# Grid Readiness for HDV Charging

## a Survey among European DSOs

on behalf of

**Transport and Environment**

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# Summary


## Motivation, objectives and scope

The regulation on the deployment of alternative fuels infrastructure (AFIR) obliges member states to ensure the deployment of recharging pools dedicated to heavy-duty vehicles along the TEN-T core network and specifies maximum distances between and minimum capacities for these recharging pools for the target years 2025, 2027 and 2030.

The targets as have been challenged by several member states. Raised questions address the suitability of existing electricity (distribution) networks to support the intended development, required actions to make network connections available and the periods required for these changes.

The objective of this assessment is to evaluate the technical feasibility of the charging infrastructure for heavy-duty vehicles in the perspective of the AFIR targets for a selected subset of EU member states. The analysis is restricted to member states with a perceived more challenging starting position and will focus on short term challenges (2025 to about 2027).

The dominating source of information were explorative expert interviews with representatives from distribution system operators and other national stakeholders in the selected member states.

## Key findings at a glance

From the stakeholder interviews the following critical aspects can be derived:

- **AFIR ambition level:**
  The AFIR targets specify two metrics: time lines and distance / capacity tuples. The time lines of the targets, in general, are perceived as the more problematic metric.
  - 2025: Given the short remaining time, even at sites where sufficient network capacity is available, timely implementation will be challenging. If any permitting procedures are required, implementation by 2025 seems to be unrealistic. Accepting a delay to 2027 or 2028, would make it more realistic that the targets can be met in many regions.
  - 2030: The general feedback of the stakeholders was that the volumes specified in the proposals are challenging but feasible. Nevertheless, at least in certain regions, network development is required in order to meet the AFIR targets. The earlier planning security will be

achieved, the more straightforward DSO's can plan. Sites and timelines will only be fixed after AFIR formally enters into force.

- **Periods for planning and permitting:**
  The challenging character of the proposed timelines is even more evident as usual periods for network planning and permitting in several EU member states are very long. If HV lines are included procedures may take more than a decade, hence planning periods may already now conflict with 2030 targets. The existing legal frameworks do not allow an acceleration of permitting processes. From this perspective, the time until AFIR enters into force is even more problematic.

- **Studies and strategic views:**
  Nearly all stakeholders mentioned ongoing studies matching scenarios for charging hubs with network development needs. Studies contribute to a clear understanding of short- and medium-term development needs and support stakeholder engagement as well as consistent company policies.

- **DSO awareness and focus:**
  DSOs will only be able to successfully tackle the challenges related to AFIR targets with an anticipating and proactive approach, sufficient resources and respective corporate cultures.

- **Role of stakeholders:**
  Any action requires that stakeholders feel in charge and responsible. Not all roles with respect to charging infrastructure implementation are clearly defined yet. This needs to be addressed by the political level in due time.

- **Coordination of TEN-T and distribution network planning:**
  At EU and national levels planning of motorway infrastructure and distribution networks, so far, is not coordinated. This also applies to EU funding. There is potential for improvement.

### Recommendations for policy development

Periods for planning and permitting are too long to resolve existing congestions in the given period. As decarbonization of transport is a priority task in climate policies, adjusting and accelerating planning and permitting procedures may be justified. As a complementary action early and strategic planning should be encouraged.

Ambitious policy targets correctly reflect the expected growth in demand for charging infrastructure. Political ttargets should be in line with the actual charging needs. This helps DSOs and other stakeholders to plan strategically and to communicate their needs and challenges to policy makers.

Lessons learned from national studies should be compiled at EU level and findings should be disseminated among the involved stakeholders as well as among different member states. This also minimizes the risk of supply gaps in border regions and for transit routes.

Specific national policy instruments incentivizing DSOs may be justified, at least in a transitional period until 2030. Incentives possibly should not focus on charging infrastructure but should stimulate provision of connections in general, i.e. also for renewables. Both developments are important and partly complementary.

While the distribution network perspective is important, requirements have to be set by transport demand and patterns. Involving DSOs in the identification of potential sites will likely accelerate grid connection and reduce costs in some cases.

There will be charging hubs which are crucial for geographic coverage but will not be economically viable due to low customer intensity and thus low utilization. These require special attention in planning but even more in implementation. Suitable policy instruments have to be applied. Examples for policy instruments are subsidies for charging hubs with low customer outcome, concessions combining sites with high and low customer outcome together with a service obligation or distinct operators for such locations.

# Table of Contents

## List of acronyms

| | |
|---|---|
| AFIR | Alternative uels infrastructure regulation |
| CPO | Charge point operator |
| DSO | distribution system operator |
| HD | heavy-duty |
| HDV | heavy-duty vehicle |
| HV | high voltage |
| LDV | light-duty vehicle |
| MCS | megawatt charging system |
| MSP | mobility service provider |
| MV | medium voltage |
| TEN-T | Trans-European Transport Network |
| TSO | transmission system operator |

# 1 Introduction

## 1.1 Motivation and scope

On 14 July 2021 the European Commission adopted a proposal for a regulation on the deployment of alternative fuels infrastructure (AFIR). As part of its proposal, the European Commission introduced mandatory targets for heavy-duty vehicle charging infrastructure along the TEN-T road network which consists of a core network and a larger (in terms of road length) comprehensive network. The network furthermore encloses a number of urban nodes.

Article 4 of the proposal obliges member states to ensure the deployment of recharging pools dedicated to heavy-duty vehicles along the TEN-T core network and specifies maximum distances between and minimum capacities for these recharging pools for various target years (2025, 2030 and 2035).

During the ordinary legislative procedures, the European Parliament and the Council of the European Union have agreed to an amended version of the Commission position[1].

The ambition level associated of the regulation differ per member state, simply because geography and topology of TEN-T road and electricity networks differ. Uniform requirements represent differing challenges in terms of technical and economic feasibility, time lines, service levels and funding of investments.

The targets as outlined by the provisional agreement have been challenged by several member states. Raised questions address the suitability of existing electricity (distribution) networks to support the intended development, required actions to make network connections available and the periods required for these changes.

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1 see https://www.europarl.europa.eu/RegData/commissions/tran/inag/2023/04-26/TRAN_AG(2023)746979_EN.pdf

## 1.2 Objectives and Approach

### Objective

The objective of this assessment is to evaluate the technical feasibility of the charging infrastructure for heavy-duty vehicles in the perspective of the AFIR targets for a selected subset of EU member states. The analysis will focus on short term challenges (2025 to about 2027) with a qualitative outlook on longer term development needs. Given the extremely short period from formally enacting AFIR until the 2025 to 2027 target years, the assessment can be boiled down to the question whether grid connections for charging hubs can be supplied without or with minor reinforcement of the existing distribution grids.

The selected member states are those with a perceived more challenging starting position. In addition to the technical assessment, we will compile general information about potential legal requirements and describe necessary actions at a policy making level.

### Approach

Consistent public data about distribution networks and their capacities are sparsely available. As our dominating source of information we organised a series of explorative expert interviews with representatives from distribution system operators and other national stakeholders in the selected member states.

The interviews covered some standard topics, among others familiarity with ongoing developments related to AFIR and its general methodology and requirements, technical feasibility of grid connections for charging hubs for trucks along the TEN-T network, development needs, respective timelines for permitting, planning and construction as well as financing issues.

In a more open conversation, we also addressed matters of EU and national policies and legal frameworks, regulation and stakeholder positions.

The key information from the interviews was fixed in minutes and the participants had the opportunity to comment or correct the collected information. This input finally has been used for compiling this report. The interviews were conducted under the Chatham House rules. As a consequence, factual information is presented in the member state specific section. Personal views or opinions are aggregated in a separate section without explicit reference to the source.

## 1.3 Structure of the report

This report is divided in three parts. In the following section we describe the AFIR targets and their ambition levels. Additionally, we give some impression regarding design of charging hubs for trucks and respective grid connections.

Consequently, in section 3 we describe the specifics of the five member states with respect to the topic. We combine general information from public sources with some input from the expert interviews. This section illustrates differences and specific conditions of the member states.

Findings which more or less apply to all considered member states are set out in section 4. These findings are mostly derived from the expert interviews. The emphasis of this section is to evaluate challenges and assess the ambition level of the AFIR.

In the final section we summarise major conclusions and draw key recommendations, mostly from a policy design and stakeholder engagement perspective.

# 2 Background - AFIR Regulation and Grid Requirements

## 2.1 Alternative Fuel Infrastructure Regulation (AFIR)

As part of the ‘Fit for 55 package’, the European Commission proposed a regulation in July 2021 that shall ensure a sufficient public infrastructure for alternative fuels, called ‘Alternative Fuels Infrastructure Regulation’ (AFIR). The AFIR aims at the provision of charging infrastructure for light and heavy duty road transport vehicles (targeted by this report) as well as refueling stations for hydrogen, LNG and electricity supply for and heavy duty road transportation, maritime ports and aviation. Concerning charging infrastructure, the idea of the AFIR are legally binding targets for charging power and density of charging hubs along the Trans-European Transport Network[2] (TEN-T).

The Council of the EU and the European Parliament agreed on a provisional agreement on 28 March, which will enter into force in August 2023.

Table 2-1 gives an overview of the ambition level of the provisional agreement.

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[2] The TEN-T network defines the major roads of transportation in Europe and (besides other corridors) distinguishes between the core network (most important trans-European connections) and the comprehensive road network which defines secondary roads of European concern. Not all roads are constructed yet but need to be in operation in 2030 (core) resp. 2050 (comprehensive). For details, see [4].

**Table 2-1: Required charging power for light- and heavy-duty vehicles according to provisional agreement**

| | | TEN-T Core | | | TEN-T Comprehensive | | |
|---|---|---|---|---|---|---|---|
| | | 2025 | 2030 | 2035 | 2025 | 2030 | 2035 |
| **European Com-mission 14.07.2021** | density | 60 km | | | 60 km (LDV), 100 km (HDV) | | |
| | LDV | 300 kW | 600 kW | - | - | 300 kW | 600 kW |
| | HDV | 1,400 kW | 3,500 kW | - | - | 1,400 kW | 3,500 kW |
| | **total** | **1,700 kW** | **4,100 kW** | **-** | **-** | **1,700 kW** | **4,100 kW** |
| **Agreed text 28.03.2023** | density | 60-100 km. | | | 60-100 km | | |
| | LDV | 400 kW | 600 kW | - | - | 300 kW | 600 kW |
| | HDV | 1,400 kW 15% | 3,600 kW 100% | - | 1,400 kW 15% | 1,500 kW 100% | 1,500 kW |
| | **total** | **1,800 kW** | **4,200 kW** | **-** | **1,400 kW** | **1,800 kW** | **2,100 kW** |

The provisional agreement requires charging hubs along the TEN-T core network with a total charging power for light- and heavy-duty vehicles from 1.8 MW in 2025 and 4.2 MW in 2030 every 60 km along the TEN-T network. Along the comprehensive network, lower charging powers are obligatory. The required hub density is 60 km (LDV) resp. 100 km (HDV). Additionally, there is a ‘phase-in’ until 2030 with only 15% of the TEN-T network to be covered until 2025 and 50% until 2027.

These capacity figures are valid for charging hubs for one direction of travel. If both directions of travel are connected with a single grid connection point, of course, the figures double and thus require capacities of up to 8.4 MW In many cases, the charging hubs will most likely offer charging opportunities for passenger cars, additionally increasing the necessary grid capacity.

The AFIR furthermore defines ‘Urban Nodes’ (the most important urban areas of the member states) which have to provide additional charging infrastructure (see Table 2-2). Moreover, save and secure truck parking areas along the TEN-T road network need to be equipped with 400 kW until 2030.

**Table 2-2: Required charging power for light- and heavy-duty vehicles according to the proposals of the European Commission and the European Parliament.**

| | Urban Nodes | |
|---|---|---|
| | 2025 | 2030 |
| **European Commission 14.07.2021** | 600 kW | 1200 kW |
| **Agreed text 28.03.2023** | 900 kW | 1800 kW |

With regard to grid connection capacity, the agreement [1] explicitly addresses the long-term planning of charging requirements and power grid development:

> "Member States should take all necessary steps to ensure that the electricity grid meets the power demand of the recharging infrastructure mandated in this Regulation. To that end, Member States should upgrade and maintain the grid so that it is able to handle present and future demand from the transport sector for electricity. "

## 2.2 Technical Requirements of Charging Hubs

### Charging Infrastructure

The proposals of the European Commission and the Council require charging powers of individual recharging points of up to 350 kW. This power can be delivered e.g. by CCS Combo 2 chargers, already available and widely used in the market today.

However, it is likely that in the future recharging points with an individual charging power of 700 kW or more will be deployed. This power cannot be delivered by CCS Combo 2 chargers, but demands the novel charging standard MCS (Megawatt Charging System). The MCS standard allows charging powers of up to 3.75 MW and is currently still in development. The commercial rollout of the MCS standard is expected in 2024[3] [4]. First products (chargers and vehicles) are on a prototype level already existing today.

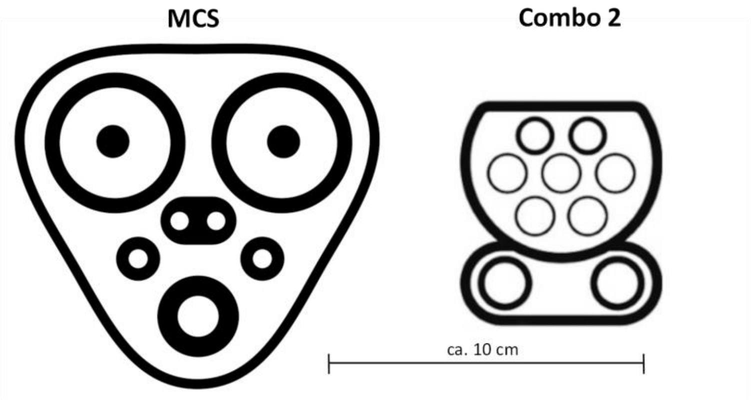


**Figure 2-1 Estimated size comparison of CCS Combo 2 connector (right, usually up to 350 kW) and MCS connector (left, up to 3,750 kW)[4]**

[4] based on a schematic drawing of the plug design presented at EVS35 Oslo (13th June 2022) (source: https://commons.wikimedia.org/wiki/File:Megawatt_Charging_System_Schematic_Plug_Design.svg)

## Grid Connection Requirements

The grid connection capacity of charging hubs will in most cases match the combined rated power of all installed chargers plus an additional margin. The rated power of a charger on power-grid side is slightly higher than on outlet side, as the charger's losses and the power demand for ancillary equipment (e.g. cooling) as well as other facilities (e.g. service facilities) have to be supplied as well. Additionally, chargers and local transformers have a demand for reactive power. The required grid capacity will thus exceed the total charging power on DC side by at least a factor of 10%.

By use of charging management, the required grid capacity can be reduced substantially if favourable preconditions are given. A high number of chargers, long durations of stay (e.g. because of mandatory breaks in driving times) and high charging powers are in general beneficial for reducing the required grid capacity below the rated power of chargers. The different proposals do not specify the possibility to apply charging management. Thus, there can be a significant potential to further decrease the necessary grid connection power[5].

The charging hubs being defined in the different AFIR proposals cover a total charging power of 1.8 MW (single direction) to up to 8.4 MW[6] (both directions). In this range of power, the charging hubs will at least demand a grid connection point in the medium voltage level (usually 10 to 35 kV). Higher grid connection powers can require connection points in the medium- to high-voltage transformer level (i.e. a distinct medium voltage line or cable to the nearest transformer station). From around 10 to 30 MW on, charging hubs can require grid connection points in the high-voltage level (above 36 kV). However, a generalization is not possible and the best grid connection point has to be identified for each location individually. Important considerations for the determination of the grid connection point, resp. voltage level are:

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[5] However, this instrument should be implemented cautiously and should not delay requesting higher connection powers, that become necessary in the further development of a charging hub, For more details, see [4]

[6] For classification: 11.8 MW equals about the necessary grid connection power of 6.000 to 10.000 private households (excl. electric heating and e-mobility).

- The **voltage levels** of the local power grids – the voltage can vary across member states[7] and regions (e.g. urban or rural). Higher voltage levels offer higher grid connection powers but are in many cases associated with a lower density of power infrastructure.
- The **distance** to the next connection point – the longer the distance, the lower the transferable power. Higher voltages also allow longer distances.
- The **available capacity** in the pre-existing grid. Local lines and/or transformers can be pre-loaded significantly so that a grid connection point further away or in a higher voltage might be necessary.
- The **expectation of the further development** – given a long-term planning and plannability, grid connection points on higher voltage levels can be reasonable.
- Further, **grid fees, infrastructure costs, spatial and environmental aspects** of different grid connection alternatives can be weight up against each other.

Additionally, the voltage levels can be allocated to different grid operators. While for example in Germany, the 110 kV level is assigned to the DSOs, all voltage levels above and including 66 kV is in France assigned to the transmission system operator (TSO).

Figure 2-2[8] gives on overview over possible concepts from connections points in pre-existing medium voltage grids to high voltage.

[7] For an overview of common voltage level of European distribution grid operators, see [5] p. 15.

[8] The figure is derived from another study, conducted by the authors for Transport & Environment [3]. The stated power range is however adapted to the interview results of this investigation.

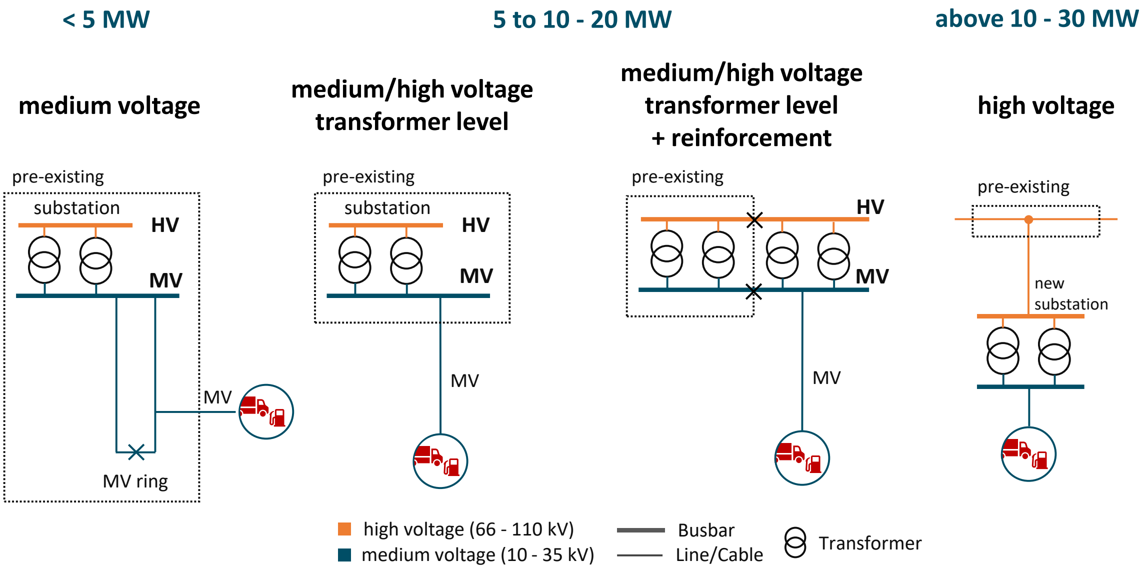


**Figure 2-2 Grid connection concepts for charging hubs (derived from** [5] **with updated connection powers according to interviews with European DSOs). Capacity ranges are indicative and need individual assessment.**

A given grid connection power can thus not be precisely assigned to a definite voltage level or grid connection concept and merely rough general numbers can be indicated. A charging hub within a short distance to an existing medium voltage grid and its supplying substation might for example be connected in the medium voltage grid. The same charging hub but with a higher distance to an existing medium voltage grid might need a distinct power line or cable towards the closest substation. Higher voltages in the medium voltage (e.g. 20 or 35 kV instead of 10 kV) enable higher possible distances and powers. Additionally, the pre-loading of transformers can vary significantly. While at some locations, free transformer capacities allow the installation of rather large hubs without upgrade, other locations might need expansions of substation and transformer.

Taking into account AFIR targets, charging hubs will until 2030 in most cases require a grid connection in the medium voltage level, if only one direction of travel is supplied. In case of a single grid connection for both directions of travel (or if additional demand, such as charging infrastructure for passenger cars apply) a separate connection to the nearest substation can be necessary. Some locations can require connections in higher voltage levels earlier. In any case and due to the longevity of grid infrastructure, scenarios beyond 2035 should be taken into account in the planning process of grid connection layouts.

# 3 Situation in Member States

Distributions grid operators (DSOs) in Europe are very diverse. In addition to the structural differences between the member states (e.g. population density, degree of development) different technical concepts (e.g. voltage levels) are applied. In some states, there exist a three-digit number of DSOs, while in others, a single DSO holds the complete concession area.

The ambition of this examination is not a comprehensive analysis of all European member states (or even DSOs). There were two key reasons for this restriction.

- In a number of member states, the different AFIR targets are not perceived as a general challenge. They are more or less in line with national targets. In those cases, an assessment does not reveal much additional information.

A complete analysis would be excessive in terms of budget but even more in execution time. Hence, the assessment focussed on member states where particular challenges may be expected. Criteria are a coverage of Eastern and Western member states, the relevance of transport sector, and the density and strength of the TEN-T network. Based on these criteria we selected the following member states for detailed interviews:

- Czech Republic
- France
- Poland
- Romania
- Spain

This section summarizes the results of interviews, that were hold to assess the general ambition level of member states with special regard to potentials and challenges of grid connections for AFIR compliant charging hubs.

For these member states, interviews with distribution system operators (where available for an interview) were hold, and if possible persons with context to e-mobility were selected. We interviewed representatives of one (or in some cases multiple up to all) national DSOs. In one case DSO representatives were not available and the interview was hold with a representative of a sector association, familiar with the topic and the DSO perspectives. During the interview, the following topics were discussed:

1) Check-up of the familiarity with the AFIR requirements and the national TEN-T network (also in combination with the national grid infrastructure)
2) Discussion of the general feasibility of the AFIR requirements with regard to grid connection
    - Voltage levels and 'rule-of-thumb' for AFIR charging hubs
    - Implementations periods of grid connections
    - Particular challenges
3) Ongoing activities in terms of heavy-duty charging infrastructure
    - Ongoing activities of the DSO and from national perspective
    - Particular member-specific challenges
    - Assessment of a reasonable ambition level
4) Needs and recommendations for policy makers and regulation

The following sections give a short description of factual situation and member state and member state specific information. In addition publicly available sources were included. In those cases, explicit references will be provided. To a large extent the information is based on the interviews, though. In those cases, no explicit references are provided (also in part for guaranteeing pledged confidentiality). Only in exceptional cases, the information and facts provided by interview partners have been verified or cross checked using additional (public) sources. The aggregated findings from the interview with respect to action needs are synthesized in section 4. Again, no explicit references are provided.

For the interviews, maps of the national TEN-T network[9] and the grid infrastructure[10] (as far as publicly available) were used as additional basis for discussion. These maps are displayed in the following sections. They serve an illustrative purpose only and do not claim completeness or correctness.

## 3.1 Czech Republic

### Road network

In the Czech Republic, the requirements of the TEN-T road network currently fulfilled to 50 % (around 1000 km of the 2000 km TEN-T road network fulfill the requirements of the respective regulation (Regulation (EU)

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[9] Based on TENtec Interactive Map Viewer, European Union, link

[10] Based on openstreetmaps, www.openstreetmaps.org

No 1315/2013). Future sites of HD charging infrastructure are not known yet and currently not be regarded in the further planning of the road network.

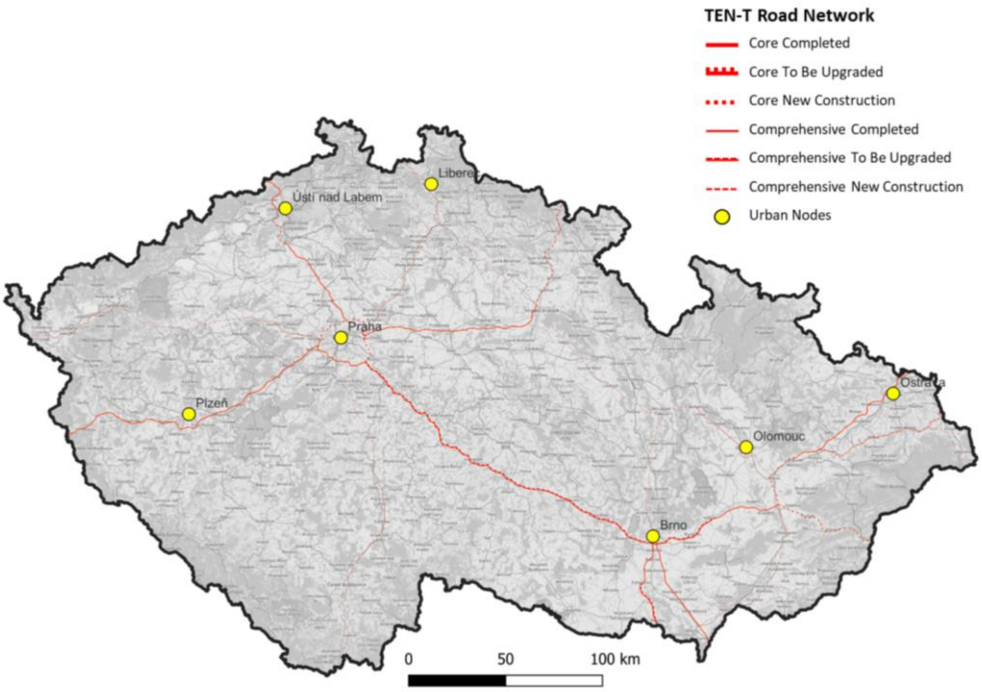


**Figure 3-1: TEN-T road network in the Czech Republic**

### Power Distribution Infrastructure

The medium voltage grid in the Czech Republic is in major parts at 20 kV level. The high voltage network (HV) is operated at 110 kV and in most rural parts realized as overhead line. High voltage underground cables are an exception and due to technical reasons not preferred. Urban areas are on the contrary usually connected by underground cables. Currently, a major renewal of the high voltage infrastructure (which dates from the cold war period) is ongoing and consumes (together with new grid connections for renewable energies and power-to-heat projects) the lion share of resources for planning and construction. DSOs report, compared to other member states, long durations for planning and permitting of power infrastructure, taking at least two years and up to ten years for the medium voltage level and up to 20 years for the high voltage level.

The following figure shows the TEN-T road network as well as the high voltage power infrastructure in the Czech Republic. In many cases, the power infrastructure uses the same corridors as the road network. If this is not the case, the road network is however mostly in direct vicinity of the power network[11]. Larger gaps (e.g. on 1/3 of the distance from Praha to Brno) are usually caused by borders between concession areas between different DSOs.

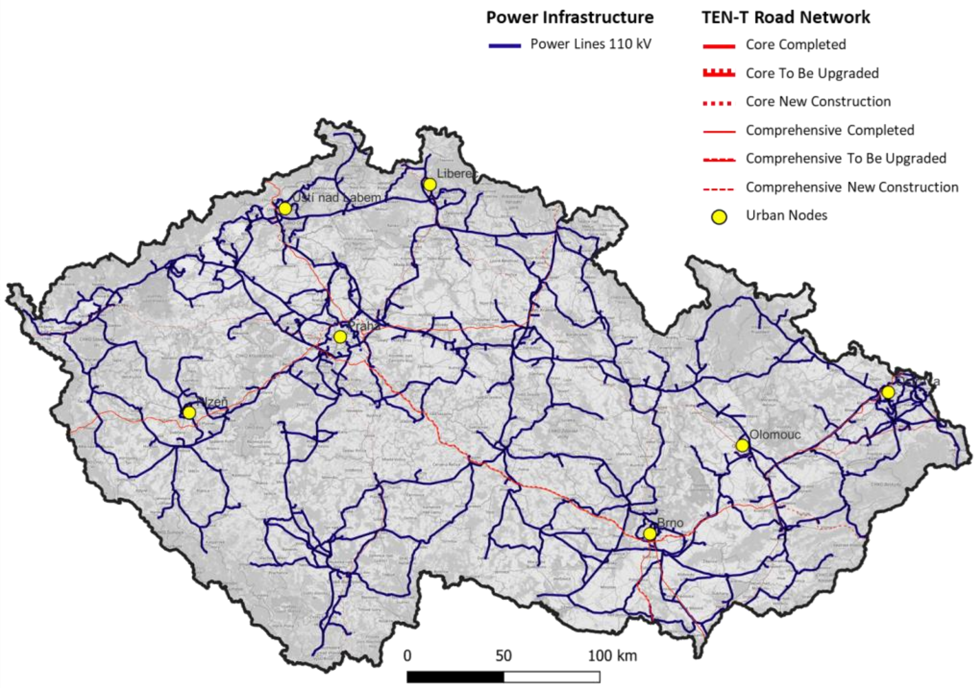


**Figure 3-2: TEN-T road network and high voltage power infrastructure in the Czech Republic**

## Planning of Charging Infrastructure

Currently, a national action plan for the planning of charging infrastructure is ongoing. This involves not only the demand forecast and positioning of charging hubs but also supporting instruments like financial incentives. Heavy-duty transportation by means of battery-electric vehicles is part of the regarded scenarios. In some scenarios, the AFIR requirements are already taken into account. The Czech DSOs are also members of the working groups of the national action plan.

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[11] Though this does not imply that there is a suitable service station, an existing substation / power grid or sufficient available grid capacity at this specific location

## 3.2 France

### Road network

The French road network is almost completely compliant to the TEN-T regulation and covers more than 11,000 km[12] and is in large parts operated by private concession holders. Satisfying the need of charging hubs along the highway network will presumably require more than 300 charging hubs. The following figure shows the French motorways network with regard to TEN-T roads.

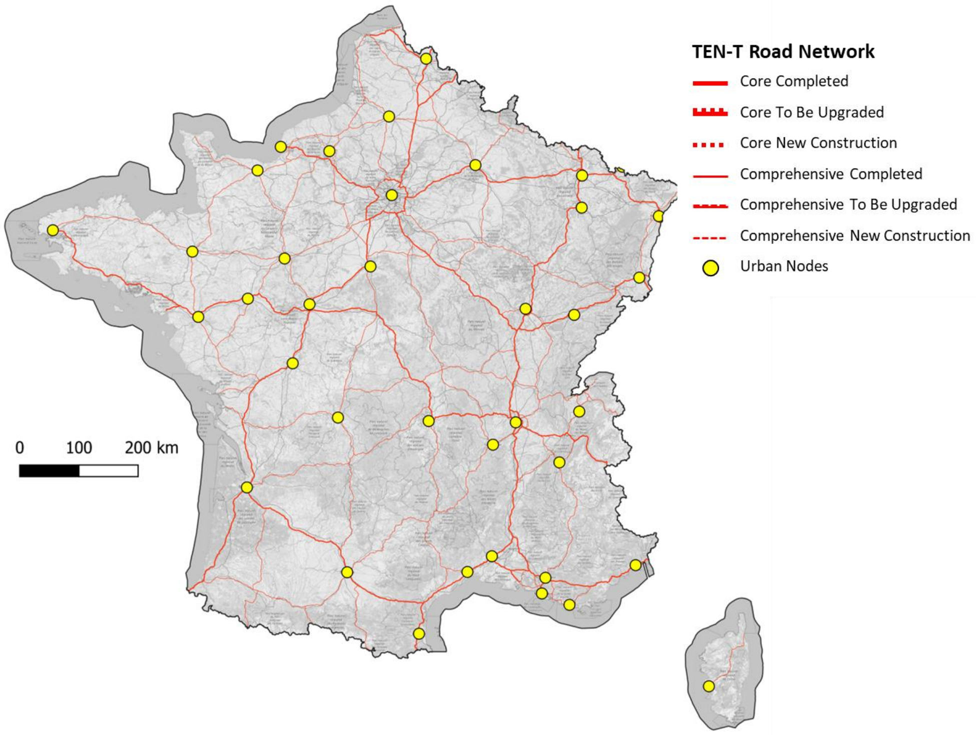


**Figure 3-3: TEN-T road network in France**

### Power Distribution Infrastructure

Unlike in many other European countries, the French distribution grid is operated almost entirely by a single DSO: ENEDIS. Additionally, the distribution grid covers all voltage levels below and including 20 kV. The extensive 66 kV grid (see Figure 3-4) and voltage levels above are operated by the transmission system operator RTE. In many cases, larger charging hubs will thus

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12 see https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=road_if_motorwa&lang=en

formally require grid connections in the transmission level and, hence, active involvement of the transmission system operator as an additional stakeholder. This is a clear difference to other EU member states. Figure 3-4 also shows the high spatial correlation of road and grid infrastructure.

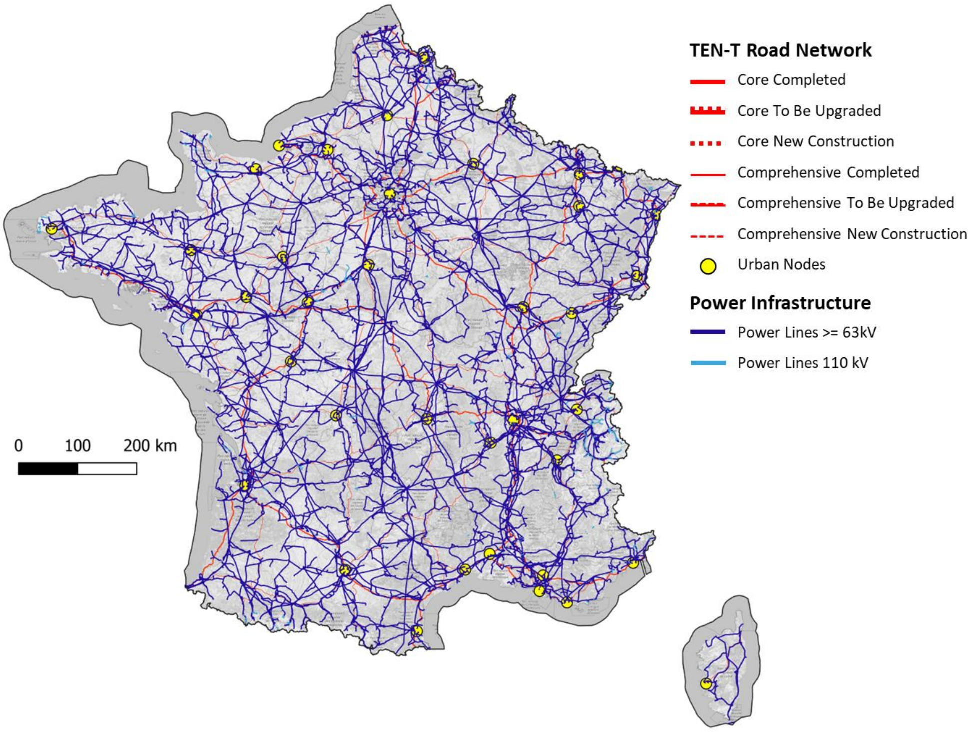


**Figure 3-4: TEN-T road network and high voltage power infrastructure in France**

## Planning of Charging Infrastructure

Stakeholders (among others truck manufacturers, transmission and distribution system operator and highway operators) are working on a comprehensive study of the charging requirement of heavy-duty vehicles in France. Results of the study are to be expected in Q1 2023. The results of the study are expected to be picked up by political actors as well as highway and charge point operators. Recently, the government issued a requirement to equip all motorway service areas with charging infrastructure for light duty vehicles by 2023 and highway operators comply with this obligation [6].

## 3.3 Poland

### Road network

The Polish motorway network includes around 5,000 km[13] in operation and is under ongoing expansion. Main transportation routes are not limited to the TEN-T core network and thus the comprehensive network (mainly expressways) plays an important role in terms of transportation.

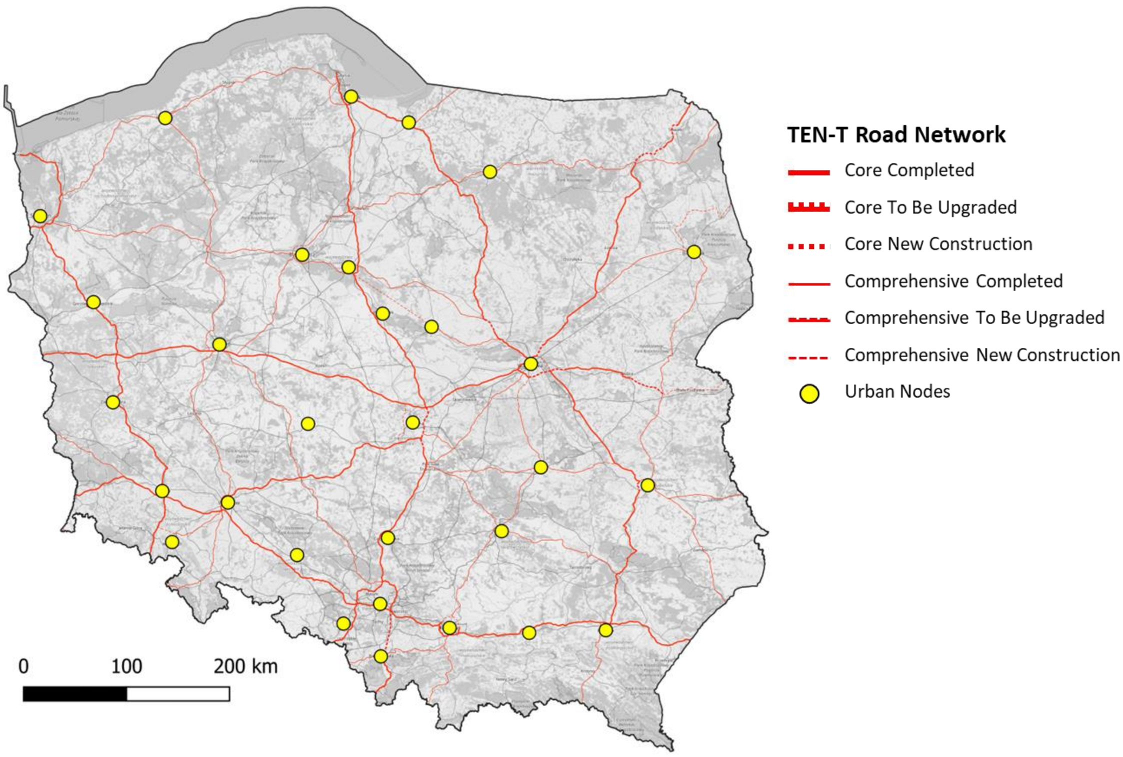


**Figure 3-5: TEN-T road network in Poland**

Poland has the highest share of road transport of goods in Europe. In 2020, around 30% of weighted cargo (almost 330 million tons) was transported by Polish carriers[14]. Poland is in third place regarding new truck registrations in

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13 see https://www.gov.pl/web/gddkia

14 see https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Road_freight_transport_by_journey_characteristics#Road_freight_transport_in_tonnage_and_average_loads

the EU (after France and Germany) and highest share of the EU's international road freight transport. In 2021, about 30.000 trucks with more than 16 tons GVW were registered [7].

### Power Distribution Infrastructure

The Polish distribution grid is operated by five DSOs, of which four are in large parts state-owned [8]. The distribution grid covers all voltage levels below and including 110 kV and is thus the main supplier of grid connections for EV charging infrastructure.

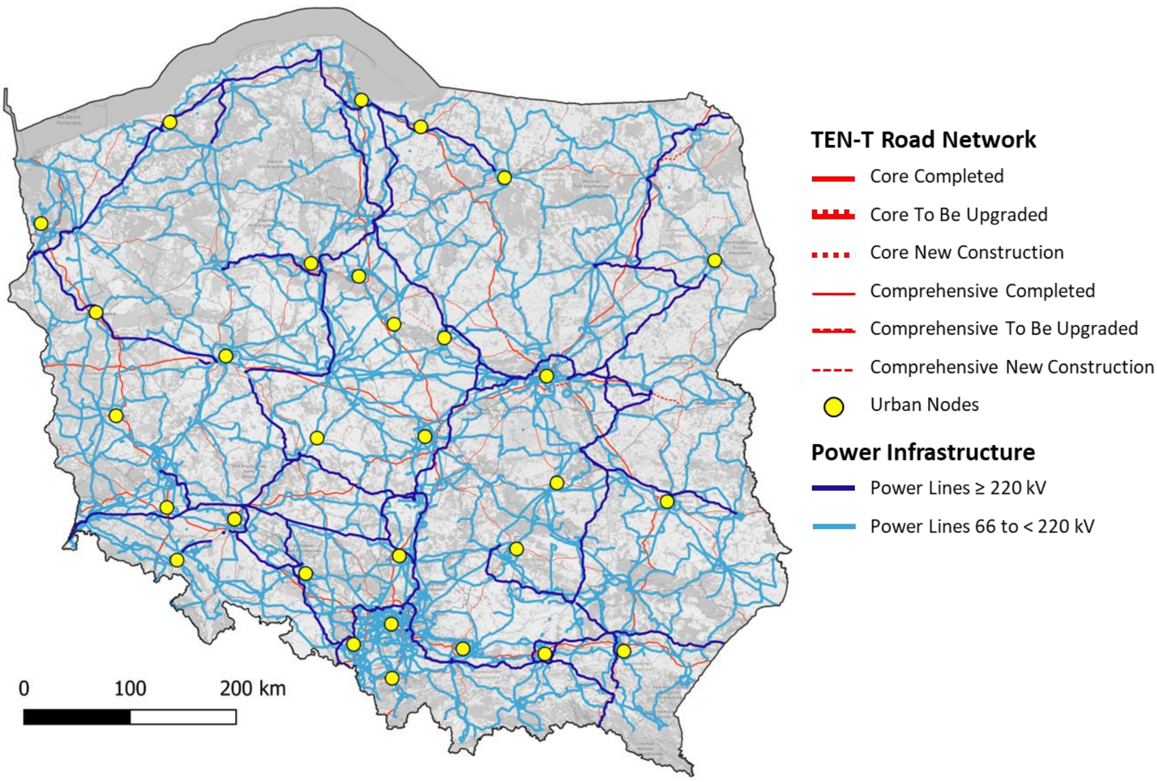


**Figure 3-6: TEN-T road network and high voltage power infrastructure in Poland**

### Planning of Charging Infrastructure

The transport sector is highly relevant from an economic and labour point of view. Around 750,000 people are working in this sector with a large share of SME (small and medium sized enterprises) companies. Keeping up with the decarbonization of the transport sector is thus of strategic interest. An example for ongoing activities is the eHDV infrastructure lab[15], a cross sector demonstration project that aims to analyze the market needs, the development of charging stations as well as the implementation of four pilot charging hubs across Poland.

## 3.4 Romania

### Road network

The Romanian highway network consists of few motorways and a high share of expressways, compared to other member states. The highway network is under continuous renewal and expansion. A large share of the TEN-T network needs new construction or upgrades and is not yet executed as motorway but as expressways (see Figure 3-7).

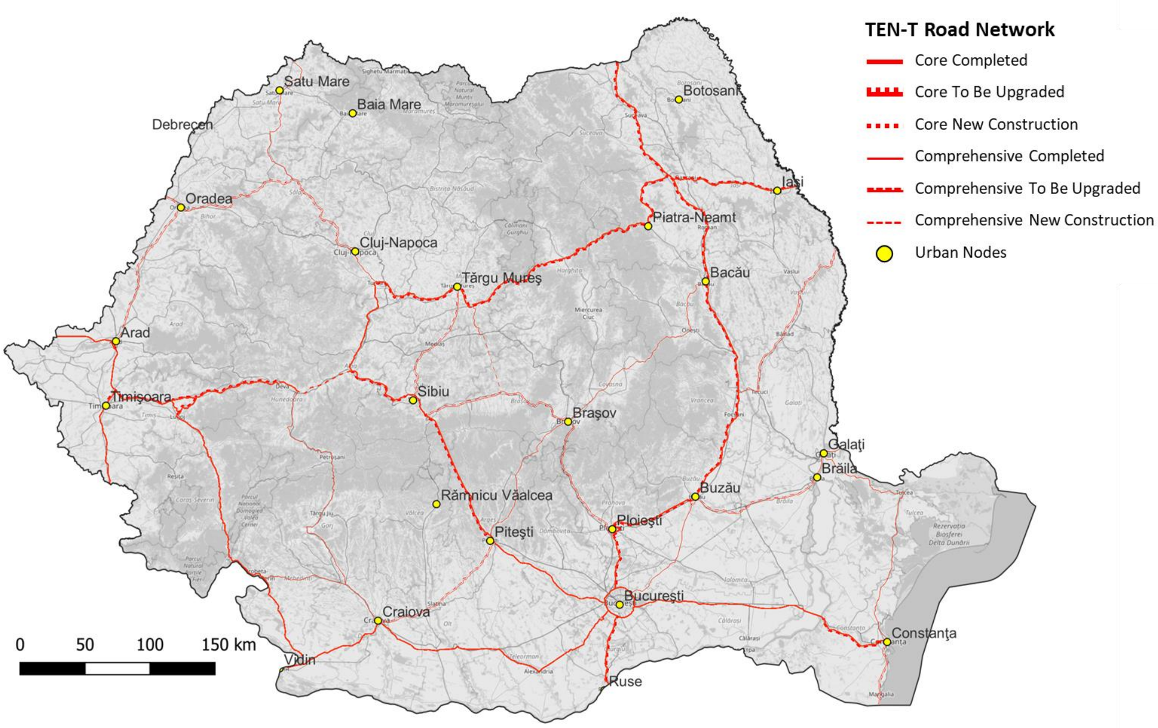


**Figure 3-7: TEN-T road network in Romania**

With the regard to the AFIR regulation this means, that the required charging infrastructure must be implemented simultaneously with major upgrades of

[15] See https://ehdv.eu/

the road network, imposing challenges and opportunities. Major challenges lay in the change of already planned or recently built service areas and grid connections. On the upside, requirements of HDV charging such as space requirements and an adequate traffic guidance are much easier to regard in newly built service areas than as in retrofit solutions.

### Power Distribution Infrastructure

The Romanian distribution system is operated by more than 50 distribution system operators, of which some are state-owned and some private. Projects concerning the electricity infrastructure (as well as the highway network) are in parts co-financed by European funds. The medium voltage level is mainly operated at 20 kV (mostly overhead lines except for urban areas) and DSO responsibility reaches up to 110 kV.

The connection of charging hubs up to around 4 MW is not regarded as a significant challenge, while exceptions might apply for sparsely populated (mountain) areas. Charging hubs with more than 6 - 7 MW will in many cases require new substations.

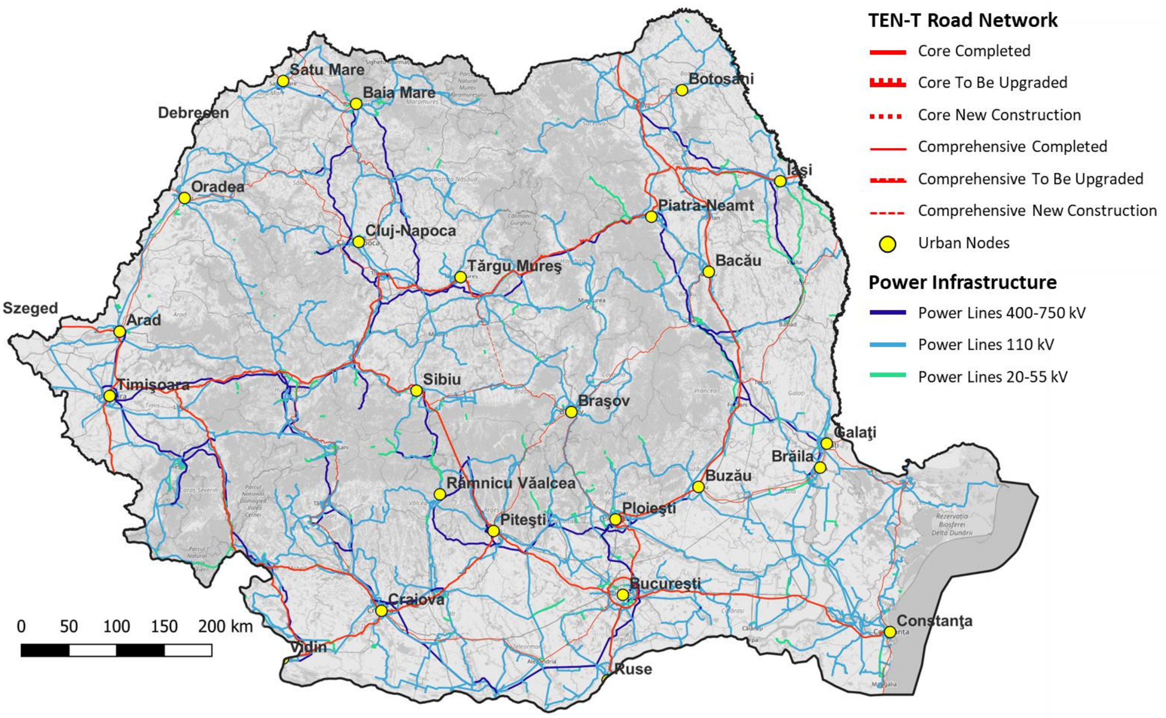


**Figure 3-8: TEN-T road network and high voltage power infrastructure in Romania**

### Planning of Charging Infrastructure

Romania is currently running an installation program of EV charging infrastructure, which is co-financed by the European Union which will run until 2025. The uptake of charging points was fast during the recent years. This however applies to charging infrastructure for passenger cars. A national plan for heavy-duty charging infrastructure is neither known to the interviewees nor to the authors.

## 3.5 Spain

### Road network

The Spanish TEN-T network is the largest in Europe and encompasses more than 15.000 km of road infrastructure[16]. The Population and the transportation industry are concentrated on a comparatively small fraction of the country (70% of the population lives in around 9% of the country's area). The transport sector is in large parts ran by small businesses (51% of truck companies in Spain have less than 3 truck) and concentrated to specific regions. The TEN-T comprehensive network almost of the same significance as the core network and both are almost fully completed (see Figure 3-9).

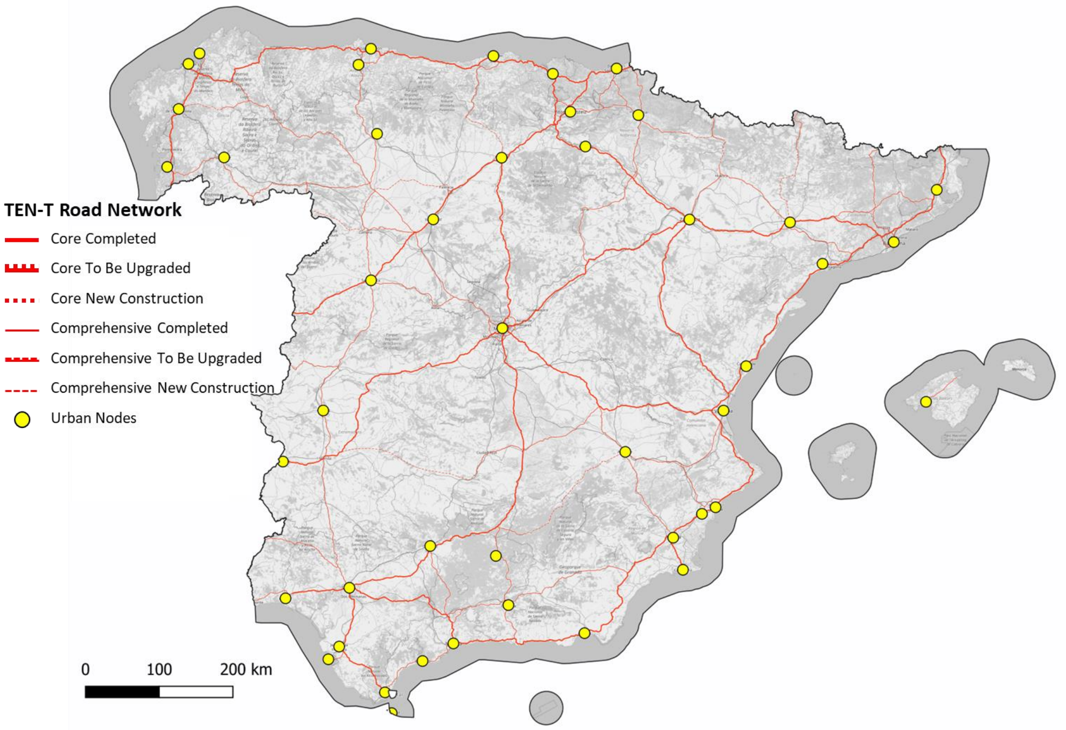


**Figure 3-9: TEN-T road network in Spain**

### Power Distribution Infrastructure

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[16] See https://ec.europa.eu/eurostat/databrowser/view/ttr00002/default/table

Spain has more than 350 DSOs but a large share of the country's distribution grid is operated by five, largely private DSOs. The distribution grid covers voltages below and including 220 kV. The density of the power infrastructure reflects the distribution of population: The coastal areas (as well as Madrid region) show a higher concentration of high voltage infrastructure (see Figure 3-10, light blue).

The deployment of AFIR infrastructure in Spain is with regard to grid connections judged as generally feasible. Local grid reinforcements can become necessary, but possibly only in isolated cases. Regions with a high transportation outcome will require heavy-duty charging hubs above the AFIR ambitions but these regions also offer higher grid capacities in general.

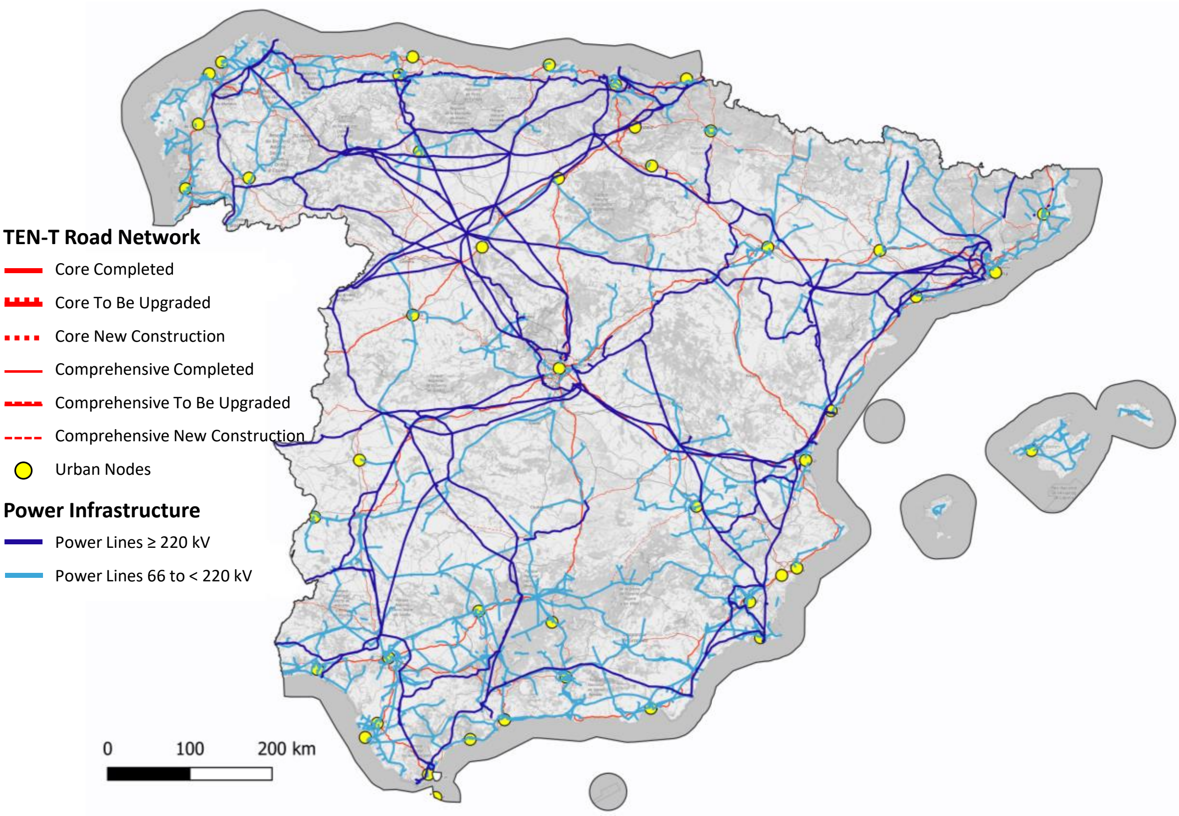


**Figure 3-10: TEN-T road network and high voltage power infrastructure in Spain**

### Planning of Charging Infrastructure

Spanish DSOs are preparing for charging infrastructure for heavy-duty vehicles. This includes observation of the market-uptake as well as own analyses of transportation requirements and infrastructure demand, including the identification of individual locations. AFIR requirements (Parliament position) are assessed as balanced, but charging power of more than 1 MW per charge point are expected in the long term. Smaller but (in order to cover minimum distances) necessary inter-urban hubs might be economically challenging and can require subsidies or other form of market intervention. The demand for a national planning of heavy-duty charging infrastructure is emphasised and is already initiated.

# 4 General findings derived from the interviews

The stakeholders mentioned several aspects and challenges in common. The following paragraphs aggregate and evaluate these aspects[17].

### Critical aspects

- **AFIR ambition level**
  The AFIR proposals specify two metrics: time lines and distance / capacity tuples. The time line of the targets, in general, are perceived as more problematic (as the targets themselves).
    - 2025: Given the short remaining time, even at sites where sufficient network capacity is available, timely implementation will be challenging. If any permitting procedures are required, implementation by 2025 seems to be unrealistic. Also lead times for supply of network assets and components may conflict with the available period. This is even more critical as still is uncertain when AFIR will be in force. Before this date, activities resulting in legally binding agreements and firm financial commitments will be the exception.
    - 2030: The general feedback of the stakeholders was that the volumes specified in the proposals are challenging but feasible. Nevertheless, the existing distribution networks will not be sufficient to accommodate the complete capacity and in certain regions network extension will be a precondition for connection of charging hubs. This means that network development is a required in order to meet the AFIR targets. Network planning can start as soon as locations and capacity are fixed but will take some time. The earlier this planning security will be achieved, the earlier DSO's could start planning. Still, sites and timelines will only be fixed after formal AFIR enacting. The role of DSO is to serve their customers. In general, they have little means to contribute to the planning of the charging infrastructure itself. Setting low but not sufficient targets for 2030/2035 today, could hence further delay the uptake of the infrastructure in the future.

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[17] We consciously do not refer to individual interview partners. The interviews were held under the Chatham house rule.

- **Periods for planning and permitting**
The challenging character of the proposed timelines is even more evident as usual periods for network planning and permitting in several EU member states are very long. If HV lines are included procedures may take more than a decade and, hence, planning periods can already conflict with 2030 targets today. The existing legal frameworks do not allow an acceleration of permitting processes.

- **Studies and strategic views:**
Nearly all stakeholders mentioned ongoing studies matching scenarios for charging hubs with network development needs. Where such studies are not yet underway, interview partners emphasized their importance. In some of the member states, ongoing studies cover the complete geographic area and started from a fundamental analysis of the required charging hub locations, i.e. specifying sites and required connection capacity. Study teams involve a wide spectrum of relevant stakeholders. Of course, such a coherent and comprehensive approach does not only contribute to a clear understanding of short- and medium-term development needs. It also supports stakeholder engagement and consistent company policies. Some of the studies are organized as official national initiative, some are initiated inhouse by individual companies. In most cases, results are expected soon and will be made publicly available.

- **DSO awareness and focus:**
All interview partners were aware of AFIR and the respective requirements. Still, our impression was that the engagement and the structural support of the topic within the organizations differed. As described above, the challenges will only be tackled successfully with an anticipating and proactive approach. A wait and see culture within the companies inevitably will lead to additional delays in a later stage of development.

- **Role of stakeholders:**
Any action requires that some stakeholder feels in charge and responsible. Not all roles with respect to charging infrastructure implementation are clearly defined yet. Example: is a DSO allowed to offer services as a charge point operator (CPO) or mobility service provider (MSP)? This may be tolerated as long as different stakeholders see enough perspective to take risk and deploy initiatives. The following aspects need careful monitoring and possibly clarification from policy:

- At a certain moment in time clarity is required because it does not make sense to plan and develop parallel infrastructure: two different CPOs progressing their plans at one truck charging hub.
- There will be activities and sites where commercial exploitation will not be possible. Still these sites and services are crucial for achieving the required spatial coverage. A consistent framework is required in order to avoid cherry picking and to develop these sites and services adequately.

- **Coordination of TEN-T and distribution network planning:**
At EU and national levels planning of motorway infrastructure and distribution networks, so far, is not coordinated. This also applies to EU funding. DSOs acknowledge the need to adjust network planning.

### Aspects which are considered being less critical

- **Investment and funding:**
Regularly, DSOs are only able to invest if there is a formal request for implementing the infrastructure. In most cases this is a connection agreement with a network customer. Once a connection agreement exists, in most cases, funding of necessary investments is not a bottleneck. (In one case, respective challenges have been reported, though.)

- **Stakeholder coordination and involvement:**
Relevant stakeholders come from different communities and, so far, no structural dialogues have been organised. Cross sector communication has to be raised to a higher, structural level. According to the interview partners, this process is on its way and willingness to align views and initiatives is high.

- **Availability and capacity of charging hubs in urban nodes:**
Implementing the required charging infrastructure in urban areas or large logistic hubs is not perceived as a particular challenge. In those areas, regularly strong distribution networks already exist. According to the interview partners, integration of chargers will be straightforward without requiring massive network upgrades and related investments.

# 5 Conclusions and recommendations

The ambition level of the AFIR proposals is mostly related to timing, not so much to specified capacity and distance requirements.

To a certain extent, timing challenges can be addressed by maximizing efficiency of processes, which means coordination and stakeholder communication.

However, periods for planning and permitting are too long to resolve existing congestions in the given period. As decarbonization of transport is a priority task in climate policies, adjusting and accelerating planning and permitting procedures may be justified. As a complementary action early and strategic planning should be encouraged.

Regardless specific target years, the AFIR focuses on the transitional phase when e-mobility in the trucking sector is going to be introduced at an industrial scale. Additionally to the AFIR targets, it is certain that even more infrastructure will be required in the future. From this perspective, setting higher targets when implementing AFIR nationally (and thus matching the future charging needs better) would be a sensible approach. Anticipating these needs helps DSOs and other stakeholders to plan strategically and to communicate their potential roadblocks and challenges to policy makers.

In many of the analysed member states, studies are on the way addressing the topic of charging infrastructure for trucks and AFIR requirements. They cover the complete country and aim to connect developments from the motorway and distribution network perspectives. In most cases these studies involve representatives from different sectors and industries (road authorities, DSOs, OEMs, academia). Those studies are a key success factor. Lessons learned should be compiled at EU level and findings should be disseminated among the involved stakeholders as well as among different member states. This also minimizes the risk of supply gaps in border regions and for transit traffic.

The engagement of DSOs as perceived by us differs. This is an impression and may not adequately reflect specific challenges and difficulties. Specific national policy instruments incentivizing DSOs may be justified, at least in a transitional period until 2030. Incentives, possibly should not focus on charging infrastructure but should stimulate provision of connections in general, i.e. also for renewables. Both developments are important and in large parts complementary.

Deployment can only start once roles and responsibilities are clear. Given that timing is critical, this clarity has to be achieved as soon as possible. Preliminary and overlapping institutional structures are justified during an initial phase. Flexibility and pragmatism will be important.

The distribution network perspective is important. Still, requirements have to be set by transport demand and patterns. The distribution network will follow. Nevertheless, involving DSOs in the identification of potential sites will likely accelerate grid connection and reduce costs in some cases.

There will be charging hubs which are crucial for geographic coverage but will not be economically viable due to low customer intensity. These require special attention in planning but even more in implementation. Suitable policy instruments have to be applied. Examples for policy instruments are subsidies for charging hubs with low customer outcome, concessions combining sites with high and low customer outcome together with a service obligation or distinct operators for such locations.

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