BRIEFING - May 2024

HDV charging manual

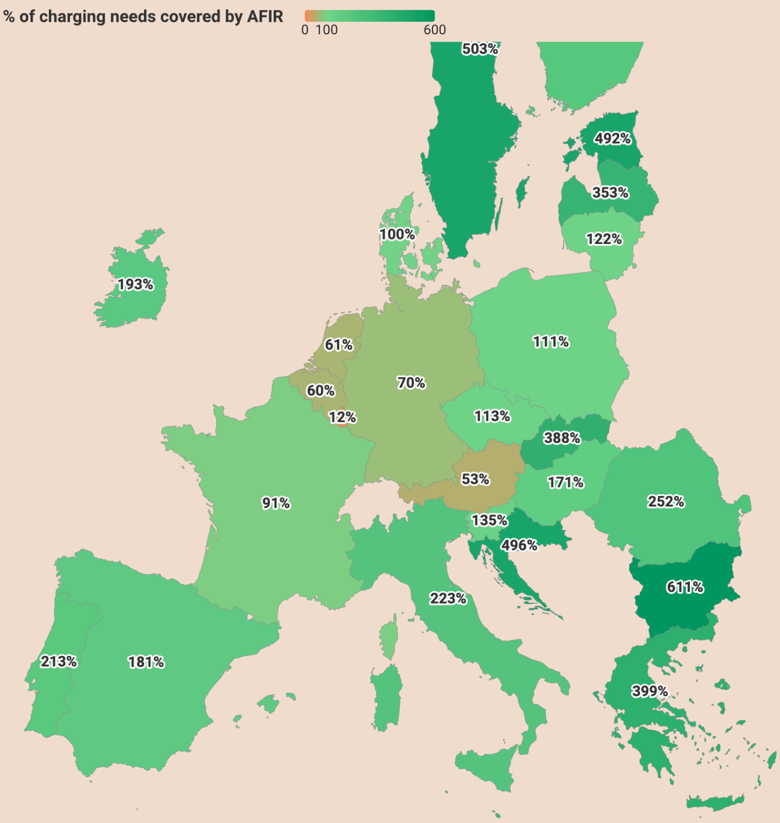
How to get public HDV charging infrastructure right

Summary

The EU's highway charging law, or AFIR in EU jargon, sets ambitious targets for member states to develop a robust and dense public charging network for heavy-duty vehicles (HDVs) across the EU by 2030. However, the law's 'one size fits all' approach may not sufficiently address the varying truck and coach activity across member states, regions and road sections. This creates the risk that in some member states charging infrastructure might be insufficient to meet demand, whereas other member states are required to deploy chargers that will hardly ever be used.

If HDV manufacturers produce just enough electric vehicles to meet the new HDV CO2 standards ('Current Policies' scenario), the AFIR targets could supply a fleet 6 times the expected size in Bulgaria in 2030, while in Luxembourg an AFIR-aligned deployment would be barely enough to power 12% of the public charging needs.

'Current Policies' scenario 2030



Source: European Union (2023), Council of the European Union (2024), EUTRM (2024).

Figure 1: AFIR sufficiency in 2030 - 'Current Policies' scenario

In this briefing, T&E has instead modelled what a ['tailored' charging roll-out approach] could look like, realigning the AFIR targets to the actual needs. It largely builds on the original density prescribed by AFIR while adapting the required installed capacity to the projected local electrified traffic volumes.

Building on that analysis, T&E recommends EU member states to take the following into account when planning their HDV charging infrastructure:

1. Adapt AFIR targets to real-world demand:

Align national deployment plans with real-world traffic data and projected battery electric fleet sizes. This includes adjusting the power output and spacing of charging hubs to better match actual HDV traffic volumes and thus charging needs.

2. Forward looking grid capacity and planning:

- Make proactive grid planning a priority to support the anticipated surge in adoption of battery electric vehicles. National Regulatory Authorities (NRAs) should ensure that Transmission and Distribution System Operators (TSOs and DSOs) expand their capacities in anticipation rather than in reaction to demand.
- Streamline and harmonise administrative processes for grid connections, facilitating quicker setup of charging infrastructure. This includes setting clear timelines for connection requests, making capacity maps easily available to prospective charging providers and providing transparency throughout the process.

3. Economically efficient use of public funds:

- Deploy public funding in a non-market distorting manner to bridge the gap at initially unprofitable locations to ensure timely and comprehensive network coverage. The implementation of the Renewable Energy Directive's (RED III) crediting mechanism should be fast-tracked to support early-stage charging infrastructure until a sustainable market-driven model is viable.
- Consider smart tendering strategies that bundle high and low utilisation locations to avoid creating operational subsidies dependencies and to prevent monopolistic control over charging networks.

4. Stakeholder engagement and collaborative planning

Set up a continuous engagement process involving all relevant stakeholders including vehicle manufacturers, Charge Point Operators (CPOs), grid operators, and public authorities. This approach will facilitate the sharing of critical information and ensure that infrastructure development is responsive to the specific needs and capabilities of each region.

5. Market-led infrastructure deployment:

While initial public support is necessary, the long-term goal should be to transition to a market-led deployment strategy. This ensures that the infrastructure development is sustainable and capable of adapting to evolving market conditions without continuous public financial support.

1. How to implement the EU’s highway charging law for trucks?

The EU’s highway charging law, also known under the acronym AFIR (Alternative Fuel Infrastructure Regulation), came into force on 13th April 2024. Alongside mandatory targets for other transport modes, AFIR requires member states to install a dedicated charging infrastructure for heavy-duty vehicles (HDVs) every 60 km along their main highways, and every 100 km along their secondary highways. This briefing aims to provide member states with a manual on how to best implement AFIR. It looks at how member states could best adjust the targets to the actual demand, how to plan for the needed grid connections, and how to balance a market-based approach with public support.

The first targets for HDVs are kicking in at the end of 2025 with member states needing to make sure that at least 15% of their share of the EU’s Trans-European Transport Network (TEN-T) is equipped with chargers that are exclusively accessible by HDVs.[1] By 2027 they need to increase the coverage to at least 50%, with a full coverage reached by the end of 2030. This briefing will focus on the 2030-targets, the year the newly increased HDV CO2 standards will take effect. There will also be an outlook to the amount of public charging infrastructure needed in 2035 and 2040.

1.1 Targets and timeline of the EU law

By 2030 truck charging infrastructure needs to be available along the TEN-T network, which spans over 108,000 km of roads across the EU. As per the AFIR, member states are required to install a minimum of one charging hub exclusively for HDVs every 60 km (TEN-T core) to 100 km (TEN-T network) in each direction of travel by 2030.

Figure 2: TEN-T core (bold red) and comprehensive (red) network (yellow: urban nodes)[2]

[1] European Union (2024). TEN-T regulation. Link.
[2] European Commission (2023). TEN-T interactive map viewer. Link.

Each charging hub needs to have a prescribed minimum power output that increases over time, meaning it will be able to serve a growing number of trucks at higher charging speed. Every major EU city also needs to install a certain number of charging stations for HDVs, as do the the so-called *Safe and Secure Truck Parking Areas*[3,4] along the TEN-T roads. In total, AFIR could lead to HDV charging opportunities at almost 4,000 different locations across the whole continent. Figure 2 summarises the targets for the years 2025 - 2030.

	2025	2027	2030	Number of Charging hubs
TEN-T core	At least every 120 km: 15% of the network with 1,400 kW/hub	At least every 120 km: 50% of the network with 2,800 kW/hub	At least every 60 km: whole network with 3,600 kW/hub	1565
TEN-T non-core	At least every 120 km: 15% of the network with 1,400 kW/hub	At least every 120 km: 50% of the network with 1,400 kW/hub	At least every 100 km: whole network with 1,500 kW/hub	1239
Urban nodes		900 kW	1,800 kW	424
SSTPA		200 kW	400 kW	726

Figure 3: HDV-charging infrastructure AFIR

Charging infrastructure for light-duty vehicles has grown at astonishing rates, with the number of public chargers more than tripling in just three years.[5] Contrary to that, the development of charging infrastructure for battery electric heavy-duty vehicles (BEV) is still in its infancy, due to the fact that BEV models are only beginning to enter the mass market. The ICCT estimated that the number of heavy-duty chargers in 2023 was merely 200 across all of Europe, with most of these chargers only capable of charging a truck with up to 400 kW.[6]

2. Fully charged 2.0 - are the AFIR targets sufficient?

T&E published a first assessment of the AFIR targets in April 2024, analysing whether the ambition level set out in the infrastructure law was enough to meet the demand likely to result from the truck CO2-standards (which were still under negotiation then).[7] With truck CO2 standards now finalised, this briefing gives an updated outlook on how much charging energy the infrastructure member states need to build under the AFI regulation is able to provide. Based on that we can give an estimation of the sufficiency of the AFI-targets.

2.1 How much charging does AFIR provide?

The available power output has not changed compared to our previous assessment. In the present analysis however, we only took the AFIR targets into account, without national deployment plans that go beyond the legislative requirements. We also left out the targets for

[3] AFIR sets requirements for each so-called ‘urban nodes’. The TEN-T regulation has a list of 424 urban nodes across the EU.
[4] European Union (2022). EU standards for safe and secure parking areas for trucks. Link.
[5] T&E (2024).Most EU countries on track to meet charging targets. Link.
[6] ICCT (2023) European heavy-duty vehicle market quarterly (January-June 2023). Link.
[7] T&E (2023) Fully charged for 2030. Link.

safe and secure truck parking areas (SSTPA). This is because the final TEN-T regulation requirements for SSTPAs have been significantly weakened and made more indicative. It's thus unclear when and in what numbers these parking areas will eventually be built.

Based on this we are now estimating that 8.25 GW of charging capacity will be installed in 2030. That would equal a total annual electricity supply to HDVs of almost 11 TWh in 2030. As utilisation rates are expected to increase, we estimate that the same infrastructure will be able to supply 13.17 TWh in 2035 and 16.54 TWh in 2040.[8]

2.2 How much charging does Europe need?

Based on the revised truck CO2 standards we have updated T&E's EU Transport Roadmap Model (EUTRM).[9] It models Europe's HDV fleet to assess the impact of the CO2 emission standards on the fleet composition, zero-emission vehicle (ZEV) uptake, energy consumption and CO2 emissions.

We have modelled two scenarios:

- **The 'Current Policies' scenario** which is based on the recently agreed HDV CO2 standards. It includes CO2 targets for trucks and coaches of -45% in 2030, -65% in 2035 and -90% in 2040, a ZEV target for urban buses of 90% in 2030 and 100% in 2035 as well as the extension of the scope to medium lorries, all heavy trucks (including those with special axle configurations), vocational vehicles (from 2035) and trailers, representing 87% of HDV sales and 93% of HDV fleet emissions.
- **The 'Industry Plans' scenario** which is based on voluntary sales announcements by Europe's truck makers, which go beyond their legal requirements and would result in 63% zero-emission truck sales by 2030.[10] Translated into CO2 targets for certified trucks and coaches, this commitment would equal -70% in 2030, -85% in 2035 and -100% in 2040, ZEV targets for non-certified vehicles of 60% in 2030, 80% in 2035 and 100% in 2040 and a ZEV target for urban buses of 100% in 2030.[11]

From this analysis we have excluded the energy demand stemming from urban buses as today they are solely charged at depots and it is highly unlikely that they will be charged at publicly accessible charging points in the future.

The resulting total annual public energy demand is 28.18 TWh in the ‘Current Policies' scenario and 51.81 TWh in the 'Industry Plans' scenario.

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[8] We expect the average utilisation rate to increase from 5/day in 2030 to 6.8/day in 2040 due to a higher maturity of the HDV BEV market.
[9] Transport & Environment (2024). Transport emissions: modelling and analysis. Link.
[10] Based on official talks between German government authorities and European truck manufacturers - the so-called 'cleanroom talks' - Europe's truck makers plan to reach 63% zero-emission truck sales in Europe by 2030. Weighting the assumed CO2 and ZEV targets mentioned above across the EU trucking fleet results in an overall ZEV sales share of around 63%, in line with the truck maker announcements. Link.
[11] The assumed 2040 target is in line with the announcement of both Daimler and Scania to only sell zero-emission HDVs by 2040, as well as with the ACEA pledge to only sell fossil-free trucks by the same year. Link, Link, Link.

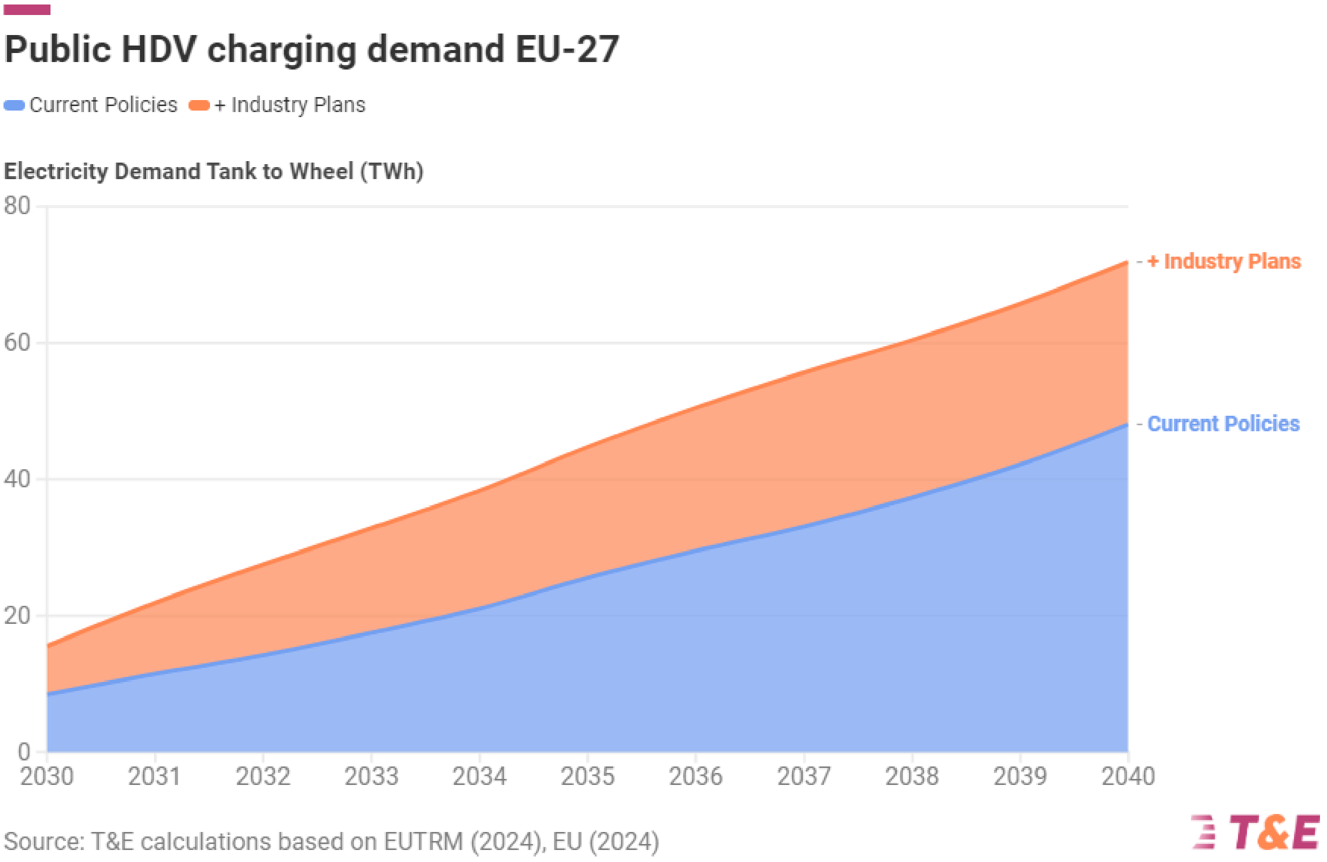

Figure 4: Public HDV charging demand

Energy demand projections at member states level

It is important to note that our analysis assumes the increasing sales share of ZEVs to be the same across member states, meaning all member states contribute equally to the targets truck makers need to meet under the HDV CO2 standards. In reality, ZEV market uptake will likely differ between EU countries depending on, for example, energy prices, taxes and levies or tolling systems. However, while we can expect such differences notably at the beginning of the ramp-up during the 2020s, they should become less relevant towards the turn of the decade. In the mid 2030s electrification will make increasingly economic sense in more and more regions and haulage applications. Hence, the electricity fleet demand projected here per individual member state should be treated as an approximation.

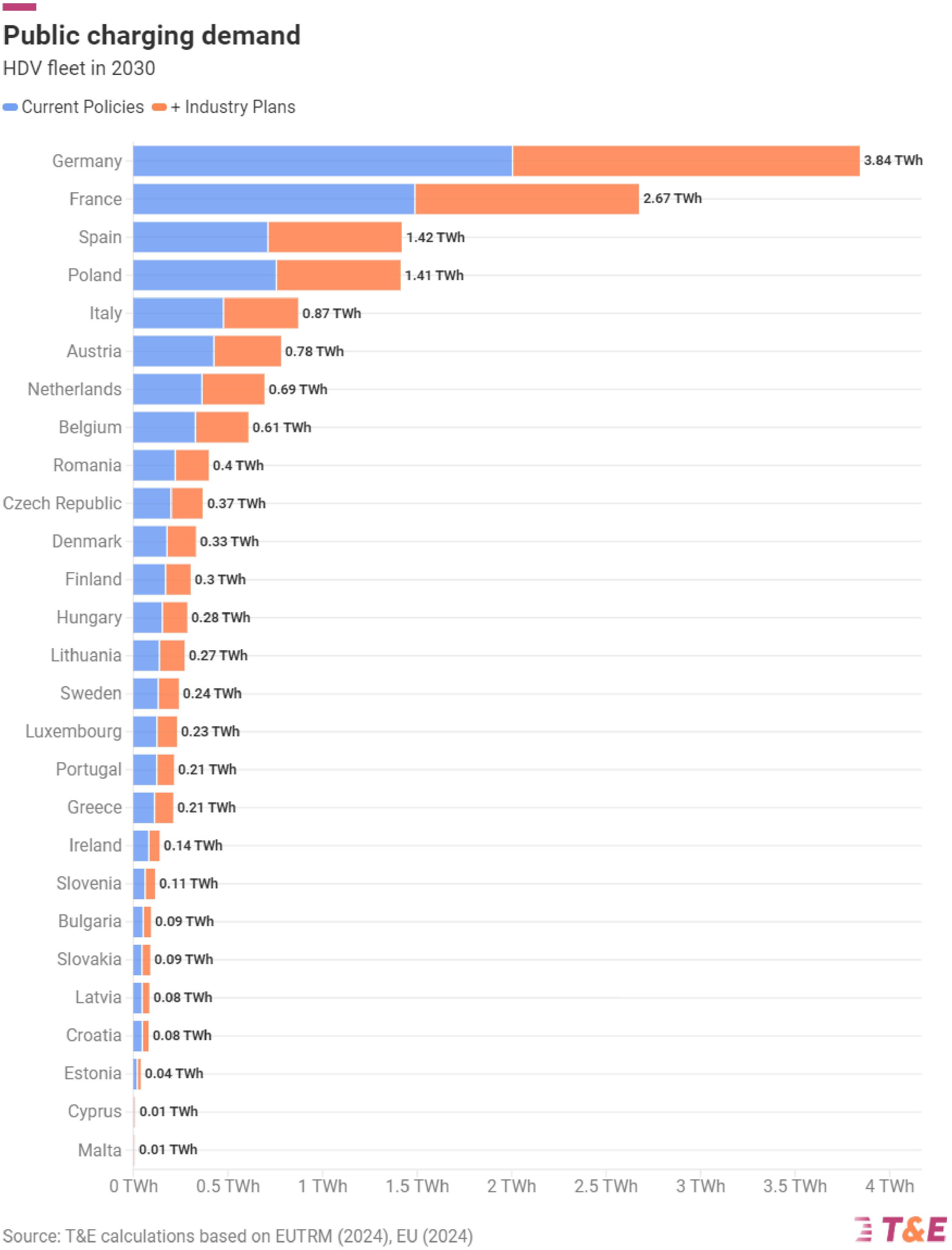

Figure 5: Public HDV charging demand at member state level

2.3 Is AFIR sufficient?

From a macro perspective, the 2030 AFIR target would be capable of covering 130% of the public charging needs under the 'Current Policies' scenario. If the uptake of BEVs goes faster - in line with the 'Industry Plans' scenario - the charging infrastructure mandated by AFIR would not be sufficient to power the entire fleet. It would however still be able to cover 71% of the public charging needs in 2030.

The results at member state level on the other hand show quite extreme differences between countries. The coverage in 21 countries is sufficient, and in one case could power a fleet that is 10 times larger than the expected HDV-fleet under the 'Current Policies' scenario (Cyprus). However, in 6 countries (Austria, Belgium, France, Germany, Luxembourg and the Netherlands) it would fall short to sufficiently supply the expected BEV fleet in 2030 (see figure 4).

Under the more ambitious 'Industry Plans' scenario, coverage would still be sufficient in most member states (14) and could in some still power a fleet multiple times larger than the projected fleet size. Notably in Eastern European countries such as Bulgaria, the Baltic states, as well as Sweden, AFIR can be regarded as overly ambitious.

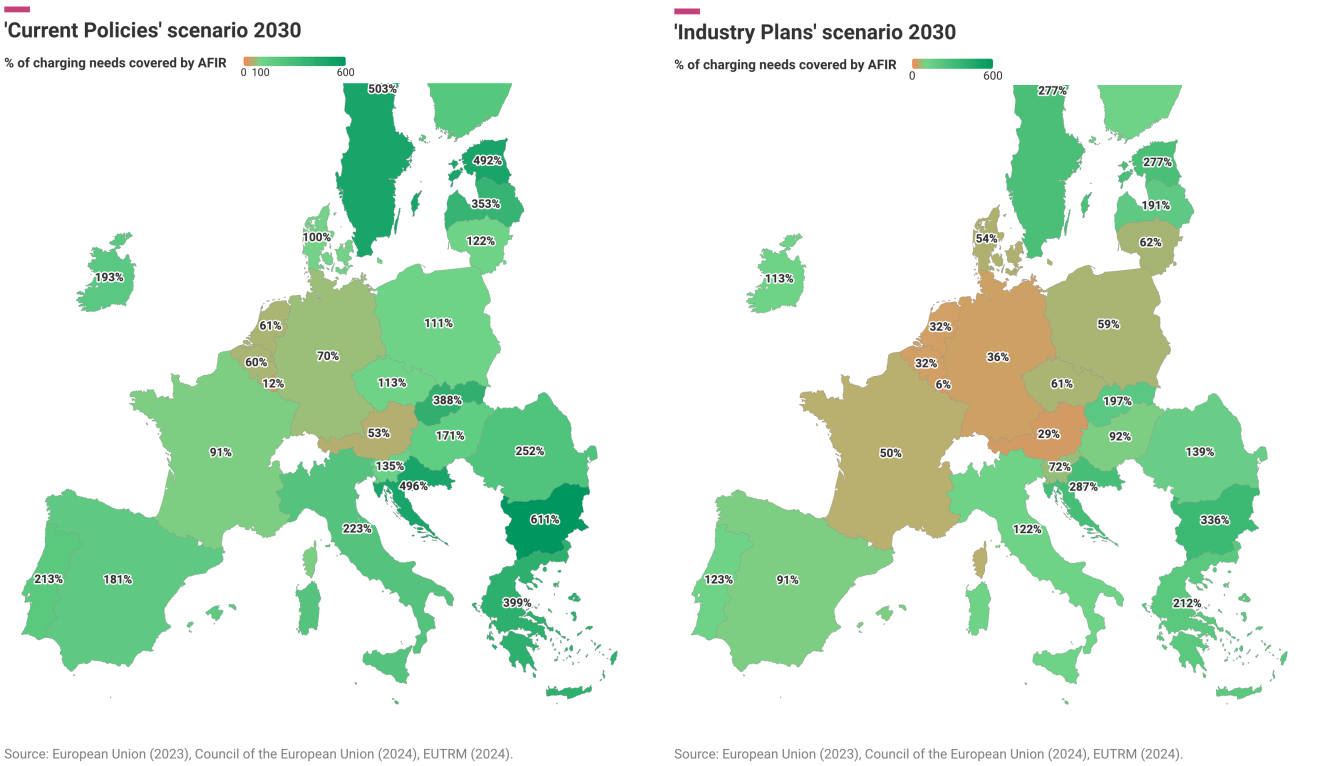

Figure 6: AFIR sufficiency in 2030

The imbalance of AFIR's 'one size fits all' target becomes apparent when looking at 2040. Under the 'Current Policies' scenario, Cyprus' HDV charging infrastructure would still be double of what the BEV traffic in the country actually needs in 2040. Whereas the AFIR mandated infrastructure could only supply 16% of the public charging needs in Austria in 2040.

3. Adjust power output to the actual demand

As outlined above, despite AFIR being an unprecedented and highly needed law, its 'one size fits it all' approach has serious shortcomings, as it does not reflect the actual public charging demand from the expected BEV fleet. This would lead to a scenario where many AFIR prescribed charging hubs could remain seriously underutilised for years, while on the other hand a significant number of hubs would not be able to match the actual demand in 2030.

This could for one hamper the urgently needed BEV uptake in the HDV segment, but could also lead to uneconomical assets, a partial overspending of public funds and the need for long term cross-financing of underutilised charging assets.

For this reason T&E has compared the above outlined energy demand scenarios and estimated the amount and the distribution of HDV charging infrastructure necessary per country.

To see the full results of our analysis on member states level, we have published these results online.

Results

4. How to get truck charging right

By the end of this year, member states need to prepare so-called draft national policy frameworks, in which they explain how they will ensure sufficient deployment of alternative fuels infrastructure. Next to an assessment of the current number of charging points, these frameworks need to include plans on how each country intends to achieve their respective AFIR targets and what measures they intend to take to achieve those targets.

The following section includes T&E's high level recommendation for a successful implementation of the AFIR goals for HDVs.

4.1 Adapt the AFIR targets to actual demand

As emphasised above, it is imperative to tailor AFIR targets to the actual projected needs, which can vary significantly among member states. Given the anticipated divergence in the pace of

BEV uptake and the varying dynamics of public and private charging across countries, a one-size-fits-all approach is insufficient.

The distinction between targets for the core and comprehensive networks is not ideal as it does not take into account the actual traffic volumes. In some countries, roads designated as TEN-T comprehensive witness higher HDV traffic compared to core roads elsewhere. Therefore, maintaining an average distance of 60 km between charging hubs along all TEN-T roads is essential.

Looking ahead to 2030, there will be road segments in numerous countries where the required power output per charging hub falls below the AFIR-prescribed minimum of 1,400 kW because the actual charging demand will be much lower. In such cases, it would be prudent to construct fewer charging hubs but with higher power output per site. Leveraging existing exemptions within AFIR, such as doubling the power output for hubs serving both travel directions, or extending the maximum distance between hubs to 120 km, provides flexibility to address future demand surges.

T&E advocates for a market-led approach to the deployment of public charging infrastructure, particularly in the long term. To achieve this, each member state should establish a dedicated process involving all stakeholders, including truck and bus makers, CPOs, grid operators, relevant transport or infrastructure ministries, and/or specialised public agencies. Through this collaborative process, stakeholders can identify specific public charging requirements, align them with projected HDV traffic, and adapt AFIR targets accordingly. Noteworthy examples for such an approach include France's multi-stakeholder cooperation led by the main DSO ENEDIS, as well as Germany's planning for the "Initiales Netz."[12] [13]

4.2 Make sure the grid is fit for truck charging

Proactive Grid Planning

Anticipating the uptake of BEVs and the corresponding surge in public charging demand through 2030 and beyond is critical for grid planning. National Regulatory Authorities (NRAs) must ensure that grid operators prioritise accommodating this growth in their network development plans.[14]

Both EU and national regulatory frameworks need updating to facilitate anticipatory grid investment, empowering Transmission and Distribution System Operators (TSOs and DSOs) to proactively expand the grid without waiting for direct connection requests. Failure to do so risks significant delays in grid expansion, potentially impeding the deployment of charging infrastructure.

[12] ENEDIS (2024). Électrification de la mobilité lourde longue distance. Link.
[13] NOW GmbH (2022). Aktivitäten zu Nutzfahrzeug Ladeinfrastruktur. Link.
[14] This applies to heavy- and light- duty vehicles equally

Grid capacity maps
Under the Energy Market Design (EMD), TSOs and DSOs are mandated to produce detailed and regularly updated capacity maps. These maps are essential for CPOs to identify suitable charging locations. Currently, CPOs often operate blindly due to a lack of grid information, risking delays of years by inadvertently selecting congested grid locations.

Streamlining administrative processes
CPOs frequently encounter disproportionate, lengthy, and inconsistent administrative procedures during the grid connection process, varying from one DSO to another. Harmonising and digitising these processes at the EU level is crucial, but member states should initiate this process immediately, especially considering the significant number of DSOs operating within some territories. Key elements of this effort should include:

- Mandating maximum response timelines for connection requests.
- Ensuring transparency throughout the process, enabling CPOs to make informed decisions.
- Accelerating application processes to minimise waiting times or providing alternatives if delays occur.
- Establishing a single contact point responsible for large charging infrastructure projects' grid connections, streamlining communication and coordination efforts.

4.3 Use public money efficiently

The deployment of charging infrastructure for cars today is in large parts market driven and this will also be the case for charging infrastructure for trucks. Truck charging sites have an additional advantage because their utilisation is much easier to predict, as logistic patterns are relatively stable compared to individual car usage. Public support should therefore be designed in such a way that distortion of the market is avoided.

Nevertheless, to allow seamless travel throughout Europe in a timely manner, some form of public support for a backbone public HDV charging network will be necessary to close the gap at initially unprofitable locations (due to low utilisation). A certain degree of public support may also be necessary to achieve a full (TEN-T) road network coverage as soon as possible. There is no one size fits all approach as different EU member states have different administrative and financial capabilities. Included below is a description of two public support schemes that could help ensure the above mentioned goals while avoiding market distortion.

Use RED III crediting mechanism
First and foremost member states should fast-track the mandatory RED III crediting mechanism and design it to support charging infrastructure uptake.[15] The mechanism allows CPOs to generate significant revenues for public charging points. Existing schemes can generate up to

[15] T&E (2023). RED III and renewable electricity. Link.

0.35 Euro/kWh. Especially in the early BEV market uptake face, many locations won't be profitable right away, as utilisation will likely remain low at many locations. So-called 'capacity-crediting' could be used to allow these locations to break even earlier. California's Low Carbon Fuel Standard (LCFS) introduced such an infrastructure credit, crediting recharging infrastructure regardless of how much electricity is actually charged at the recharging point.[16] The system starts from the total available capacity at a given site, estimated in kilowatt hours per day (kWh/day). Credits are then based on the unused recharging capacity (total capacity of infrastructure in kWh/day, minus the electricity actually charged at the recharging point). If a recharging point is successful, credits for the actual use would replace 'capacity-crediting'. In other words, infrastructure credits are meant to be "self-sunsetting".

(In)direct public funding

Alternatively or additionally, public funding to CPOs (e.g. unit contribution, CAPEX contribution) can be useful to accelerate the deployment of charging infrastructure in the short term. This funding could be given to overcome the high initial investment costs, either directly in the form of subsidies, or in the form of investment loans and public guarantees (e.g. via the European Investment Bank, or national public investment banks) where CPOs would pay back those loans after the location in question achieves a higher utilisation and starts to become profitable.

Furthermore, public funding is key to compensate for a market failure, e.g. if CPOs are not serving locations/stretches of main roads because the business case will likely remain weak for an extended period of time.

In these cases it could be useful to use smart tendering: funding a bundle of suitable charging locations (blend of locations with high and low utilisation) and give funding for this bundle. Although this might create higher initial costs, it avoids opex-subsidies that might be required for non-profitable locations for an extended period of time. If member states decide to use tendering procedure it is key to design them in a way that prevents the establishment of monopolies in certain areas. Furthermore, it is important to give enough flexibility to CPOs to choose charging locations, to avoid land price speculation.

Further information

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[16] CARB (2021). ZEV Infrastructure Crediting within the LCFS. How does it work? Link.

Annex

Methodology

To quantify the truck traffic along the TEN-T network, data from the Conference of European Directors of Road (CEDR) was used.[17] CEDR is regularly publishing complete heavy-goods vehicle (HGV) traffic data for the TEN-T road network.[18] The organisation distinguishes between four traffic bins of daily average HGV traffic.

- Less than 3000 HGVs/day
- 3000 - 6000 HGVs/day
- 6000 - 12000 HGVs/day
- More than 12000 HGVs/day

We have used the 2021 version of the report for EU Member States. Data for the missing Member States was derived from a traffic data study by the Karlsruhe Institute of Technology (KIT) and the Fraunhofer Institute for System and Innovation Research (ISI).[19]

The power requirement for each recharging hub was calculated based on a model developed by *RE-xpertise* and *ef.Ruhr* that analysed the estimated recharging needs in relation to the truck traffic density in Germany.[20] [21] Based on those results, a linear interpolation between the truck traffic and the respective future charging power requirements was assumed and adjusted based on a 60 km distance between charging pools.

Our modelling takes into account the expected activity growth of freight transport in each member state for the years 2030, 2035 and 2040 - respectively to 2021.[22] A calibration factor was used to distribute the energy needs from non-TEN-T roads freight activity. The estimated required charging power was then adjusted to the four traffic bands retrieved from CEDR. The given figures are representing the respective minimum for each traffic band (e.g. using the power output per recharging pool for 3,000 HDVs per day as a target for the traffic band of 3,000 - 6,000 HDVs per day).

Based on that we were able to identify the number of charging hubs per traffic bin needed: the length of TEN-T roads per traffic bin divided by the 60 km distance in AFIR. For each hub we have calculated the power output needed to serve the prospective BEV charging demand on

[17] CEDR (2019). TEN-T GIS Map. Retrieved from https://app.powerbi.com/view?r=eyJrIjoiMmY0YWMzODAtMWRhNy00NWNkLWEzZDItOWQ0ZDkwYzA4NGM5Iiwid CI6IjkxNmI3ODJmLTExZGUtNDZmMS1hZmFlLTkwMWUzYTI4Mzc4YiIsImMiOjl9

[18] Austria, Belgium (Flanders), Denmark, Estonia, Finland, Germany, Hungary, Ireland, Italy, Lithuania, Luxembourg, Netherlands, Poland, Slovenia, Spain and Sweden, while the data is incomplete for Italy and Belgium

[19] KIT and Fraunhofer ISI (2021).Synthetic European road freight transport flow data. Retrieved from https://www.sciencedirect.com/science/article/pii/S235234092101060X

[20] T&E (2022).Flicking the switch on truck charging. Retrieved from https://www.transportenvironment.org/discover/grid_integration_long_haul_truck_charging_study_final/

[21] The study assessed two model motorway stations, a high-traffic motorway station (22,000 trucks per day) and a low-traffic motorway station (5,000 trucks per day). For the purpose of this paper, the required minimum power output was adjusted to the traffic bands used by CEDR.

[22] European Commission. (2020). EU Reference scenario 2020. https://energy.ec.europa.eu/data-and-analysis/energy-modelling/eu-reference-scenario-2020_en

these road sections. This power output we have identified for the years 2030, 2035 and 2040. The model also distinguishes between the power output for the 'Current Policies' scenario and 'Industry Plans' scenario.

For simplification reasons the required power output requirements were rounded to the nearest 400 kW - as this is increasingly becoming the minimum power output per charging point that HDV-Charge Point Operators (CPOs) start to install at HDV charging sites.[23]

[23] Milence (2023). Milence starts operations and opens the first charging hub for heavy duty vehicles in Venlo, the Netherlands. Link. Milence is one of the first CPOs to install charging infrastructure dedicated to HDVs is installing charging infrastructure with 400 kW per charger.