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Delegations will find attached document SWD(2021) 631 final - Part 2/2.

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Brussels, 14.7.2021
SWD(2021) 631 final

PART 2/2

COMMISSION STAFF WORKING DOCUMENT

IMPACT ASSESSMENT

Accompanying the

Proposal for a Regulation of the European Parliament and of the Council

on the deployment of alternative fuels infrastructure, and repealing Directive 2014/94/EU of the European Parliament and of the Council

{COM(2021) 559 final} - {SEC(2021) 560 final} - {SWD(2021) 632 final} - {SWD(2021) 637 final} - {SWD(2021) 638 final}

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ANNEX 6: MARKET DEVELOPMENTS

Market development for alternative fuels vehicle fleets

- Since 2014, the **electric vehicles market** has strongly matured. Especially electric cars have seen a rapid increase in terms of total vehicle registrations in the period 2010-2019. In 2020, sales of electric cars accounted for 10.5% of all new vehicle registrations, compared to 3% in the year before (www.acea.be). Model availability for cars and vans has widely increased and user acceptance is strongly improving. For trucks, maturity has developed at much slower pace since 2014. The stock of vehicles (including retrofitted ones) is still at a very low level. Electric trucks are now starting to enter the market for distribution trucking, and new models with longer ranges will come into the market over the coming years. Electric buses for public transport have seen a significant uptake. The number of registered buses has more than doubled in 2019. Further acceleration of cars, vans and trucks uptake is expected, driven by policies such as the CO_2 emission performance standards for light- and heavy-duty vehicles and the Clean Vehicles Directive.

- Since 2014, the market of **hydrogen fuel cell vehicles** has remains at market niche level, although the technology is mature. The total EU vehicle stock is around 2000 cars. In 2020, only four fuel cell car models were on offer in the EU, but not in all Member States. European original equipment manufacturers (OEMs) have not announced significant investment meanwhile. The situation is slightly better for buses: different European manufacturers have started production and a number of cities and regions have started to deploy hydrogen fuel cell bus fleets. Following the adoption of CO_2 emissions standards for HDVs, different OEMs are now starting to invest strongly into hydrogen fuel cell truck solutions, in view of series production for long-distance road haul post 2025.

- Since 2014, the market of **natural gas vehicles** has developed differently per segment. The technology for natural gas vehicles and components is fully mature for both compressed natural gas (CNG) and liquefied natural gas (LNG). The fleet of passenger cars in 2019 was approx. 1.2 million cars. Vehicle models are for sale in the EU market in all segments. However, the number of brands providing CNG vehicles has contracted in recent years. Natural gas trucks have shown a more steady growth, in particular in the LNG segment.

- Already before the adoption of the Directive, a fleet of around 7 million **LPG** vehicles existed in the market. Since the adoption of the Directive, vehicle uptake increased slowly. Three quarters of those vehicles were registered in just two Member States (Italy and Poland); hence, a strong geographic concentration of those vehicles persists in the EU. Fleets of LPG buses exist in several cities. However, the number of new acquisitions or replacements of LPG buses are decreasing.

The evaluation showed significant growth rates for electric recharging infrastructure for cars of almost 40% between 2018 and 2019 alone. However, this growth was concentrated in very few member States and approx. 70% of all recharging infrastructure is today located in Germany, France and the Netherlands. The indicative fleet based

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targets of 1 recharging point per 10 vehicle is met in most Member States while the indicative target of having one recharging point every 60 km along the TEN-T network has not been met (see also chapter 2.3.1 for detail). Some growth in infrastructure deployment can be noted in the areas of CNG and LPG reflecting the much smaller growth in vehicle uptake. However, there is no distinct publicly accessible electric recharging and hydrogen refuelling infrastructure deployed yet for heavy duty vehicles while the LNG infrastructure developed along the TEN-T network is largely sufficient for the number of LNG trucks currently in the market.

Table 1: Evolution of publicly accessible alternative fuel infrastructure and alternatively fuelled cars for road transport in EU27 by type

Type	Indicator	2014	2015	2016	2017	2018	2019
Electricity	Battery electric vehicles	75,067	119,222	164,681	244,231	376,534	616,644
	Plug in hybrids	56,758	126,032	191,561	254,249	349,181	474,724
	Number of Normal chargers (≤22kW)	24,917	44,786	93,721	97,287	107,502	148,035
	Number of Fast chargers (>22kW)	1,331	3,396	8,124	8,784	11,155	17,071
	Total number of chargers	26,248	48,182	101,845	106,071	118,657	165,106
	% of fast chargers in total	5.1%	7.0%	8.0%	8.3%	9.4%	10.3%
	Fast chargers per 100 km highway	2	5	7	12	15	20
	Vehicle per charging point (average)	5.1	5.7	4.0	5.4	7.2	7.5
LPG	Number of vehicles	6,906,769	7,089,523	7,232,050	7,264,111	7,628,053	7,714,409
	Number of filling stations	29,343	29,733	29,969	31,174	32,196	33,724
	Vehicle per filling station (average)	248.2	255.9	258.2	251.7	246.5	237.6
CNG	Number of vehicles	999,044	1,058,992	1,089,701	1,113,714	1,161,118	1,193,806
	Number of CNG filling stations	-	2,957	3,091	3,111	3,216	3,519
	per 100 km highway	-	3.9	4.1	4.1	4.2	4.6
	Vehicle per filling station (average)	-	408.9	405.3	409.6	411.0	391.6
LNG	Number of HDV	190	331	496	1,425	2,923	4,179
	Number of LNG filling stations	-.	63	80	110	133	242
	per 100 km highway	-.	0.08	0.11	0.15	0.17	0.32
	Vehicle per filling station (average)	-	95.4	79.6	57.5	11.8	10.1
H2	Number of vehicles	53	192	362	531	714	1,187
	Number of filling stations	-	-.	35	39	39	127
	per 100 km highway	-	-	0.05	0.05	0.05	0.15
	Vehicle per filling station (average)	-	-	12.3	16.2	20.9	9.5

Source: EAFO and own elaboration

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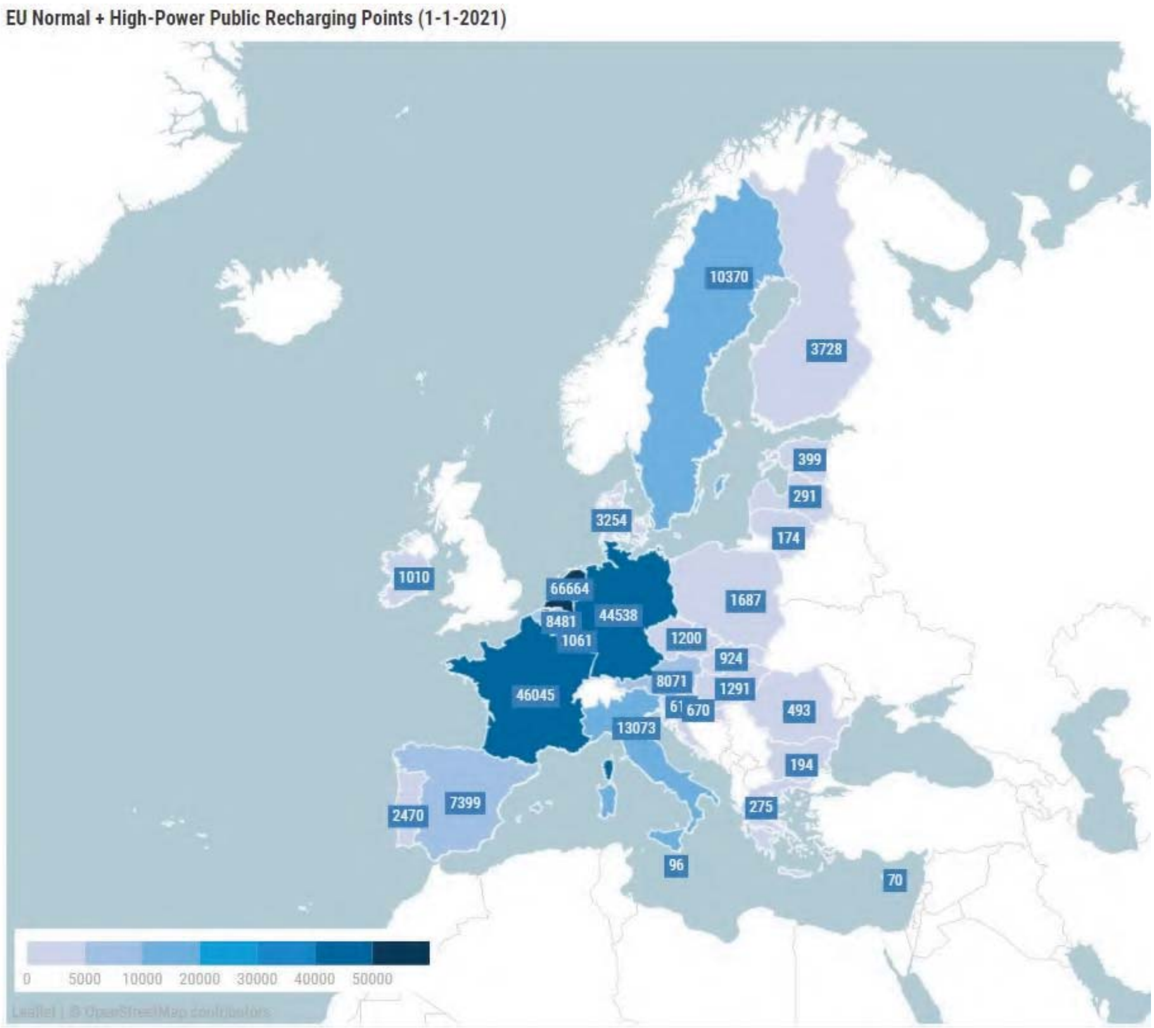
Market development for alternative fuels infrastructure

With respect to recharging points, the development is not coherent across the EU with 70% of all recharging points in the EU located in Germany, France and the Netherland as described in chapter 2.

Figure 1: Number of recharging points per Member State, 2020



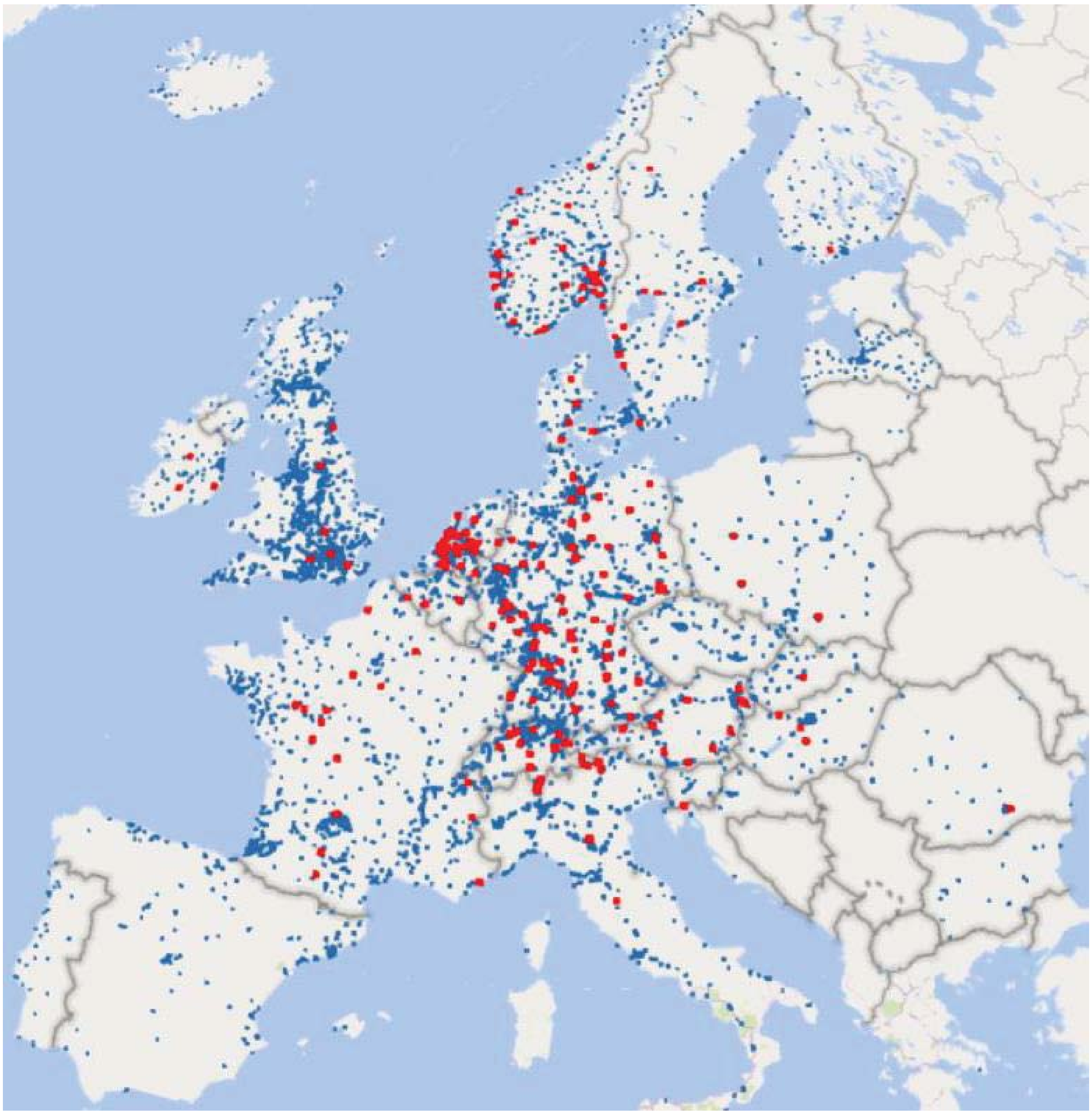
Source: EAFO and own elaboration

Those findings are also confirmed by other assessments. For example a recent analysis by Transport & Environment[1] points to the significant differences among MS in terms of the share of high power recharging points. Fast chargers (with a power capacity of > 50 kW) are mostly located in the Northern and Western Europe. The map below illustrates the gaps in the EU's high power recharging network, especially in Central and Eastern Europe and in Southern Europe. A sufficiently dense network of high power recharging

[1] https://www.transportenvironment.org/sites/te/files/publications/01%202020%20Draft%20TE%20Infrastructure%20Report%20Final.pdf

points is particularly important to enable cross border travel throughout the EU for cars and heavy duty vehicles. For the latter, no distinct infrastructure is yet available.

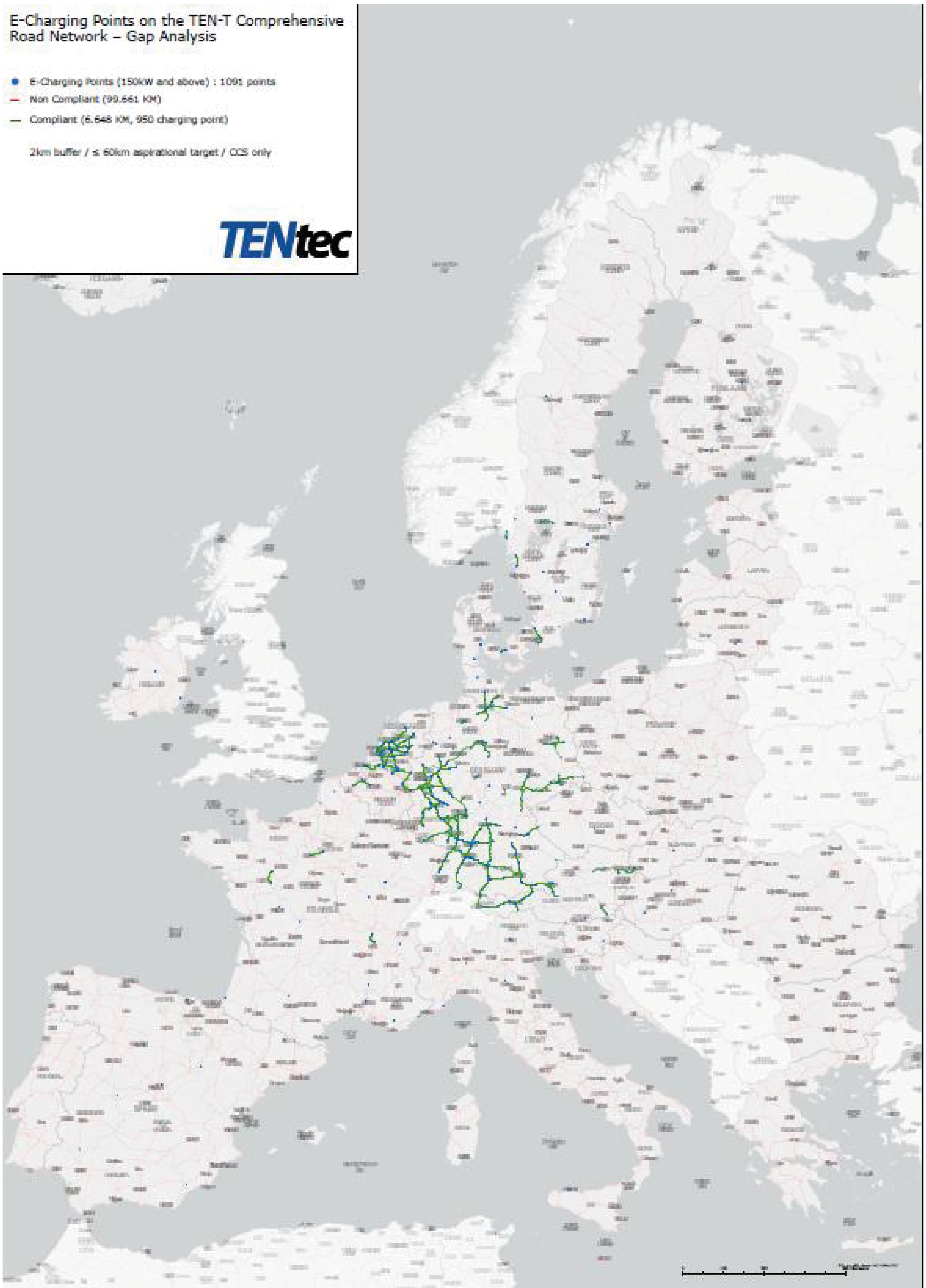
Figure 2: High power recharging points (blue >22 kW, red > 50 kW)



Source: (Tranport and Environment, 2020)

Those findings are equally true for the specific case of the TEN-T network. At the end of 2020, only 7% of the TEN-T network were equipped with at least one 150 kW charger at every 60 km. A sufficiently dense network only exists in the urban corridor stretching from the Netherlands, through German Rhineland and from there to Northern and Southern Germany. Outside that corridors only some stretches around agglomerations in Northern and Western Europe are currently equipped while in most Member States in Southern, Easter and South East Europe very little ultra fast recharging points are located on the TEN-T network making seamless travel across the EU difficult if not impossible.

Figure 3: Coverage of 150 kW chargers on the TEN-T network



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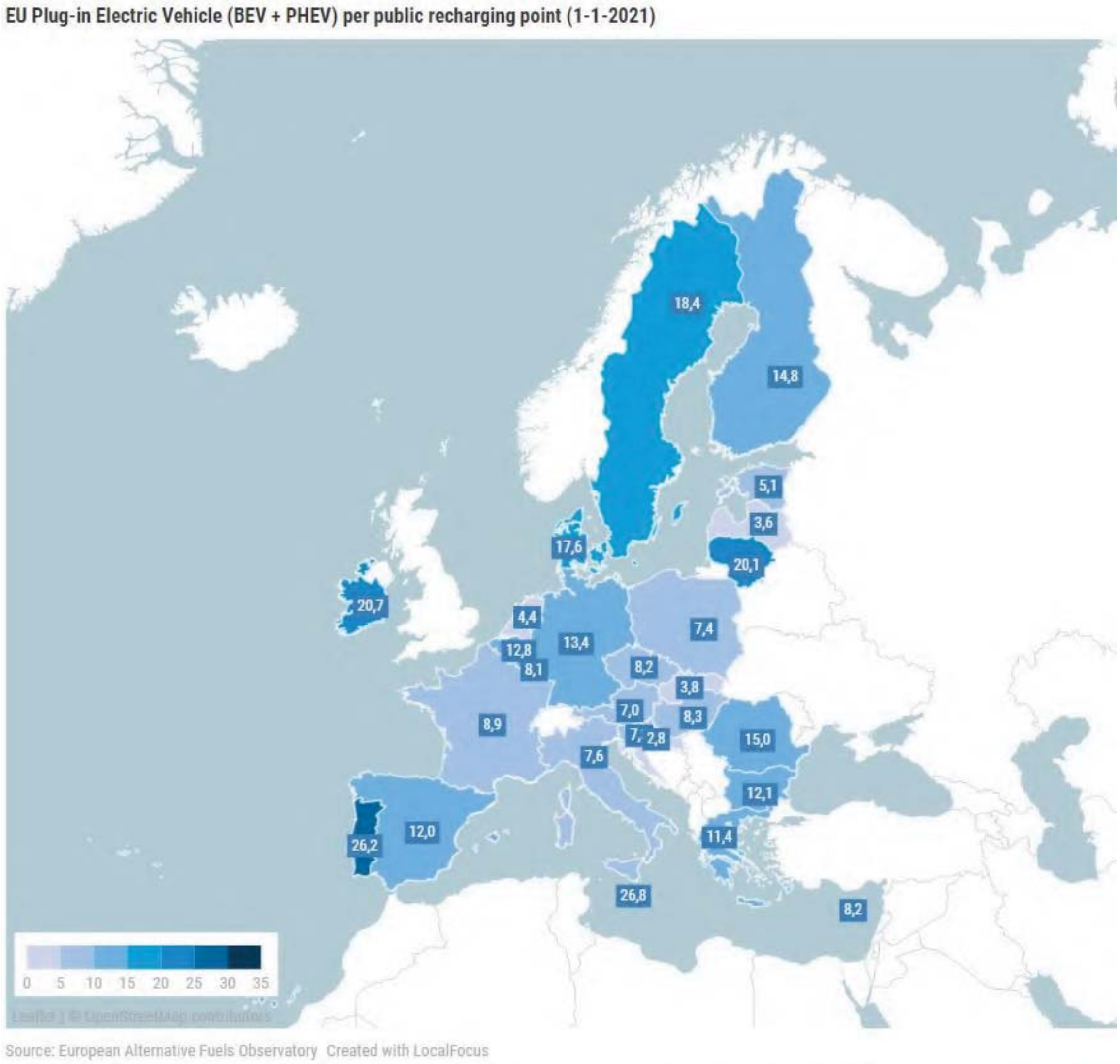
In terms of number of registered electric vehicles per recharging point, in 2020, Member States had ratios between the number of registered electric vehicles per recharging point ranging from 3.6 and 20.7. Those ratios are considered to be sufficient to accommodate the electric vehicle fleets in 2020. However, this assessment is only true for the existing vehicle fleets that need to increase rapidly under the EGD objectives. If recharging infrastructure does not keep pace with the increase of vehicles, there is a great risk that there won’t be sufficient infrastructure in the future.

Figure 4: Number of electric vehicles per recharging point per Member State in 2020



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With respect to Hydrogen refuelling stations, only ten Member States provided a total of 103 refuelling stations serving hydrogen at a pressure of 700 bar and 19 refuelling stations serving hydrogen at 350 bar. Almost 70% of all stations are located in Germany. Network connectivity across the EU is therefore not ensured.

Figure 5: Number of hydrogen refuelling stations (700 bar) per Member State in 2020

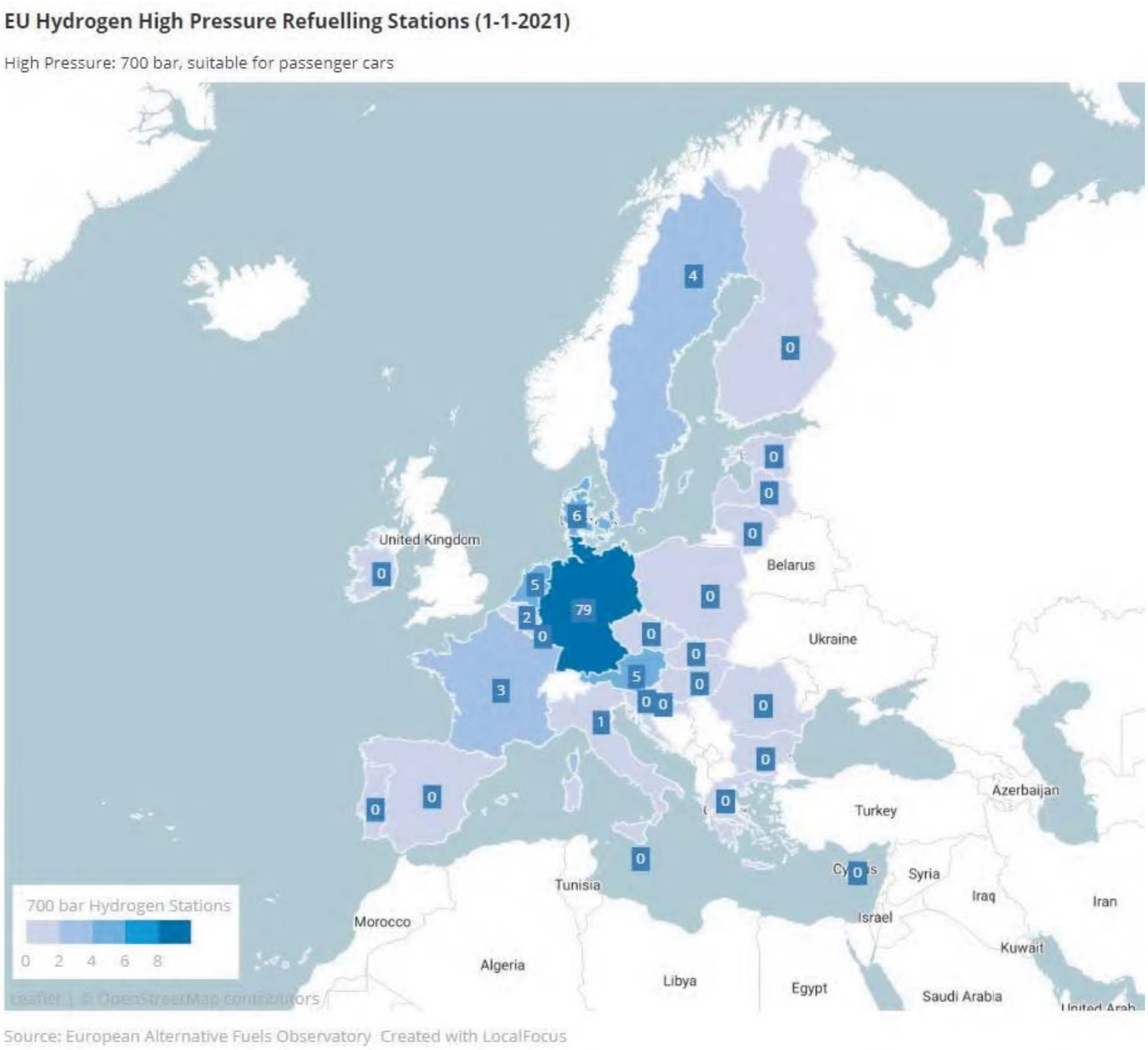
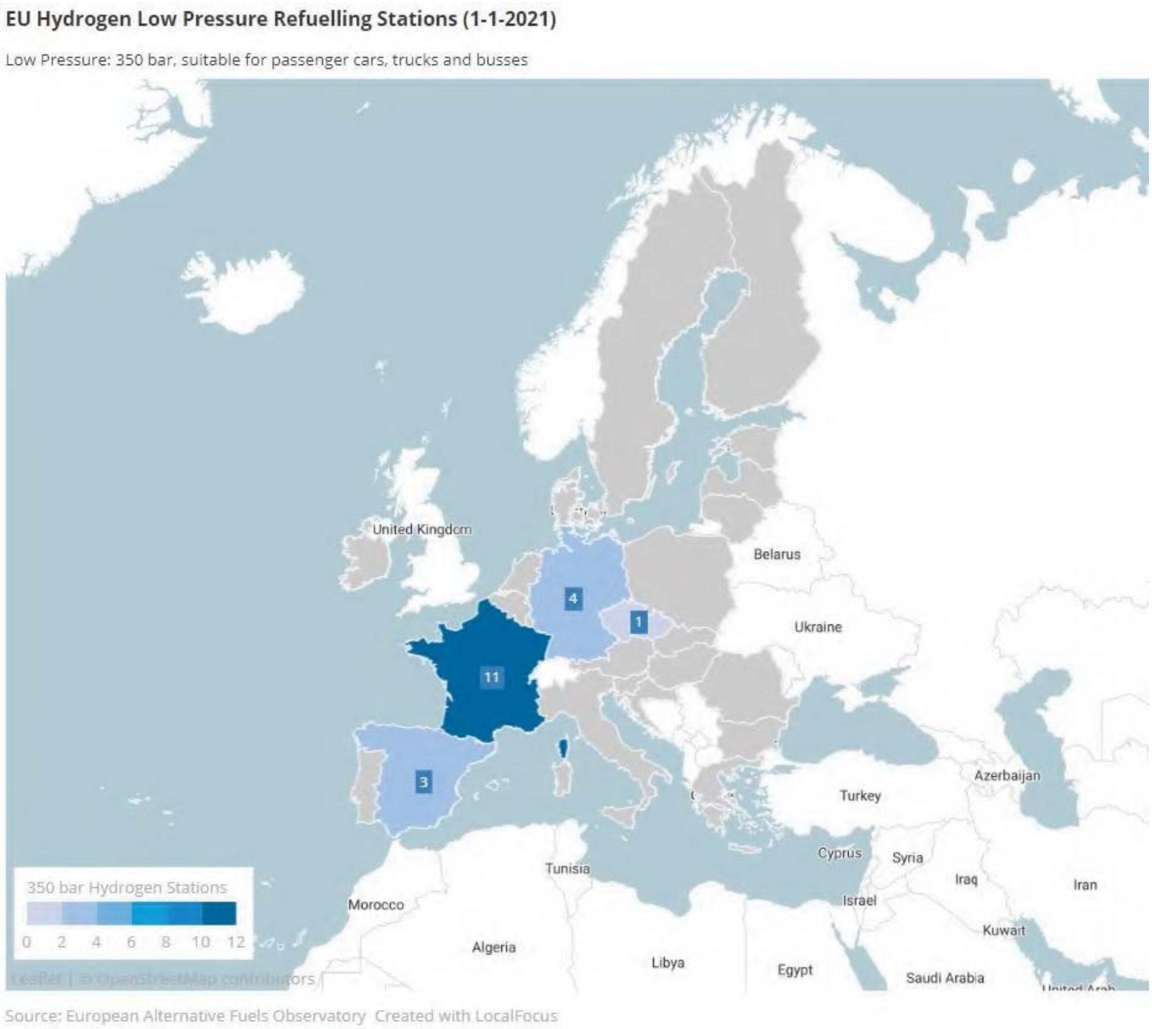
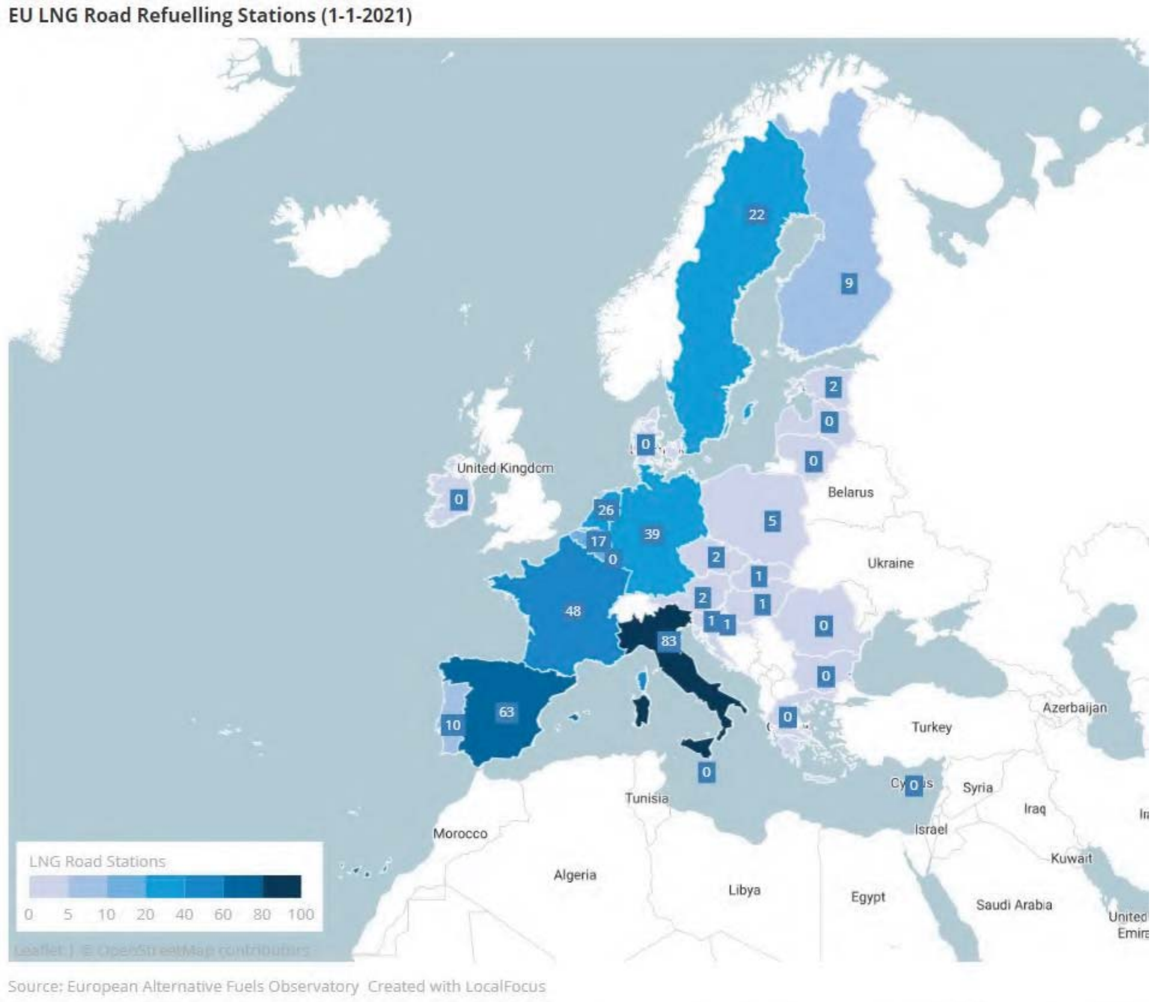


Figure 6: Number of hydrogen refuelling stations (350 bar) per Member State in 2020



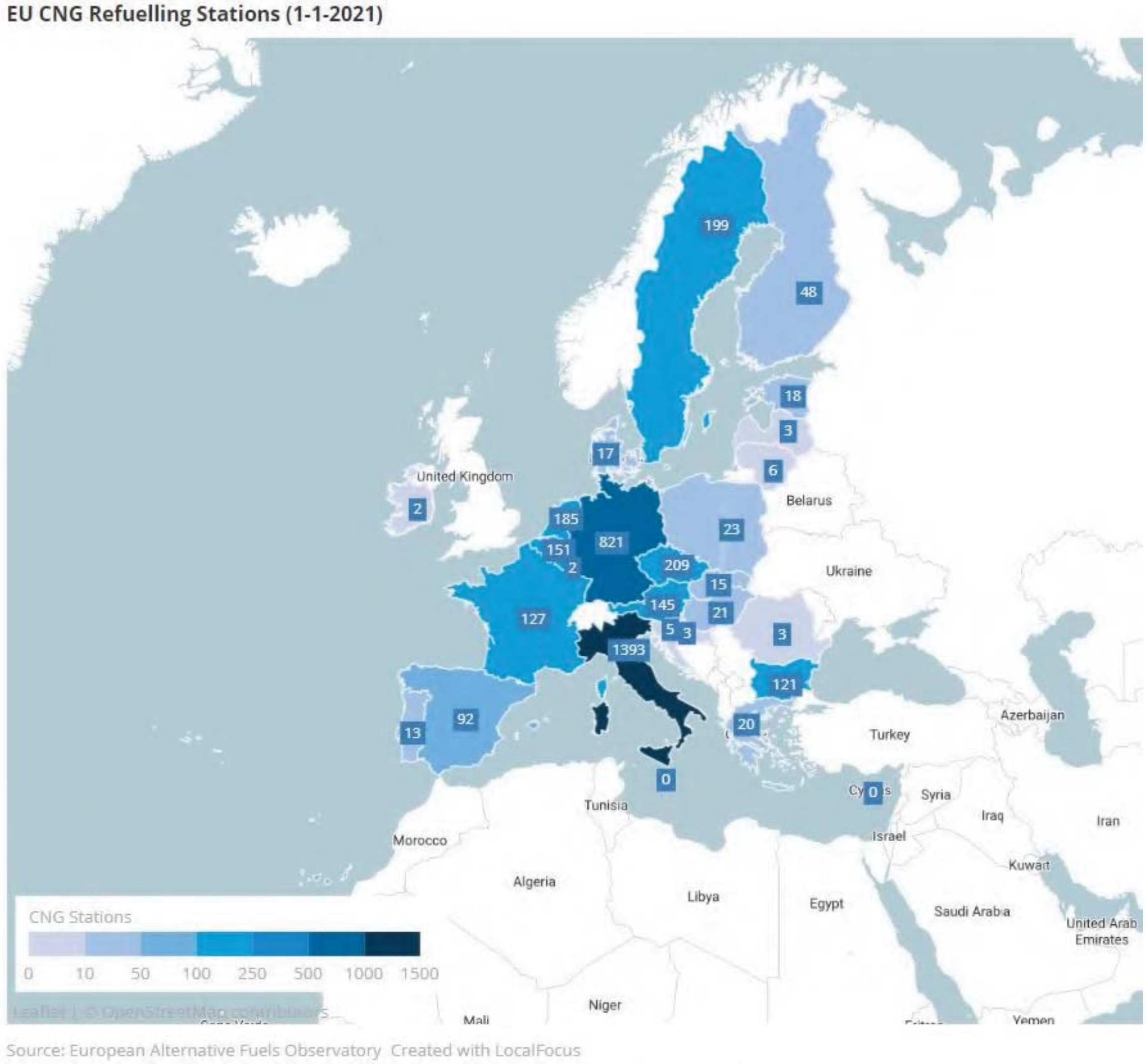
With respect to natural gas, in total 332 LNG stations were deployed in 2020 in a total of 17 Member States. Considering that the distance between refuelling stations should be around 400 km across the TEN-T network, those figure suggest that already today travel with an LNG truck is feasible across most of the EU. However, gaps persist in particular in South-East Europe where full network connectivity is not ensured.

Figure 7: Number of LNG refuelling points per Member State in 2020



In contrast, CNG refuelling stations are available throughout the EU with the exception of Malta and Cyprus where also no CNG vehicles are registered. IN total 3642 CNG refuelling stations were deployed in the EU. Around 38% of those stations were deployed in Italy reflecting the great concentration of vehicles in only some EU Member States. The CNG market seems to be mature with refuelling stations ensuring network connectivity across the EU and developing by market forces following the demand from vehicles in the respective Member States.

Figure 8: Number of CNG refuelling points per Member State in 2020



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Market development for alternative fuels in shipping

Progress in the shipping sector has been much slower than in the road sector. Data provided by Member States in their NPFs and NIRs on maritime and inland waterway vessels and infrastructure deployment is scarce. The evaluation could not draw a coherent assessment of the current and planned development of LNG bunkering and Onshore Power Supply across the EU. For maritime ports, however, data from the European Alternative Fuels Observatory (EAFO) shows that in early 2020, 33 EU maritime ports provided LNG bunkering – either through fixed terminals or vessels - of which 25 are located inside the TEN-T. Hence, less than 50% of all TEN-T ports are equipped with LNG bunkering facilities. Data on inland waterway ports is scarce. Information provided through the consultation exercise points out that almost no port in the EU currently provides such facilities.

What concerns On Shore Power Supply (OPS), in December 2020, 41 maritime and inland waterway EU ports had at least one berth equipped with OPS. However, depending on the location within the port and the power provided at each OPS, only specific vessels can be supplied with power while at berth. For example, an OPS located at a container terminal can only supply container vessels but not passenger vessels.

Table 2: LNG bunkering in TEN-T maritime ports

EAFO — **TEN-T Seaports & LNG Bunkering for LNG fueled vessels**

2020-Q1	Total		Core		Comprehensive	
	Ports	LNG facilities	Ports	LNG facilities	Ports	LNG facilities
Belgium	4	2	4	2	0	
Bulgaria	2	0	1		1	
Croatia	7	0	1		6	
Cyprus	1	0	1		0	
Denmark	22	1	2		20	1
Estonia	8	2	1	1	7	1
Finland	17	1	5		12	1
France	28	2	9	2	19	
Germany	21	3	6	2	15	1
Greece	25	0	5		20	
Ireland	5	0	3		2	
Italy	39	1	14		25	1
Latvia	3	0	2		1	
Lithuania	1	1	1	1	0	
Malte	4	0	2		2	
Netherlands	13	3	5	3	8	
Poland	5	0	4		1	
Portugal	13	1	3	1	10	
Romania	5	0	2		3	
Slovenia	1	0	1		0	
Spain	37	14	13	11	24	3
Sweden	25	2	5	2	20	
United Kingdom	42	0	16		26	
Total	**328**	**33**	**106**	**25**	**222**	**8**

Source: EAFO for LNG Bunkering, MoS Study EU Cie (2018)

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Table 3: On Shore Power supply at European ports

EAFO overview Onshore Power Supply (OPS) for shipping infrastructure in Europe

Country	Port	Latitude	Longitude	Berths with OPS	Types of vessel	Voltage (kV)	Category HV/LV	Power (MW)	TEN-T	Year installed	Location details
Austria	Ennshafen	48,23	14,51	30	Inland vessels	0,4	Low Voltage	1.4 (total)	Core	1995-2010	Inland Port
Belgium	Zeebrugge	51.33	3.2	1	RoRo	6.6	High Voltage	1.25	Core	2006	
Denmark	Frederikshavn	57.43	10.55		Navy vessels		High Voltage	4.48	Comprehensive	2016	Navy port
Denmark	Helsingor	56.03	12.62	1	Ferry	11	High Voltage	4.5	Comprehensive	2018	Ferry Terminal
Denmark	Kalundborg	55.68	11.1	22		0.4	Low Voltage	0.065	Comprehensive		
Estonia	Tallinn	59.45	24.77	10	RoPax	0.4	Low Voltage	0.350-0.600	Core		Old City Harbour
Estonia	Tallinn Paljarsaare Harb	59.46	24.70	1	Oil & Product tankers	0.4	Low Voltage	0.140	Core		Paljarsaare Harbour
Estonia	Tallinn Paljarsaare Harb	59.46	24.71	8	Barges	0.4	Low Voltage	0.210-0.800	Core		Paljarsaare Harbour
Finland	Helsinki	60,15	24,92	1	Ferry, Roro		High Voltage		Core	2020	
Finland	Helsinki	60.17	24.97	4	Ferries	0.4	Low Voltage	0,175	Core		
Finland	Helsinki	60.17	24.97	6	other	0.4	Low Voltage	0,175	Core		
Finland	Kemi	65.73	24.56	1	RoPax	6.6	High Voltage		Comprehensive	2006	
Finland	Oulu	65.02	25.47	1	RoPax	6.6	High Voltage		Comprehensive	2008	
France	Antibes	43.58	7.13	1	Maxi Yacht	6,6	High Voltage	1.2		2015	Quai des Milliardaires
France	Dunkerque	51.05	2.38	1	Container	6,6	High Voltage	6	Core	2019	Quai des Flandres
France	Le Havre (Inland)	49.27	0.29	2	Barges	0,41 / 0,23	Low voltage	0,05	Core	2018	Terminal Multimodal
France	Le Havre (Inland)	49.28	0.27	1	Barges	0,41 / 0,23	Low voltage	0,05	Core	2018	Tancarville ancienne écluse
France	Marseille	43.32	5.37	3	Ferry , RoRo	11	High Voltage	1.44	Core	2015	La Joliette
France	Port de Paris (Inland)	48.9	2.27	1	Barges	0,41 / 0,25	Low voltage	0,05	Core	2018	Darse 3 Port de Gennevilliers
France	Rouen (Inland)	49,4	1,06	2	Barges	0,41 / 0,24	Low voltage	0,05	Core	2018	Quai Emile Duchemin
Germany	Hamburg	53.55	9.93	1	cruiseship	11	High Voltage	9.8	Core		
Germany	Kiel	54.33	10.13		ferry Oslo-Kiel ,Cruise	10	High Voltage	4,5	Comprehensive	2019	
Germany	Lübeck	53.96	10.88	2	ROPAX	11	High Voltage	3.5	Core	2010	
Germany	Lübeck	53.955	10.88	2	Container <140m	6.6	High Voltage	2	Core		
Germany	Lübeck	53.955	10.875		Cruise	11	High Voltage	9.8	Core		
Germany	Lübeck	53.88	10.7	2	RoRo and vehicle vessels	11	High Voltage	3.5	Core		
Greece	Ancona	43.62	13.51	2	Shipyard	0,44 / 0,69	High Voltage	1.6		2016	
Latvia	Liepaja	56.52	21.02	2	RoRO and vehicle vessels	10	High Voltage	0.5	Comprehensive		
Latvia	Riga	56.95	24.1	2	Container	6,6	High Voltage	1.6	Core	2014	FreePort
Latvia	Riga	56.96	24.1	5		0.4	Low Voltage	0.25	Core		
Latvia	Ventspils	57.4	21.53	23		0.4	Low Voltage	0,05	Core		
Lithuania	Klaipeda	55.72	21.12	1	Oil & Product tankers	0.4	Low Voltage	0.015	Core		
Lithuania	Klaipeda	55.71	21.12	5	Barges	0.4	Low Voltage	0.4	Core		
Lithuania	Klaipeda	55.70	21.12	1	Ferries	0.4	Low Voltage	0.4	Core		
Malta	Delimara	35.83	14.56	1	LNG to Power Floating Storag	6,6	High Voltage	2.4		2016	
Netherlands	Hoek van Holland	51.98	4.13		Ro-ro/Ferry		High Voltage	4.8		2012	
Netherlands	Rotterdam	51.9	4.48	2	RoPax	11	High Voltage	2.8	Core	2012	
Norway	Bergen	60.4	5.33	3	3 cruiseships	11 / 6,6	High Voltage	12.8		2020	Skolten / Montelabo
Norway	Bergen	60.4	5.31	1	OSV	0,4	Low Voltage	0,8		2015	Skolten
Norway	Floro	61.6	5.03	3	OSV	0,44 / 0,69	Low Voltage	0,8		2017	Fjordbase
Norway	Larvik	59.04	10.05	1	Ro-ro/Ferry	11	High Voltage	1.8		2015	
Norway	Oslo	59.90	10.74	1	Cruise ship	11	High Voltage	4.5		2018	
Norway	Sandefjord	59.12	10.22	1	Ro-ro/Ferry	11	High Voltage	2.75		2017	
Portugal	Leixões	41.18	-8.70	9	Tugs and other vessels	0,4	Low Voltage	0,0825 / CP	Core	1980-2020	
Slovakia	Bratislava (Inland)	48.08.13.6	17.08.47.1	3	unspecified/ river	0,4	Low Voltage	)40 (connection poi	Core	2009	Cargo Port
Spain	Barcelona	41.373	2.187	1	Yachts	6	High Voltage	3.4	Core	2014	Marina 92
Spain	Barcelona	41.364	2.185	1	Yachts	6	High Voltage	3.0	Core	2020	Marina 92
Spain	Melilla	35.291389	-2.931372	1	Ferry	0,4	Low Voltage	0.8	Comprehensive	2014	Terminal de ferries
Spain	Motril	36.723133	-3.523067	1	Ferry	0,42	Low Voltage	0.8	Comprehensive	2018	Muelle de Costa
Spain	Motril	36.722547	-3.522778	1	Ferry	0,42	Low Voltage	0.8	Comprehensive		Muelle de Levante
Spain	Palma de Mallorca	39.552722	2.627161	1	Ferry	11	High Voltage	1.6	Core	2020	Muelles Paraires - Norte
Spain	Palma de Mallorca	39.550672	2.624514	1	Ferry	0,4	Low Voltage		Core		Muelles Paraires - Sur
Spain	SC de La Palma	28.677581	-17.765861	1	Ferry	0,4	Low Voltage	0.5	Comprehensive	2019	Dique Este
Spain	SC de La Palma	28.677989	-17.76665	1	Ferry	0,4	Low Voltage		Comprehensive		Pantalán
Spain	SC de Tenerife	28.469778	-16.244472	1	Ferry	0,4	Low Voltage	1.44	Core		Pantalán Anaga - Ribera
Spain	SC de Tenerife	28.469833	-16.244711	1	Ferry		Low Voltage	1.44	Core		Pantalán Anaga - Dique Este
Spain	SC de Tenerife	28.469594	-16.246339	1	Ferry	0,4	Low Voltage	0.2	Core		Ribera I
Spain	SS de La Gomera	28.084803	-17.1084	1	Ferry	0,4	Low Voltage	0.4	Comprehensive		Dique del Este (Ro-pax)
Spain	SS de La Gomera	28.086358	-17.107792	1	Ferry	0,4	Low Voltage	0.140	Comprehensive		Dique del Este (Fast ferris)
Sweden	Gothenburg	57.70	11.95	6	RoRo, RoPax	6.6 & 11	High Voltage	1.25-2.5	Core	2000	
Sweden	Helsingborg	56.04673	12.69437	1	Ferry	11	High Voltage	4.5	Comprehensive	2018	Ferry Terminal
Sweden	Stockholm	59.35250	18.1144444	2	RoPax	11	High voltage	6 (2*3)	Core	2019	Port of Värtahamnen
Sweden	Stockholm	58.904	17.956	1	RoPax	6,6	High voltage	2	Core	2017	Port of Nynäshamn
Sweden	Stockholm	59.3450	18.1300	2	RoPax	0,69	Low voltage	4 (2*2)	Core	1990's	Port of Frihamnen
Sweden	Stockholm	59.316667	18.09611	2	RoPax	0,69	Low voltage	4 (2*2)	Core	1980's	Port of Stadsgården
Sweden	Trelleborg	55.37	13.15	6	Ferry	10.5	High Voltage	0-3.2	Core	2017	
Sweden	Ystad	55.43	13.83	1	Cruise ship	11	High Voltage	6.25-10	Comprehensive	2013	
Sweden	Visby	57.64	18.28	4	Ferry	11	High Voltage	5	Comprehensive	2019	Ferry Terminal
Switzerland	Basel (Inland)	47.562135	7.586467		River Cruiseships	5,8	High Voltage				Dreilaendereck / St. Johann
UK	Fraserburgh	57.62	-2	6	Fishing vessel	Multiple	Low Voltage	< 0,5		2015	
UK	Stromness	58.96	-3.3	1	Ferry	10	Low Voltage	0,8		2019	Ferry Terminal

Sources: EAFO Research, ESPO, EFIP, NPF of MS, Ministry of Transport Spain, individual Ports, CLEANSHIP final report, T&D Europe communication package SSE

The Directive required Member States to consider the need to install electricity supply at airports for use by stationary airplanes but reporting by Member States is scarce, not allowing for getting a complete overview on the availability.

ANNEX 7: METHODOLOGY FOR DETERMINING SUFFICIENT INFRASTRUCTURE

This annex presents the methodology for determining the sufficiency of infrastructure as it has been developed under the support study for this impact assessment[2] and described in detail in that document.

7.1 Approach for developing the methodology to determine sufficient infrastructure requirements

There is no unified consensus with respect to which methodology or criteria can most accurately represent sufficient AFI provision. Partly, this is due to there being very limited historic data and relatively small current market size that would help to establish what "sufficient" infrastructure looks like, especially in light of technology developments and changes in user behaviour, and related changes in business cases.

The approach drew on an analysis that was divided into three different sub-tasks:

- Assessment of the suitability of metrics and criteria for the assessment of sufficiency of AFI provision.
- Assessment whether specific criteria need to be developed for HDV AFI coverage that differ from the criteria for LDVs.
- Exploration of different types of electric charging points and a possible need for a differential assessment for targets for charging infrastructure provision.

The methodology comprised of a combination of desk-based research and stakeholder engagement which informed the identification of the metrics and criteria most well-suited to measure sufficient AFI provision. Three overarching metrics were explored in greater detail:

- Distance-based: maximum distance between recharging or refuelling stations (km).
- Fleet-based: number of vehicles per recharging or refuelling station.
- Traffic volume-based: vehicle kilometres per recharging or refuelling station.

The results of the analysis informed the most suitable metrics to be used for assessing sufficient infrastructure requirements for different types of alternative fuels infrstructure.

7.2 – Specification of sufficient infrastructure requirements

This section presents the numerical targets for the various types of road transport alternative fuels infrastructure, using the results of the assessment of the metrics and criteria identified in Annex 7.1 for each category of alternative fuels infrastructure. The presented numerical targets should be interpreted as an avaerage sufficient level of infrastructure for all Member States rather than the optimum level of infrastructure. As such Member States would be free and encouraged to go beyond these minimum figures, should demand exist in a Member State. The specific numerical targets identified in this

[2] Ricardo et al (2021), impact assessment support study

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annex have been incorporated into the policy options within the overall AFID Impact Assessment.

Electricity

LDV targets for TEN-T networks

On the basis of desk research, stakeholder engagement and the expected uptake of electric vehicles it is considered that the following infrastructure should be deployed on the **Core TEN-T network:**

- 300kW installed charging capacity every 60km in each direction by **2025**, including at least one 150kW charging point per direction.
- 600kW installed charging capacity every 60km in each direction by **2030** (1.2MW total), including at least two 150kW charging points per direction.

And on the **Comprehensive TEN-T network:**

- 300kW installed charging capacity every 60km in each direction by **2030**, including at least one 150kW charging point per direction.
- 600kW installed charging capacity every 60km in each direction by **2035** (1.2MW total), including at least two 150kW charging points per direction.

The justification for these figures is based on a synthesis of the desk-based and field research. In particular, some points can be drawn out:

Fast and ultra-fast charging is seen as the preferred charging solution on the Core and Comprehensive TEN-T networks, with a sufficient provision defined using a distance-based metric

For the **Core TEN-T Network**, an original target of one ultra-fast (150kW+) charge point every 60km was developed based on desk-based research and initial feedback from stakeholders during the targeted interviews. In summary, this initial "indicative" target was chosen in response to commuting patterns on the Core network and distances achievable by EVs. In response to this element of the survey, stakeholders supported a higher target to the one proposed. Stakeholders in the survey also strongly supported prioritising fast and ultra-fast charging on the Core and Comprehensive networks (19 of 21 respondents); and also strongly supported the usage of a distance-based metric on these networks (20 out of 22 respondents). Responses to the questionnaire showed that the preferred distance between charging points on the Core TEN-T was 30-70km.

For the **Comprehensive TEN-T network**, an original target of one ultra-fast (150kW+) charge point every 100km was developed based on desk-based research and initial feedback from stakeholders during the targeted interviews. Stakeholders supported either for the target to stay the same as proposed or an increased target to the one proposed. As noted in the section above, stakeholders were strongly supportive of a distance-based metric for both the Core and Comprehensive TEN-T networks. In terms of the distance between recharging points suggested by stakeholders, the preferred range amongst stakeholders was 50-100km. In addition, the consensus from literature is that sufficient level of infrastructure is 150kW per 60-100km, adding that this should be in two directions or that each site should have two recharging points. In consideration of the expected distances achievable by EV batteries, and the necessity for frequent public recharging, it was concluded that keeping the 60km distance the same as for the Core

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network is the most logical target to implement, but that this should be implemented in 2030 due to the lower volumes of traffic on the Comprehensive network.

Stakeholders were strongly supportive of having flexibility to achieving targets

From the survey analysis and based on stakeholder feedback during targeted interviews, there was an overall desire to have flexibility within targets to avoid being too prescriptive on the types of charging. At the same time, there is clear consensus in literature and amongst stakeholders that ultra-fast should be prioritised for the Core network, and fast or ultra-fast for the Comprehensive network, to serve the travel patterns of users on these more heavily utilised and crucially located networks (i.e. users require a shorter time to recharge in order to continue their journey). As such, the recommended approach is based on specifying a required charging power per charging site, using a distance-based metric, which allows for a certain degree of flexibility to achieving the target. In addition to this, chargers need to be deployed in both directions to ensure travel in either direction is supported with accessible charging infrastructure to the road network; as such the recommended target is on a per-direction basis.

The approach of having an allocation of stated power requirement at a site along the TEN-T networks, along with a specification of a minimum power requirement of 150kW for at least one charger, is recommended as it satisfies the strong support for fast and ultra-fast charging along the TEN-T networks whilst also allowing a degree of flexibility for Member States in achieving targets.

What do these targets mean in practice?

In practice, the power requirement per site can be fulfilled by different combinations of recharging points of different power ratings, thereby influencing the total number of recharging points deployed on the network. For example, for the 2025 target on the Core TEN-T network, two possible combinations to fulfil the sufficient requirement can be considered, ensuring that at least one recharging point has a power rating of 150kW:

- 2 x 150kW recharging points; or
- 1 x 150kW and 3 x 50kW recharging points.

The table below presents the total number of recharging points along the Core and Comprehensive networks for each of the years 2025 and 2030 for an example low and high scenario, where low refers to fewer recharging points deployed and high refers to a greater number of recharging points deployed.

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Table 4: Number of chargers deployed for recommended LDV targets on TEN-T networks

Scenario	Combination of recharging points	Distance between RP	Total number of RP along Core network
2025			
Core TEN-T Network			
Low	2 x 150kW recharging points	60km	3,124
High	1 x 150kW and 3 x 50kW recharging points	60km	6,250
2030			
Core TEN-T Network			
Low	4 x 150kW recharging points	60km	6,250
High	2 x 150kW and 6 x 50kW recharging points	60km	12,500
Comprehensive TEN-T Network			
Low	2 x 150kW recharging points	60km	3,982
High	1 x 150kW and 3 x 50kW recharging points	60km	7,964

Assuming a national fleet-based vehicle to charger ratio of 12:1 (see Section below), the total number of recharging points on the Core and Comprehensive TEN-T network will constitute a relatively small proportion of the **total** recharging network (i.e. not just the fast / ultra-fast charging networks), the targets will account for approximately 3.5% of the total installed power in 2030 and a considerable smaller share in the number of recharging points because of the great power of each recharging point along the TEN-T network.

The specification of 300kW per 60km in each direction is considered to be a minimum infrastructure provision. Where the charging demand is shown to exceed this capacity, it is expected that the market will deploy additional chargers due to a positive business cases, as a result of proven high demand.

LDV national-level targets

On the basis of desk research, stakeholder engagement and the expected uptake of electric vehicles it is considered that infrastrucure deployment could be considered sufficient if for each battery electric vehicle a total of 1 kW recharging power was installed and for each plug in hybrid a total of 0.66 kW recharging power was installed. Assuming an average power output of 11 kW per recharging point, this would correspond to a an infrasrucure – electric vehicle ratio of 1-12.

The desk-based research and field research has indicated that the previous 10:1 ratio of EVs to charge points in the cuurent directive is no longer fit-for-purpose, and that an updated national level ratio would be necessary to deterine the sufficient infrastructure needed to cater for a growing EU electric LDV fleet. This is due to aspects such as changing utilisation rates of chargers, higher-powered chargers being deployed, and battery sizes within vehicles getting larger, with accompanying longer ranges.

In order to determine an updated sufficient national-level target for electric LDVs, an energy-based approach was utilised, whereby the sufficient level of charging infrastructure was determined by assessing the energy requirements of EVs, the proportion of energy delivered by public chargers, and the utilisation of charging infrastructure. All values used as data inputs are based on a combination of a comprehensive literature review and the assumptions made under the baseline scenario used for this Impact Assessment. The resulting output is the power required per electric vehicle (separately for BEVs and PHEVs) on which basis further assumptions on the ratio between infrastrcure an dvehciles and between normal and fast recharging points can be made.

To determine the energy requirements of EVs for the year 2030 for both BEVs and PHEVs, the total number of vehicles in the EU was multiplied by the average distance driven in a year and the efficiency factor (electric energy per distance in kWh/km). For PHEVs, an additional utility factor was applied in the PHEV calculation to account for the proportion of distance travelled using electricity (as opposed to conventional fuel). The number of EVs and distance driven per year were both derived from the baseline The efficiency factor and utility factor are also in line with those used in the baseline.

Table 5: Calculation of total energy consumed per year for EVs for 2030

Field (Green text = input data; red text = calculation)	Value
Number of BEVs	34,322,000
Number of PHEVs	13,716,000
Average km / year (assume same for BEV / PHEV)	13,141
Electric energy per km BEV (kWh/km)	0.127
Electric energy per km PHEV (kWh/km)	0.165
Uplift for more recent data on efficiencies from Ricardo	16.5%
2030 electric energy per km BEV (kWh/km)	0.148
2030 electric energy per km PHEV (kWh/km)	0.192
UF for PHEVS (% of km in EV)	52%
Total energy consumed per year BEV (kWh)	68,138,505,584
Total energy consumed per year PHEV (kWh)	18,369,204,572

It is necessary to determine the proportion of energy delivered by public recharging infrastructure (as opposed to private home or workplace recharging infrastructure). Although a significant majority of recharging occurs in private locations currently and will continue to do so in the future, the proportion of energy delivered by public recharging infrastructure is expected to increase by 2030 as the number of EV users living in urban areas that do not have access to private parking (e.g. living in apartment blocks) is expected to increase. In addition electric vehicles will perform longer journeys, that will require access to public charging. Thus, it is also expected that the usage of high-powered recharging points will increase. It is therefore assumed that around 40% of all recharging events for battery electric vehicles will take place at publicly accessible recharging points towards 2030.

PHEVs will only charge at normal publicly accessible recharging points due to the smaller battery and technical limitations to use fast recharging points. The respective proportions of public charging were estimated based on latest available research and expert opinion on how this is likely to evolve in the future, taking into account anticipated greater EV ownership by people with no off-street parking. On that basis, the

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total energy to be delivered by each type of public recharging point for each year was calculated and is presented in the table below.

Table 6: Calculation of total energy to be delivered by each type of recharging point per year for 2030

Field (Green text = input data; red text = calculation)	Value
Total energy consumed per year BEV (kWh)	68,138,505,584
Total energy consumed per year PHEV (kWh)	18,369,204,572
Proportion of energy delivered via public normal BEV	20%
Proportion of energy delivered via public normal PHEV	33%
Proportion of energy via public fast BEV	20%
Total energy delivered via public normal chargers per year BEV (kWh)	13,627,701,117
Total energy delivered via public normal chargers per year PHEV (kWh)	6,061,837,509
Total energy delivered via public fast chargers per year BEV (kWh)	13,627,701,117
Power Output required per BEV in kW	1
Power Output required per PHEV in kW	0.66

To translate this to the total number of each type of recharging point, it is first necessary to determine the energy delivered per year for an individual recharging point. This requires an assessment of the average power output and utilisation of recharging points. As an example, it is unrealistic for an 11kW recharging point to be used 24 hours per day and supply 11kW of power for the whole duration. Furthermore, the distribution of 'normal chargers' needed to be accounted for which includes a range of types from 3.4kW to 22kW chargers (noting that the use of on-board chargers that accept a 3-phase AC supply will likely remain limited, especially at the 22kW AC power rating). The same logic applies for 'fast' chargers. As such, the average power of normal recharging was determined to be 7.7kW, as calculated in the energy-based model. Similarly, on the basis of the existing and expected range of fast chargers, an average rate of 130kW was assumed for fast chargers, that can deliver an average epower of 104 kW.

Based on assumptions based on expert knowledge of the industry, a realistic daily utilisation of each charging point type was derived, based on a combination of practical average usage time and availability. For normal chargers this was determined to be around 2 hours per day on average, and for fast chargers it was determined to be 3 hours per day on average. From this, the energy that could be delivered by each charger per year was calculated and the power required per electric vechles established.

By dividing the total amount of energy that needs to be delivered by each public charger type per year for the fleet by the respective energy delivered by individual recharging points per year, the number of normal recharging points and fast charging points needed to support the EV fleet was derived. The values are presented in the table below.

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Table 7: Total number of normal and fast chargers derived from the energy-based calculation

Field	Value
Number of normal chargers BEV	2,693,000
Number of normal chargers PHEV	120,000
Number of fast chargers BEV	1,108,316

These values have been compared with the number of AFVs under the baseline to determine a ratio of vehicles to each type of recharging point and ultimately a combined fleet-based ratio. A fleet-based ratio of **12:1** was calculated with the average power per recharging point to be approx. 11 kW.

However, the chosen energy-based approach to estimating required minimum infrastructure is very sensitive to the assumptions used (e.g. a change in utilisation rate and share of private recharging has a notable impact on the ratio of charging infrastructure to EVs). Furthermore, the ratio also assumes an ideal geographical distribution of the recharging points.

The energy-based calculation shows the assumed split between normal and fast chargers, but a fleet-based should not suggest a relative split between these types of chargers as this depnds on local conditions and user preferences that can vary greatly between Member States and even within regions. The fleet based sufficiency index includes all publicly accessible recharging points. Therefore, the recharging points on the Core and Comprehensive TEN-T networks contribute to this fleet based target.

HDV targets for TEN-T networks

The analysis of recharging infrastrucre needs was carried out throughout 2020. However, in view of the upcoming revision of the Regulation on CO2 emission performace standards for new heavy-duty vehciles, a much higher uptake of heavy duty vehciles as anticipated by stakeholders in 2020 can be expected. This would then require also more infrastructure. While the main analysis in the Impact assessment was carried out on the basis of stakeholder views and assumptions in 2020, a sensitivity analysis was added in chapter 7.8 of this Impact Assessment to analyse the impacts of a higher HDV uptake.

On the basis of the 2020 desk research, stakeholder engagement and the expected uptake of electric vehicles it is considered that the following infrastructure should be deployed on the Core TEN-T network:

- 700kW installed charging capacity every 60km in each direction by **2025**, consisting of 350kW (or higher) charge points.
- 1.4MW installed charging capacity every 60km in each direction by **2030**, consisting of 350kW (or higher) charge points.

And on the Comprehensive TEN-T network:

- 700kW installed charging capacity every 100km (maximum) in each direction by 2030, consisting of 350kW (or higher) charge points.

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- 1.4MW installed charging capacity every 100km (maximum) in each direction by 2035, consisting of 350kW (or higher) charge points.

The justification for these figures is based on a synthesis of the desk-based and field research. In particular, some points can be drawn out:

HDVs have different recharging patterns than LDVs

It is essential that the infrastructure supporting electric HDVs fits in with the duty cycles of HDVs. In general, HDVs are used more frequently than LDVs and have busier duty cycles than LDVs, requiring higher-powered charging due to their larger batteries. In general, smaller HDVs and vans may be able to utilise infrastructure for LDVs, but the larger categories of HDVs will require dedicated charging infrastructure.

15 out of 23 respondents to the survey agreed that HDV and LDV recharging targets should be differentiated (with 2 out of 23 disagreeing). Additionally, the survey investigated whether charging targets should be segmented by category of HDV (with the recommended categories being small rigid HDVs (up to 3.5t); large rigid HDVs (greater than 3.5t); and long haul HDVs / coaches). 13 out of 23 respondents supported this segmentation, with 4 out of 23 disagreeing with this segmentation – resistance to this suggested segmentation was either based on the segmentation not being detailed enough, or the segmentation being too detailed, with different stakeholders voicing different opinions. In consideration of the above, it was considered necessary to distinguish targets for LDV and HDV recharging. Whilst the targets above are not segmented into specific HDV categories, HDV segmentation is implicitly considered within the specification of targets (as outlined below).

Market readiness of electric HDVs

With respect to technological readiness of electric HDVs, desk and field research has noted that long haul (i.e. articulated) HDVs are at a lower technology readiness level than small rigid and large rigid HDVs. Long haul HDVs will require infrastructure in the future, but not within the current timescales being considered within the AFID as volumes of long haul electric HDVs are expected to be very low up until 2030. As such, the infrastructure should be prioritised for small rigid and large rigid HDVs, though infrastructure for long haul trucks will become important in future and needs to be in place to support the uptake.

Suitability of charging infrastructure for electric HDVs

Prior work has determined that 350kW charge points would be required for small rigid HDVs in public locations; and that at least 700kW charge points would be needed for large rigid HDVs in public locations. This analysis was based on a combination of expected market development of electric HDVs (in particular battery sizes in electric HDVs) along with the specification of EU regulations that state that drivers have to take breaks every 4 hours for 45 minutes – as such, drivers can utilise these rest breaks to charge their vehicles in the allocated time using suitably high-powered charge points.

This analysis contributed to the specification of the stated power to be available at charging sites along the TEN-T networks and the associated years for implementation, where the dedicated infrastructure would need to be at least 350kW in order to serve the duty cycles of electric HDVs coming to the market. In consideration of the distances between chargers for the targets, the distance for the Comprehensive network target was increased from 60km to 100km – this is due to the fact that HDVs more heavily utilise the Core network in comparison to the Comprehensive network, and as such a greater

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amount of infrastructure would be required on the Core network – stakeholder feedback agreed with this, where a majority of respondents recommended a distance between 100-150km for the Comprehensive network target.

What do these targets mean in practice?

Similar to the LDV targets, the power requirement per site can be fulfilled by different combinations of different recharging point powers, thereby influencing the total number of recharging points deployed on the network for HDVs. For example, for the 2025 target on the Core network, Member States can adopt two possible combinations to fulfil the obligation:

- 1 x 700kW recharging point; or
- 2 x 350kW recharging points.

The table below presents the total number of recharging points along the Core and Comprehensive TEN-T networks for each of the years 2025 and 2030 for example low and high scenarios, where low refers to fewer recharging points deployed and high refers to a greater number of recharging points deployed.

Table 80: Number of chargers deployed for recommended HDV targets on TEN-T networks

Scenario	Combination of recharging points	Distance between RP (per direction)	Total number of RP along Core network (both directions)
2025			
Core TEN-T Network			
Low	1 x 700kW	60km	1,562
High	2 x 350kW recharging points	60km	3,124
2030			
Core TEN-T Network			
Low	2 x 700kW	60km	3,124
High	4 x 350kW recharging points	60km	6,248
Comprehensive TEN-T Network			
Low	1 x 700kW	100km	1,194
High	2 x 350kW recharging points	100km	2,388

HDV national-level targets

No national targets can be reasonably defined for electric charging infrastructure for HDVs on the basis of the the registered electric HDV due to the early stage of the market. At this stage, it is not possible to determine what exctly the evolution of demand for different HDV technologies will be and how exactly this will affect the demand for publicly accessible recharging, that would go beyond providing for a minimum level of infrastructure to allow the markets to develop. As such, the Core and Comprehensive TEN-T networks should be the primary focus of targets (rather than a national target) until the market develops further to assess whether another target is required.

HDV targets at safe overnight parking areas

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On the basis of desk research and stakeholder engagement it was confirmed that to cater for long haul truck journeys, overnigh recharging would be required in addition to fast recharging as addressed in the previous chapter. Therefore each of the certified **safe and secure parking areas for HDVs** should have at least one 100kW recharging station by 2030.

In consideration of the power of charging infrastructure that should be considered in safe and secure areas, analysis has indicated that 100kW charging stations are suitable to charge HDVs overnight, based on the expected evolution of battery capacities of electric HDVs and based on the fact that HDVs expected to use these sites will be there for at least a number of hours or overnight.

HDV targets for urban nodes

TEN-T Urban Nodes play a crucial role as intersection between the large European transport networks and uran areas. For electric recharging they are relevant in terms of destination charging for long haul trucks and charging for urban delivery trucks. However, most of such recharging needs are expected to be satisfied by depot-based charging. To ensure that basic recharging needs are met where no private charging is possible, the following minimum infrastructure should be at least available:

- 600kW installed charging power per urban node should be deployed with at least 150kW per charging point, by 2025.
- 1.2MW installed charging power per urban node should be deployed with at least 150kW per charging point, by 2030.

The provision of targets for AFI in urban areas generally received mixed opinions from stakeholders in both the targeted interviews and the survey – the characteristics of urban areas vary considerably depending on a large number of characteristics (e.g. population, vehicle characteristics, parking characteristics), and as such a single target for urban areas is seen to be not fit-for-purpose. However, the role and importance of TEN-T Urban Nodes in connecting the TEN-T Core and Comprehensive networks has been highlighted in separate stakeholder discussions, in particular to serve urban delivery trucks which are expected to transition to electric before other categories of HDV. Stakeholders noting that the importance of TEN-T Urban Nodes needed to be recognised. The importance of deployment of charging infrastructure in urban areas to serve urban delivery trucks has also been highlighted in previous literature.

Hydrogen

LDV and HDV targets for TEN-T networks

The recommendation is for the **Core and Comprehensive TEN-T networks** to have

- one hydrogen refuelling station serving both directions every 150km for HDVs at 700 bar by 2030;
- LDVs should also be able to refuel at all hydrogen refuelling stations.
- The sufficient daily capacity for all stations should be 2 tonnes.
- Every 450 km, liquid hydrogen should be available

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The justification for these figures is based on a synthesis of the desk-based and field research. In particular, some points can be drawn out:

Ranges of hydrogen LDVs and HDVs coming to the market

The results of the survey showed that stakeholders were supportive of a distance-based target on the Core and Comprehensive TEN-T networks for hydrogen refuelling infrastructure for both LDVs and HDVs. For LDVs, 20 out of 22 respondents recommended a distance-based metric for LDVs for both networks; and for HDVs, 14 out of 17 and 13 out of 16 respondents recommended distance-based metrics for the Core and Comprehensive networks, respectively.

Within the survey, stakeholders were asked to provide feedback on an indicative target of one hydrogen refuelling station every 300km, with this indicative target based on the expected ranges of hydrogen LDVs and HDVs coming to the market, along with findings from a survey conducted the Sustainable Transport Forum[3]. Feedback from stakeholders indicated that this distance is too large and is approaching the distances achievable for both LDVs and HDVs, and as such a shorter distance would be required to give confidence to the ability to refuel hydrogen powered vehicles. Based on stakeholder feedback and expected ranges of hydrogen vehicles, the recommended distance is one HRS every 150km along the Core and Comprehensive TEN-T networks.

The same distance is recommended for both the Core and Comprehensive networks to allow for a sufficient level of infrastructure for hydrogen powered vehicles to move around the EU. The recommended target year is 2030, as hydrogen vehicles are unlikely to start entering the market in significant numbers until the late 2020s at the earliest.

Combined location for LDV and HDV refuelling

As outlined in the analysis of survey responses, and from engagement with stakeholders during targeted interviews, along with general industry knowledge, hydrogen LDVs are unlikely to be deployed in large quantities due to the growing prominence of electromobility, and as such hydrogen infrastructure is more likely to be deployed to serve hydrogen HDVs. Numerous stakeholders commented on the efficiency of supplying and storing hydrogen in one facility / location for both LDVs and HDVs; as such, the recommendation is to combine the locations for both LDV and HDV hydrogen refuelling.[4] Such an approach will also minimise the risk of stranded assets in case hydrogen vehicles will only be deployed in one of the two market segments.

Characteristics of hydrogen refuelling stations

A sufficient level of hydrogen infrastructure is dependent on the number of stations, the distance between stations, the capacity of each station and the technology used (e.g. pressure). The latter characteristic can be treated independently, whereas the number of stations, distance between each station and the capacity of each station are all dependent on one another when determining targets for the TEN-T networks at an EU level. The distance between HRS must not exceed a maximum value to ensure that there are no issues with vehicle range and ability to refuel, and the capacity of each HRS must not fall below a minimum to ensure that it can support the expected demand for hydrogen. This is particularly important for HDVs, which require a significant mass of hydrogen at each refuelling session.

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[3] https://ec.europa.eu/transport/sites/transport/files/2019-stf-consultation-analysis.pdf

[4] Of note, additional stakeholders commented on the possibility of combining refuelling locations for hydrogen, CNG and LNG, pending the continued inclusion of CNG and LNG refuelling in the AFID.

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In order to determine a suitable target for hydrogen refuelling stations, a capacity-based approach was utilised, whereby the sufficient level of refuelling infrastructure was determined by assessing the capacity requirements of hydrogen vehicles, the proportion of energy delivered by public refuelling station and the distribution of HRS along the Core and Comprehensive TEN-T networks. Similar to the electricity calculations, all values used as data inputs are based on a combination of a comprehensive literature review, the baseline scenario (where relevant) and expert opinions. The resulting output is the total number of refuelling stations, the distance between each station and the required capacity of each station.

To determine the energy requirements of hydrogen vehicles for the year 2030 for both LDVs and HDVs, the total number of vehicles in the EU was multiplied by the average distance driven in a year and an efficiency factor (hydrogen consumption per distance in kg/km). The number of vehicles and distance driven per year were both derived from the baseline.

Table 619: Calculation of hydrogen fuel requirements for expected fleet evolution (2030)

Field (Green text = input data; red text = calculation)	Value
Number of passenger cars	251,598
Number of LCVs	22,496
Number of Small Rigid	272
Number of Large Rigid	4,991
Number of Articulated	36,701
Passenger Car average km/year	13,344
LCV average km/year	20,332
LDV average km/day	37
LCV average km/day	56
Small rigid average km/day	96
Large Rigid average km/day	265
Articulated average km/day	597
LDV efficiency (kg/km)	0.0087
LCV efficiency (kg/km)	0.0137
Small rigid efficiency (kg/km)	0.0367
Large Rigid efficiency (kg/km)	0.0593
Articulated efficiency (kg/km)	0.0881
Fuel consumed per day passenger car	80,117
Fuel consumed per day LCV	17,193
Fuel consumed per day small rigid	958
Fuel consumed per day large rigid	78,375
Fuel consumed per day articulated	1,930,641

Similar to the calculations for charging infrastructure, it is necessary to determine the proportion of energy delivered by public refuelling infrastructure (as opposed to private (e.g. depot) refuelling infrastructure). The current level of private infrastructure is negligible and given the high CAPEX of hydrogen refuelling stations and challenges in

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terms of fuel distribution, it is expected that the proportion of energy to be delivered via private refuelling infrastructure in 2030 will continue to be small. The respective proportions of public charging were estimated based on expert opinions on how this is likely to evolve in the future, considering greater uptake of hydrogen within the freight industry. By multiplying the required capacity to support hydrogen vehicles by the proportion to be delivered via public refuelling infrastructure, a final (public) capacity is calculated.

Table 10: Calculation of required public hydrogen refuelling capacity

Field (Green text = input data; red text = calculation)	Value
Proportion of fuel delivered by public HRS passenger cars	100%
Proportion of fuel delivered by public HRS LCV	80%
Proportion of fuel delivered by public HRS small rigid	80%
Proportion of fuel delivered by public HRS large rigid	80%
Proportion of fuel delivered by public HRS articulated	80%
Total fuel delivered via public HRS per day passenger car	80,117
Total fuel delivered via public HRS per day LCV	13,754
Total fuel delivered via public HRS per day small rigid	766
Total fuel delivered via public HRS per day large rigid	62,700
Total fuel delivered via public HRS per day articulated	1,544,513
Total fuel delivered via public HRS per day (kg)	1,701,850
Total fuel delivered via public HRS per day (t)	1,702

To develop the daily capacity into a target for Member States, the length of the TEN-T network was divided by the distance between HRS (recommended by stakeholder input and literature) to determine the number of HRS that will be distributed on the TEN-T network. Given that the traffic flow on the TEN-T network will be much greater than that for urban areas for hydrogen vehicles (due to the uptake in freight vehicles), it was assumed that 90% of the total capacity would be delivered on the TEN-T network. Thus, the capacity of each HRS could be calculated. The calculation is presented in Table 10 above.

The calculation results in a capacity of 2t for each HRS on the TEN-T network – this was determined to be the required capacity to satisfy the refuelling for the expected number of hydrogen vehicles for the MIX scenario. As outlined previously, and supported by the desk and field research, the trajectory of the hydrogen market is very unclear, with uncertainty around the numbers of vehicles and the technology that will be used. Furthermore, from stakeholder input, it is clear that a priority at this stage is to ensure a sufficient network of infrastructure and that in areas where there is greater demand, the market will increase the capacity of the infrastructure.

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Table 11: Calculation of required targets along TEN-T networks and TEN-T Urban Nodes

Field (Green text = input data; red text = calculation)	Value
TEN-T Network	
TEN-T network length	106,605
Distance between HRS	150
Number of refuelling stations	710
Percentage of energy from comprehensive	0.9
Total capacity delivered (t)	1,531.665
Required capacity of each HRS (t)	2.155.142
TEN-T Urban Nodes	
Number of nodes	88
HRS per node	1
Number of HRS in nodes	88
Percentage of energy from nodes	0.1
Total capacity delivered (t)	170.185
Required capacity of each HRS (t)	1.93

LDV and HDV national-level targets

No national targets can be reasonably defined for hydrogen infrastructure on the basis of the the registered hydrogen vehcles HDV due to the early stage of the market. At this stage, it is not possible to determine what exctly the evolution of demand in particular for different HDV technologies will be and how exactly this will affect the demand for publicly accessible recharging, that would go beyond providing for a minimum level of infrastructure to allow the markets to develop. As such, the Core and Comprehensive TEN-T networks should be the primary focus of targets (rather than a national target) until the market develops further to assess whether another target is required.

HDV targets for urban nodes

The recommendation is for TEN-T Urban Nodes to have at least

- one hydrogen refuelling station for HDVs by 2030,
- at 700 bar (and 350 bar optionally),
- The minimum daily capacity for all stations should be 2 tonnes.
- One out of three urban nodes should provide liquid hydrogen – in particular relevant for locations within intermodal terminals

Similar to the specification of targets for electric infrastructure in urban areas for HDVs, the provision of targets in urban areas for HDVs received mixed opinions, with many considering targets for urban areas as being unnecessary as hydrogen infrastructure is mainly intended to serve HDVs. However, the role of TEN-T Urban Nodes in connecting the Core and Comprehensive TEN-T Networks has been highlighted several times in stakeholder discussions, and as such it is desirable to the hydrogen industry to have HRS

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infrastructure at TEN-T Urban Nodes in particular – and in the absence of private refuelling opportunities - for destination charging.

The recommendation is for each of the TEN-T Urban Nodes to have at least one hydrogen refuelling station installed by 2030, to coincide with the targets for the Core and Comprehensive TEN-T networks, which will assist in ensuring a sufficient network of hydrogen refuelling stations is deployed across the EU to allow the market to develop. Stakeholder feedback has indicated that the market is expected to respond with further locations once the infrastructure requirements are more understood. It is not considered necessary to provide infrastructure for hydrogen powered LDVs in urban areas, but this can be deployed as an optional consideration should the market respond. In particular, it could be an option to install stations in intermodal terminals that are very often the destination or source of long haul road transport. Furthermore – and with a long tern perspective – such location could also used to supply hydrogen to the shipping or rail sector.

Liquid hydrogen

There were no suggestions or questions within the surveys related to provision of targets for liquid hydrogen refuelling stations (rather than gaseous hydrogen). However, subsequent discussions with stakeholders, particularly with HDV manufacturers, have indicated that some truck manufacturers are developing liquid hydrogen trucks. As such, a target was developed for liquid hydrogen refuelling to ensure that the infrastrucure also caters for emerging technologies.

The recommendation is for deployment of liquid hydrogen infrastructure every 450km along the Core TEN-T network. This is expected to be a suitable level of infrastructure provision to allow for the potential liquid hydrogen market to develop.

CNG

LDV and HDV targets for TEN-T networks

The recommendation is for the **Core TEN-T network** to have one CNG refuelling station every 150km by 2025, serving both LDVs and HDVs. However due to the maturity of the market, th established infrastructure and the expected evoluation of market uptake of CNG vehciles under the baseline, there is no need for strict adherence to that recommendation.

The recommendation for the target for CNG infrastructure along the Core TEN-T network is based on the targeted interviews with stakeholders and the responses to the survey, which largely indicated that the proposed (and existing indicative) target was appropriate. Several stakeholders indicated that CNG refuelling sites should serve both HDVs and LDVs, noting that the criteria for CNG HDVs can follow the same as for LDVs, ensuring stations are designed for heavy duty requirements (e.g. considering flow rate and nozzle design). Alignment with CNG LDV infrastructure criteria with HDV infrastructure criteria would simplify the implementation of stations.

Of note, according to EAFO, there are more CNG LDVs (1,240,540) than HDVs (41,667), but the LDVs are mainly located in Italy (around 80%). The expected vehicle uptake for both vehicle categories is not expected to be that high, and as such it is not considered necessary to have separate infrastructure for LDVs and HDVs. As such, to avoid having too much infrastructure and to save on implementation costs, the same refuelling points should be used for both LDVs and HDVs.

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There was very little support from stakeholders for CNG recommendations going beyond the Core TEN-T network. Additionally, it is worth noting that many stakeholders question the continued consideration of CNG in the AFID, with numerous stakeholders supporting the removal of CNG – and also LNG - from the Directive.

LNG

HDV targets for TEN-T networks

The recommendation is for the **Core TEN-T network** to have one LNG refuelling station every 400km by 2025, with a 5,000 t capacity, to serve HDVs.

The recommendation for the target for LNG infrastructure for HDVs along the Core TEN-T network is based on the targeted interviews with stakeholders and the responses to the survey. There is limited information in literature in terms of specifying a target for LNG infrastructure, or why it should change from what is currently specified in the AFID. In general, stakeholders were in support of using the same target that is currently within the Directive's non-binding recommendation. There was very little support from stakeholders to expand the scope of targets for LNG infrastructure beyond the Core TEN-T network.

Similar to CNG infrastructure, many stakeholders also question the continued inclusion of LNG in the AFID for road transport, with numerous stakeholders supporting its removal. However, some stakeholders noted the potential benefits LNG can provide for modes of transport separate to road transport and the potential of biogas and e-gases to replace natural gas without the need for modifications to the LNG infrastructure.

The suggested year for the target is 2025, based on the expected fleet evolution and to ensure full connectivity on the TEN-T network. It is not considered necessary to provide a different recommendation or target for 2030 for LNG infrastructure due to the expected vehicle fleet development.

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ANNEX 8: EFFECTIVENESS OF POLICY OPTIONS

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Table 12: Effectiveness of the different policy options

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Key: Impacts expected					
××	×	O	✓	✓✓	
Strongly negative	negative	No or negligible impact	positive	Strongly positive	Unclear

	PO1	PO2	PO3
Specific policy objective 1: Ensuring sufficient infrastructure to support the required uptake of alternatively fuelled vehicles across all modes and in all MS			
Increase of number of public accessible recharging	Positive effect on road transport recharging infrastructure: increase to 3.501 million public accessible chargers by 2030, 11.4 million by 2040 and 16.3 million by 2050, fully addressing overall needs of the LDV fleet. Some shortcomings in cross-border connectivity for 2030 as some parts may not be fully equipped due to lack of provision. PO leads to a steady increase in public accessible recharging points for HDV, including 6,173 chargers in 2030, 10,340 by 2040 and 12,694 in 2050 along the TEN-T.	Positive effect on road transport recharging infrastructure: increase to 3.512 million public accessible chargers by 2030, 11.4 million by 2040 and 16.3 million by 2050, fully addressing overall needs of the LDV fleet and ensuring full cross-border connectivity in the TEN-T. PO leads to a steady increase in public accessible recharging points for HDV, including 6,493 chargers in 2030, 10,660 by 2040 and 13,014 in 2050 along the TEN-T.	Positive effect on road transport recharging infrastructure: increase to 3.574 million public accessible chargers by 2030, 11.5 million by 2040 and 16.3 million by 2050, fully addressing overall needs of the LDV fleet and ensuring full cross-border connectivity in the TEN-T. PO leads to a steady increase in public accessible recharging points for HDV, including 7,612 chargers in 2030, 11,779 by 2040 and 14,134 in 2050 along the TEN-T.
Increase of number of refuelling points on roads	Positive effect also for road transport refuelling infrastructure: hydrogen refuelling points to increase to 1,852 by 2030, 8,222 by 2040 and 20,153 by 2050; the number of LNG refuelling points would be 2,904 in 2030 ensuring minimum connectivity, while in 2050 slight decrease to 2,896.	Positive effect also for road transport refuelling infrastructure: hydrogen refuelling points to increase to 1,993 by 2030, 8,341 by 2040 and 20,154 by 2050 but with almost double the capacity than in PO1. The number of LNG refuelling points would be 2,904 in 2030 ensuring minimum connectivity, while in 2050 slightly decrease to 2,896.	Positive effect also for road transport refuelling infrastructure: hydrogen refuelling points to increase to 1,990 by 2030, 8,337 by 2040 and 20,104 by 2050 with the same capacity as in PO2. The number of LNG refuelling points would be 2,904 in 2030 ensuring minimum connectivity, while in 2050 slightly decrease to 2,896.

Increase of number of OPS and other alternative fuels infrastructure in ports	PO also has a moderate positive effect on OPS provisioning in ports, leading to a total installed capacity of 856 MW in maritime ports and equipping 85 TEN-T core inland ports with OPS (net of 18). No impact on LNG provisioning	PO has a strongly positive effect on OPS provisioning in ports, leading to a total installed capacity of 3,676 MW in maritime ports and equipping 85 TEN-T core inland ports (net of 18) and additional 160 TEN-T comprehensive inland ports with OPS (net of 88). No impact on LNG provisioning.	PO has a strongly positive effect on OPS provisioning in ports, leading to a total installed capacity of 3,676 MW in maritime ports and equipping 85 TEN-T core inland ports (net of 18) and additional 160 TEN-T comprehensive inland ports with OPS (net of 88). All 91 TEN-T ports will be equipped with LNG bunkering.
Increase of number of electricity supply to stationary aircraft	Positive impact also on electricity supply to stationary aircraft, equipping 11,051 passenger gates and outfield position (net of 1,078)	Strong positive impact on electricity supply to stationary aircraft, equipping 14,729 passenger gates and outfield position (net of 4,756)	Strong positive impact on electricity supply to stationary aircraft, equipping 14,729 passenger gates and outfield position (net of 4,756)
Specific policy objective 2 Ensuring full interoperability of the infrastructure			
Increase in the directional alignment of the EV charging backend	The option has a positive effect on the directional alignment on the EV charging backend through requiring a set of open communication interfaces and protocols that will prevent technological lock in of proprietary solutions.	The option has a positive impact on the alignment of the EV charging backend, as it prescribes transfer of relevant standards (when finalised) for communication protocols and interfaces into EU law by means of delegated action, securing common technical specifications in the internal market. It will ensure common communication standards between the recharging infrastructure and the grid and thereby facilitate smart recharging	The option has a positive impact on the alignment of the EV charging backend, as it prescribes transfer of relevant standards (when finalised) for communication protocols and interfaces into EU law by means of delegated action, securing common technical specifications in the internal market. It will ensure common communication standards between the recharging infrastructure and the grid and thereby facilitate smart recharging

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Extent to which outstanding technology developments are standardised	The option also has a positive impact on standardisation of technology developments by addressing additional charging standards for trucks, supplementary standards for hydrogen	The option has a strongly positive impact on outstanding technology standardisation needs, as it addresses requirements for maritime transport and inland navigation in addition to the road transport standards in PO1.	The option has a strongly positive impact on outstanding technology standardisation needs, as it addresses requirements for maritime transport and inland navigation in addition to the road transport standards in PO1.
Specific policy objective 3: Ensuring full user information and adequate payment options.			
Increase in the extent of customer information available	The option has a positive impact as it increases consumer information on location, opening time and certain charging stations characteristics, hence increasing certainty of consumers.	The option has a strong positive impact on consumer information available as it extends to the relevant information on operational status, availability, price ad-hoc, which will strongly improve user experience. Physical signposting will complement the extent of consumer information	The option has a strong positive impact on consumer information available as it extends to the relevant information on operational status, availability, price ad-hoc, which will strongly improve user experience. It has the most comprehensive requirement for physical signposting for customers.
Increase in the provision of data to national access points	It also positively impacts the provisions of data reporting to national access points of Member States. The requirement to share static data will enable better user services development.	Through this requirement for static and dynamic data, PO2 will also have a strong positive impact on the increase in provision of data to national access points	PO3 will also have a strong positive impact on the increase in provision of data to national access points.

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Availability of one common ad-hoc payment option at all recharging points	The option improves minimum requirements for consumers to pay with bank card at every recharging point (NFC, terminal or QR code), thus reducing the approaches to payment and ease travelling especially across borders	The option also has a strong positive impact on user payment experience. Not only requires it consistent application of the two most user-friendly payment options (NFC, terminal payment), but it also ensures that users can always choose between the ad-hoc price and contract price in case of automatic authentication. Moreover, PO2 secures customer satisfaction by preventing unduly differentiation of business-to-business and business-to-consumer pricing.	Moreover, PO3 has the same strong positive impact on user payment experience as PO2, by mandating terminal payment at all new fast chargers.

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ANNEX 9: OVERVIEW OF THE MONITORING AND EVALUATION FRAMEWORK

The detailed list of operational objectives, indicators and data sources is presented in the table below. Some of these monitoring arrangements will be established more in detail only after thorough discussion with Member States and key stakeholders, in particular when the planning and reporting provisions under NPFs and NIRs are being established.

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Table 13: Proposed monitoring and evaluation framework

General objective	Specific objectives	Operational objectives	Indicators	Data source
Support the uptake of low and zero emission vehicles and vessels and thereby contribute to achieving climate neutrality by 2050 (i.e. achieve net zero GHG emissions by 2050) and to contribute to the reduction of air pollution by	Ensuring sufficient infrastructure to support the required uptake of alternatively fuelled vehicles across all modes and in all MS.	Establish clear short and long tern targets on the number or capacity and the location of alternative fuels infrastructure for all transport modes	- Number of low and zero emission vehicles/vessels per MS - Number of recharging and refuelling stations and installed capacity per MS - Location and installed capacity of recharging and refuelling stations along TEN-T core, TEN-T comprehensive and urban nodes - Location and installed capacity of OPS in inland and maritime ports - Location of LNG bunkering in maritime ports - Location and number of gates/outfield positions equipped with electricity supply for stationary aircrafts	- Member State planning through NPFs and reporting through NIRs - The European Alternative Fuels Observatory (www.EAFO.eu) - Monitoring under TEN-T regulation - Evaluation in the context of the Review of the Directive envisaged for 2026
	Ensuring full interoperability of the infrastructure.	Ensure that standardisation mandates issued to the ESOs cover all standardisation needs and are taken up by the ESOs	- Adopted standards by ESOs vis a vis the standardisation mandates issued to them	- ESOs reporting - Stakeholder contacts through the already established dedicated working groups on data and standards under the Sustainable Transport Forum
	Ensuring full user information and adequate payment options.	Creating user friendly recharging and refuelling infrastructure	- User access to all relevant static and dynamic data - Full price transparency - Easy to use ad hoc payment options	- Sustainable Transport Forum - Dedicated study on recharging markets envisaged for 2022 - Evaluation in the context of the Review of the Directive envisaged for 2026

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