and long-haul truck categories, nor between trucks and buses.

Thanks to diesel truck efficiency improvements, mainly driven by the truck CO_2 regulation, CO_2 emissions per tkm of the diesel truck fleet are assumed to improve by 7.5% in 2025, 12.5% in 2030 and 15.2% in 2035[16] in all scenarios, compared to 2020. Based on this, and as shown in Figure 17, we calculate the total direct CO_2 savings from shifting a given part of the road freight activity from diesel to electric.

In the Road-2-Zero scenario in 2030, the annual TTW savings are about 9 $MtCO_2$. In the EV-Leaders scenario, the TTW emissions savings are about 6.4 $MtCO_2$, roughly equivalent to truck GHG emissions from the Netherlands (6.0 $MtCO_2$) and in the Industry-Baseline scenario, these emissions savings only reach up to 4.3 $MtCO_2$).

When taking into account indirect emissions from diesel extraction and processing[17] [35] as well as the GHG emissions from the electricity generation based on the ENTSO-E projections [36], then total GHG emissions avoided increase from 32 $MtCO_2$ to 34 $MtCO_2$ in 2035, meaning that the upstream emissions from the fuel production (diesel and electricity) roughly cancel each other out.

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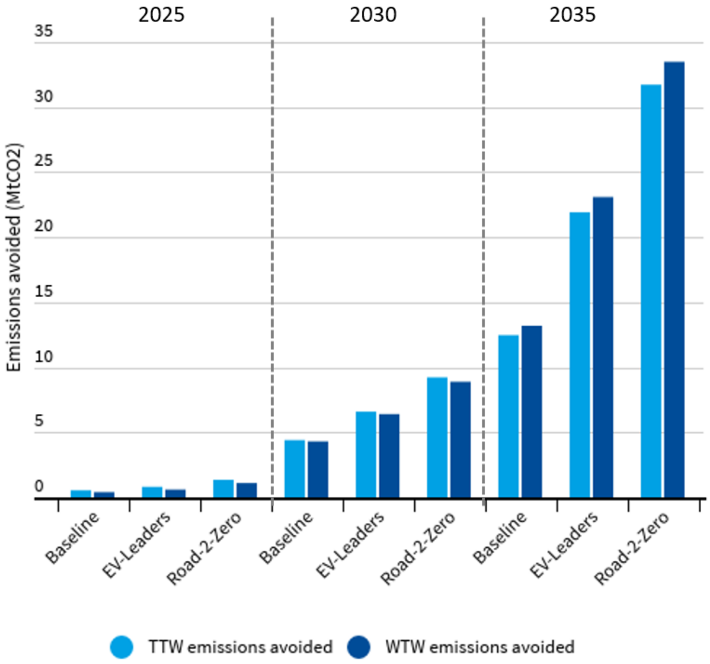
[16] New ICE trucks improvements could reach up to 21% in 2030 compared to 2020, according to the ICCT [34]. The average fleet improvement is then calculated based on the amount of ICE trucks sold each year. No more fuel efficiency is assumed after 2030. However, this 21% diesel trucks improvement is unlikely to happen as most truck makers are counting on zero-emission trucks to comply with the CO_2 standards.

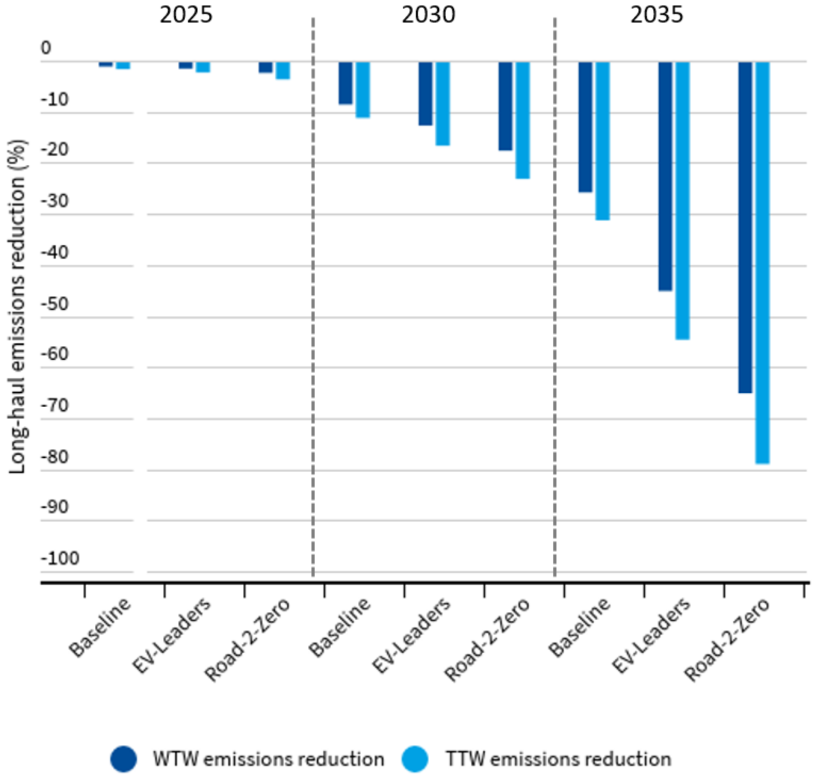
[17] On average, indirect (WTT) emissions from diesel vehicles increase the tailpipe emissions (TTW) by 28%.



Source: T&E analysis, data from the ETIS Plus project and Eurostat

Figure 17: TTW and WTW emissions avoided, EU27+UK+NO+CH

As shown in Figure 18, in the climate-compatible scenario, in 2030 up to 23% TTW CO_2 emission reduction can be achieved compared to long-haul current emissions, with long-haul heavy trucks representing about 20% of all trucks' emissions. In the EV-Leaders and Industry-Baseline scenarios, only 16% and 11% emissions reduction could be achieved.



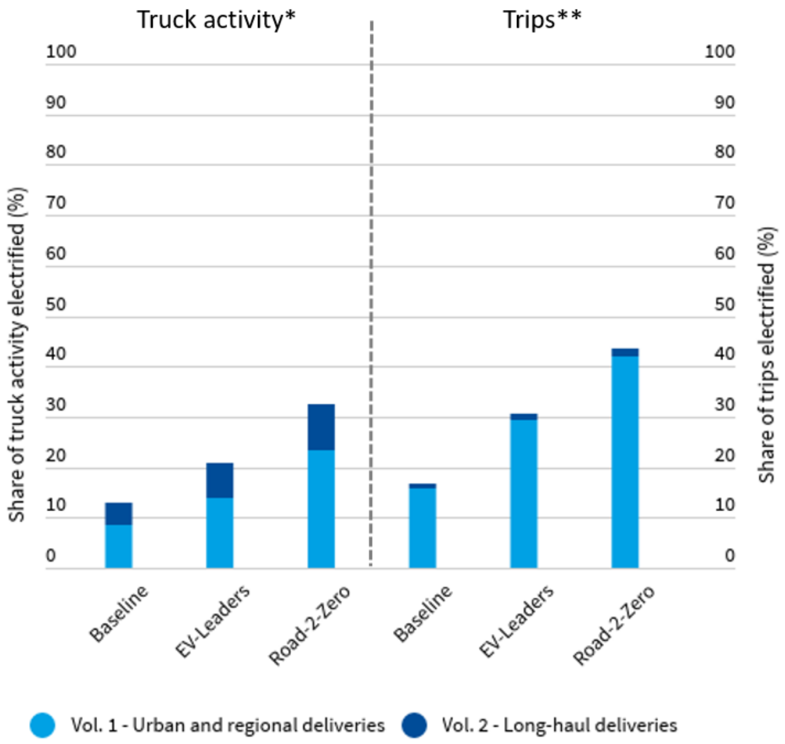
Source: T&E analysis, data from the ETIS Plus project and Eurostat

Figure 18: Emissions reduction compared to current emissions from long-haul trucks, EU27+UK+NO+CH

4.7. Combination of results from Vol. 1 and Vol. 2

Combining urban and regional deliveries results from Vol. 1 and long-haul deliveries results from Vol. 2, truck activity electrified is expected to reach up to 33% of all tonne-kilometers in 2030; which means that 37% of urban and regional tkm will be electrified and 25% of long-haul in the best-case scenario.

Since urban and regional deliveries account for around 95% of trips today, most of the trips electrified are expected to be on the short-haul side with 41.8% of all trips, and 1.7% of long-haul all trips (Figure 19).



Source: T&E analysis, data from the ETIS Plus project and Eurostat

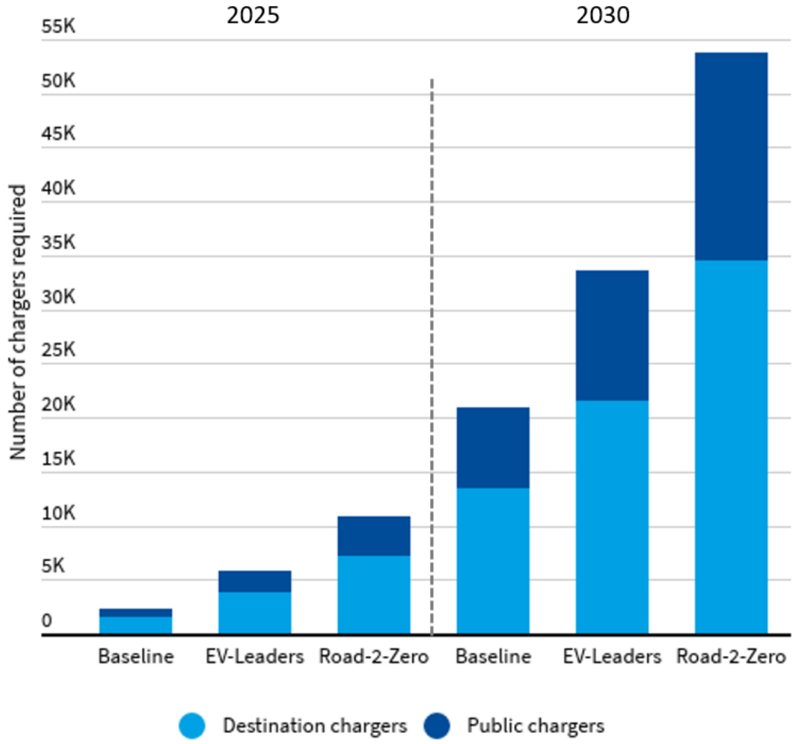
*Truck activity is quantified thanks to tonnes.kilometers (tkm)

**Trips are defined by tonnes (10 tonnes/truck for urban & regional trucks and 12.5 tonnes/truck for long-haul trucks)

Figure 19: Vol. 1 and Vol. 2 comparison: trucks flows electrified in 2030, EU27+UK+NO+CH

Looking at final energy consumption, short and long-haul electric trucks would represent up to 67.8 TWh in 2030 in the Road 2 Zero scenario, 42.8 TWh in the EV-Leaders scenario and 26.6 TWh in the Industry-Baseline scenario. This energy would be consumed by 678,000 trucks in the best-case scenario, 425,000 trucks in the intermediate scenario and 264,000 trucks in the baseline scenario. Considering only the EU27, these three scenarios will see a final electricity consumption between 23.8 TWh and 71.8 TWh in 2030 and a fleet of between 147,000 and 617,000 battery electric trucks.

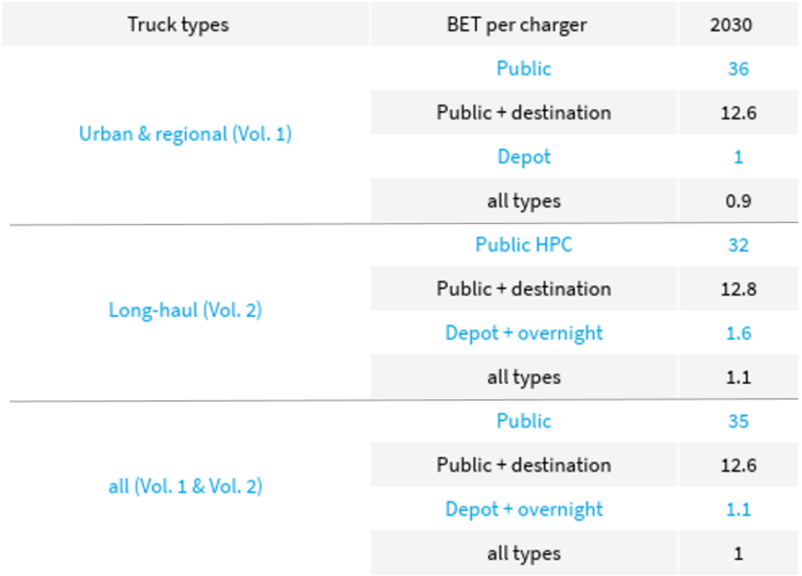
From the charging infrastructure perspective, both studies combined reach a total estimate of between 257,000 and 673,000 chargers in 2030 (13,000-35,000 destination chargers and 8,000-19,000 public HPC chargers), as shown in Figure 20, and upfront investments between €10 billion and €25 billion over the decade to come (2020-2030). This translates into 11,900-31,400 destination chargers and 6,700-17,400 public chargers in the EU27, requiring upfront investments between €9.3 million and €22.9 million for the upcoming decade.



Source: T&E analysis, data from the ETIS Plus project and Eurostat

Figure 20: Destination and public chargers for urban & regional trucks (Vol. 1) and long-haul trucks (Vol. 2), EU27+UK+NO+CH

Looking at the ratio of electric trucks per chargers in 2030, combining Vol. 1 and Vol. 2 would give 12.6 battery electric trucks per public and destination chargers and 1.1 battery electric trucks per depot and overnight chargers (Table 7), whether it is by looking at Europe or at the EU27 only.

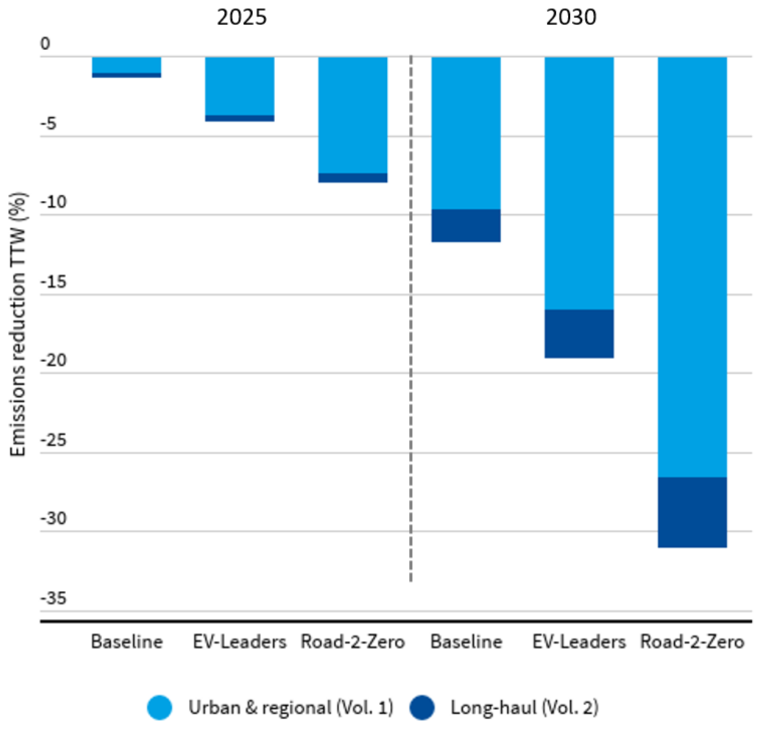


Truck types	BET per charger	2030
Urban & regional (Vol. 1)	Public	36
	Public + destination	12.6
	Depot	1
	all types	0.9
Long-haul (Vol. 2)	Public HPC	32
	Public + destination	12.8
	Depot + overnight	1.6
	all types	1.1
all (Vol. 1 & Vol. 2)	Public	35
	Public + destination	12.6
	Depot + overnight	1.1
	all types	1

Source: T&E analysis, data from the ETIS Plus project and Eurostat

Table 7: Battery electric trucks per charger for urban & regional (Vol. 1) and long-haul (Vol. 2)

Finally, results from Vol. 1 and Vol. 2 suggest that electrifying short and long-haul trucks in Europe would avoid up to 65 MtCO$_2$ (TTW) in 2030, translating into a 31% emissions reduction compared to 2019 emissions from heavy-duty trucks (Figure 21). On the EU27 perspective, it would avoid up to 59 MtCO$_2$ (TTW) in 2030, which would represent a 32% emissions reduction compared to 2019 emissions. These emissions reductions will be mainly done thanks to urban and regional deliveries as they represent most of the trips.



Source: T&E analysis, data from the ETIS Plus project and Eurostat, emission estimate from ACEA

Figure 21: Emissions reduction from urban & regional trucks (Vol. 1) and long-haul (Vol. 2), EU27+UK+NO+CH

5. Hydrogen trucks

Most European manufacturers are planning to begin series production of fuel cell electric trucks only from the second half of the 2020s [12] [37] [38] [39]. Previous T&E analysis has shown that long-haul battery electric trucks with an 800 km range will likely represent the most cost-effective option to decarbonise long-haul trucking and would also likely be cheaper than fuel cell electric trucks if, for example, the renewable hydrogen is produced overseas under ideal conditions and shipped to Europe [28].

Road freight is a business and transport operators will opt for the most cost-competitive vehicle technology provided that it offers sufficient operational flexibility and can use a dense and reliable infrastructure network. It is highly unlikely that hauliers would be willing to pay an additional premium for technologies which offer a significantly higher vehicle range if their real-world operational profile actually does not require it. On the contrary, it should be expected that hauliers will opt for a vehicle range that does not go beyond their route and flexibility requirements in order to reduce costs.

Ultimately, the economic cost-competitiveness of the two vehicle technologies will depend on how their respective economies of scale will evolve over the coming decade. Automotive batteries are currently experiencing a self-reinforcing dynamic which will drive down their costs dramatically due to the accelerating ramp-up in the passenger car market and this is soon expected to spill over to the urban and regional delivery truck segment and, subsequently, to long-haul trucking.

Fuel cells and hydrogen storage tanks will likely not see substantial cost reductions due to the lack of larger scale before the second half of the 2020s. Other potential fuel cell markets such as maritime shipping or stationary back-up applications will likely not scale up to any critical extent before the 2030s. This will likely make it extremely challenging for hydrogen trucks to attain any sizable market share in the heavy-goods vehicle segment in the next decade.

However, hydrogen fuel cell trucks could be part of the solution in particular for demanding long-distance applications where a combination of range and operational flexibility is necessary. There might also be other niche applications where hydrogen trucks may benefit from range- or cost-related advantages. For example, off-road vehicles such as dump trucks for mining operations may need higher amounts of energy stored onboard due to their exceptional operational uptime requirements and lower recharging or refuelling flexibility [40]. Likewise, vehicles for heavy-load and special road freight movements may need larger onboard energy storage as a result of specific operational needs, such as range or higher energy consumption. Remote areas which lack the necessary grid infrastructure for high-power charging could be another possible application scenario for fuel cell electric trucks.[18]

Hydrogen trucks could also have an operational and cost advantage for drayage applications in and around sea ports and their adjacent economic hinterland since container swaps are characterised by short pick-up times and because they would benefit from synergy effects and lower costs with the use of hydrogen to decarbonise maritime shipping [41].

In the context of the wider energy transition and the imperative to fully decarbonise all economic sectors including the power, industry and heating sectors, substantial additional renewable electricity capacity will be needed in Europe. Renewable electricity should therefore be used as efficiently as possible. Because the decarbonisation of the aviation and shipping sectors as well as other hard-to-abate sectors such as industry will rely on electricity-based fuels and renewable hydrogen in

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[18] This will be subject to future analysis in an upcoming publication, which will assess potential roles of hydrogen trucks.

particular, direct electrification should take precedence in road transport wherever feasible, including long-haul trucking [42] .

Proponents of renewable hydrogen in road transport often refer to the need of temporary and seasonal energy storage in a fully renewables-based power system. It is, however, disputable, whether road transport should be used for such storage capacities. There are likely more cost-effective options to balance and store renewable electricity which should be exploited first: additional interconnector capacities between EU countries, load levelling and peak shaving through cross-sectoral demand management, temporary stationary battery storage to balance daily surpluses and pumped storage facilities in Northern Europe for longer electricity storage needs. Renewable hydrogen imports could be used to balance seasonal renewables fluctuation by using it in gas peaker plants to generate electricity [43].

Hydrogen refuelling infrastructure in major EU ports by 2027

In regards to the deployment of refuelling infrastructure for hydrogen trucks, sea ports should be prioritised for initial pilot projects. Ports and industrial clusters represent a no-regret starting point to roll out hydrogen refuelling stations for trucks as this will create synergy effects with hydrogen's future application in the shipping and industry sectors. Sea ports will also serve as major landing terminals for hydrogen imports from offshore or overseas production sites which will improve the initial business case for these hydrogen trucks by lowering their initially high fuel costs.

The European Union should adopt deployment targets for sea ports by 2027. Given that most of the main ports are also urban nodes, high-power electric charging infrastructure also needs to be deployed at these locations.

6. Policy recommendations

6.1 Revision of the AFID

6.1.1 Zero Emission Infrastructure Regulation (ZEIR)

The Directive on the deployment of Alternative Fuels Infrastructure, or AFID [7], sets a regulatory framework for the roll out of public recharging and refuelling infrastructure for the following alternative fuels in transport: electricity, CNG, LNG and hydrogen. The current directive dates back to 2014 and its revision is part of the European Green Deal as a key element of the EU's decarbonisation strategy for the road transport sector.

The current Directive doesn't cover charging infrastructure for electric trucks and only sets targets for natural gas refuelling infrastructure when it comes to heavy-duty vehicles. This conflicts with the European Green Deal, as evidence shows that there are no significant climate benefits in shifting from diesel to fossil gas nor it will help decarbonise road freight [44]. In relation to biomethane, the latest evidence shows that volume of renewable gas that can be sustainably and cost-effectively produced is limited, and that it would not be sufficient to meet the relevant demand from transport (the total renewable methane potential in the EU in 2050 is only 11% of the total demand from heavy duty vehicles and ships, see Section 1.3 of T&E truck charging roadmap for more details [4]).

It is high time that the revised AFID framework starts taking electric trucks seriously by including them in the scope of the technologies and setting appropriate binding targets for their charging infrastructure. This opportunity can not be missed as it would put a halt to the development of a new market where European industry stands a chance for global leadership [45].

First and foremost the revision of the AFID should be coherent with the European Green Deal: **Targets on gas refuelling infrastructure should be taken out of the revised legislation** as they are not a solution to decarbonise road freight transport. All natural gas refuelling infrastructure will rapidly become stranded assets as there is increasing pressure for cities to go zero emission and increasing supply of cost-effective electric trucks. The focus needs to shift exclusively to zero emission technologies: electricity and hydrogen. As such, the **AFI Directive should be turned into a Zero Emission Infrastructure Regulation (ZEIR)**, **focusing exclusively on electricity and hydrogen.**

The definition of what qualifies as an 'alternative fuel' (or a zero emission one) is of paramount importance because it shows what fuels the EU considers to be compatible and coherent with it's Green Deal ambition. This definition is also at the heart of many EU and national funding programmes (including regional and structural funds). For example CEF Transport Blending calls, which are the main tool to finance alternative fuels infrastructure and vehicles, links directly the definition of alternative fuels eligible for funding with the AFID definition [46].

The AFID should be **changed from a Directive to a Regulation**, in line with the EU subsidiarity principle, to allow for a swift adoption and implementation. If the revised framework stays a Directive, it is unlikely that any target would be set before 2025 as it would take an additional 2-3 years to translate the directive into national law. A regulation also allows for a more **harmonised implementation** as current national plans have led to a fragmented approach with regards to road freight fuels, putting some regions at risk to be left behind in the e-mobility transition and greatly reducing the business opportunities. Harmonisation is also essential for the various industry players to streamline their activity rather than have tailored specifications for each market.

Finally a regulation opens the possibility for the EU to set requirements and targets on market players like shippers operating distribution centres. The scope of the revised AFID can then be widened to address **destination charging of electric trucks** at medium and large distribution centers (private or shared industrial premises and are used during loading or unloading of trucks). When relevant, it should be made possible that these chargers can be shared between the different transport operators accessing the delivery center.

6.1.2 Geographic coverage: Binding targets at urban areas and along highways

Urban areas

The revised framework should set **binding targets** for the deployment of **public and destination** charging infrastructure at **urban nodes for 2025 and 2030 (as shown in T&E's previous report on urban and regional deliveries** [5]**)**.

Deploying charging infrastructure at medium and large urban areas will enable the decarbonisation of urban and regional delivery trips thanks to a growing and maturing battery electric truck market, already in the first half of the 2020s. As part of the revision of the TEN-T Regulation, road freight activity hot spots, or 'freight urban nodes' should be identified as locations where the deployment of charging infrastructure would maximise the benefits of the roll-out of the initial charging network.

Accordingly, the revision of the AFID should set the following targets for the deployment of public charging at urban nodes for 2025 and 2030 (at least 350 kW): **a minimum of four public chargers per urban node in 2025, increasing to 10 public charge points in 2030.**

Deployment of public charging at urban nodes should be further incentivised in the first half of the 2020s to meet the demand of early adopters.

For destination charging, all medium and large logistics hubs should have at least one opportunity charger (350 kW or higher) from 2025.

Highway

With long-haul battery electric trucks (400-500 km range) expected to hit the market in the first half of the 2020s, it is crucial that the essential highway networks across the EU are covered with high power charging infrastructure to enable long distance trips.

The revised AFID should require **at least one megawatt charger (MCS) charging station** with a minimum of 4 charging points **every 100 km by 2025** and **at least one site every 50 km by 2030** on the TEN-T Core Network. At least one charging point per station has to be accessible for coaches.

The **minimum power level should be at 700-800kW** in order to ensure that these trucks will be able to do long-distance journeys and stop to fully charge during the drivers' mandatory breaks.

A cross-industry consortium has been working on the deployment of MCS public charging with the first pilot project aiming to deploy the first MCS by 2023 [47]. Setting a target for MCS charging in 2025 is adequate as it gives two years for the new standard to be deployed since the first project. However, in the case of delays in the standards, the 2025 target could be enforced with high power chargers (above 350 kW) as a first step and then the minimum power level increased to 700-800 kW from 2027.

Furthermore, when travelling long distances, a long haul battery electric truck will not always come back to the depot overnight. The revised AFID should thus set targets for the deployment of lower power (100 kW) **public overnight chargers at truck parking areas along the highways** with at least **40,000 overnight public chargers in 2030**.

6.1.3 Binding targets - EU overview

Beyond the minimum geographic coverage requirements (which are based on the TEN-T network and urban nodes), the revision of the AFID should also guarantee that the number of public and destination chargers increases in line with the number of electric trucks on the road. Therefore the new legislation should set the right framework and targets to reach the level of infrastructure deployment needed for an ambitious uptake of electric trucks (T&E's Road 2 Zero scenario).

The total number of public and destination chargers should amount to around 50,000 charge points in the EU27+UK, or 42,000 charge points in the EU. Between one third to one half of these charging points are estimated to be for public charging.

Based on the truck movements analysis detailed previously, the table below presents T&E's recommendations with respect to the deployment of electric trucks and their charging infrastructure for the next decade.

EU27[19]	2025	2030
Public charge points [HPC]	3,000 [900]	15,000 [4,000]
Destination charge points	5,000	27,000
Public + Destination	9,000	42,000
Battery electric trucks	120,000	520,000

Table 8: T&E's recommendations regarding the number of battery electric trucks on the road and the required charging infrastructure[20]

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[19] Given the uncertainties on their charging requirements, non regulated trucks are excluded from these recommendations, which explains the difference with the results presented before (non regulated trucks are estimated to represent about 15% of the current truck fleet).

[20] The sum of public and destination might not match the total because of rounding.

6.1.4 Binding targets per Member States

The revision of the AFID should ensure that the above values for the deployment of charging infrastructure in the EU27 are met by setting minimum binding per Member State.

Setting binding targets for each country would create a **clear and harmonized pathway for deploying charging infrastructure,** independent of national agendas which could risk undermining the longer-term coherence in the deployment strategy. Such targets would also grant certainty and visibility to the e-mobility value chain, including the truck manufacturers, the grid and charging operators, and transport companies.

T&E's recommendations for the country binding targets are presented in Annex. Table 9 below gives an overview of the target for 6 key EU countries: Germany, France, Italy, Spain, Poland and the Netherlands below:

	Germany	France	Spain	Italy	Poland	Netherlands
Public chargers	3,500	2,200	2,000	1,400	1,500	500
Destination chargers	6,200	4,000	3,700	2,600	2,600	900
Public + Destination	9,700	6,300	5,700	4,000	4,000	1,400
Battery electric trucks	120,000	80,000	72,000	51,000	51,000	18,000

Table 9: Targets per Member State (only regulated trucks are presented here)

6.1.5 Grid connection

Charging locations (public parking and distribution centers) should be prepared with sufficient grid connections as early as possible. The preparation of the grid can take several years but will ensure that the chargers can be rolled out and integrated to the grid quickly when needed.

The EU should ensure that when a truck parking site is built or renovated under the Safe and Secure Parking Areas framework [48], the grid connection is sufficient for the future truck charging demand. It is key that there should be adequate planning of the deployment of the electricity grid and upgrades in line with the expected needs along the highways. In a letter sent in summer 2020, an alliance of truckmakers, suppliers, NGOs and the power sector urged the Commission to plan ahead for the future deployment of electric charging and hydrogen refuelling stations for zero-emission trucks [49].

6.2 Revision of the TEN-T Regulation

The Trans-European Transport Network (TEN-T) Regulation addresses the implementation and development of a Europe-wide network of railway lines, roads, inland waterways, maritime shipping routes, ports, airports and railroad terminals. The current TEN-T policy is based on TEN-T Regulation (EU) No 1315/2013 which is planned to be revised in 2021 under the European Commission's Action Plan on the European Green Deal. Both the revision of AFID and the revision of the TEN-T Regulation should be addressed in a coherent manner as they are both part of the same action point in the EU Green Deal planning [50].

Article 30 of the 2013 TEN-T Regulation called for the *'promotion of efficient low-noise and low-carbon urban freight delivery'* at the urban nodes of the TEN-T Core network, but so far very little has been done to promote electric urban deliveries. T&E asks for the revision of the TEN-T Regulation to make this one of the key objectives of the new regulation and to strengthen it by **championing urban nodes as EU's leaders for zero emission mobility**. The sentence in Article 30 should then read *'promotion of efficient low-noise and* ***zero tailpipe emission urban and regional freight delivery****'.*

To achieve the significant reduction of emissions as demonstrated in this paper, the revised TEN-T Regulation should widen the scope of the urban nodes to a **secondary set of freight nodes, effectively doubling the number of urban nodes** and roughly doubling the potential of urban nodes to electrify trucks as demonstrated in this paper. These freight nodes should be selected with the specific aim to cover as much of the EU's urban and regional road freight activity, thus maximising the CO_2 emission reduction and air quality benefits in cities.

6.3 Finance: Accelerating the uptake of electric trucks

As of today, the two main barriers to adoption of electric trucks are the high upfront costs and the very limited supply of vehicles. These two factors are intrinsically linked as current low production volumes entails high unit production costs on the one hand and high purchase prices reduces the demand on the other hand[21].

In May 2020, the European Commission presented a new €750 billion recovery instrument, Next Generation EU [52] (on top of the €1.1 billion revamped seven year budget). The spendings on EU's main fund for transport infrastructure projects, Connecting Europe Facility or CEF, have been

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[21] This is observed through high battery costs for electric heavy duty vehicles (373$/kWh outside of China) which compares with the average for electric heavy duty vehicles produced in China and the average for BEV which are respectively at 140$/kWh and 150$/kWh, according to BNEF [51].

increased to €14.5 billion [53][22]. If this money is well spent, the market for electric trucks can be kick-started in the next few years and break the self-sustaining cycle of high-costs and low-volumes.

6.3.1 EU Recovery Fund & Recharge flagship

As part of the Recovery and Resilience Facility (RRF), the EC strongly encourages Member States to put forward investment and reform plans on the so-called 'Recharge and Refuel' flagship. The seven EC flagships do not set any requirements but 'strongly encourage' Member States to include them in their recovery and resilience plans investment and reforms. The EC highlights that these flagships underpin common challenges, call for coordinated investments and reforms, and will bring tangible benefits to the economy and citizens across the EU, notably for jobs and growth and for making Europe greener.

To meet the climate objectives, it is essential that Member States place a strong focus on the 'Recharge and Refuel' flagship in their recovery plans, notably on electric truck charging infrastructure. Financing and funding support are necessary to support the initial rollout of the dedicated truck charging infrastructure: at the depot, at the distribution centre and at public locations, being it urban areas or along highways. The proactive and anticipated preparation of the electricity grid is also needed to allow for smooth infrastructure deployment throughout the next years.

Furthermore, financial support to the trucking sector should be targeted to enable the transition away from diesel and gas as well as for the deployment of charging infrastructure. Firstly, it is essential that no financial support can be granted to fossil fueled vehicles and infrastructure. Secondly, these plans should set up financial support programmes to help truckmakers scale up manufacturing of zero-emission trucks and commit to reach 10% of sales production by 2025. This short term recovery fund would help support OEMs' transition of manufacturing platforms and help them navigate through the economic crisis.

6.3.2 CEF Transport Blending Calls & Strategic Rollout Action Plan

To achieve the objectives laid out in this report, T&E recommends to **redesign the CEF transport blending calls and to target the announced 'Strategic Rollout Action Plan'**[23] to have adequate and streamlined funding mechanisms to accelerate the uptake of electric trucks.

It is of paramount importance that both mechanisms **focus on zero emission only** (see 5.1.1 Zero Emission Infrastructure Regulation). Providing financial support to gas trucks would not be compatible with the Green Deal objectives, would create lock-in and path dependency effects with adverse

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[22] The previous budget proposal from 2018 was for €11.4 billion.

[23] The 'Strategic Rollout Action Plan' is planned by the European Commission as a flanking measure -in complement to the revised AFID - to accelerate the roll-out of alternative fuel infrastructure.

consequences on the speed of the uptake of electric trucks and would direct limited financial resources to the creation of stranded assets rather than towards the much needed decarbonisation of transport.

Secondly, both mechanisms should address the three different electric truck charging use cases:

- **Transport companies**: a fixed amount of money should be made available for the purchase of electric trucks and the installation of the associated depot chargers. This amount could be fixed per truck size/weight category, or better, it could increase in line with the range of the vehicle (e.g. 100-200€/km of range for heavy trucks, which would fund 20%-40% of the additional cost)[24]. The latter solution is preferable as it incentivises vehicle efficiency improvements and longer range vehicles. However, given the official VECTO certification will only be available in a couple of years (possibly around 2023), the former solution (fixed amount) can be used in the meantime (or battery capacity could be used as a proxy of range).
- **Shippers** owning and operating medium and large **distribution centers**: streamlined financial support should be provided to install the necessary high power opportunity charging infrastructure at the distribution centers. These destination chargers can be shared by several transport companies that load or unload cargo at the distribution center and a booking system would maximise utilisation while eliminating charge anxiety for transport operators.
- **Charge point operators** should benefit from a high co-funding rate for the deployment of public charging infrastructure at the urban nodes and along the TEN-T Core network. As the market maturity for electric trucks is lower than for electric cars, the co-funding rates should be adjusted accordingly and increased from the current 20% co-funding rate applied to public charging networks for cars (e.g. Ionity) to 50% co-funding rate, as the new CEF regulation (art 14) allows it.

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[24] The marginal cost of adding one km of range to a heavy duty truck is about 500€/km (373$/kWh or 338€/kWh for e-HDVs outside of China according to BNEF [51] and efficiency around 1.5 kWh/km). This simplified calculation excludes the cost difference of the diesel engine and electric motor.

7. Annexes

7.1. T&E's approximated TEN-T core network

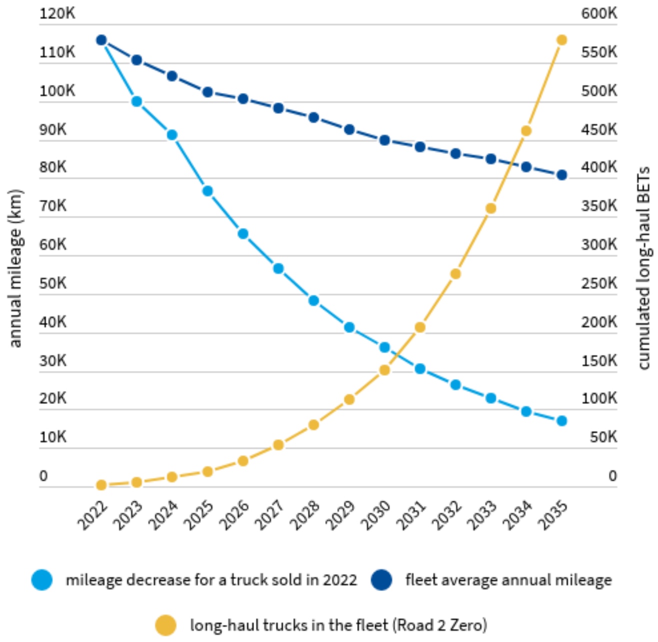
As explained in Section 2.2, in order to analyze truck flows going through main freight routes in Europe, T&E modelled an approximated TEN-T core network. This model is based on the 88 urban nodes defined in the TEN-T regulation and has has been built according to the following methodology:

1. Urban nodes pairs have been selected based on distance and on tonnes transported between both locations, thanks to the O/D matrix T&E built on ETIS Plus and Eurostat data. Which means that for each urban node, only the busiest nodes among the nearest ones were kept to build these urban node pairs.
2. From each pair, the section of the TEN-T network has been approximated as straight lines between two nodes.
3. Then, the TEN-T network has been completed including all NUTS3 regions within a 50 km distance to the straight lines described above. These regions crossed by the network are called TEN-T regions in this study and are the basis of the analysis.
4. Finally, minor manual changes have been made in order to take into consideration local discrepancies where straight lines did not make sense and to fit better the actual TEN-T network (e.g. connections crossing seas).

Therefore, the TEN-T network modelled here is a combination of TEN-T regions making up the network. These regions include almost all urban nodes and account for 793 regions out of the 1,348 NUTS3 regions in the EU.

7.2. T&E's BET truck activity modelling

As explained in Section 3.2, the tonnes.kilometers per electric truck have been modelled based on different parameters: the average payload per truck, the average payload factor and the annual mileage. While the payload and the payload factors are expected to remain constant throughout the ageing of a truck, the annual mileage will decrease. This annual decrease has been calculated based on the EUTRM model and is illustrated below in Figure 23.



Source: T&E analysis, data from Traccs and EUTRM truck fleet modelling

Figure 23: Annual mileage modelling for long-haul electric trucks

Therefore, the average fleet truck activity will slightly decrease over time as the fleet grows and gets older. Pushing this modelling up to 2050 with an average lifespan of 15 years, this led to a fleet having a 600,000 tkm/truck average per year, slightly higher than the current average for long-haul trucks.

7.3. Charging infrastructure estimate

In order to estimate the charging infrastructure required for the new battery electric truck fleet, the average power needed per truck for each type of charger has been approximated as followed:

$$average\ power_{charger} = distance * SoC * energy / charging\ time$$

Where:

$average\ power_{charger}$ is the power output needed in average for each truck to charge in order to drive a certain distance, depending on the charger type.

$distance$ is the average trip distance driven by the growing battery electric truck fleet, based on the truck flows modelling (e.g. in 2030, more trips will be electrified in the 600-700 km band than in 2025, see Section 3.2).

SoC is the ‘state-of-charge’ of the battery. This parameter takes into consideration the fact that most of the time the battery won’t need to be completely filled, as the truck won’t arrive at the charging location with an empty battery and as it won’t charge up to 100% of the battery capacity as between 80 and 100% SoC charging the battery is slower.

$energy$ is the truck energy consumption. As explained in Section 3.2, the truck energy consumption has been calculated for each period depending on the fleet age (i.e. more and more electric trucks will be sold and they will have lower energy consumption, which will lower the average fleet energy consumption).

$charging\ time$ is the average time spent by a truck to charge at a specific charger. This time will depend on the charger type as chargers are designed for specific use cases.

All the parameters being used for each charger are summarized below:

	Year	Depot	Public overnight	Destination	HPC
Charging time per truck	all	8h		1.5h	45 min
Average BET trip distance	2025	442 km in 2025, 491 km in 2030 and 518 km in 2035			
SoC	2025	60% in 2025, 70% in 2030 and 80% in 2035			

Table 10: Assumptions for the average power calculation

7.4. Detailed electric truck uptake assumptions

Trip type	Distance band (km)	Industry-Baseline			EV-Leaders			Road-2-Zero		
		2025	2030	2035	2025	2030	2035	2025	2030	2035
TEN-T to TEN-T	400-500	10.9%	49.3%	100%	9.1%	67.3%	100%	13.7%	70.8%	100%
TEN-T to TEN-T	500-600	4.7%	43.1%	100%	7.1%	53.8%	100%	11.0%	70.8%	100%
TEN-T to TEN-T	600-700	1.6%	30.8%	89.0%	5.1%	40.4%	100%	8.2%	56.6%	100%
TEN-T to TEN-T	700-800	0.0%	12.3%	44.5%	2.0%	20.2%	100%	4.1%	28.3%	100%
TEN-T to TEN-T	800-900	0.0%	6.2%	29.7%	1.0%	13.5%	100%	2.7%	21.2%	100%
TEN-T to TEN-T	900-1000	0.0%	0.0%	14.8%	0.0%	6.7%	91.6%	1.4%	14.2%	100%
TEN-T to TEN-T	> 1000	0.0%	0.0%	0.0%	0.0%	0.0%	45.8%	0.0%	7.1%	100%
TEN-T to X	400-500	7.8%	36.9%	100%	8.1%	60.6%	100%	12.4%	70.8%	100%
TEN-T to X	500-600	3.1%	30.8%	100%	6.1%	47.1%	100%	9.6%	63.7%	100%
TEN-T to X	600-700	0.0%	18.5%	74.2%	4.1%	33.6%	100%	6.9%	49.5%	100%
TEN-T to X	700-800	0.0%	6.2%	29.7%	1.0%	13.5%	100%	2.7%	21.2%	100%
TEN-T to X	800-900	0.0%	0.0%	0.0%	0.0%	6.7%	91.6%	1.4%	14.2%	100%
TEN-T to X	900-1000	0.0%	0.0%	0.0%	0.0%	0.0%	45.8%	0.0%	7.1%	100%
TEN-T to X	> 1000	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	62.0%
X to X	400-500	3.1%	24.6%	74.2%	4.1%	33.6%	100%	6.9%	42.5%	100%
X to X	500-600	0.0%	12.3%	44.5%	2.0%	20.2%	100%	4.1%	28.3%	100%
X to X	600-700	0.0%	6.2%	14.8%	0.0%	6.7%	91.6%	1.4%	14.2%	100%
X to X	700-800	0.0%	0.0%	0.0%	0.0%	0.0%	45.8%	0.0%	7.1%	62.0%
X to X	800-900	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
X to X	900-1000	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
X to X	> 1000	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

7.5. Detailed results per country - Truck activity electrified (Mtkm)

Country	Industry-Baseline			EV-Leaders			Road-2-Zero		
	2025	2030	2035	2025	2030	2035	2025	2030	2035
AT	275	2207	6390	412	3415	10874	698	4615	12790
BE	152	1220	3519	226	1876	7817	383	2827	13089
BG	37	298	928	59	477	1657	98	697	2806
CZ	261	2108	6080	396	3229	9957	660	4387	12227
DE	2226	19093	50807	3359	27054	79738	5527	37036	104424
DK	55	617	1888	109	954	3875	195	1393	5371
EE	25	180	524	35	280	956	57	406	1570
ES	1111	9221	26137	1696	13610	44722	2781	19328	72465
FI	35	490	1701	76	804	4566	164	1205	5473
FR	1383	10609	29674	1988	16023	49439	3274	21757	69076
GR	16	171	542	30	271	2816	55	645	7521
HR	78	592	1743	111	905	2768	185	1217	3751
HU	187	1458	4199	272	2261	8481	462	3235	12168
IE	28	241	719	46	378	1247	77	529	1710
IT	960	7588	21910	1414	11560	38374	2362	16059	54418
LT	44	411	1253	76	641	2756	131	982	5028
LV	17	132	413	25	218	1319	45	380	2531
NL	307	2483	7136	462	3800	14582	776	5559	23353
PL	1069	8441	24903	1586	13215	50856	2700	19172	77075
PT	87	808	2429	148	1271	6681	260	2110	11434
RO	133	1023	3079	199	1633	6379	334	2427	12403
SE	474	3302	8936	619	4866	12148	994	6301	15133
SI	90	684	1873	125	1020	3640	208	1450	5190
SK	151	1140	3387	220	1819	6082	372	2510	8841
CY	0	0	0	0	0	4	0	1	12

LU	31	237	669	44	357	1085	73	489	1392
UK	484	4209	12932	799	6495	20289	1327	8921	30326
NO	95	970	3046	163	1434	5344	293	1938	6355
UK	111	1001	2945	185	1539	5003	314	2126	6285
EU27	9232	74756	210838	13736	111937	372817	22870	156720	541251
EU27+UK	9716	78965	223771	14534	118431	393106	24196	165641	571578
EU27+UK+ NO+CH	9922	80936	229762	14882	121405	403454	24804	169705	584217

7.6. Detailed results per country - Energy needs (GWh)

Country	Industry-Baseline			EV-Leaders			Road-2-Zero		
	2025	2030	2035	2025	2030	2035	2025	2030	2035
AT	31	225	628	46	349	1069	78	471	1257
BE	17	125	346	25	192	768	43	289	1286
BG	4	30	91	7	49	163	11	71	276
CZ	29	215	598	44	330	979	74	448	1202
DE	248	1949	4994	375	2762	7837	617	3781	10264
DK	6	63	186	12	97	381	22	142	528
EE	3	18	51	4	29	94	6	41	154
ES	124	941	2569	189	1389	4396	310	1973	7122
FI	4	50	167	8	82	449	18	123	538
FR	154	1083	2917	222	1636	4859	365	2221	6789
GR	2	18	53	3	28	277	6	66	739
HR	9	60	171	12	92	272	21	124	369
HU	21	149	413	30	231	834	52	330	1196
IE	3	25	71	5	39	123	9	54	168
IT	107	775	2153	158	1180	3772	264	1639	5349

LT	5	42	123	9	65	271	15	100	494
LV	2	13	41	3	22	130	5	39	249
NL	34	253	701	52	388	1433	87	568	2295
PL	119	862	2448	177	1349	4998	301	1957	7575
PT	10	82	239	17	130	657	29	215	1124
RO	15	104	303	22	167	627	37	248	1219
SE	53	337	878	69	497	1194	111	643	1487
SI	10	70	184	14	104	358	23	148	510
SK	17	116	333	25	186	598	41	256	869
CY	0	0	0	0	0	0	0	0	1
LU	3	24	66	5	36	107	8	50	137
UK	54	430	1271	89	663	1994	148	911	2981
NO	11	99	299	18	146	525	33	198	625
UK	12	102	289	21	157	492	35	217	618
EU27	1030	7631	20723	1533	11427	36643	2552	15998	53198
EU27+UK	1084	8061	21994	1622	12090	38637	2701	16909	56179
EU27+UK+ NO+CH	1107	8262	22583	1661	12393	39654	2768	17324	57421

7.7. Detailed results per country - Long-haul electric trucks

Country	Industry-Baseline			EV-Leaders			Road-2-Zero		
	2025	2030	2035	2025	2030	2035	2025	2030	2035
AT	215	1970	6328	322	3047	10769	546	4119	12666
BE	119	1088	3485	177	1674	7741	300	2523	12962
BG	29	266	919	46	426	1641	76	622	2779
CZ	204	1881	6021	310	2881	9860	516	3915	12108
DE	1743	17038	50315	2629	24141	78965	4326	33049	103412

DK	43	550	1869	86	852	3838	153	1243	5319
EE	20	161	519	28	250	947	45	362	1555
ES	869	8228	25883	1328	12145	44289	2176	17247	71763
FI	27	437	1684	59	717	4522	128	1076	5420
FR	1082	9467	29387	1556	14297	48960	2562	19414	68407
GR	13	153	537	24	242	2788	43	576	7448
HR	61	528	1726	87	807	2741	145	1086	3715
HU	147	1301	4158	213	2018	8399	362	2886	12050
IE	22	215	712	36	337	1235	60	472	1694
IT	751	6771	21698	1107	10315	38002	1849	14330	53891
LT	34	367	1241	60	572	2729	102	876	4979
LV	14	118	409	20	195	1307	35	339	2507
NL	240	2216	7067	362	3391	14441	608	4961	23127
PL	837	7532	24662	1241	11792	50363	2113	17108	76328
PT	68	721	2406	116	1134	6616	203	1883	11323
RO	104	913	3049	156	1457	6317	261	2166	12282
SE	371	2946	8850	484	4342	12030	778	5623	14987
SI	71	611	1855	98	911	3605	163	1294	5139
SK	118	1017	3354	172	1623	6023	291	2240	8756
CY	0	0	0	0	0	4	0	1	12
LU	24	212	662	35	319	1074	57	437	1379
UK	379	3756	12807	625	5795	20093	1039	7961	30033
NO	74	865	3017	127	1279	5293	229	1729	6294
UK	87	894	2917	145	1374	4955	246	1897	6224
EU27	7226	66707	208796	10751	99885	369206	17900	139846	536008
EU27+UK	7605	70463	221603	11376	105680	389299	18939	147806	566041
EU27+UK+ NO+CH	7766	72222	227536	11649	108333	399546	19414	151433	578558

7.8. Detailed results per country - Public HPC chargers

Country	Industry-Baseline			EV-Leaders			Road-2-Zero		
	2025	2030	2035	2025	2030	2035	2025	2030	2035
AT	13	62	118	20	95	202	34	129	237
BE	7	34	65	11	52	145	18	79	243
BG	2	8	17	3	13	31	5	19	52
CZ	13	59	113	19	90	185	32	122	227
DE	107	533	942	162	755	1478	267	1033	1936
DK	3	17	35	5	27	72	9	39	100
EE	1	5	10	2	8	18	3	11	29
ES	54	257	485	82	380	829	134	539	1343
FI	2	14	32	4	22	85	8	34	101
FR	67	296	550	96	447	917	158	607	1281
GR	1	5	10	1	8	52	3	18	139
HR	4	17	32	5	25	51	9	34	70
HU	9	41	78	13	63	157	22	90	226
IE	1	7	13	2	11	23	4	15	32
IT	46	212	406	68	323	711	114	448	1009
LT	2	11	23	4	18	51	6	27	93
LV	1	4	8	1	6	24	2	11	47
NL	15	69	132	22	106	270	37	155	433
PL	52	236	462	76	369	943	130	535	1429
PT	4	23	45	7	35	124	13	59	212
RO	6	29	57	10	46	118	16	68	230
SE	23	92	166	30	136	225	48	176	281
SI	4	19	35	6	28	67	10	40	96
SK	7	32	63	11	51	113	18	70	164
CY	0	0	0	0	0	0	0	0	0

LU	1	7	12	2	10	20	4	14	26
UK	23	117	240	39	181	376	64	249	562
NO	5	27	56	8	40	99	14	54	118
UK	5	28	55	9	43	93	15	59	117
EU27	445	2086	3909	662	3123	6911	1103	4373	10034
EU27+UK	469	2203	4148	701	3305	7287	1167	4622	10596
EU27+UK+ NO+CH	479	2258	4259	718	3388	7479	1196	4735	10830

7.9. Detailed results per country - Destination chargers

Country	Industry-Baseline			EV-Leaders			Road-2-Zero		
	2025	2030	2035	2025	2030	2035	2025	2030	2035
AT	20	92	222	30	143	378	50	193	445
BE	11	51	122	16	79	272	28	118	455
BG	3	12	32	4	20	58	7	29	98
CZ	19	88	211	29	135	346	48	184	425
DE	161	799	1766	243	1132	2772	400	1550	3630
DK	4	26	66	8	40	135	14	58	187
EE	2	8	18	3	12	33	4	17	55
ES	80	386	908	123	570	1554	201	809	2519
FI	3	21	59	5	34	159	12	50	190
FR	100	444	1031	144	671	1718	237	911	2401
GR	1	7	19	2	11	98	4	27	261
HR	6	25	61	8	38	96	13	51	130
HU	14	61	146	20	95	295	33	135	423
IE	2	10	25	3	16	43	6	22	59
IT	69	318	762	102	484	1334	171	672	1891

LT	3	17	44	6	27	96	9	41	175
LV	1	6	14	2	9	46	3	16	88
NL	22	104	248	33	159	507	56	233	812
PL	77	353	866	115	553	1768	195	802	2679
PT	6	34	84	11	53	232	19	88	397
RO	10	43	107	14	68	222	24	102	431
SE	34	138	311	45	204	422	72	264	526
SI	7	29	65	9	43	127	15	61	180
SK	11	48	118	16	76	211	27	105	307
CY	0	0	0	0	0	0	0	0	0
LU	2	10	23	3	15	38	5	20	48
UK	35	176	450	58	272	705	96	373	1054
NO	7	41	106	12	60	186	21	81	221
UK	8	42	102	13	64	174	23	89	218
EU27	668	3129	7328	994	4685	12959	1655	6560	18813
EU27+UK	703	3305	7778	1052	4957	13664	1751	6933	19867
EU27+UK+ NO+CH	718	3388	7986	1077	5081	14024	1794	7103	20307

7.10. Detailed results per country - Depot chargers

Country	Industry-Baseline			EV-Leaders			Road-2-Zero		
	2025	2030	2035	2025	2030	2035	2025	2030	2035
AT	159	845	1777	238	1307	3024	404	1766	3557
BE	88	467	979	131	718	2174	222	1082	3640
BG	21	114	258	34	183	461	56	267	780
CZ	151	807	1691	229	1236	2769	382	1679	3400
DE	1288	7307	14128	1944	10353	22173	3199	14173	29037

DK	32	236	525	63	365	1078	113	533	1494
EE	14	69	146	20	107	266	33	155	437
ES	643	3529	7268	982	5208	12436	1609	7396	20150
FI	20	187	473	44	307	1270	95	461	1522
FR	800	4060	8251	1151	6131	13748	1895	8326	19208
GR	9	66	151	17	104	783	32	247	2091
HR	45	227	485	64	346	770	107	466	1043
HU	108	558	1168	158	865	2358	267	1238	3384
IE	16	92	200	26	145	347	45	202	476
IT	556	2904	6093	819	4424	10671	1367	6145	15132
LT	25	157	349	44	245	766	76	376	1398
LV	10	50	115	14	84	367	26	145	704
NL	178	950	1984	267	1454	4055	449	2127	6494
PL	619	3230	6925	918	5057	14141	1563	7337	21432
PT	50	309	676	86	486	1858	150	808	3179
RO	77	392	856	115	625	1774	193	929	3449
SE	274	1263	2485	358	1862	3378	575	2411	4208
SI	52	262	521	73	391	1012	121	555	1443
SK	87	436	942	127	696	1691	215	961	2458
CY	0	0	0	0	0	1	0	0	3
LU	18	91	186	26	137	302	42	187	387
UK	280	1611	3596	462	2485	5642	768	3414	8433
NO	55	371	847	94	549	1486	170	742	1767
UK	64	383	819	107	589	1391	182	813	1748
EU27	5343	28607	58628	7950	42836	103669	13236	59973	150506
EU27+UK	5623	30218	62224	8412	45321	109311	14004	63387	158938
EU27+UK+ NO+CH	5743	30972	63890	8614	46459	112188	14356	64942	162453

7.11. Detailed results per country - Overnight chargers

Country	Industry-Baseline			EV-Leaders			Road-2-Zero		
	2025	2030	2035	2025	2030	2035	2025	2030	2035
AT	71	375	790	106	581	1344	179	785	1581
BE	39	207	435	58	319	966	99	481	1618
BG	10	51	115	15	81	205	25	119	347
CZ	67	359	751	102	549	1231	170	746	1511
DE	573	3247	6279	864	4601	9854	1422	6299	12905
DK	14	105	233	28	162	479	50	237	664
EE	6	31	65	9	48	118	15	69	194
ES	286	1568	3230	436	2315	5527	715	3287	8956
FI	9	83	210	19	137	564	42	205	676
FR	356	1804	3667	511	2725	6110	842	3700	8537
GR	4	29	67	8	46	348	14	110	930
HR	20	101	215	29	154	342	48	207	464
HU	48	248	519	70	385	1048	119	550	1504
IE	7	41	89	12	64	154	20	90	211
IT	247	1291	2708	364	1966	4743	608	2731	6725
LT	11	70	155	20	109	341	34	167	621
LV	4	22	51	6	37	163	11	65	313
NL	79	422	882	119	646	1802	200	946	2886
PL	275	1436	3078	408	2248	6285	695	3261	9525
PT	22	137	300	38	216	826	67	359	1413
RO	34	174	381	51	278	788	86	413	1533
SE	122	562	1104	159	828	1501	256	1072	1870
SI	23	116	231	32	174	450	54	247	641
SK	39	194	419	57	309	752	96	427	1093

CY	0	0	0	0	0	0	0	0	2
LU	8	40	83	11	61	134	19	83	172
UK	124	716	1598	205	1105	2508	341	1517	3748
NO	24	165	376	42	244	661	75	330	785
UK	29	170	364	48	262	618	81	362	777
EU27	2375	12714	26057	3533	19038	46075	5883	26655	66891
EU27+UK	2499	13430	27655	3739	20143	48583	6224	28172	70639
EU27+UK+ NO+CH	2552	13765	28395	3828	20648	49861	6380	28863	72201

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