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COMMISSION STAFF WORKING DOCUMENT

EVALUATION

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

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) 631 final} - {SWD(2021) 632 final} - {SWD(2021) 638 final}

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Glossary

Term or acronym	*Meaning or definition*
AFI	alternative fuels infrastructure
AFID	Directive on alternative fuels infrastructure
TEN-T	Trans-European Transport Network
LNG	Liquid Natural Gas
CNG	Compressed Natural Gas
NPF	National Policy Framework
NIR	National Implementation Report
EU	European Union
FCEV	Fuel cell electric vehicle
BEV	Battery electric vehicle
TTW	Tank-to-Wheel
WTT	Well-to-Tank
WTW	Well-to-Wheel
LCV	Light commercial vehicles
CEN	Committee for Standardisation
Cenelec	European Committee for Electrotechnical Standardisation
CEF	Connecting Europe Facility
H2020	Horizon 2020
EGVI	European Green Vehicles Initiative
PPP	Public Private Partnership
FCH JU	Fuel Cells and Hydrogen Joint Undertaking
EAFO	European Alternative Fuels Observatory
V2G	Vehicle to Grid

1. INTRODUCTION

Directive 2014/94/EU[1] ('hereinafter the Directive or AFID') creates a common framework of measures for the deployment of alternative fuels infrastructure for vehicles and vessels in the EU. It sets out minimum requirements for the build-up of alternative fuels infrastructure that are to be implemented by means of Member States' national policy frameworks. It further sets common technical specifications for recharging and refuelling points, and user information requirements. It should support a single market for alternative fuels infrastructure along urban areas and nodes and the core network of the Trans-European Transport Network (TEN-T).

Recently, the Communication on the European Green Deal[2] and the 2030 Climate Target Plan[3] as well as the Communication on the Sustainable and Smart Mobility Strategy have underlined the need for a rapid take up of zero- and low-emission vehicles in view of the increased climate change ambition for 2030 and the overall long-term objective of achieving climate neutrality by 2050. Providing a sufficiently dense, widespread network of recharging and refuelling infrastructure is of central relevance in this regard.[4]

Against this background, the Commission has carried out an evaluation of AFID, in a back-to-back manner with the Impact Assessment for the review of the Directive. More specifically and in line with the Better Regulation Guidelines, this evaluation analyses:

- its overall **effectiveness**, i.e. assess the actual changes the Directive has triggered, particularly in view of its original objectives;
- its **efficiency**, i.e. assess the actual costs relative to the actual benefits of the implementation, and whether there is potential for simplification and increasing cost-efficiency;
- its **relevance,** i.e. assess whether the overall problem analysis and related objectives are still adequate and how the policy context has evolved.
- its **added value to the EU**, i.e. its impact beyond what reasonably could have been achieved by national and regional policies; and
- the **coherence** of the regulatory framework, regarding both the internal coherence and the coherence with other key legislation and policy initiatives at EU level.

The evaluation also draws on the Commission assessment of the National Policy Frameworks[5] (NPFs) and the recent assessment of the application of the Directive based on the National Implementation Reports (NIR)[6].

1 Directive 2014/94/EU of the European Parliament and of the Council of 22 October 2014 on the deployment of alternative fuels, OJ L 307/1.

2 European Commission, 'The European Green Deal' COM(2019) 640 final.

3 European Commission, 'Stepping up Europe's 2030 climate ambition Investing in a climate-neutral future for the benefit of our people' COM(2020) 562 final.

4 European Parliament, 'Report on deployment of infrastructure for alternative fuels in the European Union: time to act!' (2018/2023(INI)).

5 Commission, 'Report on the Assessment of the Member States National Policy Frameworks for the development of the market as regards alternative fuels in the transport sector and the deployment of the relevant infrastructure pursuant to Article 10 (2) of Dir. 2014/94/EU' SWD(2019) 29 final.

6 European Commission, 'Report on the application of Directive 2014/94/EU on the deployment of alternative fuels infrastructure' COM/2021/103 final

2. BACKGROUND TO THE INTERVENTION

2.1 Political context of the original initiative

The 2011 Transport White Paper[7] stressed the relevance of developing a framework for the adoption of alternative fuels as part of the effort to reduce transport emissions. In 2013, the Commission published its "Clean Power for Transport" strategy[8], including a legislative proposal for establishing a Directive on the promotion of alternative fuels infrastructure.[9] The "Clean Power for Transport" strategy underlined the need to reduce the EU's dependency on imported oil, the need for low-CO_2 fuels and energy sources, as well as the need to promote the use of a range of alternative fuels to decarbonise the transport sector. It considered the increased use of renewable electricity and potentially hydrogen, as well as an increased use of 'sustainable biofuels' and gas (including biomethane).

The Impact Assessment accompanying the 2013 legislative proposal for AFID[10] found that on the basis of projected market developments, the infrastructure for electric, hydrogen and natural gas (LNG and CNG) vehicles is likely to remain insufficient and not in line with what a broad market take-up would require. The reason was a combination of 'technological and commercial short-comings, and a lack of consumer acceptance and missing adequate infrastructure', resulting in a "chicken and egg" problem (market failure): without a minimum network of recharging and refuelling points, the uptake of alternatively fuelled vehicles will be hampered, and vice versa.

Further, at the time no common technical specifications and related standards existed in the EU for alternative fuels infrastructure, creating uncertainty to investment and scale up of different technologies at early stage of technological maturity. The impact assessment concluded on the need for a framework of common measures to ensure the interoperability of alternative fuels infrastructure as a condition for wider uptake of alternative fuels vehicles and vessels that circulate in urban/suburban agglomerations and on the TEN-T network. In addition, it underpinned the need for clear, comparable and understandable information on alternative fuels to consumers, in order to increase public awareness, usability and a general appreciation of possible benefits.

The Commission adopted its legislative proposal on 24 January 2013. Following the co-decision procedure, the Directive was published on 28 October 2014.

2.2 General, specific and operational objectives of the Directive

The general objective is to establish a common framework of measures for the deployment of alternative fuels infrastructure in the EU, minimizing the dependency on fossil fuel (ensuring the security of supply) and mitigating the environmental impact of transport by reducing GHG emissions and air pollutant emissions.

[7] European Commission, 'White Paper: Roadmap to a Single European Transport Area - Towards a competitive and resource efficient transport system' COM(2011) 144 final.

[8] European Commission, 'Clean Power for Transport: A European alternative fuels strategy' COM(2013) 17 final.

[9] European Commission, 'Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the deployment of alternative fuels infrastructure' COM(2013) 18 final.

[10] European Commission, 'EXECUTIVE SUMMARY OF THE IMPACT ASSESSMENT Accompanying the document Proposal for a Directive on the deployment of alternative fuels infrastructure' SWD(2013) 6 final.

Specific objectives concern: ensuring and supporting the development of a comprehensive network of alternative fuels infrastructure within the EU for all modes of transport and to trigger investment therein (SO1); supporting the interoperability of infrastructure where necessary through harmonisation to enable economies of scale (SO2); increasing the availability of appropriate consumer information and awareness about alternative fuels (SO3); and allowing the efficient integration of electro-mobility into the electricity system and compliance with electricity market rules (SO4).

SO1: Support the development of a comprehensive network of alternative fuels infrastructure in the Union for all transport modes (Article 3 to 6 of the Directive)

In order to ensure that alternatively fuelled vehicles are able to circulate freely in urban and suburban areas and on the TEN-T, Member States have to implement the requirements of the Directive by means of their national policy frameworks (NPFs), including setting targets, objectives and measures in the NPFs for publicly accessible recharging and refuelling points. This would provide certainty for investors, address the chicken and egg problem and trigger investment in alternative fuel infrastructure.

Member States had to define and adopt a national policy framework (NPF) for the development of an alternative fuels market and the deployment of relevant infrastructure by 18 November 2016 (Article 3). NPFs were to include an assessment of the current state of alternative fuels infrastructure, national targets for the deployment of alternative fuels infrastructure, measures to promote the deployment of alternative fuels in public transport, designation of urban/suburban agglomerations to be equipped with recharging points and (separately) CNG refuelling points, and an assessment of the need to install LNG refuelling points in ports outside of the TEN T core network.

Member States have to provide an appropriate number of recharging points for electricity (Article 4) and refuelling points for natural gas (Article 6) accessible to the public in urban and suburban agglomerations and other densely populated areas by 2020 as well as for CNG and for LNG on the TEN-T core network by 2025. Member States could decide whether to include hydrogen refuelling points in their NPFs, but if they decided to do so have to provide an appropriate number by 2025 (Article 5). Similarly to road transport vehicles, Member States have to ensure an appropriate number of refuelling points for LNG in TEN-T maritime ports by 2025 and in TEN-T inland ports by 2030. They also have to ensure that onshore power supply for seagoing and inland waterways vessels is installed with priority in TEN-T core ports by 2025, unless there is no demand and the cost are disproportionate to the benefits.

SO2: Ensure interoperability of infrastructure where necessary through harmonisation (Articles 4 to 6 of the Directive)

Member States have to ensure that refuelling stations meet, as a minimum, European standards for recharging/refuelling points for electricity, hydrogen and natural gas (with requirements being specified separately for LNG for maritime and inland waterway vessels and for LNG and CNG for motor vehicles). For developing technologies, the Directive contains several provisions to ensure that its provisions can be adapted to market developments and technological progress by means of delegated acts in respect of technical specifications of refuelling and recharging points and relevant standards.

SO3: Ensure availability of appropriate consumer information and awareness about alternative fuels (Article 7 of the Directive)

The Directive also contains provisions on the display of information on fuel prices at stations, requiring that comparisons are made available between the different fuels on a 'per unit' basis, so that consumers can identify which alternative fuels would provide them with the most cost-advantageous option for their needs.

SO4: Ensure efficient integration of electro-mobility into the electricity system and compliance with electricity market rules (Article 4 of the Directive)

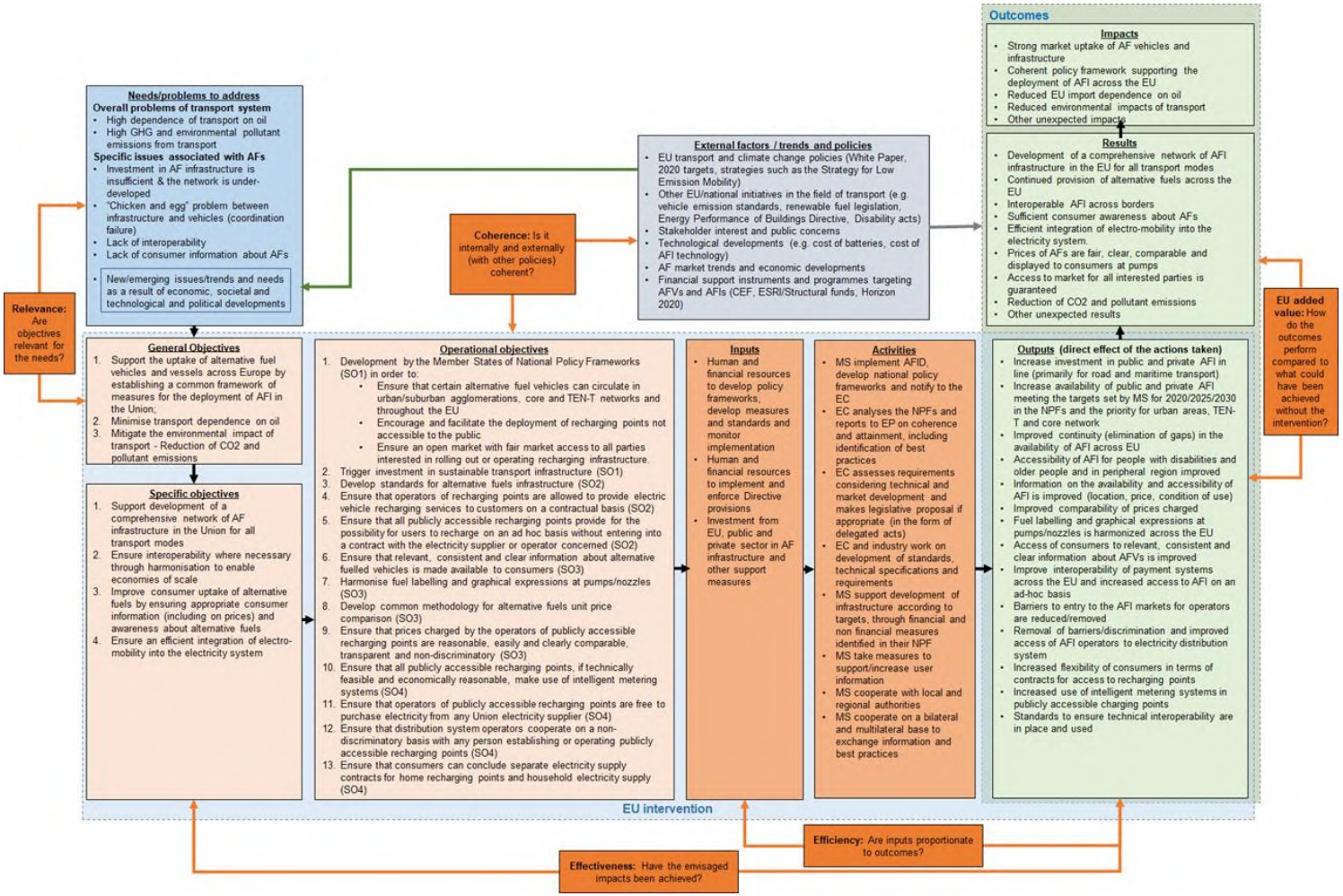
The Directive requires publicly accessible recharging points to use intelligent metering systems wherever technically feasible and economically reasonable to enable the future development of functions such as selection of green energy for charging and electricity delivery from the vehicle at peak hours. Further, it establishes that operators of electric vehicle charging points should be free to purchase electricity from any EU supplier and that electricity suppliers must cooperate with any person establishing or operating publicly accessible charge points. Further, it mandates that consumers should be free to recharge their vehicles at any publicly accessible charging point on an ad-hoc basis, without the need for a contract with the electricity supplier.

2.3 Intervention logic

The intervention logic for the evaluation is presented in Figure 1. Implementation of the Directive (actions) should lead to specific, short-term outcomes (outputs) as well as longer-term results and impacts, reflecting the objectives of the Directive. The identified outputs represent the expected direct outcomes of the activities and obligations of Member States as defined in the Directive and the NPFs. The results and their impacts should be in line with the specific and general objectives of the Directive. In addition, external factors as well as unexpected or unintended impacts have to be considered as well as their impact on the AFID.

Direct outputs were expected from the activities at Member States and European level as well as private actors. They include the actual investment (public and private) on alternative fuels infrastructure with the focus on covering the Directive requirements, while also ensuring that there are no gaps in cross-border regions. The actions taken should lead to improved information for consumers and improved accessibility to recharging/refuelling points with lower barriers in relation to technical and payment aspects as well as in relation to specific parts of the population (e.g. disabled/older people). It also includes the improved operation of the market to remove barriers to access to the market and, in the case of electro-mobility to facilitate the access to the electricity distribution system. Those outputs should be achieved on a consistent basis across the EU while taking into account the specific characteristics of the Member States.

Figure 1: Overview of drivers, problems and implications Intervention Logic



2.4 Baseline and points of comparison

A Baseline scenario has been developed for the purpose of the current evaluation, showing the projected developments without the implementation of the AFID. It builds on the Baseline scenario of the impact assessment accompanying the AFID but takes into account the revised macro-economic framework, fuel price projections, changes in technology costs and other policies adopted by the end of 2019. Annex 3 provides a description of the Baseline scenario.

Baseline of the Impact Assessment underpinning the 2013 legislative proposal

At the time of the adoption of the Directive, there was a limited deployment of alternative fuels and infrastructure. The Impact Assessment accompanying the proposal for the Directive considered the infrastructure network for electricity, hydrogen and natural gas (LNG and CNG) as insufficient compared to a network that would be necessary to enable market take up of these fuels. The availability of recharging and refuelling stations was regarded not only as a technical prerequisite for the functioning of alternative fuel vehicles, but also one of the most critical components for consumer acceptance.

The Impact Assessment developed a projection of the expected evolution of the problem and its expected impacts under the 'no-policy change' scenario with no additional policy interventions besides those already in place or those already announced by Member States, including funding for R&I and deployment at national and European level.

Despite existing initiatives and projected increase in oil prices, under the 'no-policy change' scenario the level of infrastructure would be expected to remain below what was considered necessary to enable the market take up of alternative fuelled vehicles.

In terms of the identified root causes of the problem, common standards would eventually develop since the persistence of different technical solutions would represent a serious obstacle to pan-European mobility. However, delays would still lead to considerable stranded costs and additional expenditure for adaptation.

Besides, investment uncertainty, problems of coordination and the identified market failures would continue. Member States would take relevant measures to address these problems. Those however could lead to a fragmented market, driving up costs and limiting consumer confidence with a negative impact on both demand and supply.

Therefore, the baseline of the Impact Assessment underpinning the 2013 legislative proposal projected that the share of alternative fuels in the energy consumption of passenger cars and vans would remain less than 10% by 2050 without further action on infrastructure. LNG and CNG would not make significant inroads in road transport, while the same would be the case for LNG use in waterborne transport due to the lack of refuelling infrastructure.

Updated Baseline for this evaluation – no-policy-change (no AFID) scenario

Even without the Directive in place, there are some important European policy instruments that drive the uptake of alternative fuels, vehicles and infrastructure that entered into force after the adoption of the Directive in 2014. Key among them are the

CO_2 standards for light-duty vehicles[11] and heavy-duty vehicles[12], the recast of the Renewable Energy Directive[13] and the revision of the Clean Vehicles Directive[14]. As explained above, the Baseline scenario ('no-policy change' scenario) for this evaluation builds on the Baseline scenario of the impact assessment accompanying the AFID but takes into account the revised macro-economic framework, fuel price projections, changes in technology costs and other policies adopted by the end of 2019. It does however not include measures that are part of the "Fit for 55" package.

In the Baseline scenario, the car stock is projected to continue to be mainly based on thermal engine technologies for the years to come. The share of conventional gasoline and diesel vehicles in the total stock would reduce from 97% in 2010 to 65% in 2030 and 36% in 2050. Importantly, the implementation of the post-2020 CO_2 standards would drive the uptake of hybrid vehicle technologies in the market, in the absence of a larger contribution from battery electric vehicles (BEVs) and plug-in hybrids (PHEVs), due to the lack of recharging infrastructure. The hybrid technologies would increase their share from less than 1% in 2010 to 25% in 2030 and 35% by 2050, at which point the hybrid vehicles would hold the second largest share in the total car stock, comparable to that of conventional gasoline and diesel vehicles. For electric vehicles, a gradual market uptake would take place driven by the CO_2 standards and the gradual reduction of the battery costs, with BEVs and PHEVs each reaching a share of around 3% in 2030 and 13% in 2050 in the total stock of cars. The share of the liquefied petroleum gas (LPG) cars would decrease from 3% in 2010 to about 2% in 2050. The share of fuel cell electric vehicles (FCEVs) is projected to remain negligible for all the projection period. Similarly to cars, for light commercial vehicles (LCVs) the share of conventional gasoline and diesel vehicles is projected at 66% by 2030 and 37% by 2050, while that of hybrid technologies at 32% by 2030 and 48% by 2050. The uptake of battery electric and plug-in hybrids would be more limited in lack of recharging infrastructure (up to 15% by 2050). For heavy-duty vehicles, fuel cell, LNG and electric vehicles would not make significant inroads in the vehicle stock by 2050 in the Baseline scenario.

The share of alternative fuels in the energy consumption of passenger cars and vans would remain limited, at around 14% by 2030 and 18% by 2050, without further action on infrastructure. The share of alternative fuels in the energy use in transport would go up from 7% in 2010 to 12% in 2030 and remain limited to around 17% by 2050.

What concerns infrastructure, in the baseline scenario around 172,000 recharging points would be deployed by 2020, increasing to just under a million by 2030 and to 5.4 million by 2050. The number of hydrogen stations would increase to 174 by 2030 and 1,236 by 2050. For LNG bunkering in ports, 9 facilities would be deployed by 2030 and 14 by 2050.

[11] Regulation (EU) 2019/631

[12] Regulation (EU) 2019/1242

[13] Directive 2018/2001/EU

[14] Directive (EU) 2019/1161

3. IMPLEMENTATION / STATE OF PLAY

This section provides an overview of the implementation of the AFID at EU and national level up to now, together with an overview of the current status of the AF market. The analysis is primarily based on information extracted from the Member States' NPFs and National Implementation Reports (NIRs), supplemented by relevant literature, data sources and inputs from stakeholder engagement activities. The evaluation cross-references the recent Commission report on the application of that Directive.

3.1 Activities at EU level in support of implementation of the Directive

3.1.1 Delegated Acts

In 2015, the Commission requested the European Committee for Standardisation (CEN) and the European Committee for Electrotechnical Standardisation (Cenelec) to develop and adopt appropriate European standards, or to amend existing European standards concerning alternative fuels for transport (M/533)[15] The Commission adopted the Delegated Regulation (EU) 2018/674[16] to include technical specifications for L-category vehicles, short-side electricity supply for inland waterways vessels, CNG/LNG refuelling points for motor vehicles, inland waterway vessels and sea-going ships and replace specifications for hydrogen refuelling points in the Directive. The act was repealed and replaced by Commission Delegated Regulation (EU) 2019/1745[17]. The standards included in this Regulation will apply to renewed and newly deployed recharging and refuelling points from 12 November 2021.

The Commission adopted specification for the majority of infrastructure network aspects listed in Annex II of the Directive; however, no technical specifications for points 1.3 (wireless recharging for motor vehicles), 1.4 (battery-swapping) and 1.6 (recharging points for electric buses) were adopted yet. A delegated regulation for point 1.6 is foreseen for 2021; a delegated regulation for point 1.3 might be adopted by end of 2021 subject to progress of discussion within the European Standardisation Organisations; no action is currently planned on point 1.4.

3.1.2 Implementing Acts on user information

The Commission adopted Implementing Regulation 2018/732[18] on a common methodology for alternative fuels unit price comparison, in line with Article 7(3) and initiated a Common Programme Support Action under the Connecting Europe Facility to

[15] COMMISSION IMPLEMENTING DECISION of 12.3.2015 on a standardisation request addressed to the European standardisation organisations, in accordance with Regulation (EU) No 1025/2012 of the European Parliament and of the Council, to draft European standards for alternative fuels infrastructure, C(2015) 1330 final.

[16] Commission Delegated Regulation (EU) 2018/674 of 17 November 2017 supplementing Directive 2014/94/EU of the European Parliament and of the Council as regards recharging points for L-category motor vehicles, shore-side electricity supply for inland waterway vessels and refuelling points for LNG for waterborne transport, and amending that Directive as regards connectors for motor vehicles for the refuelling of gaseous hydrogen [2018] OJ L 114/1.

[17] Commission Delegated Regulation (EU) 2019/1745 of 13 August 2019 supplementing and amending Directive 2014/94/EU of the European Parliament and of the Council as regards recharging points for L-category motor vehicles, shore-side electricity supply for inland waterway vessels, hydrogen supply for road transport and natural gas supply for road and waterborne transport and repealing Commission Delegated Regulation (EU) 2018/674 [2019] L 268/1.

[18] Commission Implementing Regulation (EU) 2018/732 of 17 May 2018 on a common methodology for alternative fuels unit price comparison in accordance with Directive 2014/94/EU of the European Parliament and of the Council [2018] OJ L 123/85.

identify possible approaches to the implementation of the common methodology[19]. By Commission Implementing Regulation 2020/858[20], amending Implementing Regulation 2018/732, the entry into force was postponed to December 2020 because of the impact of the COVID-19 pandemic.

3.1.3 EU-level reporting and review

The Commission adopted the following reports and guidelines:

- In 2016, a Commission Guidance document[21] to support Member States in developing their NPFs.
- In 2017, a Commission Staff Working Document assessing the NPFs of 24 Member States that were available at the time[22];
- In 2017, a Commission Action Plan towards the broadest rollout of alternative fuels infrastructure, outlining different supporting actions including funding available under EU financial instruments[23].
- In 2019, a Commission Guidance document accompanied by an Excel® reporting template to facilitate compliance with the national reporting requirements outlined in Article 10(1).
- In 2019, an updated Commission Staff Working Document to include the NPFs of EL, MT, RO and SI[24].
- In 2021, a report on the application of Directive 2014/94/EU on the deployment of alternative fuels infrastructure[25]

3.1.4 Financial support to deployment

Connecting Europe Facility (CEF) Transport was the main EU funding instrument used to support investment in AFI in the time period covered by this evaluation. It supported investments into alternative fuels infrastructure for road transport and ports.

Since 2014, alternative fuel projects have been funded under nine different calls for proposals, in the form of annual and multi-annual work programmes covering general, blending and cohesion calls[26]. One such call is the **CEF Transport Blending Facility[27]**, a tool to promote the participation of private sector investors and financial institutions in projects concerning the deployment of alternative fuels. It was launched in 2019 and

[19] German Energy Agency (DENA), Study on the Implementation of Article 7(3) of the Directive on the "Deployment of Alternative Fuels Infrastructure" – Fuel Price Comparison: Final Report (2017).

[20] Commission Implementing Regulation (EU) 2020/858 of 18 June 2020 amending Implementing Regulation (EU) 2018/732 as regards postponing its date of application [2020] OJ L 195/57.

[21] European Commission, Clean Transport - Support to the MS for the Implementation of the Directive on the Deployment of Alternative Fuels Infrastructure: Good Practice Examples (2016).

[22] COM(2017) 652 final, ***SWD(2017) 365 and*** SWD(2019) 29.

[23] European Commission, 'Towards the broadest use of alternative fuels - an Action Plan on Alternative Fuels Infrastructure under Article 10(6) of Directive 2014/94/EU, including the assessment of national policy frameworks' COM(2017) 652 final.

[24] European Commission, 'Report on the Assessment of the Member States National Policy Frameworks for the development of the market as regards alternative fuels in the transport sector and the deployment of the relevant infrastructure pursuant to Article 10 (2) of Directive 2014/94/EU' SWD(2019) 29 final.

[25] COM/2021/103 final

[26] Blending calls are open for projects aimed at maximising the private involvement in the delivery of CEF transport and cohesions calls are open exclusively for MS eligible for funding from the Cohesion Fund (under the European structural and investment funds).

[27] https://ec.europa.eu/inea/en/connecting-europe-facility/cef-transport/apply-funding/blending-facility

accepts proposals on a rolling basis with quarterly cut-offs and blends loans with grants and other financing form. The infrastructure deployment supported by CEF has been located on all nine Core Network Corridors, including the urban nodes with a total project value of 3,883.6 million.

Further, the **CEF Debt Instrument** addresses projects with expected financial viability but a risk profile that is too high for conventional market financing. By the time of concluding this evaluation five projects related to alternative fuels infrastructure had received grants under the debt instrument, with a total of € 1.1 billion funding. This, in combination with the calls for proposals, brings the total CEF contribution towards AF in excess of € 6.8 billion.

Funding **for R&I for alternative** fuels has been made available through Horizon 2020 (H2020) programme, for electric vehicles and recharging infrastructure in particular through the Societal Challenge 'Smart, Green and Integrated Transport" and the European Green Vehicles Initiative (EGVI) Public Private Partnership (PPP), but also through funding for H2020 Smart City Lighthouse projects. In addition, the Fuel Cells and Hydrogen Joint Undertaking (FCH JU) PPP supported projects that will improve performance and reduce the cost of products as well as demonstrate on a large scale the readiness of the technology to enter the market in the fields of transport and energy. Finally, H2020 also supported projects on natural gas (CNG, LNG, biomethane)

EU R&D funding allocated from 2014 in the areas of transport electrification and methane-based fuels sums up to € 1.57 billion of which the majority was spent on electrification.

3.1.5 Exchange with Member States and stakeholders at EU level

The Committee on Alternative Fuels Infrastructure (C49500) was created under Article 9 of the Directive and started meeting in July 2017. The Committee has addressed actions to support the deployment of alternative fuels infrastructure including drafting of implementing acts, programme support action for the comparison of alternative fuels prices and voting to postpone the date of effect for the implementing act on harmonised rules on electro-mobility[28].

The Sustainable Transport Forum (STF) was created in 2015[29] as an expert group on alternative transport fuels, involving Member States and 32 interest organisation and companies. The STF aims to help the Commission to advance the application of the Clean Power for Transport Strategy and facilitate the implementation of the AFID, in particular through exchange of technical expertise and information. Under the STF, different subgroups have been formed on advanced biofuels (dissolved), on the creation of an electro-mobility market of services; on alternative fuels in cities (dissolved), on the implementation of the Directive, on the standards for alternative fuels infrastructure and on electric buses.

3.1.6 Other activities

The Directive mandated CEN to develop standards that would improve existing user information. CEN adopted on 12 October 2016 standard EN 16942, "Fuels-Identification of vehicle compatibility-Graphical expression for consumer information", which entered into force 2 years later, on 12 October 2018. Furthermore, the standard EN 17186:2019

[28] Meeting minutes can be accessed here: https://ec.europa.eu/transparency/regcomitology/index.cfm?do=search.search

[29] C(2015) 2583 final

laying down harmonized identifiers for power supply for electric road vehicles was adopted in 2019 and is due to enter into force in February 2021.

The European Alternative Fuels Observatory (EAFO)[30] disseminates information on alternative fuels in Europe, funded by the Commission. The portal regularly updates figures on AFI and AFV and includes details on each of the national policy frameworks, including information on the targets and objectives.

3.2 Overview of national activities implementing the Directive

3.2.1 Transposition of the Directive

Member States had to transpose the Directive by 18 November 2016. Some Member States delayed its transposition. The Commission opened 24 infringement cases for non-transposition in 2017 and 2018. The Commission closed most cases in the course of 2018 and closed the remaining cases in 2019 and 2020. At the end of 2020, there were no open infringement cases against Member States for non-transposition of the Directive.

3.2.2 National Policy Frameworks

By the original deadline of 18 November 2016, not all Member States had submitted their national policy frameworks. By summer 2017, 24 NPFs were available that informed the first assessment of NPFs by the Commission in 2017. By end of 2018 all NPFs had been received.

In its 2017 assessment of the NPFs and in its 2019 update, the Commission concluded that the NPFs are not fully coherent from an EU perspective in terms of the priorities they set. Member States' ambition with regard to the uptake of alternative fuels and their infrastructure varied significantly. It also concluded that not all NPFs set clear and sufficiently ambitious targets and objectives, supported by comprehensive measures.

3.2.3 National Implementation Reports

The Directive requires that Member States submit to the Commission by 18 November 2019 a national implementation report (NIR) on the execution of its national policy framework (NPF) in the period from submission of the NPF until at least 31 December 2018. These reports shall cover the information listed in Annex I of the Directive, including, where appropriate, relevant argumentation on the level of attainment of the national targets and objectives referred to in Article 3(1). Not all reports were delivered on time, but by end of 2020 all reports had been received.[31]

3.2.4 Provision of User Information at national level

Ensure relevant, consistent and clear information

As well as providing information through vehicle manuals, dealerships and on cars, the analysis of the NPFs and NIRs shows that the information has also been made available on websites, national information points and through educational programmes in schools.

[30] https://eafo.eu/

[31] Full information on the process can be found in the Commission Report on the Application of the Directive, COM (2021)103 final

Furthermore, Member States are required to ensure that information to consumers on nozzles and pumps is provided via graphical expressions, in line with the standards developed by relevant ESOs. The standards for graphical expressions came into effect in October 2018, as such these MS may have introduced similar schemes prior to this. There is no comprehensive and coherent database to assess the use of those graphical expressions in Member States.

The common methodology for alternative fuels unit price comparison came into effect by 07 December 2020 under Commission Implementing Regulation 2020/858. To support implementation of this Regulation, the Commission issued a programme support action (PSA) under CEF for Transport[32]. It aims to pilot different options of price comparison to support, ensure consistent implementation of Article 7(3) of the AFID and develop an online portal to display fuel prices and costs. [33]Aside from this, there has been little action taken by MS to implement this article.

Open data for geographical location of AFI

AFID intends to facilitate exchange of data. There is no comprehensive information for all Member States that information on infrastructure was provided via databases, containing information on location, prices, accessibility and status of recharging and refuelling points. From the analysis of the NPFs and NIRs, AT, BE, FR, HR, LT, LU, PL, RO, SI and ES all stated that they have introduced specific measures on publishing data on AFI. As part of the survey underpinning the evaluation support study, five national authorities[34] stated that they share information accordingly.

The Commission has also supported the implementation of Article 7(7) through another Programme Support Action on data collection related to recharging/refuelling points for alternative fuels and the unique identification codes related to e-Mobility actors (IDACS)[35]. Starting in January 2019, 16 Member States work together to set up harmonised identification codes for charging point operators, implement ID registration repository for exchanging information on these ID codes and ensure that all data of infrastructure of electricity and hydrogen is readily available.

3.3 Status of markets for alternative fuels vehicles and infrastructure

An overview of the current status, broken down by fuel type and transport mode has been prepared through the report on the state of the alternative fuels transport system in Europe[36]. Moreover, the Commission has provided a full assessment of the status of markets as part of its recent report on the application of the Directive[37]. The evaluation draws on those assessments and summaries the status of markets below.

3.3.1 Electricity

Electricity for Road Transport

At EU level, the data provided by EAFO points to six-fold increase in the total number of electric charging infrastructure between 2014 and 2019, from 25,268 to 165,106

[32] http://fpc4consumers.eu/

[33] Greece is coordinating the project and the Netherlands, Finland, Germany, Croatia, Spain, Portugal and France are participating.

[34] Luxembourg, Belgium, Austria, Poland and Romania

[35]https://ec.europa.eu/transport/content/programme-support-action-addressed-member-states-data-collection-related_en

[36] https://op.europa.eu/en/publication-detail/-/publication/fd62065c-7a0b-11ea-b75f-01aa75ed71a1

[37] COM/2021/103 final

recharging points. The number of EVs (BEVs and PHEVs) during the same period increased at an even higher rate (9.4 times) with the share BEVs remaining rather stable (ca. 60%). The EAFO data also point to a significant increase in the number of fast chargers (>22kW) per 100 km of highway (from 2 per 100 km in 2014 to 20 in 2019).

Fast chargers represented in 2019 around 10% of the total public chargers, up from 5% in 2014. According to T&E, there were approximately 780 ultra-fast chargers[38] in Europe at the start of 2020. Germany has the highest number of ultra-fast recharging points (269), representing approximately a third of the network. Other MS with a significant number of ultra-fast recharging points are the Netherlands (98) and France (88).

At EU level, the number of charging points per million population increased from 112 in 2015 to 376 in 2019. The increase of recharging infrastructure at EU level is not equally spread across MS. A small number of MS are far ahead in terms of the density of the network while others are still at the very early stages. At the same time, among the frontrunners there have been different levels of development of fast infrastructure.[39]

All Member States have seen an overall increase in the number of electric vehicles from 2015 to 2019. Vehicle fleets increase has been fragmented across Member States though. Except for Sweden, the Member States with the greatest increase in electric vehicles per million population from 2015 to 2019 are also those with a corresponding high increase in recharging infrastructure.

Electricity for waterborne transport

In relation to electricity installations in sea/inland ports, in 2015, there were 20 maritime ports in the EU providing shore side electricity (SSE) supply (high or low voltage). By 2019 this had increased to 44 ports.[40].Out of the 44 EU ports, 22 are ports on TEN-T Core Network and 11 are ports on the TEN-T Comprehensive Network out of a total of 186 Core ports (104 maritime and 82 inland) and 394 comprehensive ports (225 maritime and 169 inland). In total, there were over 189 berths with SSE in these EU ports with voltage ranging from 0.4 to 11 kV and power ranging from 0.015 to 10 MW.

In terms of vessels powered by electricity, EAFO includes only data on the global seagoing fleet for 2020 with no corresponding data for inland shipping. As of May 2020, there are 101 seagoing vessels using SSE, of which 53 (52%) are pure electric and 48 (48%) are plug-in hybrid ships. There are a further 125 hybrid vessels that do not require electric infrastructure in ports.

According to report on the State of Alternative Fuels transport systems, there are 166 battery-powered vessels in operation, of which 56% are passenger ferries[41]. Furthermore, less than 0.5% of inland waterway vessels are hybrid or electric. Interviews with ECSA and ESPO stated that OPS is available in only a limited number of ports.

[38] This number includes recharging points above 100kW in Europe (including Norway, Switzerland and UK) and excludes the Tesla Supercharger network.

[39] For example, Netherlands has only a small share of fast charging infrastructure (2.1%) in comparison to a much higher share in Germany (15.1%). Other countries with high levels of EV infrastructure include Belgium, Sweden, Austria and Denmark with around 500 charging points per million population

[40] European Commission, State of the Art on Alternative Fuels Transport Systems in the European Union – 2020 Update (2020).

[41] https://op.europa.eu/en/publication-detail/-/publication/fd62065c-7a0b-11ea-b75f-01aa75ed71a1

Electricity supply in airports

An ACI EUROPE survey in 2018 based on the replies of 51 airports, found that 42 of them (82%) provide Fixed Electrical Ground Power to aircraft on-stand.[42] In the same survey, 86% of respondents reported that their vehicle fleet included electric vehicles and 47% included hybrid models. Furthermore, an interview with ACI noted that there are an increasing number of airports offering fixed-electrical ground power. However, it does not work for all types of operation, particularly low-cost airlines with short turn-around times.

3.3.2 Natural Gas

In comparison to the electric charging infrastructure, the increase in the level of natural gas (CNG/LNG) infrastructure has been more moderate, but this also reflects the fact that the natural gas infrastructure is much more centralised and with much higher throughput per station. It also reflects the moderate increase in CNG vehicle fleet that only increased by around 20% between 2014 and 2019 while the number of LNG vehicles remained low in 2019 with only 4,540 registered vehicles. In the case of CNG, a network of around 3,000 stations was already in place in 2015 (mainly in Italy and in Germany). This increased by 20% (ca 3,500 stations), largely in line with the increase in the number of vehicles. The increase in the share of LNG stations was much greater (3.8 times) albeit from a much lower starting point.

CNG

In terms of its distribution, the CNG network is concentrated in a few MS. The greatest share of filling stations are located in Italy (1,391 in 2019) both in absolute and relative terms, representing close to 40% of the total filling stations in the EU. Other countries with high number of CNG infrastructure are DE (854), SE (192) and CZ (207). Accounting for population, AT and BG also display a high number of refilling stations. Since 2015, most investment in CNG filling station has taken place in Italy (217 new stations), followed by the CZ (99) and BE (87). Conversely, some Member have been reducing the number of CNG refuelling points, namely, AT, DE, PL, and LU.

In terms of vehicles, Italy represents almost 80% of all CNG vehicles in Europe, with a ratio of 822 vehicles per refilling station. Other MS with a high ratio are Poland (309), Sweden (295) and Finland (213). Italy has also had the greatest increase in number of vehicles since 2015 (103,106), followed by Belgium (16,543) and Czech Republic (11,747).

LNG

LNG for road transport

At the end of 2019, LNG fuelling infrastructure was available in 15 Member States according to the EAFO. Italy had the greatest number of refuelling stations (59) followed by Spain (49). However, in terms of per-capita of population, Finland, Netherlands and Sweden have the highest number of infrastructure. Since 2015, the number of refuelling points at the Union level has increased almost fourfold, with a significant increase in infrastructure in Italy (47 new stations), Spain (49) and France (32).

[42] https://ec.europa.eu/transport/sites/transport/files/2019-aviation-environmental-report.pdf

Heavy-duty vehicles make up 99% of LNG vehicles in the EU. Italy had the greatest number of vehicles (1,907) followed by Spain (1,462), although Netherlands had the greatest number per million population (33.3).

LNG for water transport

In relation to water transport, in 2018 there were 16 maritime ports in Europe that had LNG refuelling points in operation.[43] Most of them were located in Belgium, Spain, France, Lithuania, Netherlands, Portugal and UK. At the beginning of 2019, there were 85 large-scale operational LNG tanks installed in 35 ports in EU, mainly in Spain (29 tanks in 9 ports) and Italy (8 tanks in 3 ports). Furthermore, according to the EAFO, there were 50 LNG powered seagoing vessels in Europe (excluding Norway) at the end of 2019, which will increase to 67 in 2020 according to forecasts. There are still a number of LNG ships on order and it is estimated that the total fleet will increase to approximately 92 ships .

Concerning inland navigation, there is no specific data available. However, in 2018, it was considered to be sufficient LNG bunkering to meet the demand for the very low number of LNG vessels in use.[44] There are 14 LNG inland vessels operating in Europe today, of which 9 are tanker vessels, and a further 12 on order (European Commission, 2020).

3.3.3 Hydrogen

Hydrogen for road transport

At EU level, the number of hydrogen filling stations in operation across the EU in 2019 was still very small (127), up from 35 in 2016 and 39 in 2018. The number FCEVs has also increased during the same period, but the total number of vehicles is still very small (around 1,200 at the end of 2019).

Moreover, hydrogen refuelling infrastructure is highly concentrated. More than half of the stations in 2019 (60%) were located in Germany (76), followed by France (14). In relative terms, Denmark has the most refuelling stations (1.7 per million population). In total, only 10 MS had at least one filling station in operation at the end of 2019. Most common types of hydrogen refuelling stations are the high pressure (700 bar) stations for road vehicles (108 according to EAFO). At EU level, the number of refuelling stations remained fairly constant until 2019 where there was threefold increase, with over 70% of new refuelling stations deployed in Germany.

11 Member States had registered hydrogen vehicles in 2019, compared to 7 MS in 2015. At the end of 2019, France had the greatest number of hydrogen vehicles (413) followed by Germany (266). Adjusting for population, Denmark and Netherlands have the most hydrogen vehicles with 18.1 and 13.6 vehicles per million population, respectively.

Hydrogen for waterborne transport

In recent years, there has been early adoption of hydrogen for waterborne transport, although the number of vessels powered by hydrogen is still extremely low. For maritime transport, there are three hydrogen vessels in operation and on order. Larger-scale demonstration projects are in preparation. In addition, the Commission funded a retrofit

[43] https://op.europa.eu/en/publication-detail/-/publication/fd62065c-7a0b-11ea-b75f-01aa75ed71a1

[44] https://op.europa.eu/en/publication-detail/-/publication/fd62065c-7a0b-11ea-b75f-01aa75ed71a1

of an inland freight vessel, which features a diesel-electric powertrain and can be powered by hydrogen. In terms of infrastructure, there is no data to report on.

3.3.4 Other fuels

LPG

In terms of infrastructure and vehicles, LPG was established as a fuel for road transport before the adoption of the AFID. There was a total of 8 million LPG vehicles in 2019, up from 7.3 in 2014 and the number of filling stations also increased along similar lines. However, year on year increase of LPG vehicles has decreased, with the number of new registrations of LPG vehicles representing only 0.9% in 2020 of total vehicle registrations, down from 3.5% in 2014.

At national level, LPG refuelling stations are present in all MS but Finland. Poland, Germany, Italy, Bulgaria and France are the countries with higher number of LPG fuelling stations and Bulgaria has the highest number when adjusting for population. However, while the overall number of refuelling points has increased in the EU from 2015 to 2019, several MS that have reduced the number of refuelling points in this period, including Bulgaria, Romania, Czech Republic and the Netherlands.

In terms of vehicles, at the end of 2019, Poland and Italy had the greatest LPG vehicle stock, accounting for almost 70% of all LPG vehicles in the EU. Since 2015, Italy has seen the greatest increase in the number of vehicles, while Poland's LPG fleet has reduced. Romania, Spain and Greece have also seen a large increase in the vehicle number during this period but in almost half of the MS there has been a reduction to the LPG vehicle fleet.

Biofuels

Data on the use of biofuels in transport are sparse and infrequently reported. Low blend bioethanol (e.g. E5, E10) is supported by traditional refuelling infrastructure, thus is widely available across the EU. However, high bioethanol blends (e.g. E85, E100) require adaptations to refuelling infrastructure, which has led to a more fragmented market, with some countries (e.g. Sweden) showing a clear preference for their use.

Of the high blend bio-gasolines, E85 is the most prominent and is available in 8 MS, according to EAFO. Sweden has the greatest number of E85 refilling stations (1,700), followed by France (1,000) and Hungary (403). There is an emerging market for ED95 in Finland, France and Sweden, although no specific data on the number of equipped refuelling points is available. In terms of biodiesel, there are 9 refuelling stations available for rapeseed methyl ester.[45]

[45] https://op.europa.eu/en/publication-detail/-/publication/fd62065c-7a0b-11ea-b75f-01aa75ed71a1

4. METHODS AND IDENTIFIED LIMITATIONS

4.1 Methods

The evaluation uses different tools, developed in line with the evaluation methodology matrix. The evaluation support matrix was elaborated throughout the evaluation support study in order to answer the evaluation questions.[46] It identifies relevant operational questions, indicators, research tools and data sources and the approach to answer the questions. The evaluation matrix is included in the evaluation support study.

4.1.1 Desk research

An extensive literature review was carried out and a full list is provided in the evaluation support study. Key sources of data used for the analysis included Member State's NPFs and NIRs and EAFO. Other sources were selected on the basis of keyword searches, as well as taking on board suggestions from stakeholders.

4.1.2 Modelling

The PRIMES-TREMOVE model was used to help quantify the baseline no-policy change scenario as well as the alternative scenario. The alternative scenario includes policy changes triggered by the Directive. Comparing the baseline with the alternative scenario helps in the answering of evaluation questions. Annex 3 provides an overview of the development of the baseline scenarios, the alternative scenario as well as the results. The model provides the quantitative analysis for the transport sector in the EU27, covering transport activity, equipment, energy and emissions.

4.1.3 Stakeholder interviews

Interviews were conducted with a range of relevant stakeholders representing EU bodies, national and local authorities, industry representatives, members of the civil society (NGOs, consumer groups) and experts. The targeted interviews focus on cross-checking or complementing the information collected via desk research and collecting evidence and opinions in relation to the various evaluation questions. Further information is included in Annex 2.

4.1.4 Survey

Two surveys were distributed aimed at national authorities and regional, local and/or city authorities in EU Member States. The surveys focused on cross-checking or complementing the information collected via desk research and collecting evidence and opinions in relation to the various evaluation questions (see annex 2 for further information). The list of respondents to the survey is included in the evaluation support study.

4.1.5 Open Public Consultation

The OPC went live 6th April 2020 and closed on 29th June 2020 (12 weeks). The OPC takes account of both the evaluation and the Impact Assessment for the amendment to the Directive. In total, 324 responses were received.

[46] The external evaluation support study can be found at : add link once published

4.1.6 Data requests

Targeted data requests were sent to associations and representatives of people with disabilities. These requests were in the form of additional questions focusing on how the Directive takes into account the needs of people with disabilities (contributing to the Relevance questions). Four responses were received. Further data requests were sent to Member States responding to the survey to gain additional information on the specific budget allocated for the implementation of the adopted measures in terms of public funding / investment and excluding private investment (see annex 2 for information).

4.2 Identified limitations and action to remedy

4.2.1 Stakeholder consultation

There were a few challenges identified in the context of the evaluation support study and limitations inherent to the methodology:

The stakeholder engagement task aimed at involving all affected stakeholders. A variety of tools were used to collect the evidence needed for the evaluation, including an Open Public Consultation, interviews, survey and targeted data requests.

There were however a few limitations in the capacity to obtain relevant input. The wide scope of the Directive (in terms of transport modes and types of technologies covered) meant that it was not possible to organise interviews with multiple stakeholder from the various groups. Furthermore, it was not always possible to have input from national and regional authorities in multiple Member States. As such, for some questions the analysis is based on a small number of respondents that may introduce bias either because of their interest or because they may have an incomplete picture of relevant issues and developments. Additional targeted desk research was used to try to mitigate these limitations. Besides, stakeholder engagement activities were tailored in a way that aimed to minimise the time requirements for individuals, to avoid consultation fatigue.

4.2.2 Member State reporting

NIRs were a key input to this evaluation. However, the level of detail provided in the NIRs varies significantly among Member States both in terms of the measures adopted as well as to the financial allocations along different types of measures. Furthermore, as the focus was on reporting on the progress in relation to the targets, there was less information on the progress in terms of other aspects (interoperability, access to information). While the information was sufficient to establish an overall picture on the implementation and progress made, it was not fully useful when it came to assessing other aspects of the implementation of the Directive. To fill the data gaps, input from the national authorities (survey and data requests) along with desk research were used.

4.2.3 Assessing the role and additionally of the Directive

Besides the Directive and the national actions, multiple other factors drive the uptake of alternative fuels infrastructure including other policy developments as well as market and technological developments. The use of the well-tested PRIMES-TREMOVE model to define a baseline and alternative scenario helped to control some of these parameters. It allowed developing an assessment of the main impacts associated with the Directive.

Furthermore, during the course of the evaluation support study, various elements of the model (e.g. AFI cost assumptions) were refined to better reflect available information and recent developments. Nonetheless, the model does only allow assessing certain

aspects (mainly focusing on the adoption of AFVs, the impact on the transport sector and the associated environment impacts). Other aspects (e.g. related to ensuring interoperability, access to information) were not covered. In this case, input from multiple stakeholder groups was used to get a balanced information base.

5. ANALYSIS AND ANSWERS TO THE EVALUATION QUESTIONS

5.1 Assessment of the effectiveness of the Directive

5.1.1 Effectiveness in achieving the general objectives of the Directive

This section summarizes to what extend the Directive has been successful in (a) establishing a common framework of measures for the deployment of alternative fuels infrastructure, (b) minimising the import dependency on oil, and (c) mitigating the environmental impact of transport.

The analysis of both the NPF and the NIR suggest that the Directive has only **partly succeeded in developing a clear and consistent policy framework** for the promotion of alternative fuels infrastructure across the EU. They are not coherent at EU level. NPFs prioritise different alternative fuels and include different ambition levels, yielding an uneven spread of infrastructure. For example, the share projected by Member States for electric cars in the total car fleet for 2030 varies between less than 1% and more than 40%.

Few NPFs define corresponding targets for infrastructure or stated their deployment status. Often, the support measures seem not to be fully adequate to ensure that the national targets and objectives of the NPFs would be reached. In most cases the measures were not fully implemented or were not considered to be comprehensive (scope and expected effect) and quite often there was not enough information on the state of play. The majority of Member States identified measures in relation to electro-mobility and in terms of promoting alternative fuels infrastructure in public transport. Few Member States have addressed other types of alternative fuels infrastructure.

Consequently, the measures adopted/proposed and the targets set could lead to a market fragmentation at EU level and even among neighbouring Member States. The analysis of the NIRs shows that there is still significant divergence among Member States concerning target setting and measure description. This divergence aggravates a coherent assessment of Member States' ambition towards the development of a network of alternative fuels infrastructure in the EU.[47]

To summarize, **Member States took action to identify targets and measures due to the Directive. However, those actions do not sum up to a comprehensive common framework of measures across the EU**. However, the implementation of the measures adopted under the AFID enabled the uptake of alternative fuels vehicles. The CO_2 standards are the main driving force for vehicle demand, but deployment of infrastructure is supportive to this uptake. This impact of AFID would become more pronounced as the penetration of AFVs increases and more users become reliant on public accessible alternative fuels infrastructure rather than what is deployed privately by the early adopters.

[47] Most Member States have provided estimates for the uptake of electric vehicles and provided targets for the deployment of electric rechargers for the year 2020. However, only around two thirds provided data on targets for 2025 or 2030. Target setting for other alternative fuels infrastructure is more limited. Around half of the Member States provide targets for CNG and for LNG. Only around one third of Member States have set targets for LNG bunkering and Onshore Power Supply (OPS) for both maritime and inland waterways. Finally, around half of the Member States opted for setting targets for road hydrogen infrastructure.

The evaluation finds a relative increase in the number of alternative fuels vehicles in the period since the adoption of the Directive (2014) with a net increase of 3.6 percentage points in comparison to the baseline. Nonetheless, the overall share of those vehicles remains limited (less than 7% of the fleet in 2019, more than half of which include LPG vehicles). The alternative fuels vehicles market is still in its early stages. Similarly, the number of alternative fuels infrastructure has also increased in relative terms since 2014, though the number of AFI remains small in absolute numbers.

The early stages in the development of the market make an assessment of the impact on the operation of the market difficult. High barriers to entry are mainly associated with the costs of upfront investment with high uncertainty as to the capacity to get a high returns, most evident in larger, more expensive AFI such as hydrogen. There is no evidence of dominant positions among the players active in the market. There are currently no dominant EU-wide players, with most providers focusing on one or a few national markets.

The assessment on the **impact of minimising oil import dependency** in transport sector is difficult. The transport sector has maintained a high share of the total consumption of oil products in Europe (close to 66% of total in 2018)[48] and has a high oil dependency[49] (93 % in 2018). At EU level, 87% of these oil products came from imports outside the EU (2018 data), although this varied among EU Member States[50].

It can be safely assumed that oil importing countries will reduce their overall oil imports under the alternative scenario compared to the baseline scenario. However, a quantification of the impacts has not been possible since it requires an in-depth analysis of the implications at Member State level and assumptions on what the approach they may follow in the case of lower petroleum product energy needs (e.g. in terms of shifts to alternatives). Nonetheless, a reduction on the level of imports is expected.

Concerning the **mitigation of environmental impacts**, there has been very limited change in terms of the level of Tank-to-Wheel (TTW) CO_2 emission up to 2019, in comparison to the baseline. The analysis also pointed to a very small contribution to the reduction of CO_2 emissions in transport (net decrease by 0.2% by 2019), the consumption of oil products in transport (net decrease of 0.2% by 2019) and the share of energy from renewable sources (net increase by 0.1% by 2019). Similarly, there has been a small positive impact on the level of pollutant emissions by 2019 (0.2% reduction of CO, 0.3% reduction of NOx and 0.5% reduction of PM). Savings in the road transport sector are largely due to other policies, such as the post-2020 CO_2 emission standards for cars and vans.

The analysis points to an expected positive and more sizeable contribution of the implementation of the Directive in terms of the uptake of vehicle and the development of infrastructure post 2020.

5.1.2 Effectiveness in achieving the specific objectives of the Directive

This section summarizes to what extend the Directive has been successful in (a) ensuring sufficient rollout of alternative fuels infrastructure (b) ensure full interoperability, (c) support adequate consumer information and d) efficient integration of electric vehicles

[48] According to Eurostat, the transport sector represented 47.5% of total oil consumption in 2018, aviation 9% and shipping 9%.

[49] Figure includes international maritime.

[50] Eurostat

and compliance with electricity market operations. The Directive has **addressed its specific objectives to some extent**.

A considerable increase in the deployment of alternative fuels infrastructure since 2015 can be detected, driven mainly by recharging infrastructure, but it is not considered sufficient in view of the need of a dense, widely spread network of alternative fuels infrastructure. The number of publicly accessible charging points currently exceeds the recommendation in the Directive of 10 vehicles per public accessible charging point. For hydrogen infrastructure, the relative level of development of the network has also been significant, albeit at very low level. For natural gas infrastructure, there is already quite some network maturity, which explains a low development trend.

The increased number of recharging points hides significant differences across Member States. There are clear frontrunners (mainly in Western Europe), while other markets (mainly in Central, Eastern and South Europe) are lagging behind. 14 Member States have either exceeded or have been close to their targets (>75%), eight were below 50% of their 2020 targets[51].

The Directive had a **considerable impact on interoperability of alternative fuels infrastructure**. The Directive has ensured standardisation of recharging plugs early on in the development of the market and has avoided the situation of multiple standards being used by players in different markets for a long period. Through delegated acts it has helped to address outstanding standardisation needs in the field of recharging and refuelling infrastructure in road and waterborne transport. Technical specifications (e.g. plugs) provided greater certainty to investors, backed by available public support at EU and national levels.

There are shortcomings to the current list of technical specifications requirements under the Directive. Standardisation of communication protocols and of payment systems are not under the scope of the current Directive. Ad-hoc payments are often restricted by the need to use specific web apps or RFID cards. However, most stakeholders expects that functionality of roaming platforms and peer-to-peer network access agreements will vastly improve and reduce the need for multiple contracts and make simple contract based charging solutions more common, while improving ad-hoc payment remains relevant.

In terms of **consumer information, there are still limitation** in terms of the availability of information on the location of AFI infrastructure, despite the increasing coverage provided by a number of online platforms and apps. Information on pricing and price comparison are even less developed, albeit with differences among Member States. However, action by some Member States in the context of the AFID (and on the basis of EU funded Programme Support Actions) should further contribute towards better availability and quality of information. There was limited input on the role of the already adopted standards of fuel labelling at pumps and nozzles. The gas industry representatives and the users representative provided a positive assessment, considered that the relevant standards have already played a positive role although also indicating that these have not been applied across all Member States.

When it comes to the **integration of electro-mobility to the electricity system**, the evaluation identifies a mixed picture. Public authorities largely considered that

[51] COM (2021)103 final

consumers can choose a different supplier for electric vehicle charging than for their general electricity supply and that DSOs cooperate with any charge point operator on a non-discriminatory basis, but other stakeholders questioned this assessment. However, there was large consensus that smart charging infrastructure deployment is much less advanced. However, the implementation of the Electricity Market Design Directive (EU) 2019/944 can lead to a greater impact; the role of AFID in this area is limited, as public accessible recharging infrastructure is not really used for smart recharging services.

5.1.3 Which external factors and developments have contributed or hindered to the achievement of the objectives?

In terms of the role of the alternative fuels vehicle uptake the supply of infrastructure has been in most cases higher than the level of demand and was mainly driven by the public sector financial support in the initial phase. However, this is changing with increases in the sales of vehicles being primarily driven by the new CO_2 standards for cars and vans: they create demand for further infrastructure investment particularly for charging points; but policy responses to alternative fuels infrastructure long-term planning depend strongly on the willingness of Member States to take action, as the assessment of the NIR shows. In the case of other types of infrastructure, the level of development of the market and the number of vehicles and vessels is still either at low initial levels (hydrogen, electricity for ship propulsion) where the viability of the relevant infrastructure on a purely commercial basis is still questionable or there is no real policy impulse. For example, the CO_2 emission standards for cars and vans, focusing on tailpipe emissions, do not set strong incentives for the uptake of gas vehicles (e.g. CNG).

The impact of the implementation of the Clean Vehicles Directive (2009/33/EC) on infrastructure provisioning has been very limited. This was due to the important limitation of that Directive: it has not made any significant contribution to the demand for clean vehicles and, as a consequence, to deployment of related infrastructure, leading to its revision in 2019. The revised Directive (2019/1161) sets binding minimum requirements for the procurement of clean vehicles and is expected to have a positive effect by ensuring demand for clean vehicles, though mainly in the segment of buses. The Directive will hence trigger particularly demand for the development of the bus recharging and refuelling infrastructure in bus depos/stations.

The Energy Performance of Buildings Directive (EPBD) (2018/844) complements the AFID by promoting the deployment of private charging points, but it was just revised in 2018. Private charging represents more than 90% of charging. It will maintain a very high share in the future. The current provisions of the EPBD focus primarily on certain new and renovated buildings (residential and non-residential) that represent a small share of the stock and introduce additional exemptions. While it is still too early for a proper assessment of its contribution, many stakeholders raised doubts as to how much should be expected from the implementation of that Directive.

5.1.4. Effectiveness of monitoring of impacts

Reporting requirements have generally had a positive role in creating a common framework for the presentation of the relevant information on both the development on the supply and demand of infrastructure and the relevant measures taken by Member States. AFID represents an important improvement in comparison to a situation where information would only be available through market reports or individual initiatives of Member States without a common reference framework. An important part of the information on market development is also included in the EAFO portal that includes

detailed data on the development of infrastructure per Member State. As such, this is an area where the MS reporting is probably of less added value. Shortcomings apply to reporting on measures, national policies and future targets at national level.

While the most recently submitted NIRs are more consistent with the template provided by the Commission, there are still important gaps among MS in terms of the level of information provided with only a subset of NIRs submitted being in full compliance with the guidance on information requirements. The shortcomings in the overall reporting and the quality of underpinning data has aggravated the common assessment of national implementation reports.

The frequency of reporting (every three years) and the support provided was considered by most stakeholders as generally adequate. Only a few Member States reported some problems, none of which appearing to be of particular concern.

5.1.5 Effectiveness of the overall focus of the Directive

The analysis suggests that the focus of the Directive on the urban agglomerations and the core network was in line with the need to cover larger part of the population with greater level of (potential) demand. At least in the case of electromobility, many Member States adopt such prioritisation in their NPFs and the national policies, and, explicitly or implicitly, targeted their efforts in urban areas and the core TEN-T network. This appears to be particularly the case for the less advanced MS that are still in the initial stages in the development.

At the same time, most stakeholders suggest that an approach without AFID and building solely on market deployment would have led to an even higher level of concentration in the larger agglomerations and part of the core network. AFID – through the respective national support measures – has played a role in ensuring a more widespread development of the network. As such, it possibly contributed to a broader geographical scope that would have been the case in the absence of any intervention.

At the same time, there are still important gaps across the network with secondary parts of the network and rural areas much less covered, particularly in some Member States. An important number of stakeholders link this to the prioritisation of the AFID and the focus of the associated financial instruments used (particularly CEF).

In relation to waterborne transport, the prescribed focus on TEN-T core network for the development of LNG infrastructure has a limited impact. Member States appear to have adopted different approaches, some focusing exclusively on the TEN-T core ports, other including ports in the comprehensive network in their future targets for 2025 and 2030. But the very early stage of market development does not allow for a real gap analysis, as there is little action anyhow.

5.1.6 Unintended positive and negative effects

The evaluation support study did not point out important unintended or unexpected effects. It did identify some second order economic, social and environmental effects, most of which are positive.

More specifically, it pointed to positive economic impacts from the development of new services associated with the provision of infrastructure-related services across Member States. Linked to that is the associated new job creation in both the manufacturing and services sectors. From the environmental perspective, stakeholders pointed to a potential

contribution to noise reduction from the gradually increasing use of electric vehicles primarily in urban areas. However, a measurable impact can only be expected only after 2030 when the share of BEVs increases significantly and is mainly due to the CO_2 standards for cars and vans. Finally, from the spatial perspective, public authorities pointed to the challenges that arise from the need to ensure an effective integration of network development. Specifically in relation to electro-mobility, authorities pointed to the practical implications from the increasing designation of charging spaces for the overall availability of parking space, with different approaches adopted across MS to address them. This area is, however, not under the competence of the Directive.

5.2 Assessment of the efficiency of the Directive

5.2.1 Proportionality of cost

The evaluation support study finds that **cost have largely been proportionate to the benefits**.

The analysis of the cost of implementation of the AFID has shown that the majority of **cost incurred by Member States** are related to the implementation of the support measures within the AFID. These included administrative support and policy support measures, as well R&D support measures. According to the information from 23 NIRs a total of €8.3 billion (including €1.6 billion from the UK) was allocated by MSs during the period 2016-2019).

Taking into account variations in terms of country size, budget allocations among Member States still varied greatly reflecting the level of ambition and support provided and ranging from only €3 million to close to €2.7 billion. On a per billion GDP basis there was also significant variation ranging from €0.44 million per billion of GDP to as low as 0.04. In terms of the distribution of costs by type of measure, the largest share was in relation to the implementation of various policy support measures (on average 62% of the total budget), followed by support for research, technological development and demonstration (23% of allocated budget), and deployment and manufacturing support (15% of the budget).

In terms of the allocation by fuel type, support for electromobility represented the largest focus area of allocated national budgets (69% of the total budget; €5.7 billion) reflecting the fast development of AFI in this area. Support for hydrogen for road transport represented the second largest share (19%; €1.6 billion) while support for natural gas infrastructure (CNG/LNG) was 9% of the total (€697 million). The amount allocated to waterborne transport was much more limited (€169 million to LNG for maritime; and €106million to LNG for IWT; 3% of the total).

Other cost elements, such as cooperation with other Member States on cross-border measures and at an EU-level for knowledge exchange, are not as significant.

Total costs for the NPFs across all Member States were estimated at around €5.3 million with a weighted average cost per MS of €196,000. However, this ranged greatly with one MS reporting €1.1 million while others pointing to no costs (presumably not including the human resources allocated to the development of the NPFs). The costs for the development of the NIRs were estimated at €3.4 million with a weighted average cost of €126,000. It ranged from €671,000 to no costs as reported by five authorities.

The PRIMES-TREMOVE model was used to determine whether the benefits achieved by the implementation of the AFID are proportionate to the costs. In terms of the cost-

effectiveness of the intervention, the analysis of the net infrastructure investment costs (public and private) versus the costs to the transport system (including the external costs of CO_2 emissions) suggests that over the whole period 2021-2050 analysed there is net decrease in the costs of €27 billion. This is mainly a result of the important net cost reduction towards the end of the period (2041-2050) where most of the benefits from the significant increase in the share of electric vehicles would arise.

The total level of investment in alternative fuels infrastructure to-date is shown to differ between fuel types and modes of transport, with road attracting higher investment than waterborne and recharging infrastructure attracting higher investment than refuelling infrastructure. A comprehensive quantitative analysis of the extent of the private sector share of AFI investment was not carried out, due to a lack of available data and information. The data has not been collected in a centralised way, which prevents a quantitative analysis at EU-level and at Member State level.

National authorities pointed to a moderate role of the AFID in terms of increasing private sector investment in AFI: responses indicate that the private sector would also have invested in AFI in the absence of the AFID. There appears to be a higher level of private sector share of investment for countries with a higher GDP or with a more developed infrastructure network. According to national authorities, private investments in other fuel types such as hydrogen, electricity for inland waterways transport and electricity for stationary airplanes at airports has stayed roughly the same, at low level, over the last three years.

Feedback from industry stakeholders, promotional banks and responses to surveys note that recharging infrastructure is taking priority in terms of private sector investments – this is due to the fact that it is the market with the highest vehicle demand.

5.2.2 Could the same or better results have been achieved at lower costs for public authorities by a different approach?

The limited data did not allow the evaluation to reach specific conclusions as to whether the results could have been achieved in a more cost-effective way. The input from stakeholders suggests that there are no areas of significant inefficiencies. Most national authorities and industry stakeholders were very supportive of the role public financing has played to-date. This is both, in terms of AFI rollout and in establishing the network on a commercial basis.

There are clear differences in the cost-effectiveness of the deployment of alternative fuels infrastructure when considering the NIR budget allocations in comparison to the numbers of infrastructure deployed – these differences are evident between Member States and between fuel types. Deployment of electromobility infrastructure represents the most cost-efficient across Member States, likely due to the more mature market for electro-mobility and lower costs for the infrastructure. Contrastingly, the rollout of hydrogen was regarded to be the least cost-efficient, likely due to the relative immaturity of the market.

Many stakeholders noted that a more coordinated approach to setting targets (i.e. at EU level) could have led to lower levels of fragmentation amongst Member States, thereby leading to increased investment in infrastructure and potentially lower costs to public authorities by improving the efficiency of the rollout. This evidence is however based on individual assessments. There are cost-effective measures used at Member State to support the deployment of the AFI network, which could lead to lower costs for public

authorities when used at EU level; however, there is no unified consensus among stakeholders.

5.2.3 Is there potential for simplification of the provisions?

The analysis indicates that there is little simplification potential, and there is a strong majority of stakeholders pointing out that the Directive does not lead to unnecessary cost for target groups. Focusing on specific aspects, the analysis concludes that there is little need for simplification of the provisions and requirements of the Directive in terms of the development of the NPFs and relevant measures (Articles 4-6), the national reporting requirements (Article 10), and other articles.

One potential area for further improvement is related to the requirements for user information under Article 7, where some (5 out of 23) national authorities and some industry stakeholders noted that requirements related to fuel price comparisons can be simplified. This aligns with the findings of EQ2, which highlighted that it is an area that could be further improved but not removed.

5.3 Assessment of relevance

5.3.1 Relevance of the general and specific objectives

The analysis of issues and challenges confirms that the **general and specific objectives were relevant at the time of adoption of the Directive, and maintain their relevance at present.** Relevant challenges identified at the time of adoption of the Directive include shortcomings in infrastructure, technological interoperability and commercial profitability or lack of consumer acceptance. However, consumer acceptance is becoming less relevant, as increase in vehicle availability and decreases in purchase price will contribute to such vehicles becoming more and more accepted by customers.

Intervention at EU level is still relevant as required by most stakeholders to ensure a coherent policy framework for a variety of alternative fuels to achieve cross border continuity, avoid varying national implementation, and to promote common standards.

The analysis also pointed to questions concerning the ongoing relevance of the scope and priorities set in the Directive in view of the new policy objectives. More specifically:

- The need to review the provisions for infrastructure distributing gaseous fuels and their compatibility with a full decarbonisation pathway (including needs for blending with bio-methane)
- The extent that current AFI deployment targets developed in the context of the NPFs are not sufficient to meet future developments, as anticipated by policy initiatives developed in the context of the Climate Target Plan and the Smart and Sustainable Mobility Strategy.
- The extent that the current scope of the Directive is sufficient or whether there is a need for the inclusion of other sectors/modes including public transport, commercial vehicle operations and aviation.

5.3.2 Relevance in view of new challenges

Since its implementation in 2014, there have been a **number of developments and trends that are likely to impact on the uptake of vehicles, but are not addressed through AFID**. Connectivity and digitisation of vehicles, and new mobility patterns and

business models make it even more important that information and data provision from AFI is standardised and consistently made available for integration with other digital transport and electric grid services.

New alternatively fuelled technologies (including for example electrified road infrastructure, or provisioning of new low-carbon and renewable transport fuels in waterborne or aviation transport (e.g. hydrogen/ammonia) are not reflected in the current AFID. Developments in the trucks market following the introduction of the CO_2 standards for trucks also suggest that more focus may need to be placed at addressing alternative fuels infrastructure for the commercial vehicle sector specifically.

Challenges, issues and obstacles relating to interoperability of AFI with consumer services include particularly better access to information on the availability of charging and refuelling points (need for real-time data and information on the availability and maintenance of charging points – local and international users). There is a lack of transparency in payments and unfair pricing models. There are issues relating to the methods of payment accepted for charging that need to be addressed, ensuring accessibility for all users. There is also a need to consider how recharging and refuelling points could become more accessible to persons with disabilities and elderly, but those are also subject to local circumstances.

5.4 Assessment of overall coherence

5.4.1 Assessment of internal coherence

In general, the analysis suggests that the **provisions of the AFID are internally coherent**, with some minor issues around fuels definitions.

The desk analysis noted that there were some examples where the treatment of different fuels might have benefitted from being more consistent. For example, only biofuels are explicitly defined, with reference to another Directive. While a definition for all of the fuels and energy sources covered might not be needed, for the avoidance of ambiguity the CN codes of the fossil fuels covered could have been stated (as they are in other fuel-related Directives), while 'synthetic and paraffinic fuels' could have been defined in the Directive or, ideally, with reference to a definition in a piece of EU fuel-related legislation, rather than in a recital of the AFID.

With respect to definitions, the evaluation suggests that the definition of 'high power recharging point' is no longer relevant, while more recent electric vehicle recharging technologies, such as wireless charging and electric road systems, are not defined at all. Furthermore, the definition of recharging points, in particular, those that are 'publicly accessible' would benefit from further refinement. It was also noted that there are different interpretations in different Member States, as to what can be classified as biogas, in terms of its origin. This is however, not legislated under AFID.

5.4.2 Assessment of external coherence

The evaluation found **no real issues with the coherence of the purpose of the AFID compared to other relevant legislation**, although it did identify some issues with respect to the scope of some other legislation compared to the AFID.

Some stakeholders noted to the need to better differentiate the origins of fuels provided to ensure that only fuels with a clear value added for emission reduction are considered. However, the main focus of AFID is on providing public accessible infrastructure,

whereas fuel and emission related aspects are dealt with under other EU legislation (Renewable Energy Directive, Fuel Quality Directive, CO_2 standards for cars and vans or heavy duty vehicles). Also as regards urban mobility, some stakeholders noted the need for better alignment of sustainable urban mobility plans (SUMP) and implementation of AFID.

In relation to the implementation of the electricity market design Directive, some stakeholders suggested that this Directive was not coherent with the aims of the AFID as it limited the number of potential investors by not allowing distribution network operators to install electric vehicle charging points unless there is substantive market failure.

Most of the financing instruments and technical assistance joint initiatives reviewed do not explicitly identify or define what they mean by alternative fuels for transport, even though they all aim to support these in some way. The exceptions to this are the CEF Regulation and ELENA, which explicitly refer to the AFID's definition of an alternative fuel. Hence, these can be considered to be coherent with the AFID.

AFID focuses on the implementation of infrastructure for alternative fuels that require an infrastructure distinct to the one used for distributing conventional transport fuels. Under the evolving strategic context for the sustainable mobility transition, there is a clear emphasis of the fact that all transport fuels have to fully comply with the requirements for achieving climate-neutrality in the EU. As such, the AFID is not incoherent with provisions of the long-term climate strategy or more recently the Green Deal Communication or the Climate Target Plan as the topic of decarbonisation of fuels is subject to other legislation than AFID. Hydrogen and natural gas refuelling infrastructure in all modes of transport is necessary to ensure that low-carbon and renewable fuels (clean hydrogen, biogas, synthetic gas) can be distributed.

5.5. Assessment of EU Added Value

The **intervention at EU level is still required and has provided, in spite of all the identified limitations, an EU value added.** There is general consensus among stakeholders that EU level intervention brought benefits (in terms of the effectiveness towards achieving key objectives, as well as in terms of efficiency and possible synergies) beyond that which would have been possible with action at national or local level alone.

There continues to be an important role for the EU in creating a coherent policy framework for a variety of AFs, and action needs to be intensified going forward to guarantee cross border continuity, avoid any further varying national implementation, and to promote common standards. Analysis of NPFs and NIRs support this, with continued gaps in targets and objectives highlighting the scale of the challenge and that further action is required. The recent increasing EU Green Deal decarbonisation targets also raise the pressure for ongoing policy action.

What has limited the EU added value is the absence of clearly defined and quantified requirements for alternative fuels infrastructure deployment. Not all Member States have decided to act and invest in deploying an 'appropriate number' of infrastructure deployment, as it has been open to interpretation. This has resulted in a divergent target-setting under NPFs that on average does not lead to the ambition needed to effectively contribute to the increased climate ambition for 2030 and the transition to climate neutrality in 2050.

The development of a common framework in the context of the AFID has, despite its limitations, contributed towards avoiding the fragmentation of measures in relation to the promotion of alternative fuels infrastructure, supporting the development of the overall infrastructure network, creating a level playing field within the industry and facilitating the free circulation of alternative fuels vehicles throughout the EU. All Member States have seen an increase in the level of refuelling and recharging infrastructure that, despite the gaps, suggest a relatively more coherent network with fewer gaps that what would have been the case in the absence of EU intervention. Electricity recharging infrastructure has seen the greatest momentum over past years, where Member States set the greatest number of targets and where the market is more developed and most investment has taken place.

Furthermore, through encouraging interoperability, relevant technical standards and setting of targets on similar timescales, EU level action has provided some cost savings and better value for money by facilitating economies of scale, avoiding duplication of effort and resources, and providing funding investments for infrastructure. The implementation of the AFID (and its supporting activities) have facilitated cooperation and information exchange on alternative fuels between MSs, industry experts and the Commission which would likely not exist without it.

At the regional/local level, stakeholders' input suggests that relevant actions/measures adopted would not have been implemented without the EU intervention. These included regional action plans for infrastructure planning and deployment; standards/technical specifications for charging infrastructure and financial instruments and guidelines.

In contrast, EU added value appears to have been more limited in those areas where the legislation does not clearly require Member States to take action, but where there is also no provision at EU level, including particularly the area of infrastructure use services.

Stakeholders noted that if EU action in the form of the AFID were to stop, in general this would negatively affect the capacity to address the issues covered by both the general and specific objectives at national level. Certain Member States would be less able to effectively develop a common framework and would revert to conventional fuels vehicles. The analysis of both the baseline and alternative scenarios using the PRIMES-TREMOVE model has highlighted that, in the absence of the EU intervention, a less developed, more limited network of AFI could be expected, where AFI is also likely to be more concentrated in a smaller number of MS by 2030.

6. CONCLUSIONS

The Alternative Fuels Infrastructure Directive was adopted in order to establish a common framework of measures to support roll-out of public accessible alternative fuels infrastructure in the EU. It should support a sufficient network of recharging and refuelling infrastructure, interoperability of infrastructure, adequate consumer information and effective vehicle integration into electricity grids.

This evaluation finds that the Directive has been slightly effective in achieving its objectives, namely by triggering policy action at the level of Member States. Back in 2014 when the Directive was adopted markets for alternative fuels vehicles and infrastructures were in an early stage of development and in many Member States no specific policies for alternative infrastructure policy existed. Member States have transposed the Directive and developed their National Policy Frameworks (NPFs). Those policy frameworks have started to help building a long-term forward-looking perspective

on infrastructure for electricity, natural gas and hydrogen until 2030 in Member States, although to different extent and detail.

Through the Directive and delegated acts under that Directive, technical specifications on recharging and refuelling infrastructure were adopted early on that helped to provide certainty to investment into alternative fuels vehicles and infrastructures. Particularly relevant in this context was the adoption of a common standard for a recharging plug for electric vehicles that helped long-term market certainty.

Consequently, the Directive has had a certain positive impact on the uptake of alternatively fuelled vehicles and their infrastructure. Cost of the Directive have been rather proportional to the benefits of the implementation of the Directive and the evaluation did not find any indication that there would have been a largely more cost-efficient approach possible for delivering the same outcomes. The evaluation confirms a principal EU value added of the intervention at EU level. Markets for alternative fuels vehicles and infrastructure would have been less developed in a scenario without the Directive. This is a general point of consensus among stakeholders. Individual action at Member State level would not have resulted in common market development and related adoption of technical specifications for infrastructure and vehicles.

The evaluation points that there are no real issues with regard to the internal and external policy coherence of this Directive. The evaluation also confirms the continued relevance of the general and specific objectives of the Directive.

However, substantive shortcomings of the current policy framework are also clearly visible, and the evaluation finds a relative strong consensus among stakeholders:

- With regard to establishing a sufficient network of alternative fuels infrastructure, Member States took action to identify targets and measures due to the Directive. However, those actions do not sum up to a comprehensive common framework of measures across the EU. The absence of a detailed and binding methodology for Member States to calculate targets and adopt measures has led to the identified divergence in the level of ambition in target setting and supporting policies in Member States. For example, the share projected by Member States for electric cars in the total car fleet for 2030 varies between less than 1% and more than 40%. A comprehensive and complete network of alternative fuels infrastructure does not exist across the Union, for both road and waterborne transport. It is therefore unlikely that under the current legislative framework the needed network would develop across Europe in the coming years even if all Member States attained their targets. The infrastructure targets set by Member States under their national policy frameworks reflect the different level of ambition, meaning that the planned deployment of infrastructure varies greatly. Moreover, the policy frameworks often do not display sufficient detail on the state of play and on the implementation of existing and planned policy measures.
- With regard to establishing full interoperability of infrastructure, the evaluation points out that important aspects are not well covered under the current Directive, including interoperability of infrastructure for recharging and refuelling heavy-duty use vehicles as well as important aspects of user services.
- With regard to adequate consumer information and payment services, there is lack of pervasive high quality of information to customers about the location,

availability and use conditions of infrastructure. Moreover, there is a plethora of approaches to finding, accessing, using and paying, particularly in the case of recharging points, which is leading to continued customer concerns. Particular points of concerns are information on availability, price transparency and payment services.

- With regard to effective integration of electric vehicles into electricity grids, the implementation practice under the Directive has shown that markets do not expect public accessible infrastructure to play a role in this market segment. A smart integration of electric vehicles and bi-directional charging will provide flexibility for the overall management of the energy system and thus help to integrate increased shares of variable renewable energy production. However, it is mainly private recharging infrastructure, where vehicles are parked for a long time, that will contribute to this use case.

The Impact Assessment supporting the legislative proposal of the Commission in 2013 projected much higher levels of alternative fuels infrastructure deployment for road and waterborne transport in 2020, but was also building on binding targets for infrastructure roll-out, which were dropped in the co-decision procedure, and estimates from Member States on alternative fuels vehicle take up that were much higher than those estimates that informed the final development of national policy frameworks. At present, investments in infrastructure are not profitable in many instances. This is particularly the case for locations with low demand and a more difficult business case, for example in rural areas or areas with little vehicle uptake. In addition, the roll-out of ultra-fast recharging points and of hydrogen stations alongside the TEN-T core and comprehensive road transport network as well as the provision of onshore power supply and other alternative fuels infrastructure in ports is at early stage and is likely to require continued public support.

The current implementation practice shows a strong link between vehicle demand and infrastructure provision. However, infrastructure provision takes time and requires policy direction. The current fragmentation of the internal market, where alternative fuels infrastructure take up is driven mainly by a handful of key Member States, is not future-proof in view of the expected rapid acceleration of vehicle take up in the years to come. The evaluation finds that the current Directive is not fit for purpose in view of the increased policy ambition for cutting transport emissions by 2030 and finally 2050.

The Commission has proposed to reduce the EU's greenhouse gas emission by 2030 by at least 55% compared to the previous 40% reduction target. This has a relevant impact on the required uptake of low-carbon and renewable fuels, vehicles and infrastructure. In order to achieve these ambitious targets, the uptake of zero-emission vehicles and the related public accessible infrastructure needs to accelerate significantly in all market segments of light-duty and heavy-duty vehicles. Efforts will need to be considerably higher than the efforts reported by Member States under the Directive. This does not only relate to road transport but equally and particularly to other transport modes such as waterborne transport and also aviation.

Moreover and importantly, the focus of the policy debate has broadened from the provision of sufficient alternative fuels infrastructure to the provision of infrastructure that is easy and transparent to use for all customers anywhere in the Union. At present, the Directive is not well-equipped to address relevant aspects of this dimension, which is essential to support an effective acceleration of the market uptake of zero- and low-emission vehicles.

The evaluation of the Alternative Fuels Infrastructure Directive confirms the need for strengthening of the policy framework at EU level for the deployment of alternative fuels infrastructure to meet the increased climate ambition of the EU for 2030 and the needs of the transition to climate neutrality by 2050.

ANNEX 1: PROCEDURAL INFORMATION

1 Lead DG, DECide Planning/CWP references

The lead DG is Directorate General for Mobility and Transport (MOVE), Unit B4: Sustainable & Intelligent Transport

DECIDE reference number: **PLAN/2019/5028**

The development of this initiative was announced under item 1i) in Annex 1 to the Commission Work Programme 2021[52] as part of the revision of the directive.

2 Organisation and timing

The Inter Service Steering Group (ISSG) for the evaluation was set up in March 2019 and includes the following DGs and Services: SG, LS, CLIMA, ENV, ENER, RTD, GROW, MARE, COMP, TAXUD, ECFIN, EMPL, JUST and JRC[53].

The ISSG approved the evaluation and discussed the main milestones in the process, in particular the key deliverables from the support study. It approved the study supporting the evaluation on 13 January 2021. In total, 10 meetings of the ISSG were organised These meetings took place on 8 March 2019, 11 September 2019, 24. September 2019, 11 December 2019, 31 January 2020, 2 April 2020, 17 June 2020, 23 September 2020, 19 October 2020, 13 January 2021. This included virtual meetings, due to the COVID-19 crisis. Further consultations with the ISSG were carried out by e-mails. When necessary bilateral discussions were also organised with the most concerned services.

3 Consultation of the RSB

The evaluation was not selected for assessment by the RSB. The Regulatory Scrutiny Board received the draft version of the evaluation report on 7 April 2021 as part of the documents supporting the Impact Assessment report. The Board meeting on the Impact Assessment report will take place on 5 May 2021.

4 Evidence, sources and quality

The evaluation is based on research/analyses done by the Commission. The Commission also contracted an external, independent consultant (Ricardo) to support this evaluation. The external support study will be published alongside this report.

Qualitative and quantitative data supporting this evaluation has been collected from Member States, operators of recharging and refuelling infrastructure, mobility service providers, fuel producers and distributors, electricity suppliers, Distribution System Operators, technology producers, academia and non-governmental organisations.

Modelling of the baseline and of the alternative scenarios has been performed by E3Modelling with the PRIMES-TREMOVE transport model. This report also draws on the activities of the Sustainable Transport Forum, a Commission's expert groups with

[52] https://ec.europa.eu/info/publications/2021-commission-work-programme-key-documents_en

[53] The ISSG was created for the evaluation and its mandate was subsequently enlarged to also cover the Impact assessment reflecting that the evaluation and the Impact Assessment were carried out back to back.

industry stakeholders and Member States representation, which was established under the Directive.

Annex 2: Stakeholder consultation

This annex provides a summary of the outcomes of the consultation activities which have been carried out for the evaluation of the Alternative Fuels Infrastructure Directive, including in the context of the external support study. It notes the range of stakeholders consulted, describes the main consultation activities and provides a succinct analysis of their views and the main issues they raised.

The objective of the consultation activities were to collect information and opinions of stakeholders on the key objectives and measures of the Alternative Fuels Infrastructure Directive, its implementation and practical outcomes and shortcomings of that process.

The main consultation activities included:

- An Open Public Consultation (OPC), organised by the European Commission that did run from 06 April 2020 to 29 June 2020. The OPC took account of both the Impact Assessment and the evaluation of this Directive.
- Exploratory interviews with EU level representatives of key stakeholders, particularly to support and refine the overall problem definition and possible policy options.
- Two surveys with national and local authorities were organised by the consultant in charge of the external support study to the evaluation
- Targeted data requests were send to individual stakeholders, including industry associations and special interest organisations.

The Commission drew also strongly on the outcomes of a broad stakeholder consultation exercise on problems and future policy needs in the field of alternative fuels infrastructure that the Commission carried out among the member of the Sustainable Transport Forum, the key expert group of the Commission, in the time period of October 2018 to November 2019 and that led to the adoption of a comprehensive report by the plenary of the Sustainable Transport Forum in November 2019[54]. Findings of that exercise helped design the overall consultation activities carried out in the context of this evaluation.

Overview of stakeholder input

The Commission launched the 12-week OPC on 6 April and it closed on 29 June 2020. The OPC invited all citizens and organisations to provide input on both the Evaluation and the Impact Assessment of the AFID[55]. In total, **324 responses** were received.

The breakdown of OPC responses by stakeholder type is shown in the Table below.

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

[55] The evaluation input was analysed in the stakeholder consultation report supporting the Evaluation Final Report.

Table 1: Classification of stakeholders responding to the OPC

Stakeholder group	Number of responses	% of responses
Company/business organisation	107	33%
Business association	80	24.7%
Public authority (national, regional and local authorities)	28	8.6%
Non-governmental organisation (including relevant industry associations)	22	6.8%
Consumer organisation	7	2.2%
Environmental organisation	1	0.3%
Academic/research institute	1	0.3%
EU citizen	70	21.6%
Non-EU citizen	1	0.3%
Other	7	2.2%

In terms of geographical/Member State distribution, the majority of respondents indicated that their country of origin was one of the EU Member States (315 respondents). Nine respondents were based outside of the EU. The number and percentage of respondents by country of origin is shown in the following table:

Table 2: Geographical distribution of responses received

Country of origin	Number of responses	% of responses	Country of origin	Number of responses	% of responses
Belgium	60	18.5	Slovakia	2	0.6
France	53	16.4	Denmark	1	0.3
Italy	50	15.4	Estonia	1	0.3
Germany	49	15.1	Greece	1	0.3
Sweden	19	5.9	Luxembourg	1	0.3
Netherlands	17	5.2	Malta	1	0.3
Spain	11	3.4	Romania	1	0.3
Austria	10	3.1	Canada	1	0.3
Czech Republic	8	2.5	Grenada	1	0.3
Poland	8	2.5	Israel	1	0.3
Finland	6	1.9	Japan	1	0.3
Hungary	6	1.9	Norway	1	0.3
Ireland	5	1.5	Switzerland	1	0.3
Slovenia	3	0.9	United Kingdom	2	0.6
Latvia	2	0.6	United States	1	0.3

As part of the targeted consultations, the consultant in charge of the support study also carried out targeted surveys with public authorities in Member States and targeted interviews with key stakeholders. 23 national public authorities and 19 regional authorities and public enterprises and their interest associations responded to the surveys.

Table 4 provides an overview of key stakeholders interviewed in the context of the evaluation.

Table 3: List of stakeholders interviewed

High-level stakeholder category	Stakeholder type	Stakeholder name
Regional / local authorities		ETRA I+D (invited to respond by CIVITAS)
		Polis
Industry	*European standardisation body*	*CEN-CENELEC*
	Refuelling station/charge point operators, fuel and battery producers, electro-mobility service providors	AVERE
		European Biogas Association / ENGIE
		Energy and Hydrogen Alliance EHA
		ePURE
		Eurelectric
		NGVA Europe
	Manufacturers of transport equipment and	ACEA
	Organisations of transport service providors	ECSA
		ESPO
		FIA Region I
		UITP
		Port of Rotterdam
		ACI EUROPE
		Inland Navigation Europe (INE)
		European Road Haulers Association (UETR)
		Central Commission for the Navigation of the Rhine (CCNR)
Civic society	Consumer representatives	BEUC
	NGOs	Transport & Environment
	Consumers with disabilities	European Disability Forum
EU		European Investment Bank
		DG CLIMA
		DG ENER
		DG REGIO
		Irish Rural Link and European Economic Social Committee

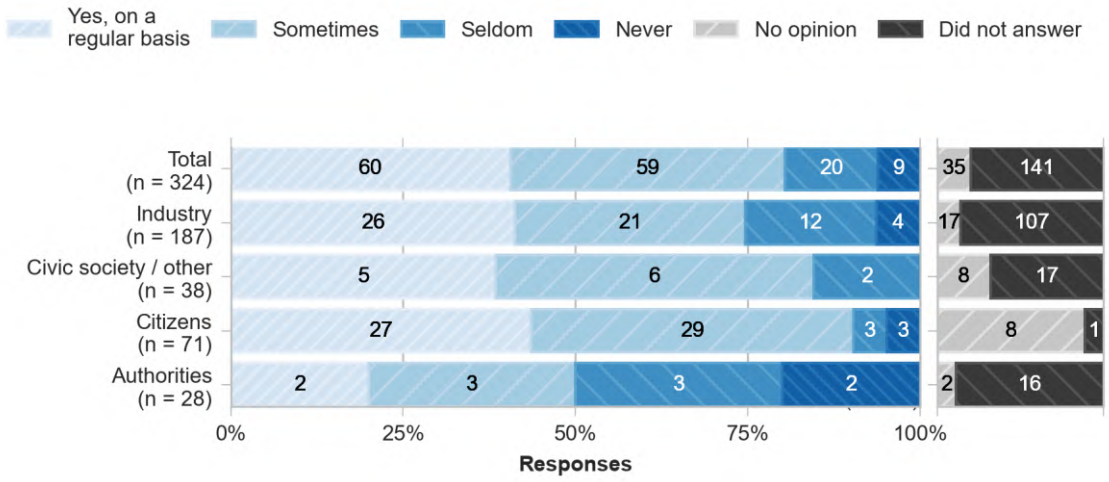
Key findings from the OPC

The OPC asked respondents whether they own or regularly drive an alternatively fuelled vehicle. 86 out of 324 participants responded that they own/regularly drive an electric

car, 17 stated that they own/regularly drive a vehicle running on natural gas, 34 stated that they own/regularly drive an 'other' type of alternatively fuelled vehicle, 50 stated that they did not and 137 did not answer the question. This shows a considerable high share of active users of alternative fuels vehicles among the respondents to the OPC.

In answer to the question 'do you have difficulty finding alternative fuels infrastructure to recharge/refuel your vehicle?', 60 responded that they have difficulty on a regular basis, 59 responded that they sometimes have difficulties, 20 responded that they seldom have difficulties and 9 responded that they never have difficulties (see figure 2). 35 did not have an opinion and 141 did not respond to the question.

Figure 2: Do you have difficulties finding alternative fuels infrastructure to recharge/refuel your vehicle?



Respondents were asked to further substantive responses to having difficulties finding recharging/refuelling infrastructure, namely in view of the main underlying problems. Of those that responded (158[56]) the following underlying problems were identified:

- "There is not sufficient infrastructure in urban areas" – 86 respondents
- "There is not sufficient infrastructure in rural areas" – 93 respondents
- "There is not sufficient infrastructure along highways and other large interurban roads" – 108 respondents
- "Even if there is infrastructure, I have trouble identifying where they are located" - 30 respondents

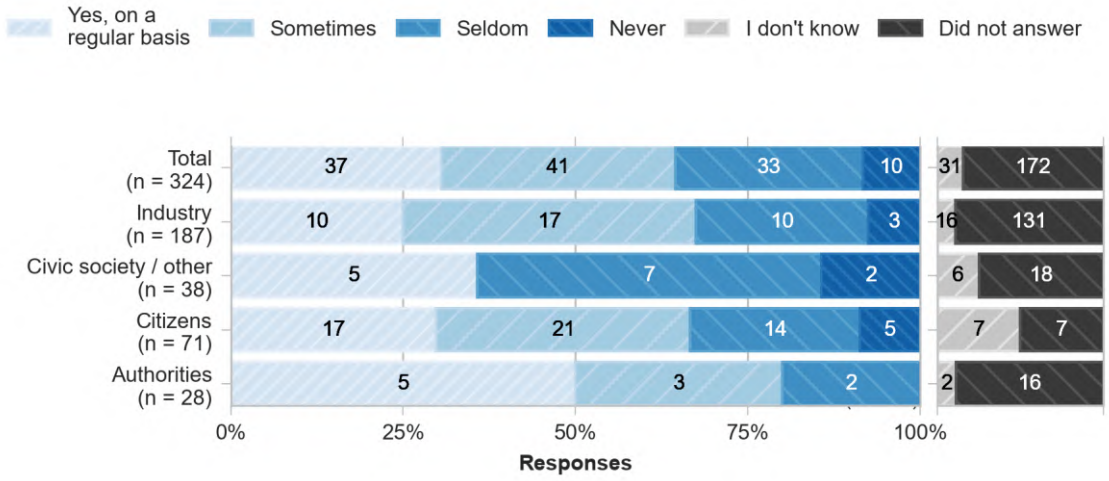
166 participants to the OPC did not respond to the question.

In answer to the question 'in case you do not on an alternatively fuelled vehicle, would you buy one, if you were certain that there was sufficient recharging or refuelling infrastructure?', 77 agreed that they would buy one and 31 stated that they would maybe buy one, showing a relatively high willingness to adopt such vehicles provided that infrastructure is available. Of the 19 participants that responded they would not buy one, 12 stated that the price for alternatively fuelled vehicles is too high, 3 stated that the technology is not yet mature and 4 stated that the vehicles on the market are not attractive enough. 207 did not answer.

[56] Respondents could select more than one answer

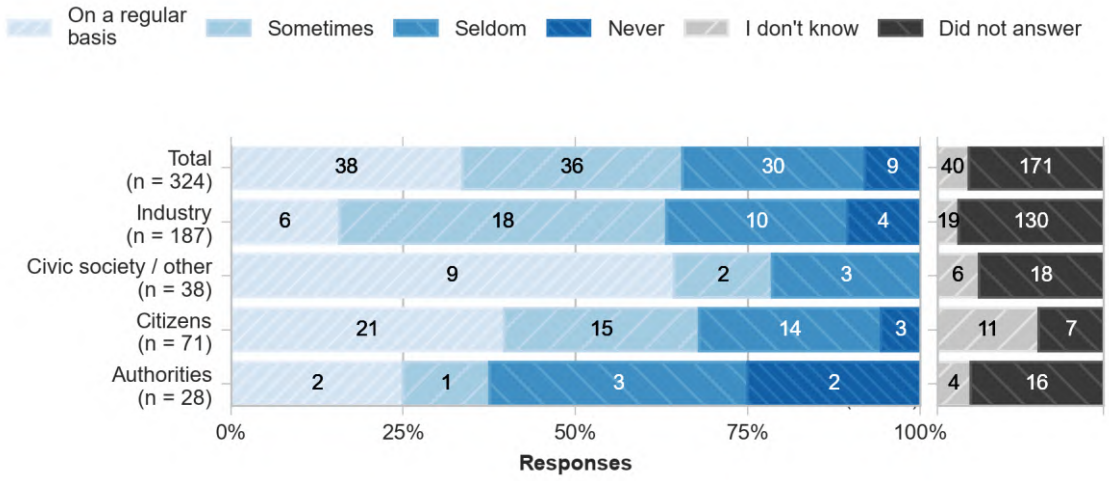
In answer to the question 'when you recharge your electric-vehicle, do you feel well informed in advance on the price you will have to pay for the charging service?', 37 agreed that they did feel well informed on a regular basis, 41 stated that they feel well informed sometimes, 33 responded that they seldom feel well informed and 10 feel that they never feel well informed (see figure 3). 31 responded that they did not know and 172 did not answer. This confirms outstanding issues with regard to having sufficient information available to active vehicle users.

Figure 3: When you recharge your electric-vehicle, do you feel well informed in advance on the price you will have to pay for the charging service?



In answer to the question 'how often do you face difficulties when trying to pay?', 38 stated that they face difficulties when trying to pay on a regular basis, 36 stated they sometimes face difficulties, 30 stated that they seldom face difficulties and 9 stated that they never face difficulties (see figure 4). 40 respondents did not know and 171 did not answer. The fact that only a very small number of participants to the OPC noted that they never face problems with payment underlines the relevance of the shortcomings of the Directive in this problem area.

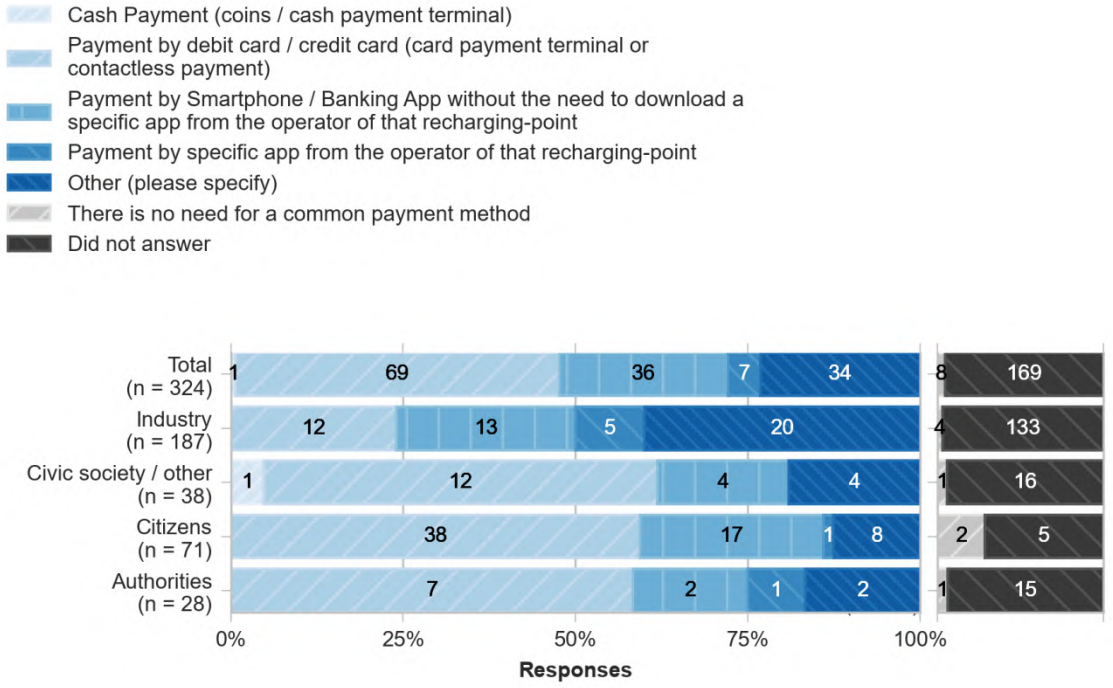
Figure 4: The Directive already requires that users can pay ad hoc at the recharging point. However, in practice many different payment options have developed throughout Europe. How often do you face difficulties when trying to pay?



Responding to the question if they believed that a common payment method should be

available at all publicly accessible recharging points the majority of respondents (69) stated that payment by debit card/credit card (card payment terminal or contactless payment) should be available (see figure 5). 36 stated payment by Smartphone / banking app without the need to download a specific app from the operator of that recharging point, 7 stated payment by specific app of the operator of that recharging point, 1 stated cash payment, and 34 stated 'other'. 8 stated that there is no need for a common payment method and 169 did not answer.

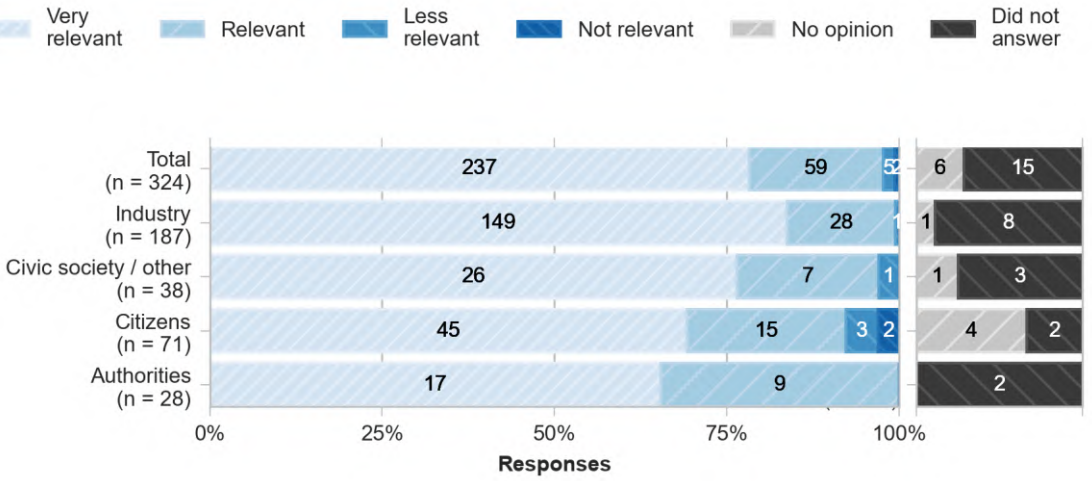
Figure 5: If you believe that a common payment method should be available at all publicly accessible recharging points, please indicate which payment option should be available?



In answer to the question 'Do you believe that roaming (payment through the user's electro-mobility service provider) should be available at every publicly accessible recharging point? 122 respondents agreed compared with 16 that did not. 28 stated that they did not know and 158 did not answer. Roaming is already a key feature of public accessible recharging points.

The OPC confirmed the ongoing strong relevance of the Directive. Respondents were asked 'In your view, how relevant is a policy on alternative fuels infrastructure at EU level as established by the Alternative Fuel Infrastructure Directive to support the uptake of alternative fuels? The majority of respondents (237) stated that it is very relevant, whereas 59 stated it was relevant, 5 stated it was less relevant and 2 stated it was not relevant (see figure 6). 6 respondents did not have an opinion and 15 did not answer.

Figure 6: In your view, how relevant is a policy on alternative fuels infrastructure at EU level as established by the Alternative Fuel Infrastructure Directive to support the uptake of alternative fuels?

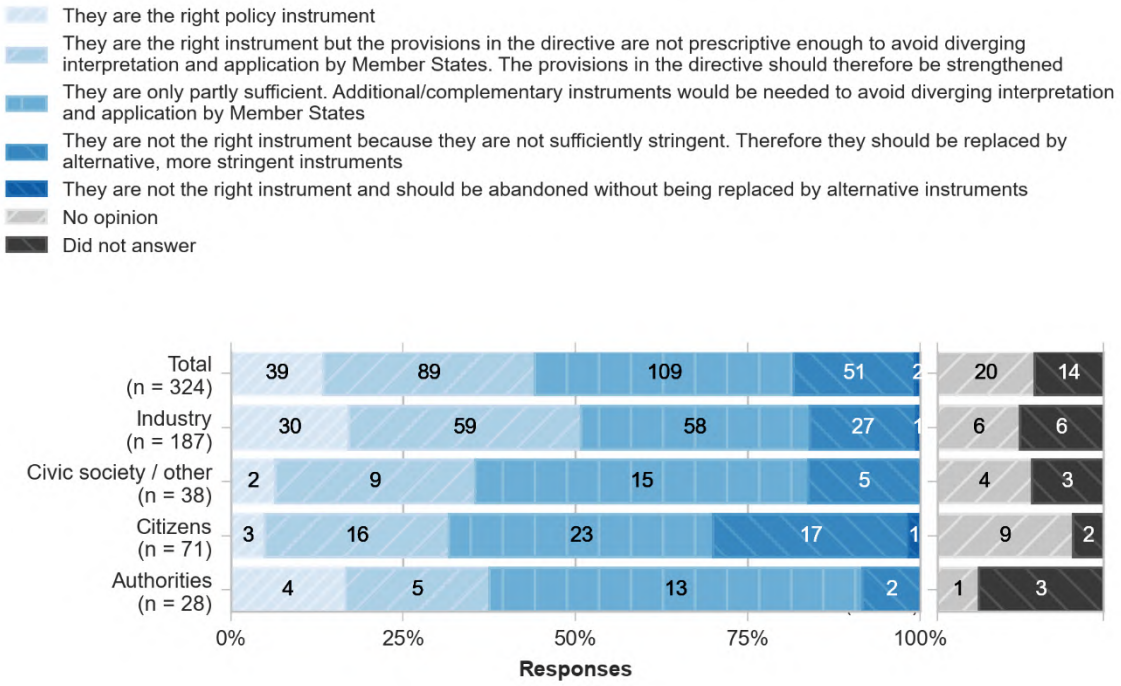


In terms of the scope of the Directive, respondents were asked 'In your view, is this scope still appropriate in the context of the long-term objective of the European Green Deal to reduce transport emissions by 90% by 2050? Slightly more respondents (165) stated that it is fully appropriate or appropriate, compared with 133 who stated it was rather not appropriate or not appropriate. 13 respondents did not have an opinion and 13 did not answer.

Respondents also pointed to the need for a better coverage of all modes of transport under the Directive. 38 respondents stated that the Directive already covered all relevant modes, but 131 respondents stated that the Directive should also cover rail infrastructure, 167 stated that it should cover airport infrastructure for ground movements, and 65 stated 'other'. 62 respondents did not have an opinion, and 18 did not answer.

There were clear views also on the adequacy of the NPFs. When being asked 'In your view, are the NPFs the right instrument to ensure the development of a coherent infrastructure network throughout the EU?' (see figure 7) the majority of respondents (109) stated that they are only partly sufficient, and additional/complementary instruments would be needed to avoid diverging interpretation and application by Member States. 39 stated that they are the right instrument, 89 stated that they are the right instrument but the provisions in the directive are not prescriptive enough to avoid diverging interpretation by Member States (and the provisions should be strengthened), 51 stated that they are not the right instrument because they are not sufficiently stringent (they should be replaced by alternative, more stringent instruments) and 2 stated they are not the right instrument and should be abandoned without being replaced by an alternative. 20 respondents did not have an opinion and 14 did not answer.

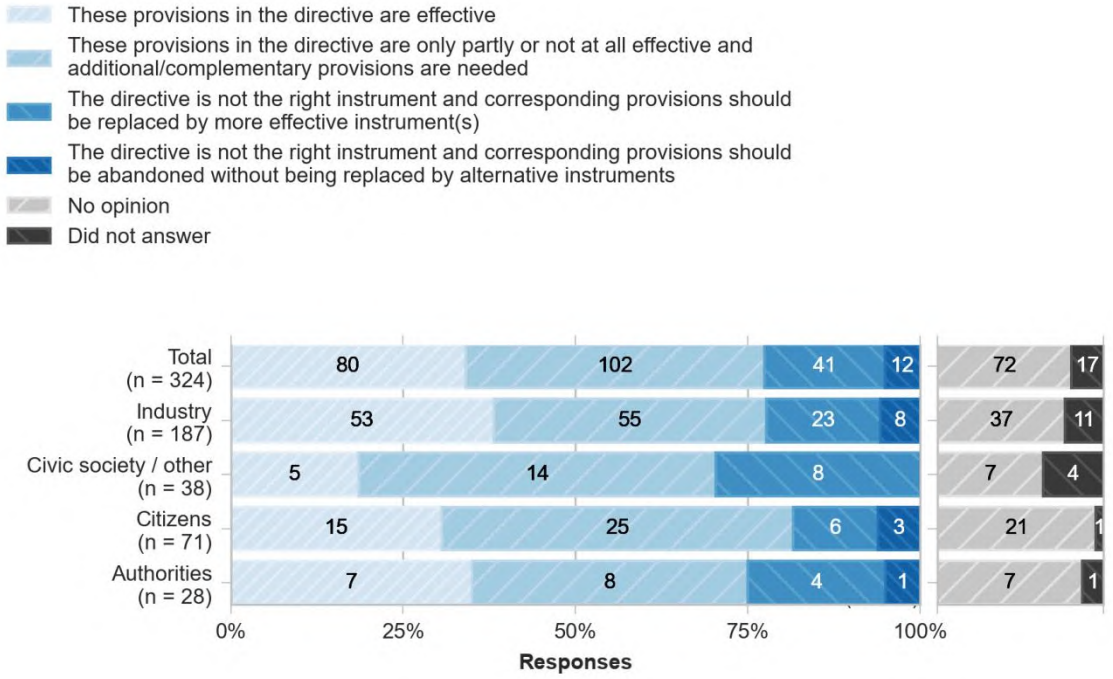
Figure 7: In your view, are the NPFs the right instrument to ensure the development of a coherent infrastructure network throughout the EU?



The majority of respondents (114) expressed that the Directive should cover all infrastructure, publicly accessible and not publicly accessible. 76 stated that it should cover publicly accessible infrastructure only (with distinction required between public infrastructure on public grounds and publicly accessible infrastructure on private ground), 53 stated that the current scope is fine, and 41 stated 'other'. 27 did not have an opinion and 13 did not answer.

The Alternative Fuels Infrastructure Directive currently requires from Member States to ensure that relevant, consistent and clear information is made available to consumers/users as regards those motor vehicles which are fuelled with alternative fuels. Such information has to be made available in motor vehicle manuals, at refuelling and recharging points, on motor vehicles and in motor vehicle dealerships in their territory (Article 7). Respondents were asked 'In your view, are the current provisions in AFID effective in ensuring that consumers/users receive relevant, consistent and clear information on the compatibility of their vehicle engine/model with the alternative fuels/recharging options available at each refuelling/recharging point?' (see figure 8). 80 respondents stated that these provisions are effective, 102 stated that they are only partly or not at all effective and additional complementary provisions are needed, 41 stated that the Directive is not the right instrument and corresponding provisions should be replaced by more effective instrument(s), and 8 stated that the Directive is not the right instrument and corresponding provisions should be abandoned without being replaced by more effective instrument(s), 72 did not have an opinion and 17 did not answer. This underpins the assessment of shortcomings of the current Directive in this important area.

Figure 8: In your view, are the current provisions in AFID effective in ensuring that consumers/users receive relevant, consistent and clear information on the compatibility of their vehicle engine/model with the alternative fuels/recharging options available at each refuelling/recharging point?



Targeted consultations

Three **exploratory interviews** were undertaken with selected stakeholders in the initial stage of the evaluation work. The purpose of the exploratory interviews was to incorporate the feedback from these stakeholders into the development of survey questions and interview guides and to ensure that all important issues are correctly identified and are covered in the intervention logic and evaluation matrix.

28 **targeted interviews** were conducted with a range of relevant stakeholders representing EU bodies, national and local authorities, industry representatives, members of the civil society (NGOs, consumer groups) and experts. The targeted interviews focus on cross-checking or complementing the information collected via desk research and collecting evidence and opinions in relation to the various evaluation questions. They included interviews with 5 public national authorities and 2 regional and local authorities representatives. Moreover, one targeted interview was carried out with a representative of a European standardisation organisation. 15 targeted interviews were carried out with industry representatives, 1 targeted interview with a representative of a transport organisation and 3 interviews with representatives of civil society organisations.

Two **targeted surveys** were distributed aimed at national authorities and regional, local and/or city authorities in EU Member States. The surveys focused on cross-checking or complementing the information collected via desk research and collecting evidence and opinions in relation to the various evaluation questions. 44 responses were received, including 23 national authorities and 19 regional and local authorities. Responses represented 20 Member States and 9 different local organisations.

Annex 3: Methods and analytical models

1. OVERVIEW

In order to assess the contribution of the AFID it is important to define the Baseline scenario that will provide the benchmark against which we measure the contribution of the intervention. For the needs of the AFID evaluation this includes:

- A description of how the problem and its underlying causes – as identified at the time of the adoption of the Directive – were expected to evolve in the case of no policy action.
- A definition of the expected evolution of the relevant parameters that reflects the key objectives of the Directive. This presents in quantitative terms (or when not possible, in qualitative terms) the Baseline scenario, namely what would have happened if the policies and measures that are deemed to be the result of the AFID were not in place.

For the purposes of this exercise the evaluation support study has used a combination of desk research and modelling. More specifically:

- It has analysed the information provided in the Impact Assessment study that supported the adoption of the Directive in 2014[57]. It focused on the description of the problem, its underlying root causes and the expected evolution under the 'no policy change' scenario. Additional input from stakeholders and further desk research is also incorporated.
- E3Modelling then used the PRIMES-TREMOVE model to quantify the Baseline and the Alternative scenario. The quantitative analysis involves a number of key indicators and reflects the objectives of the AFID.

The structure of this Annex is as follows:

- Section 2 provides a description of the problem and its underlying root causes as defined at the time of the adoption of the AFID. It also presents a qualitative description of how the problem and the root causes were expected to develop under the Baseline scenario.
- Section 3 presents the PRIMES-TREMOVE transport model and the main results of the analysis of the Baseline and the Alternative scenario. The expected evolution of key relevant parameters is provided for the EU27, for the period up to 2050. In addition, section 3 also provides the investment expenditures that are required for AFI under the Baseline and the Alternative scenario.

2. DESCRIPTION OF THE PROBLEM, THE UNDERLYING DRIVERS AND ITS EXPECTED EVOLUTION

According to the impact assessment at the time of the adoption of the Directive, the transport system continued to depend heavily on oil and oil products: for more than 95% of its needs worldwide and 96% in the European Union. The decarbonisation of the transport system had been identified as a priority policy since the adoption of the Europe

[57] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52013SC0006

2020 strategy in 2010 and the 2011 White Paper on Transport where alternative fuel technologies were expected to have a central role to play. The White Paper set a target for halving the use of conventionally fuelled cars in urban transport by 2030 and phasing them out in cities by 2050. Furthermore, the Communication "A European strategy on clean and energy efficient vehicles" recognised that there was a European framework for electric mobility and presented actions to be taken in the areas of vehicle type-approval, and of standardisation and infrastructure for electric charging.

In this context, the impact assessment report supporting the adoption of the Directive identified the issue of the development of alternative fuel infrastructure as part of the broader problem that limited the full-scale deployment and commercialisation of alternative fuels. These included a combination of:

- The high price of vehicles related to technological and production capabilities;
- Poor consumer acceptance; and
- Lack of recharging/refuelling infrastructure.

Focusing on the last point, the impact assessment defined the problem as the "**insufficient infrastructure network for electricity, hydrogen and natural gas (LNG and CNG)**" compared to a network that would be necessary to enable market take up of these fuels. The availability of recharging/refuelling stations was seen not only as a technical prerequisite for the functioning of alternative fuel vehicles, but also one of the most critical components for consumer acceptance.

The impact assessment report also provided detailed analysis of the projected evolution of the infrastructure for each type of fuel and mode. This was then compared against the expected level of infrastructure that was considered to be necessary to allow widespread commercialisation of the corresponding vehicles (i.e. enable market take up of these fuels and serve the fleet of alternative fuelled vehicles projected to be in circulation, on the basis of Member States and industry announcements).

The main conclusion of the analysis (which was based on a number of assumptions concerning technological developments and expected evolution of demand) was that, in comparison with what would be necessary to allow widespread commercialisation of the corresponding vehicles, the infrastructure for electric, hydrogen, liquefied natural gas (LNG) for trucks and vessels and compressed natural gas (CNG) for road transport vehicles was likely to remain insufficient in quantity and (in particular for electricity) in quality.

Table 4: State of development of AFI, projected evolution and comparison with the required level for commercialisation

Fuel	State of play at the time of the IA (2012)	Projected evolution	Required level of infrastructure for commercialisation
Electricity	Dedicated e-mobility installations at EU level: - 26,080 private (5,830 existing and 20,250 commissioned in 2012) - 29,800 public (10,400 existing and 19,390 commissioned in 2012) Significant imbalance among Member States in terms of quantity and quality	Existing imbalance among Member States to continue Network to increase significantly only in France (4,400,000 points by 2020). In the rest of EU, only 600,000 points by 2020.	Around 8 million points (majority located at home and at the workplace) to service the benchmark 4 million EV vehicles Around 1 charging point per 5 vehicles at a publicly accessible car park or on-street number
Hydrogen	90 hydrogen refuelling stations in operation in the EU (DE, DK, UK and Benelux)	Expected to exceed 160 by 2015	Additional 72 hydrogen fuelling stations needed to provide national coverage and be connected via the proposed Trans-European Transport Network (TEN-T) Core Network77 with the maximum distance of 300 km
LNG	Waterborne: One LNG terminal in Nynäshamn (SE) for ships Road: 23 LNG/L-CNG fuelling stations for road vehicles (ES, IT)	Waterborne: Small-scale facilities at 7 location planned or proposed Addition ports (e.g. Antwerp, Rotterdam) intended to provide LNG by 2015 or later (Marseille, Barcelona by 2017-2020) Road: 13 LNG/L-CNG stations planned (LNG Blue Corridors project)	Waterborne: LNG terminals in the 83 maritime ports of the TEN-T Core Network to enable the use of LNG in shipping LNG bunkering facilities at the 41 inland ports of the TEN-T Core Network Road: 21 LNG/L-CNG fuelling stations at the maximum distance of 400 km on road
CNG	2,800 filling stations in the EU concentrated in two Member States (DE, IT)	No information	

The analysis also identified two underlying **root causes** that meant that the infrastructure for electric, hydrogen and natural gas (LNG and CNG) vehicles is likely to remain insufficient for what broad market take-up would require:

- Existing recharging/refuelling equipment could not be connected and was not interoperable in all related alternative fuel vehicles/vessels: While the technology necessary for the construction of a network was considered substantially mature, there were no common EU-wide standards and no harmonisation, thereby discouraging potential infrastructure investors, car manufacturers and consumers.

  This had also led to the fragmentation of the internal market. The lack of common standards for recharging/refuelling prevented the creation of a single market and the reduction of costs of alternative fuels infrastructure and equipment since there were no economies of scale that could arise from an EU-wide market. A consequence was it created a disincentive to infrastructure investors, manufacturers of alternative fuel vehicles and vessels and consumers.

- Investment uncertainty hindered the deployment of recharging/refuelling infrastructure for electricity, hydrogen and natural gas (LNG and CNG): The business case for providers of alternative fuels infrastructure had not been established. A co-ordination failure among vehicle manufactures, infrastructure providers, national authorities and final users led to a so called "chicken and egg" issue. Investors would not invest in alternative fuel infrastructure as there was an insufficient number of vehicles and vessels, the manufacturing industry would not offer alternative fuel vehicles and vessels at competitive prices as there is insufficient consumer demand, and consumers would not purchase the vehicles and vessels for the lack of dedicated infrastructure. In the absence of coordination among the relevant actors uncertainty for investors would remain exceedingly high, and the markets would continue to deliver a suboptimal solution.

  Related to that was the negative impact on investment in open-access recharging/refuelling infrastructure due to risk of 'free riding'. First movers were expected to experience high upfront costs and uncertain payback times due to the low diffusion of AFVs while late comers could benefit from a more developed market. This risk discourages first movers' investments. Principal-agent-type market failures were also identified in terms of the provision of charging points for tenants/users in private dwellings and in office buildings since landlords had limited incentives to invest.

  Further to that, action to address these issues by national authorities through various measures was expected but was expected to lead to different perceptions of consumers in the respective national markets. It would not be sufficient to build up a 'critical mass' of demand and signal long-term commitment to the support of alternative fuels.

In terms of the identified root causes of the problem, it was expected that:

- Common standards would eventually develop since the persistence of different technical solutions would represent a serious obstacle to pan-European mobility and would not be tolerable. However, delays would still lead to considerable stranded costs and additional expenditure for adaptation if a decision is delayed.
- Investment uncertainty hindering the investment in AFI and problems of coordination and the identified market failures would continue. Individual Member States would be expected to take relevant measures to address these problems but these could lead to a fragmented market that would limit consumer confidence and have a negative impact on both demand and supply.

As a consequence, the share of alternative fuels in the energy consumption of passenger cars and vans was expected to remain less than 10% by 2050 without further action on infrastructure. LNG and CNG were also not expected to make significant inroads in road transport and the same would also happen with LNG for waterborne transport due to the lack of refuelling infrastructure.

3. DEVELOPMENT OF THE BASELINE AND ALTERNATIVE SCENARIO

3.1 Introduction

The quantitative analysis builds on a counterfactual scenario logic comparing the expected future impacts of the already adopted policies in comparison to a no policy scenario. More specifically, E3Modelling used the PRIMES-TREMOVE transport model to quantify two scenarios - the Baseline and the Alternative scenario in order to assess the effectiveness and the efficiency of the implementation of AFID.

The Baseline scenario projects the developments under the assumption that the AFID is not in place. In addition, an Alternative scenario has been developed to assess the expected impacts as a result of the AFID intervention.

3.2 PRIMES-TREMOVE model

The PRIMES-TREMOVE transport model projects the evolution of demand for passengers and freight transport, by transport mode, and transport vehicle/technology, following a formulation based on microeconomic foundation of decisions of multiple actors. Operation, investment and emission costs, various policy measures, utility factors and congestion are among the drivers that influence the projections of the model. The projections of activity, equipment (fleet), usage of equipment, energy consumption and emissions (and other externalities) constitute the set of model outputs.

The PRIMES-TREMOVE transport model can therefore provide the quantitative analysis for the transport sector in the EU, candidate and neighbouring countries covering activity, equipment, energy and emissions. The model accounts for each country separately which means that the detailed long-term outlooks are available both for each country and in aggregate forms (e.g. EU level).

In the transport field, PRIMES-TREMOVE is suitable for modelling *soft measures* (e.g. eco-driving, labelling); *economic measures* (e.g. subsidies and taxes on fuels, vehicles, emissions; ETS for transport when linked with PRIMES; pricing of congestion and other externalities such as air pollution; accidents and noise; measures supporting R&D); *regulatory measures* (e.g. CO_2 emission performance standards for new passenger and heavy duty vehicles; EURO standards on road transport vehicles; technology standards for non-road transport technologies, deployment of Intelligent Transport Systems) and *infrastructure policies for alternative fuels* (e.g. deployment of refuelling/recharging infrastructure for electricity, hydrogen, LNG, CNG). Used as a module that contributes to the PRIMES model energy system model, PRIMES-TREMOVE can show how policies and trends in the field of transport contribute to economy-wide trends in energy use and emissions. Using data disaggregated per Member State, the model can show differentiated trends across Member States.

The PRIMES-TREMOVE has been developed and is maintained by E3Modelling, based on, but extending features of, the open source TREMOVE model developed by the TREMOVE[58] modelling community. Part of the model (e.g. the utility nested tree) was built following the TREMOVE model.[59] Other parts, like the component on fuel consumption and emissions, follow the COPERT model.

Data inputs

The main data sources for inputs to the PRIMES-TREMOVE model, such as for activity and energy consumption, comes from EUROSTAT database and from the Statistical Pocketbook "EU transport in figures".[60] Excise taxes are derived from DG TAXUD excise duty tables. Other data comes from different sources such as research projects (e.g. TRACCS project) and reports. In the context of this exercise, the PRIMES-TREMOVE transport model is calibrated to 2005, 2010 and 2015 historical data.

3.3 Overview of the approach adopted for the Baseline and Alternative scenario

The **Baseline (no policy change) scenario** serves as a counterfactual scenario which presents what would happen if the policies and measures adopted, as a result of the AFID, were not in place. This means updating the baseline of the impact assessment accompanying the AFID – considering revised macro-assumptions, technology costs assumptions and policies[61]. These assumptions are common with those used in the context of the 2017-2018 Mobility Packages[62] and also in the in-depth analysis accompanying the Clean Planet for all long term strategy[63]. The Baseline scenario assumes, among others, the implementation of the target of 14% renewable energy in transport by 2030 (according to the Renewable Energy Directive II), the post-2020 CO_2 standards for cars, vans and heavy duty vehicles, the Clean Vehicle Directive, the implementation of TEN-T network, etc.

In addition, it accounts for specific policies and measure that would have been adopted by some Member States in support of alternative fuel vehicles and infrastructure even without the implementation of the Directive (Table 5**Error! Reference source not found.**). These specific policies and measures have been identified in the context of the evaluation support study, based on field research. In addition, it was confirmed by the Member State concerned that those measures would have been carried out irrespective of the AFID.

[58] Source: https://www.tmleuven.be/en/navigation/TREMOVE
[59] Several model enhancements were made compared to the standard TREMOVE model, as for example: for the number of vintages (allowing representation of the choice of second-hand cars); for the technology categories which include vehicle types using electricity from the grid and fuel cells. The model also incorporates additional fuel types, such as biofuels (when they differ from standard fossil fuel technologies), LPG, LNG, hydrogen and e-fuels. In addition, representation of infrastructure for refuelling and recharging are among the model refinements, influencing fuel choices. A major model enhancement concerns the inclusion of heterogeneity in the distance of stylised trips; the model considers that the trip distances follow a distribution function with different distances and frequencies. The inclusion of heterogeneity was found to be of significant influence in the choice of vehicle-fuels especially for vehicles-fuels with range limitations.
[60] Source: European Commission (2020) EU Transport in Figures. Statistical Pocketbook 2020.
[61] The scenario analysis does not account for the Covid-19 impact on the economy and the transport sector.
[62] https://ec.europa.eu/transport/modes/road/road-initiatives_en
[63] https://ec.europa.eu/clima/sites/clima/files/docs/pages/com_2018_733_analysis_in_support_en_0.pdf

Table 5: Mapping of Member States that would have implemented policies and measures related with AFI and AFV without the roll-out of AFID on the indicated transport modes

Member State	EVs	H_2	CNG/LNG
AT		Cars, Buses, LDVs, HDVs	HDVs
BE	Buses, HDVs		
DE	Buses, HDVs		Cars, Buses, LDVs, HDVs
EE	All modes/fuels		
FI	Cars, Buses, LDVs, HDVs		Cars, Buses, LDVs, HDVs
IE	Cars, LDVs		Cars, Buses, LDVs
LU	Cars, Buses, LDVs, HDVs		Cars, Buses, LDVs
LV			HDVs
NL	Buses, HDVs		
SE	All modes/fuels		

Source: Ricardo et al. (2021), Evaluation support study

The **Alternative scenario**, unlike Baseline, includes national policies and measures (NIRs) adopted for all MS (including those denoted in Table 5), as a result of the implementation of the Directive on the deployment of Alternative Fuels Infrastructure. More details on the design of the Baseline and Alternative scenarios are available in the evaluation support study.

3.4 Main results of the Baseline and the Alternative scenario

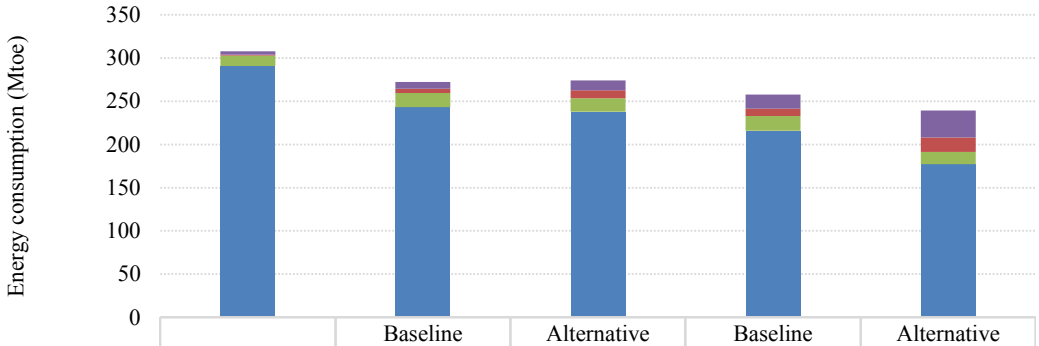
This section presents the key results of the Baseline and the Alternative scenario that have been quantified with the PRIMES-TREMOVE model. The results are provided at EU27 level.

Energy consumption in the transport sector

In the Baseline scenario, the share of alternative fuels in the energy use in transport would go up from 7% in 2010 to 12% in 2030 and remain limited to around 17% by 2050. The uptake of alternative fuels in the Baseline is mostly driven by the implementation of the post-2020 CO_2 standards for cars, vans and heavy duty vehicles, the Renewables Energy Directive and the Clean Vehicles Directive. However, the lack of infrastructure acts as a barrier for the vehicle market uptake. In the Alternative scenario, the implementation of AFID enables higher uptake of electric vehicles (battery electric and plug-in hybrids) as well as the uptake of LNG heavy duty vehicles, given the roll-out of recharging and refuelling infrastructure. Thus, the Alternative scenario projects a 3.4 percentage points increase in the share of alternative fuels relative to the Baseline in 2030 and a 11.1 percentage points increase in 2050.

The share of alternative fuels in the energy consumption of passenger cars and vans would remain limited in the Baseline scenario, at around 14% by 2030 and 18% by 2050, without further action on infrastructure. The deployment of recharging infrastructure enables higher uptake of electric vehicles (battery electric and plug-in hybrids) instead of hybrids, as explained below, and leads to an increase in the share of alternative fuels (by 4.9 percentage points in 2030 relative to the Baseline and 19 percentage points in 2050).

Figure 9: Energy consumption in the transport sector, by type of fuel, in the Baseline and the Alternative scenario (EU27)



	2010	2030 Baseline	2030 Alternative	2050 Baseline	2050 Alternative
Electricity & hydrogen	4	8	12	16	31
Gas & bio-methane	1	5	9	8	17
Biofuels	12	16	16	17	14
Petroleum products	291	243	238	216	177

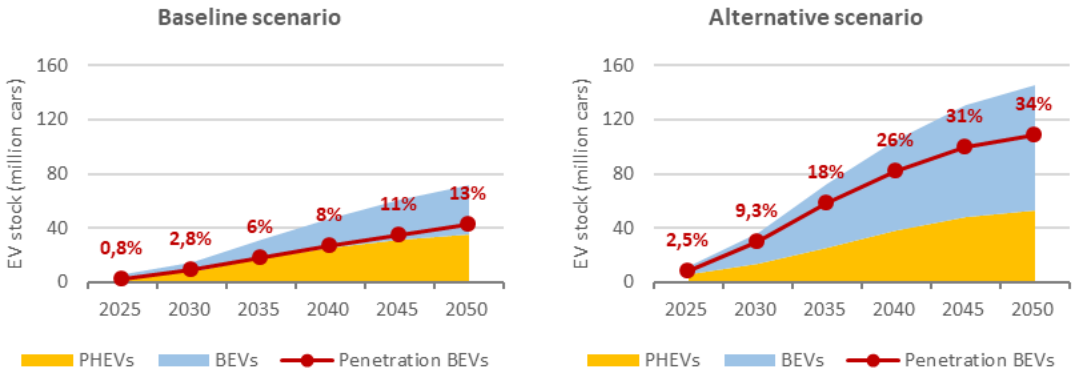
Source: PRIMES-TREMOVE, E3Modelling

Vehicle stock

In the Baseline scenario, the car fleet is projected to continue to be mainly based on thermal engine technologies for the years to come. The share of conventional gasoline and diesel vehicles in the total stock would reduce from 97% in 2010 to 65% in 2030 and 36% in 2050. Importantly, the implementation of the post-2020 CO_2 standards would drive the uptake of hybrid vehicle technologies in the market, in the absence of a larger contribution from battery electric vehicles (BEVs) and plug-in hybrids (PHEVs), due to the lack of recharging infrastructure. The hybrid technologies would increase their share from less than 1% in 2010 to 25% in 2030 and 35% by 2050, at which point the hybrid vehicles would hold the second largest share in the total car stock, comparable to that of conventional gasoline and diesel vehicles. For electric vehicles, a gradual market uptake would take place driven by the CO_2 standards and the gradual reduction of the battery costs, with BEVs and PHEVs each reaching a share of around 3% in 2030 and 13% in 2050 in the total stock of cars. The share of the liquefied petroleum gas (LPG) cars would decrease from 3% in 2010 to about 2% in 2050. The share of fuel cell electric vehicles (FCEVs) is projected to remain negligible for all the projection period.

In the Alternative scenario, the stock of cars would shift from thermal engine technologies mainly to electric power trains (Figure 10). The share of the conventional gasoline and diesel vehicles in the total stock is reduced by 3.2 percentage points relative to the Baseline in 2030 and by 13.8 percentage points in 2050. The hybrid technologies also significantly reduce their share in the car stock relative to the Baseline (by 8.1 percentage points in 2030 and 19.1 percentage points in 2050). On the other hand, the share of battery electric cars is increasing significantly relative to the Baseline (by 6.5 percentage points in 2030 and 20.6 percentage points in 2050), enabled by the availability of infrastructure and the decreasing battery costs. As previously explained, in the Baseline scenario the lack of infrastructure acts as a barrier for the uptake of electric vehicles, despite the implementation of CO_2 standards for cars. The uptake of plug-in hybrids also increases relative to the Baseline, but at lesser extent relative to the increase in the uptake of the BEVs. The share of fuel cell vehicles increase by 2050 in the Alternative scenario but still remains limited to around 3% of the stock.

Figure 10: Stock and penetration of electric cars in the Baseline and the Alternative scenario in the EU27



Source: PRIMES-TREMOVE, E3Modelling

Similarly to cars, in the Baseline scenario for light commercial vehicles (LCVs) the share of conventional gasoline and diesel vehicles is projected at 66% by 2030 and 37% by 2050, while that of hybrid technologies at 32% by 2030 and 48% by 2050. The uptake of battery electric and plug-in hybrids would be more limited in lack of recharging infrastructure (together representing up to 15% by 2050). In the Alternative scenario the uptake of battery electric LCVs would increase significantly and represent up to 25% of the LCV stock.

For heavy duty vehicles (HDVs), fuel cell, LNG and electric vehicles would not make significant inroads in the vehicle stock by 2050 in the Baseline scenario. The Alternative scenario projects slightly higher uptake of fuel cells and electric HDVs but the share of these types of power trains only increases by around 1 percentage point relative to the Baseline. The share of LNG HDVs would go up by 6.8 percentage points in 2050 in the Alternative scenario relative to the Baseline.

CO_2 emissions and air pollution emissions

In the Baseline scenario, tank to wheel CO_2 emissions from transport[64] are projected to decrease by 15% by 2030 relative to 2010 and by 24% by 2050. In the Alternative scenario, the implementation of AFID would have a limited impact on the CO2 emissions from transport by 2030 (1.2% reduction relative to the Baseline). However, the impact would be larger by 2050 (15.1% reduction relative to the Baseline) due to the higher uptake of low- and zero-emission vehicles.

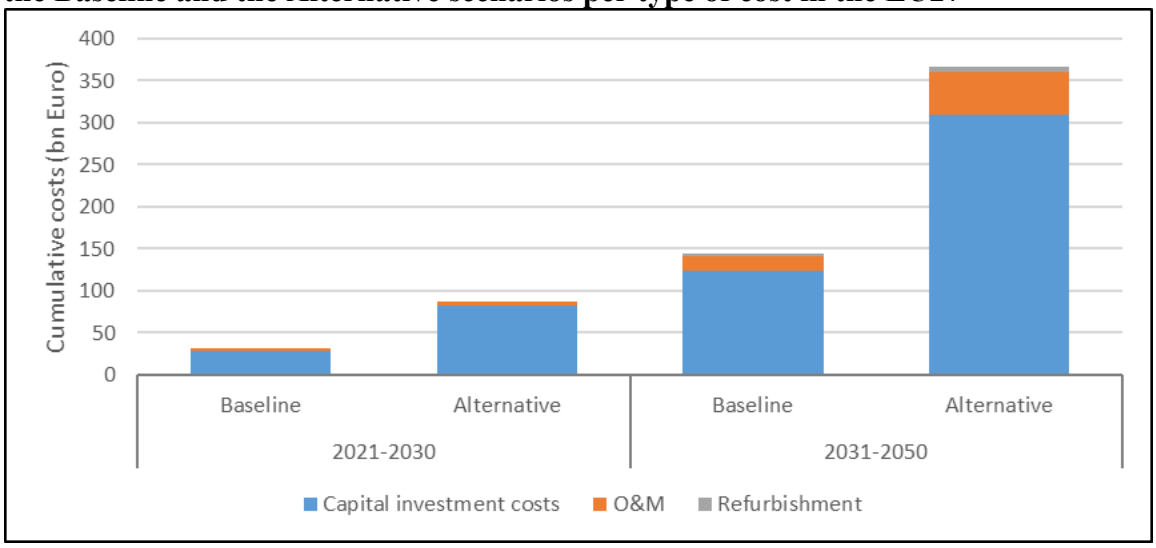
The implementation of the AFID would also have a positive impact on reducing the NOx and PM emissions. In the Alternative scenario, NOx emissions would go down by 5.5% relative to the Baseline in 2030 and 8.4% in 2050. The impacts on the PM emissions would be higher (9.4% reduction in 2030 relative to the Baseline and 20.7% in 2050). Similarly to CO_2 emissions, the reduction in the air pollution emissions is driven by the higher uptake of low- and zero-emission vehicles, enabled by the deployment of infrastructure.

[64] Excluding international shipping.

3.5 Investment costs for alternative fuel infrastructure in the Baseline and in the Alternative scenario

In the Baseline scenario, the cumulative capital expenditures on alternative fuel infrastructure (i.e. public and private infrastructure) are estimated at €29 bn for the period 2021-2030 and to €123 bn for 2031-2050 (Figure 11). The capital investments on infrastructure due to the demand induced by the AFID increase significantly, to €82 bn until 2030 and to €310 bn for 2031-2050. In addition to these costs, O&M and refurbishment costs are projected to be around €24 bn in the Baseline, and €63 bn in the Alternative scenario in the period 2021-2050, which make up about 14% of total costs. More details on the methodology for determining the alternative fuel infrastructure costs are available in the evaluation support study.

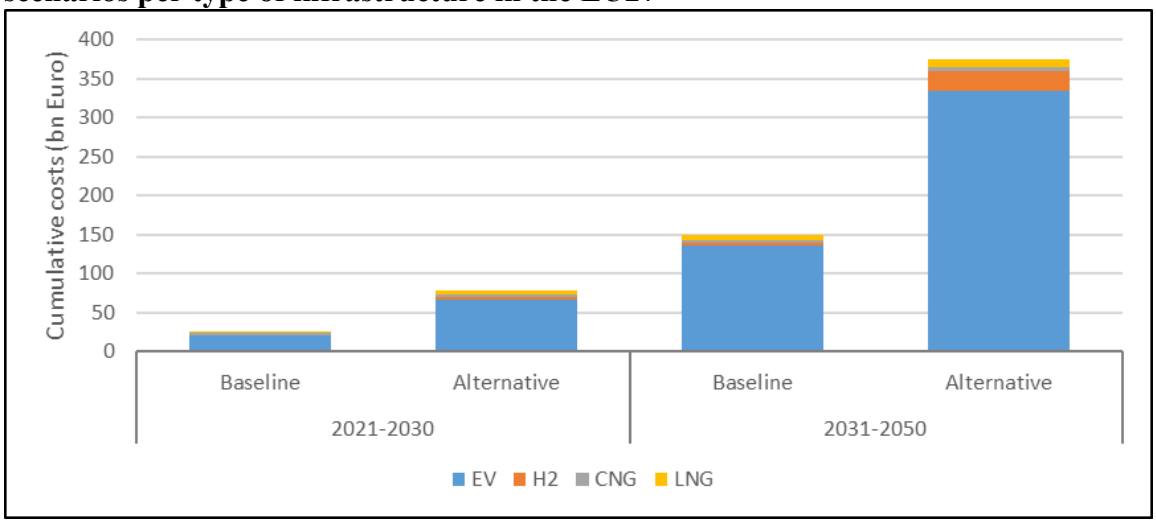
Figure 11: Cumulative investment expenditures of alternative fuel infrastructure in the Baseline and the Alternative scenarios per type of cost in the EU27



Source: Ricardo et al. (2021), Evaluation support study

The vast majority of the total expenditures (i.e. capital investment costs, O&M and refurbishment) is projected for electric vehicle charging infrastructure (Figure 12). In 2021-2030, electric vehicle recharging infrastructure makes up to 82% and 88% of the total expenditures that occur in the Baseline and the Alternative scenario, or €26 bn and €77 bn , respectively. In the period 2031-2050, investments in electric vehicle recharging infrastructure increase significantly, by a factor 5 in the Baseline to €132 bn , and by a factor 4 in the Alternative scenario, to €326 bn Euro. In both scenarios, they make up around 90% of total projected expenditures in alternative fuel infrastructure.

Figure 12: Cumulative expenditures (capital investment costs, O&M, Refurbishment) of alternative fuel infrastructure in the Baseline and the Alternative scenarios per type of infrastructure in the EU27

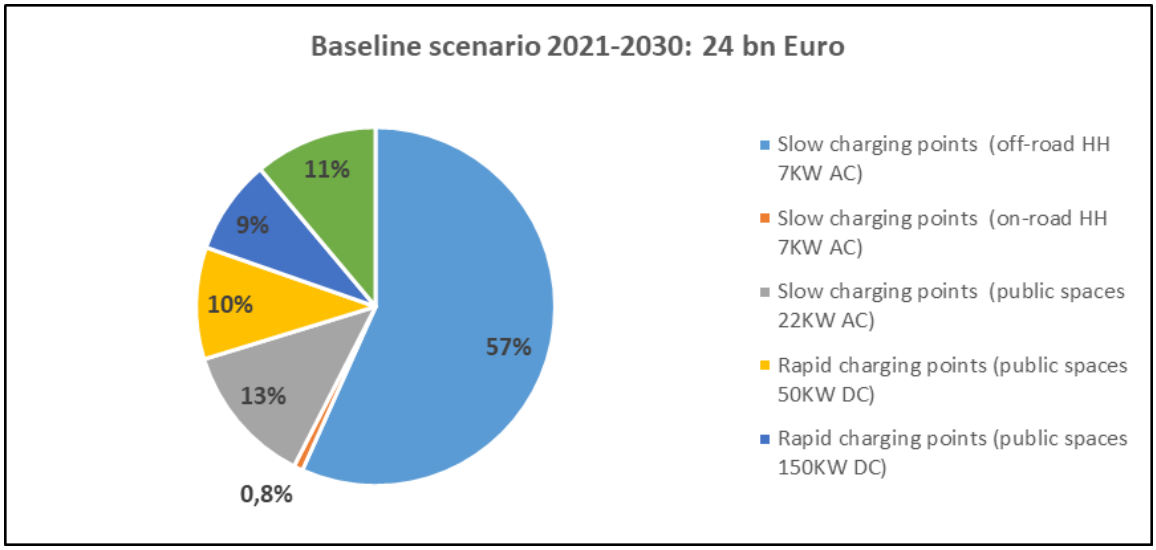


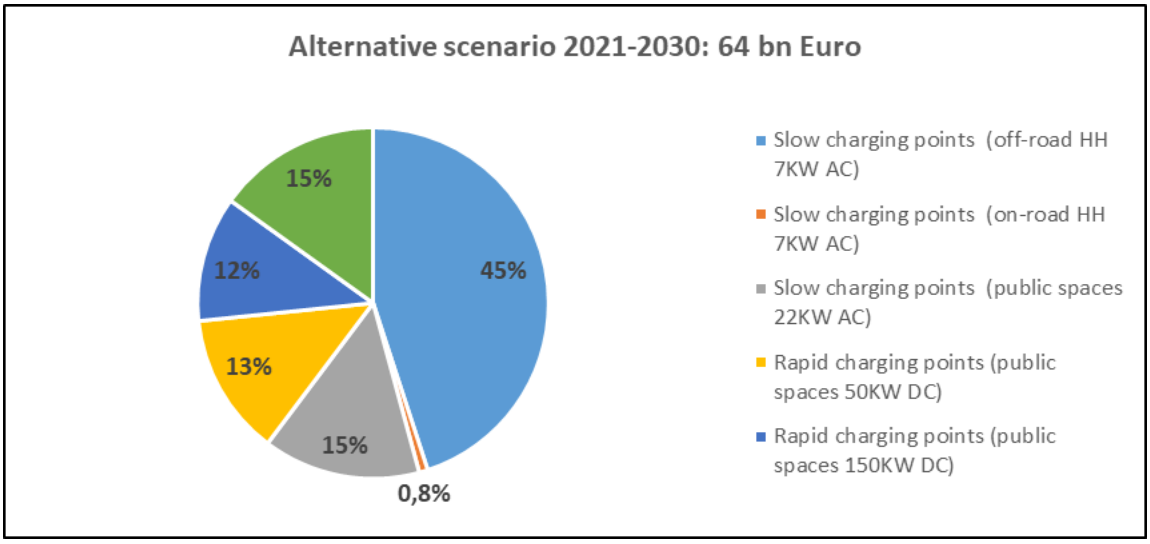
Source: Ricardo et al. (2021), Evaluation support study

Investment expenditures in electricity recharging infrastructure by 2030 and by 2050

In the Baseline scenario cumulative investments on capital for recharging infrastructure (i.e. public and private infrastructure) reach almost €24 bn in the period 2021-2030, the majority of which for slow charging points installed off-street, in private households (Figure 13; top). Investments on public chargers of all types reach almost €11 bn . The AFID implementation has an a significant impact on capital investments (Figure 13; bottom). It increases investments made on public infrastructure, and particularly on higher powered charging points. For example, in the Alternative scenario investments on public charging points are higher by a factor of 3.5-4 compared to the Baseline.

Figure 13: Cumulative capital investment costs of electric vehicle recharging infrastructure per type of charging point in the Baseline and in the Alternative scenario in the EU27 in 2021-2030

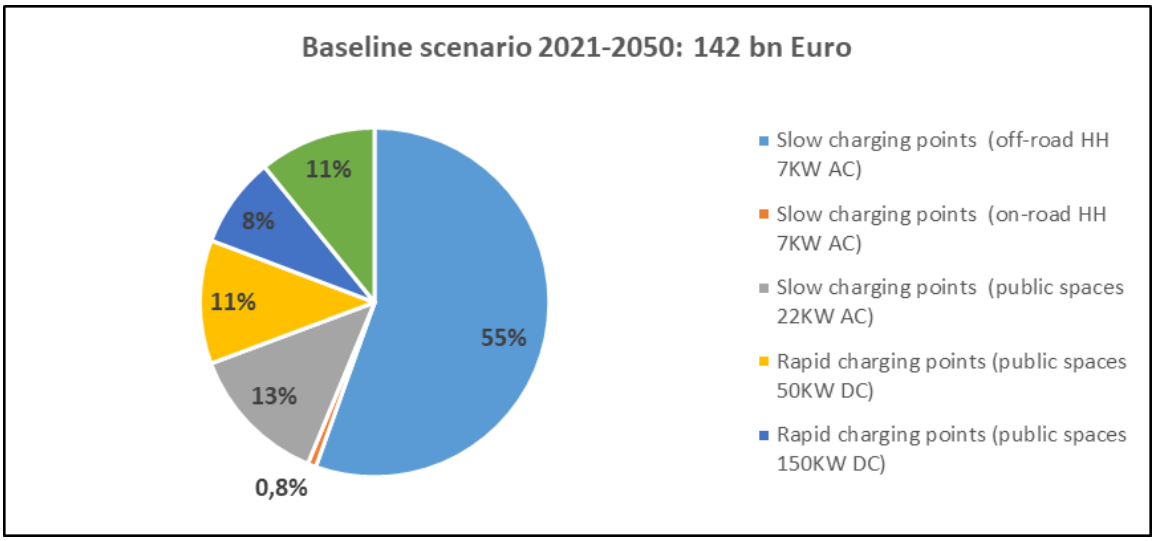


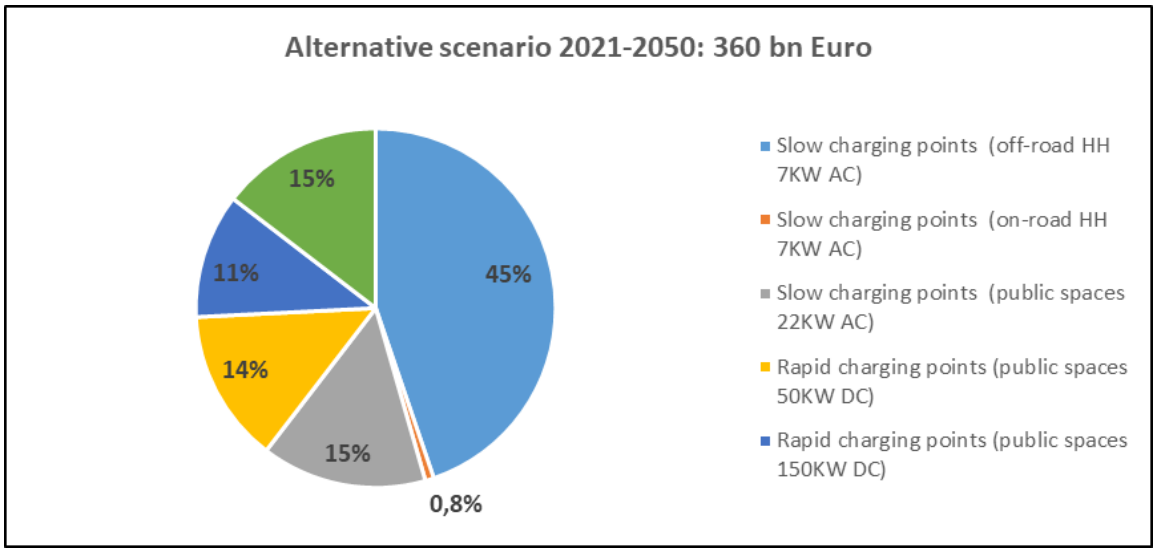


Source: Ricardo et al. (2021), Evaluation support study

Looking into the 2021-2050 horizon (Figure 14), it is estimated that the cumulative capital investments of the Alternative scenario are by a factor 2.5 higher than those of the Baseline. In the Baseline, 45% of cumulative investments are on public chargers, while in the Alternative public charging infrastructure makes 55% of total investments. As such, the share of public chargers in the total charging infrastructure and the total number of public charging points increases progressively upon the AFID implementation, compared to the Baseline.

Figure 14: Cumulative capital investment costs of electric vehicle recharging infrastructure per type of charging point in the Baseline and in the Alternative scenario in the EU27 in 2021-2050



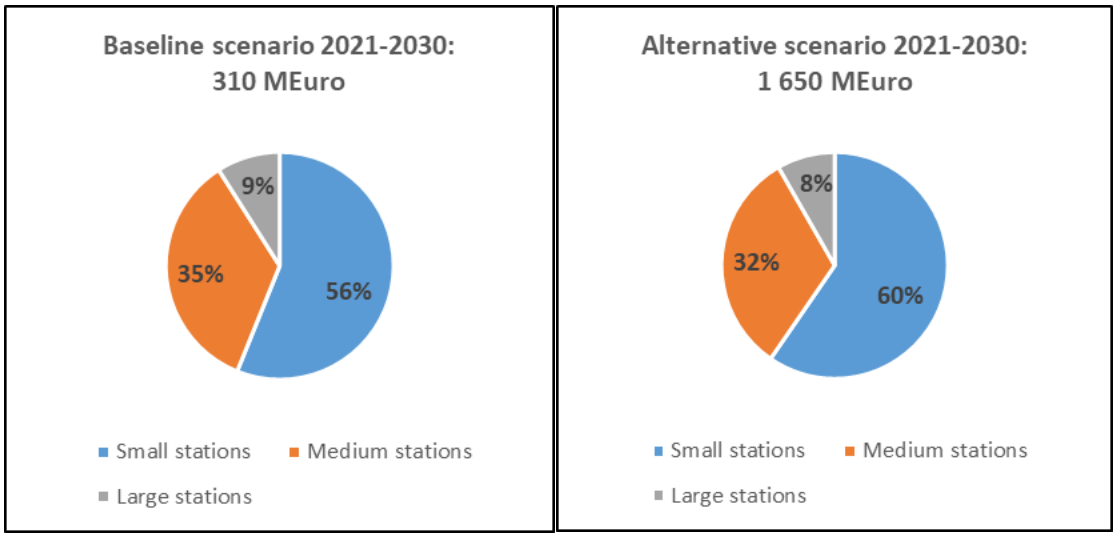


Source: Ricardo et al. (2021), Evaluation support study

Investment expenditures in hydrogen refuelling stations by 2030 and by 2050

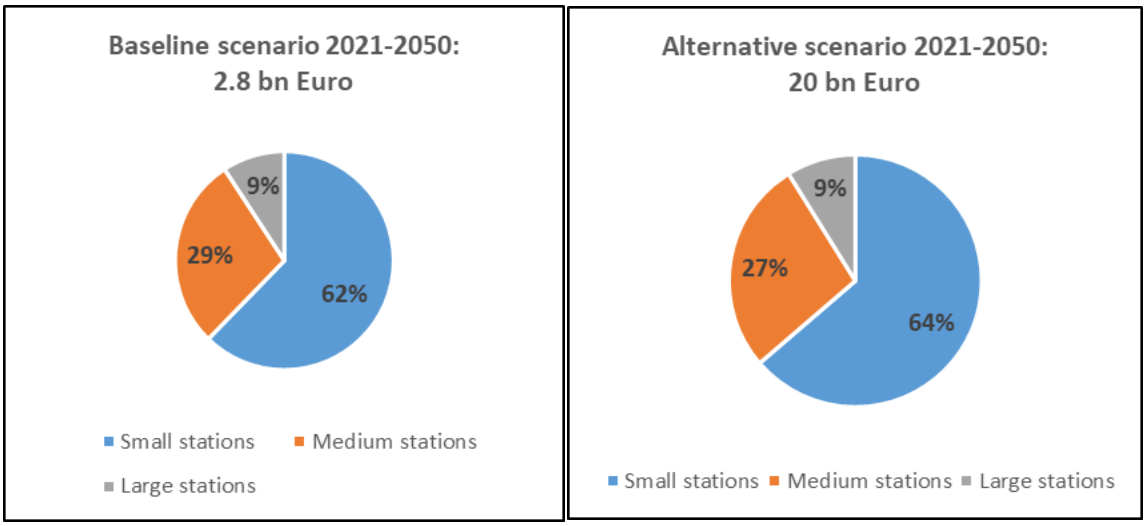
The impact of the AFID implementation is also significant on hydrogen refuelling stations (Figure 15). Capital investments of the Baseline are estimated at €310 million in 2021-2030. The investments in the Alternative scenario are higher by a factor 5 compared to the Baseline, reaching more than €1.6 bn in 2021-2030. The impact, however, of the AFID is by a factor 10 higher in the period post-2030, when cumulative capital investments increase by €18 bn in the Alternative scenario (cumulative costs in 2021-2050 reach €20 bn, Figure 16).

Figure 15: Cumulative capital investment costs of hydrogen refuelling stations per station size in the Baseline and in the Alternative scenario in the EU27 in 2021-2030



Source: Ricardo et al. (2021), Evaluation support study

Figure 16: Cumulative capital investment costs of hydrogen refuelling stations per station size in the Baseline and in the Alternative scenario in the EU27 in 2021-2050

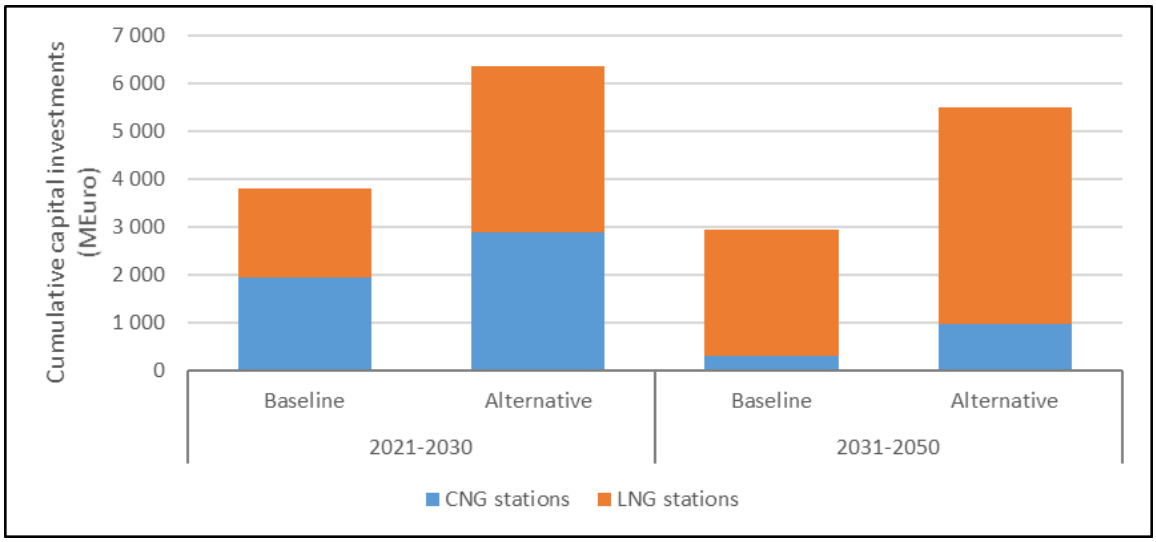


Source: Ricardo et al. (2021), Evaluation support study

Investment expenditures in CNG and LNG refuelling stations by 2030 and by 2050

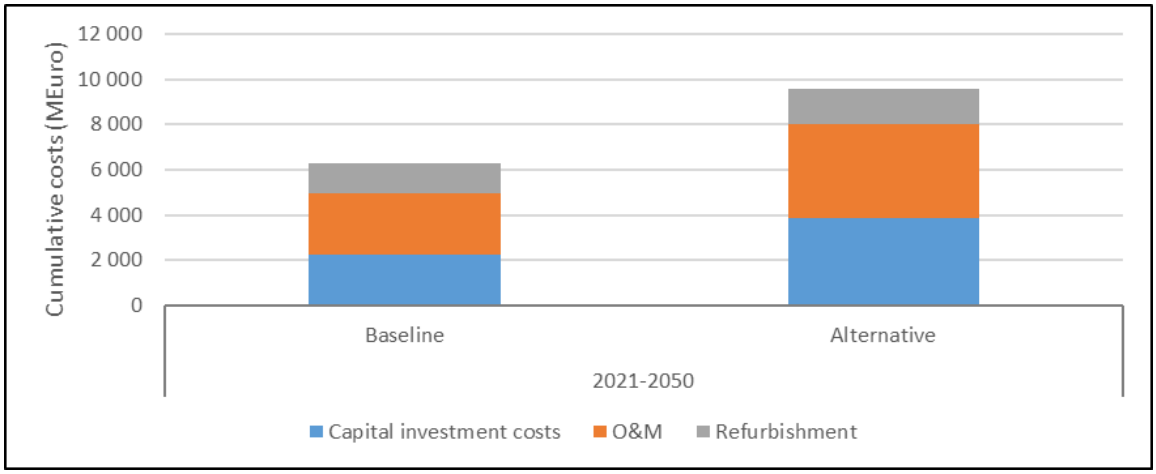
The investments in natural gas-based refuelling infrastructure reach around €3.8 bn in the Baseline and more than €6.3 bn in the Alternative scenario in 2021-2030 (Figure 17). The difference between the two scenarios is about €2.5 bn and is attributed primarily to LNG stations (€1.6 bn more investments in the Alternative scenario) and somewhat less to CNG stations (€0.95 bn), as the EU27 CNG fleet may still largely benefit from the infrastructure already deployed. In the period 2031-2050, investments in new CNG stations are lower compared to the period 2021-2030 in both scenarios. This is partly because of the demand reduction due to the decrease of the CNG vehicle stock over time, as more EVs penetrate the market due to the decreasing battery costs. In addition, since significant capacity of CNG stations has been deployed before 2020 (according to EAFO, about 1.3 million stations were in the EU27 in 2019), investments in refurbishing vintage capacity take place, in the order of €1.4 bn and €1.6 bn in the Baseline and Alternative, or 33% and 25% of the total costs, respectively (Figure 18).

Figure 17: Cumulative capital investment costs of CNG and LNG refuelling stations in the Baseline and in the Alternative scenario in the EU27 in 2021-2030 and 2031-2050



Source: Ricardo et al. (2021), Evaluation support study

Figure 18: Cumulative capital investment, O&M and refurbishment costs of CNG stations in the Baseline and in the Alternative scenario in the EU27 in 2021-2050

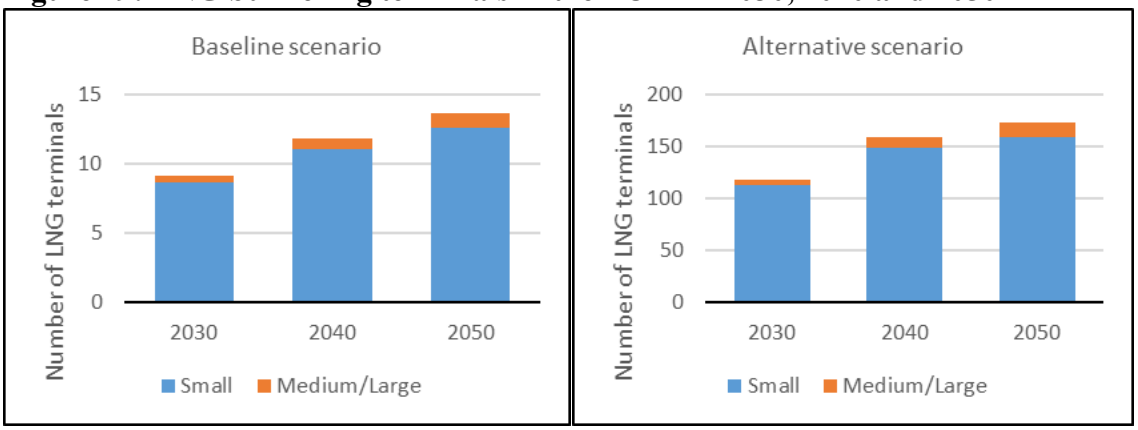


Source: Ricardo et al. (2021), Evaluation support study

Investment expenditures in LNG terminals by 2030 and by 2050

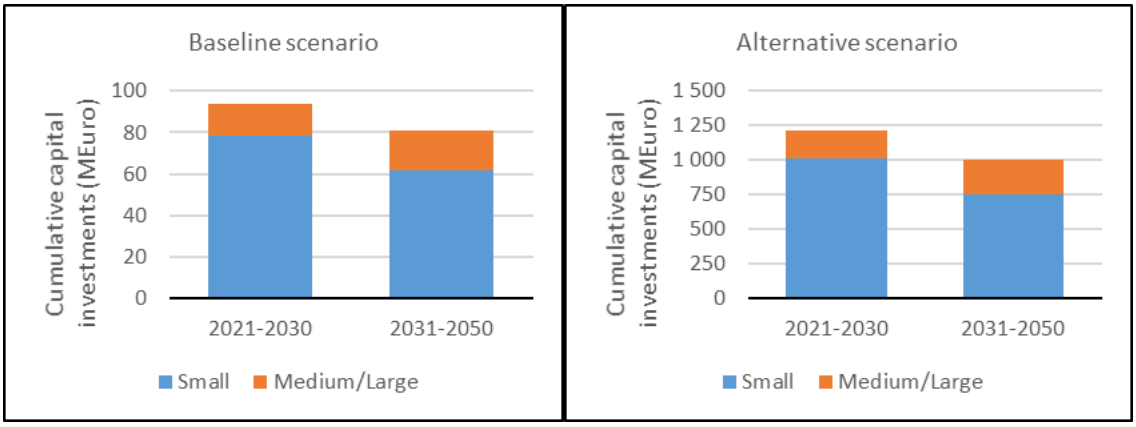
The number of LNG bunkering terminals deployed in the Baseline and the Alternative scenario in the EU27 is presented in Figure 19. Medium/large LNG terminals represent about 5% and 8% of total terminals in the EU27 in 2030 and 2050, respectively.

Figure 19: LNG bunkering terminals in the EU27 in 2030, 2040 and 2050



Source: Ricardo et al. (2021), Evaluation support study

Figure 20: Cumulative investment costs in LNG bunkering terminals in the Baseline and the Alternative scenario in the EU27 in 2021-2030 and 2031-2050



Source: Ricardo et al. (2021), Evaluation support study

The cumulative investment costs in 2021-2050 (Figure 20) for LNG bunkering terminals reach €175 million in the Baseline scenario. They are substantially higher in the Alternative scenario reaching €2,215 million. In both scenarios, the investments are slightly higher in the period 2021-2030 than in the period 2031-2050. Investments on medium/large LNG terminals are about 15% of total investments in LNG terminals in 2021-2030 and 25% in 2031-2050.

ANNEX 4: CURRENT STATUS OF THE AFI AND AFV MARKET IN EUROPE

This section presents an overview of the current status of the AFI and AFV market in Europe, broken down by fuel type and transport mode. The principle source of information/data is the European Alternative Fuels Observatory (EAFO). It has been supplemented by other sources, where relevant,

1. ELECTRICITY

1.1 Electricity for road transport

At EU level, the data provided by EAFO (see **Error! Reference source not found.**) points to six -fold increase to the total number of electric charging infrastructure over the period 2014-2019. The number of EVs (BEVs and PHEVs) during the same period increased at an even higher rate (9.4 times) with the share BEVs remaining rather stable (ca. 60%). The EAFO data also point to a significant increase in the number of fast chargers (>22kW) per 100 km of highway (from 2 per 100 km in 2014 to 20 in 2019). Fast chargers represented in 2019 around 10% of the total public chargers, up from 5% in 2014. According to T&E, there were approximately 780 ultra-fast chargers[65] in Europe at the start of 2020. Germany has the highest number of ultra-fast recharging points (269), representing approximately a third of the network. Other MS with a significant number of ultra-fast recharging points are the Netherlands (98) and France (88).

[65] This number includes recharging points above 100kW in Europe (including Norway, Switzerland and UK) and excludes the Tesla Supercharger network.

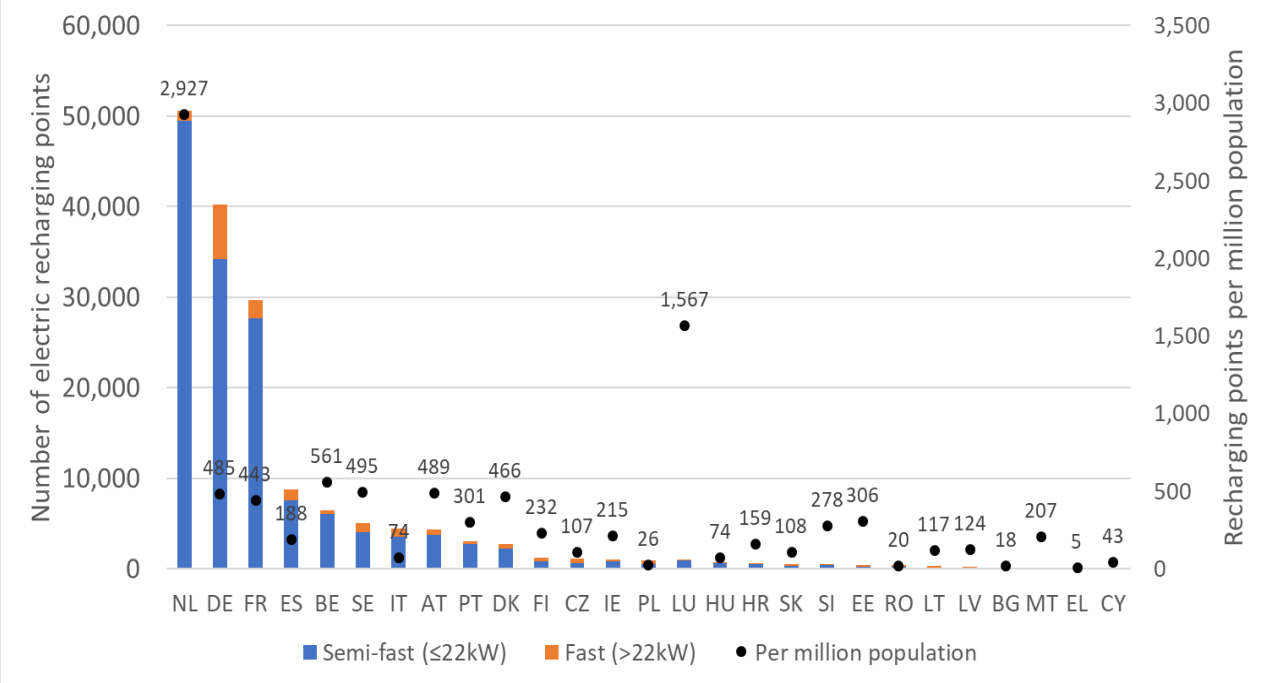
Table 6: Evolution of electric vehicles and charging infrastructure for road transport in EU27

Indicator	2014	2015	2016	2017	2018	2019
Number of normal public chargers (≤22kW)	24,917	44,786	93,721	97,287	107,502	148,035
Number of Fast public chargers (>22kW)	1,331	3,396	8,124	8,784	11,155	17,071
Total 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%
Number of MS with stations	24 (20 fast)	26 (24 fast)	27 (25 fast)	27 (25 fast)	27 (25 fast)	27 (25 fast)
Fast chargers per 100 km highway	2	5	7	12	15	20
BEVs	75,611	146,700	214,205	299,380	466,831	726,706
PHEVs	57,585	128,651	196,580	272,625	385,895	517,395
Total EVs	**133,196**	**275,351**	**410,785**	**572,005**	**852,726**	**1,244,101**
% share of new M1 registrations	0.6%	1.0%	0.9%	1.4%	1.8%	3.3%
Vehicle per charging point (average)	5.1	5.7	4.0	5.4	7.2	7.5

Source: EAFO and Ricardo elaboration

The overall increase of EV infrastructure at EU level is not equally spread across Member States. As can be seen, a small number of Member States are far ahead in terms of the density of the network while others are still at the very early stages. It highlights the high share of infrastructure – both in absolute and in relative terms – in the Netherlands and less so in Germany and France. Luxembourg has also a high number of charging points per population. At the same time, among the frontrunners there have been different levels of development of fast infrastructure. Thus, Netherlands has only a small share of fast charging infrastructure (2.1%) in comparison to a much higher share in Germany (15.1%). Other Member States with high levels of recharging infrastructure include Belgium, Sweden, Austria and Denmark with around 500 charging points per million population.

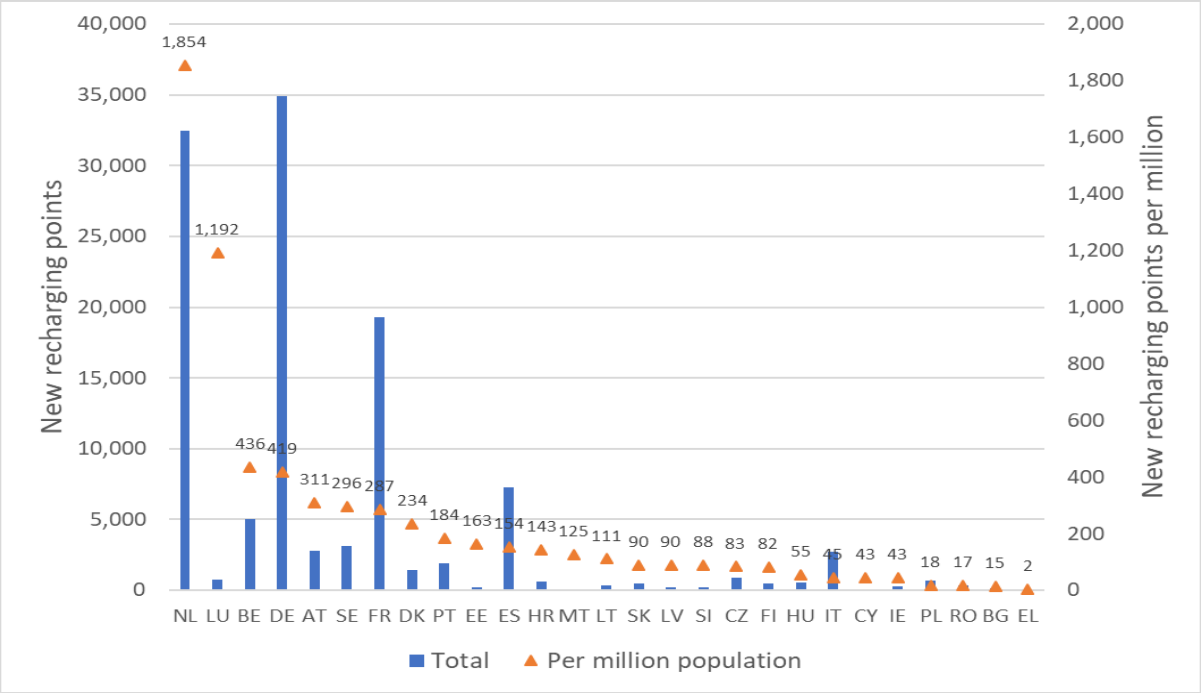
Figure 21: Charging infrastructure in EU27 by Member State, type and million population (2019)



Source: EAFO

The comparison of the evolution of recharging points between 2015 and 2019 point to the fact that the Member States with the highest level of infrastructure (NL, LU, BE, DE, AT, SE. FR) are also those with the highest level of additional investment in the last few years, based on budget data provided in the NIR (see **Error! Reference source not found.**). Nonetheless, even at smaller rates, all Member States saw an overall increase in the number of charging points per million population over the same period. At EU level, the number of charging points per million population increased from 112 in 2015 to 376 in 2019 (on the basis of EAFO data).

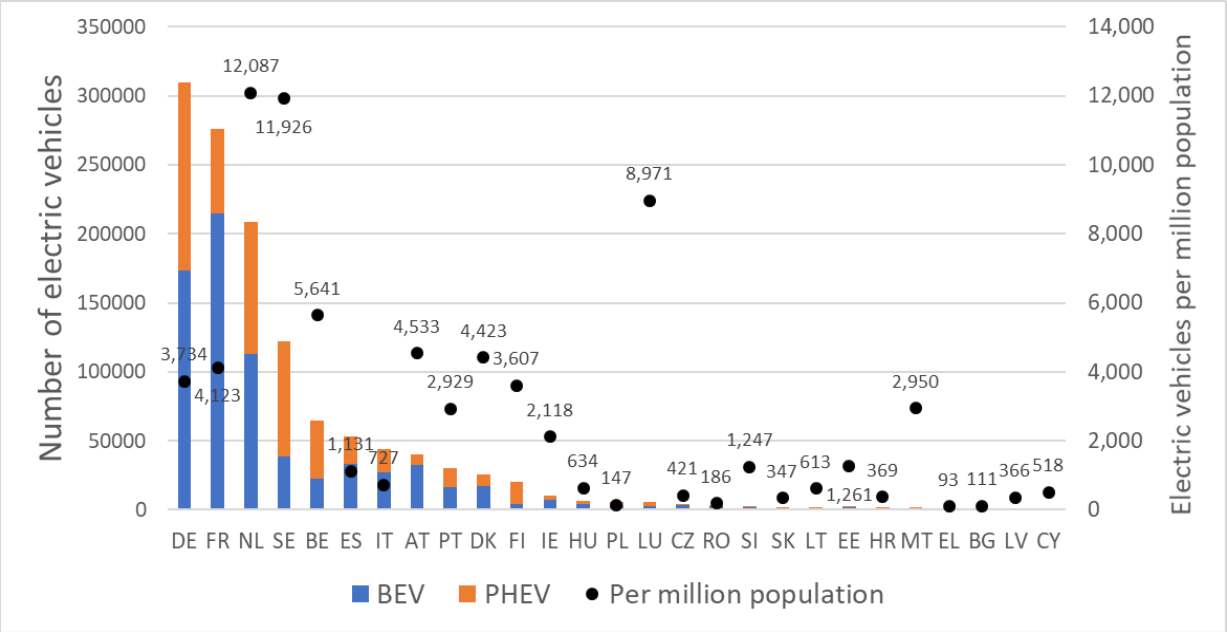
Figure 22: New recharging points between 2015 and 2019 by Member State (total and per million population)



Source: EAFO

As with recharging infrastructure, the increase has not been equal amongst Member States. The number of electric vehicles in each Member State at the end of 2019 is presented in **Error! Reference source not found.**. It shows a high volume of vehicles for Germany and France in absolute terms. In relative terms (per million population) the higher numbers are reported in the Netherlands, Sweden and (to a lesser degree) Luxembourg are leading. In general, BEVs are more common than PHEV with the highest share of BEVs in Estonia (91%), Malta (87%), Latvia (82%) and Austria (81%). Sweden and Finland have the lowest share of BEV, with 32% and 21%, respectively.

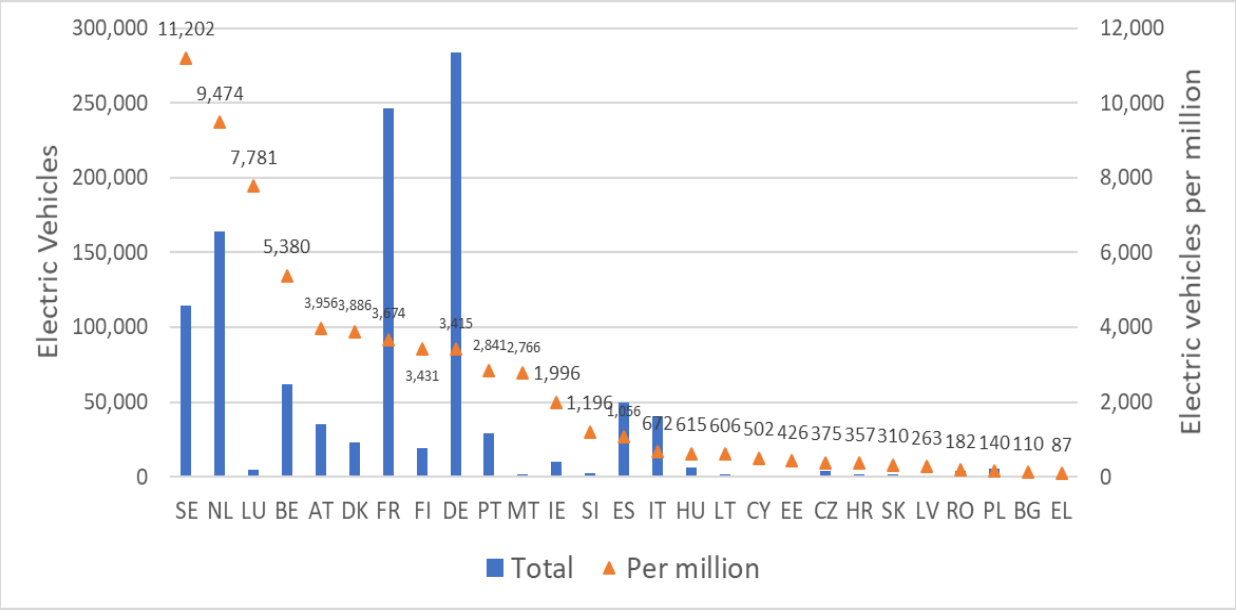
Figure 23: Electric vehicles in EU27 by Member State, type and million population (2019)



Source: EAFO

Furthermore, all EU MS have seen an overall increase in the number of electric vehicles from 2015 to 2019. Except for Sweden (which has seen the highest increase vehicles alongside only a moderate increase in infrastructure), the MS with the greatest increase in electric vehicles per million population from 2015 to 2019 are those with a corresponding high increase in recharging infrastructure.

Figure 24: New electric vehicles between 2015 and 2019 (total and per million population)



Source: EAFO

1.2 Electricity for water transport

In the water transport sector, data from EAFO on the relevant AFI (including onshore power supply and LNG) are less comprehensive. In relation to electricity installations in sea/inland ports, in 2015, there were 20 maritime ports in the EU providing shore side electricity (SSE) supply (high or low voltage). By 2019 this had increased to 44 ports (European Commission, 2020). Out of the 44 EU ports, 22 are ports on TEN-T Core Network and 11 are ports on the TEN-T Comprehensive Network. In total, there were over 189 berths with SSE in these EU ports with voltage ranging from 0.4 to 11 kV and power ranging from 0.015 to 10 MW. Among the ports with SSE, 48% offer high voltage and 86% offered low-voltage electricity supply (ESPO, 2019). Fixed installation supply is far more widespread than mobile installations, with 96% and 16% of equipped ports housing these types of infrastructure, respectively.

In terms of vessels powered by electricity, EAFO includes only data on the global seagoing fleet for 2020 with no corresponding data for inland shipping. As of May 2020, there are 101 seagoing vessels using SSE, of which 53 (52%) are pure electric and 48 (48%) are plug-in hybrid ships. There are a further 125 hybrid vessels that do not require electric infrastructure in ports. According to report on the State of Alternative Fuels transport systems, however, there are 166 battery-powered vessels in operation, of which 56% are passenger ferries. Furthermore, less than 0.5% of inland waterway vessels are hybrid or electric. Interviews with ECSA and ESPO stated that OPS is available in only a limited number of ports.

1.3 Electricity supply in airports

An ACI EUROPE survey in 2018 based on the replies of 51 airports, found that 42 of them (82%) provide Fixed Electrical Ground Power to aircraft on-stand[66]. In the same survey, 86% of respondents reported that their vehicle fleet included electric vehicles and 47% included hybrid models. Furthermore, an interview with ACI noted that there are an increasing number of airports offering fixed-electrical ground power. However, it does not work for all types of operation, particularly low-cost airlines with short turn-around times.

2. NATURAL GAS

In comparison to the electric charging infrastructure, the increase in the level of Natural gas (CNG/LNG) AFI has been more moderate. In the case of CNG, a network of around 3,000 stations was already in place in 2015 (mainly in Italy and in Germany). This increased by 20% (ca 3,500 stations), largely in line with the increase in the number of vehicles. The increase in the share of LNG stations was much greater (3.8 times) albeit from a much lower starting point.

[66] https://ec.europa.eu/transport/sites/transport/files/2019-aviation-environmental-report.pdf

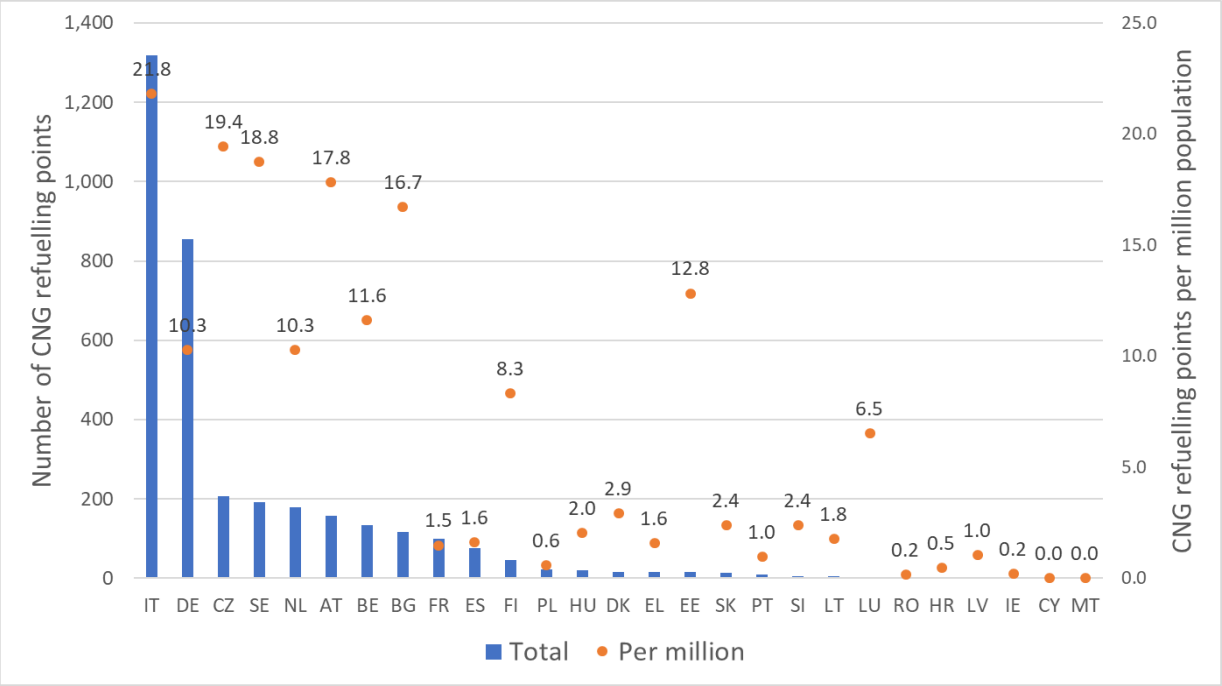
Table 7: Evolution of natural gas vehicles and fuelling infrastructure for road transport in EU27 by type

Type	Indicator	2014	2015	2016	2017	2018	2019
CNG	Number of CNG filling stations	n.d.	2,957	3,091	3,111	3,216	3,519
	Number of MS with stations	n.d.	24	24	24	23	25
	per 100 km highway	n.d.	3.9	4.1	4.1	4.2	4.6
	Number of CNG fuelled vehicles	1,065,157	1,209,033	1,252,745	1,274,392	1,321,666	1,377,985
	% share of new M1 registrations	1.0%	0.7%	0.5%	0.4%	0.5%	0.6%
	Vehicle per filling station (average)	n.d.	408.9	405.3	409.6	411.0	391.6
LNG	Number of LNG filling stations	n.d.	63	80	110	133	242
	Number of MS with stations	n.d.	8	10	11	12	15
	per 100 km highway	n.d.	0.08	0.11	0.15	0.17	0.32
	Number of vehicles	257	423	637	3,128	2,897	4,154
	Vehicle per filling station (average)	n.d.	6.7	8.0	28.4	21.8	17.2

Source: EAFO

CNG In terms of its distribution, the CNG network is concentrated in a few Member States. The greatest share of filling stations are located in Italy (1,391 in 2019) both in absolute and relative terms, representing close to 40% of the total filling stations in the EU. Other countries with high number of CNG infrastructure are DE (854), SE (192) and CZ (207). Accounting for population, AT and BG also display a high number of refilling stations. Since 2015, most investment in CNG filling station has taken place in Italy (217 new stations), followed by the CZ (99) and BE (87). Conversely, some Member States have been reducing the number of CNG refuelling points, namely, AT, DE, PL, and LU.

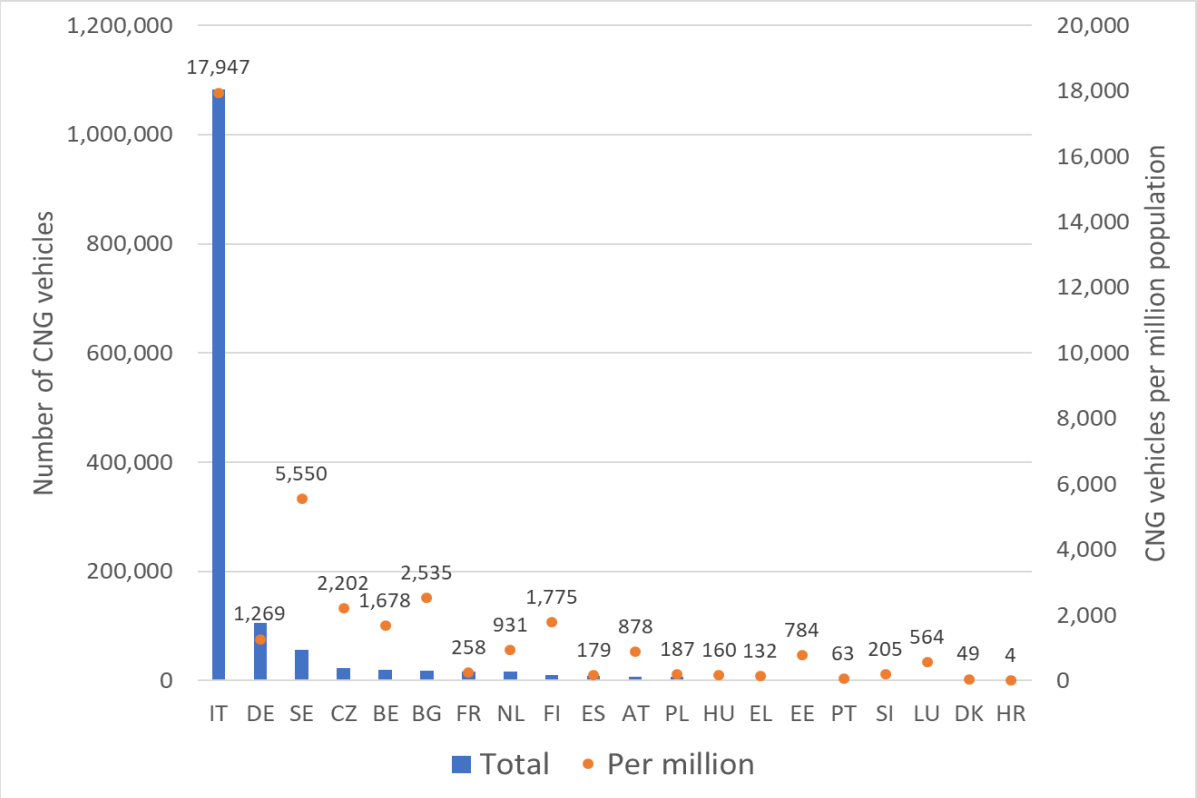
Figure 25: CNG infrastructure in EU27 by Member State and million population (2019)



Source: EAFO

In terms of vehicles, Italy represents almost 80% of all CNG vehicles in Europe, with a ratio of 822 vehicles per refilling station. Other MS with a high ratio are Poland (309), Sweden (295) and Finland (213). Italy has also had the greatest increase in number of vehicles since 2015 (103,106), followed by Belgium (16,543) and Czech Republic (11,747).

Figure 26: CNG vehicles in EU27 by Member State and million population (2019)



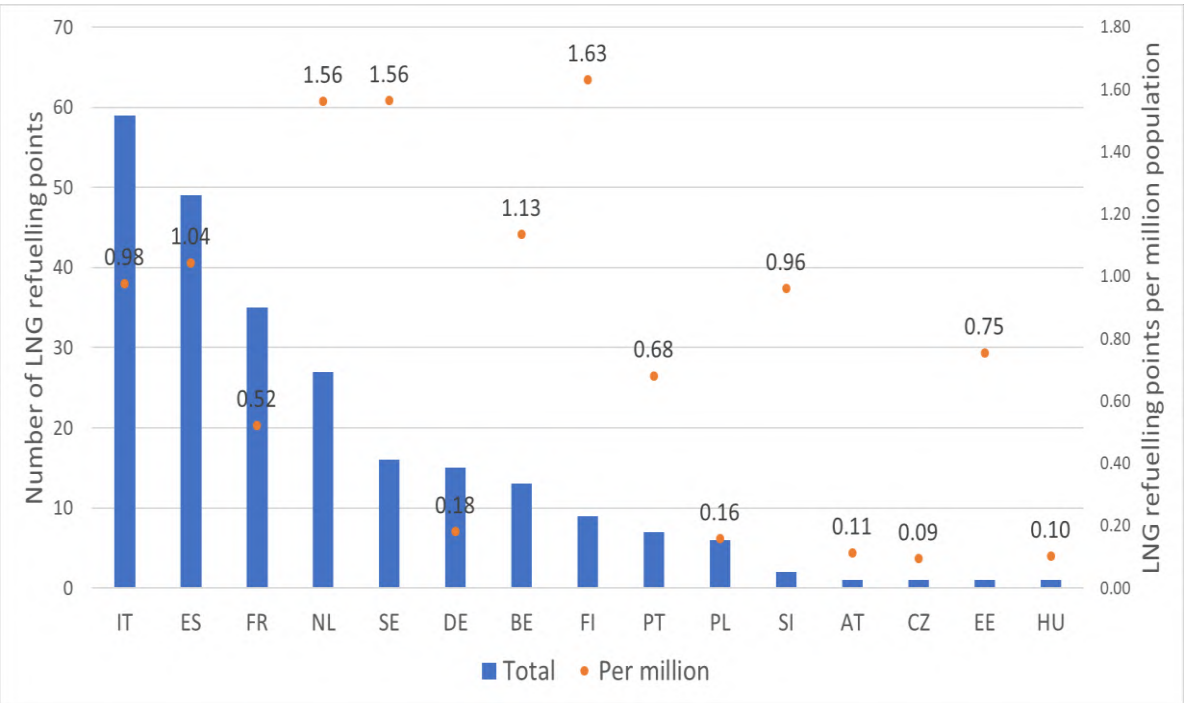
Source: EAFO

3. LNG

3.1 LNG for road transport

At the end of 2019, LNG fuelling infrastructure was available in 15 Member States according to the EAFO. Italy had the greatest number of refuelling stations (59) followed by Spain (49). However, in relative terms, Finland, Netherlands and Sweden have the highest number of infrastructure. Since 2015, the number of refuelling points at the Union level has increased almost fourfold, with a significant increase in infrastructure in Italy (47 new stations), Spain (49) and France (32).

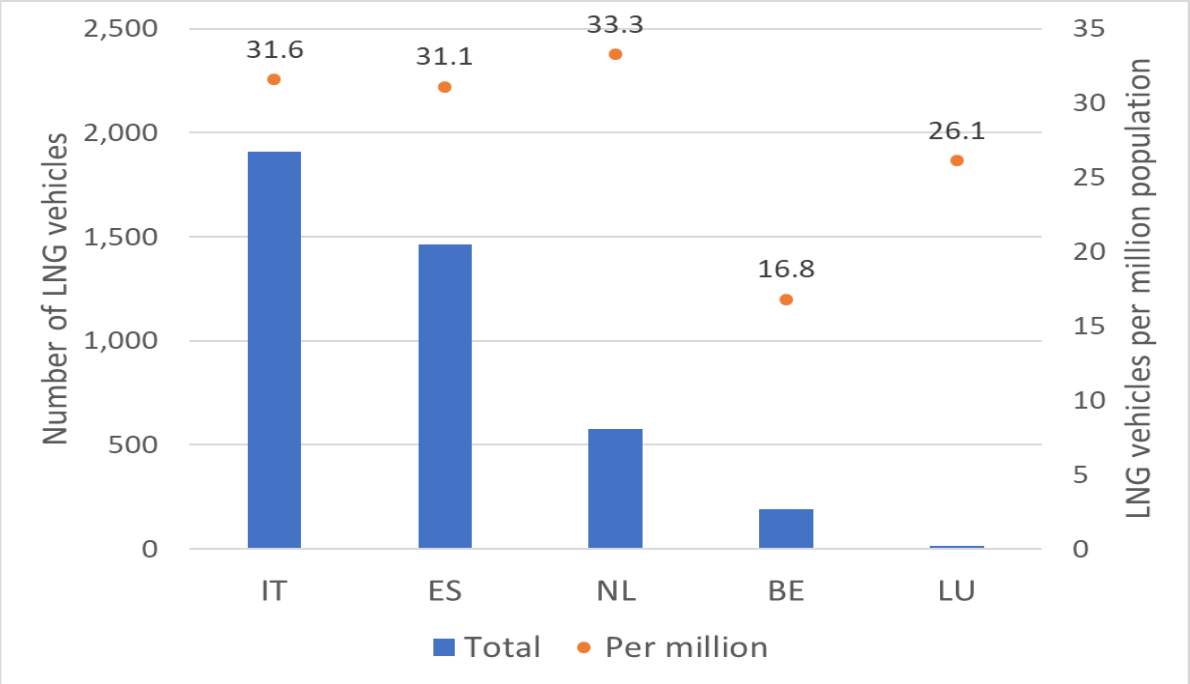
Figure 27: LNG infrastructure in EU27 at the end of 2019 by Member State and per million population



Source: EAFO

According to the EAFO, there were only 5 Member States that have registered LNG vehicles at the end of 2019. However, it should be noted that on the EAFO website, Bulgaria, Czech Republic, Finland, France, Poland, Slovakia and Slovenia have all had vehicles registered in previous years. Heavy-duty vehicles make up 99% of LNG vehicles in the EU and the Netherlands is the only MS to have any other LNG vehicle types registered. Italy had the greatest number of vehicles (1.907) followed by Spain (1,462), although Netherlands had the greatest per million population (33.3.).

Figure 28: LNG vehicles in EU27 at the end of 2019 by Member State and per million population



Source: EAFO

3.2 LNG for water transport

In relation to water transport, in 2018 there were 16 maritime ports in Europe that had LNG refuelling points in operation (European Commission, 2020). Most of them were located in Belgium, Spain, France, Lithuania, Netherlands, Portugal and UK. While limited, the dedicated LNG bunkering infrastructure for ships has also increased significantly. At the beginning of 2019, there were 85 large-scale operational LNG tanks installed in 35 ports in EU, mainly in Spain (29 tanks in 9 ports) and Italy (8 tanks in 3 ports) (European Commission, 2020). Furthermore, according to the EAFO, there were 50 LNG powered seagoing vessels in Europe (excluding Norway) at the end of 2019, which will increase to 67 in 2020 according to forecasts. There are still a number of LNG ships on order and it estimated that the total fleet will increase to approximately 92 ships when fulfilled (European Commission, 2020).

Concerning inland navigation, there are no specific data available. However, in 2018, there was considered to be sufficient LNG bunkering to meet the demand from a very low number of LNG vessels in use. There are 14 LNG inland vessels operating in Europe today, of which 9 are tanker vessels, and a further 12 on order.

4. HYDROGEN

4.1 Hydrogen for road transport

At EU level, the number of hydrogen filling stations in operation across the EU in 2019 was still very small (127), up from 35 in 2016 and 39 in 2018. The number FCEVs has also increased during the same period but an even slower pace (as can be seen from

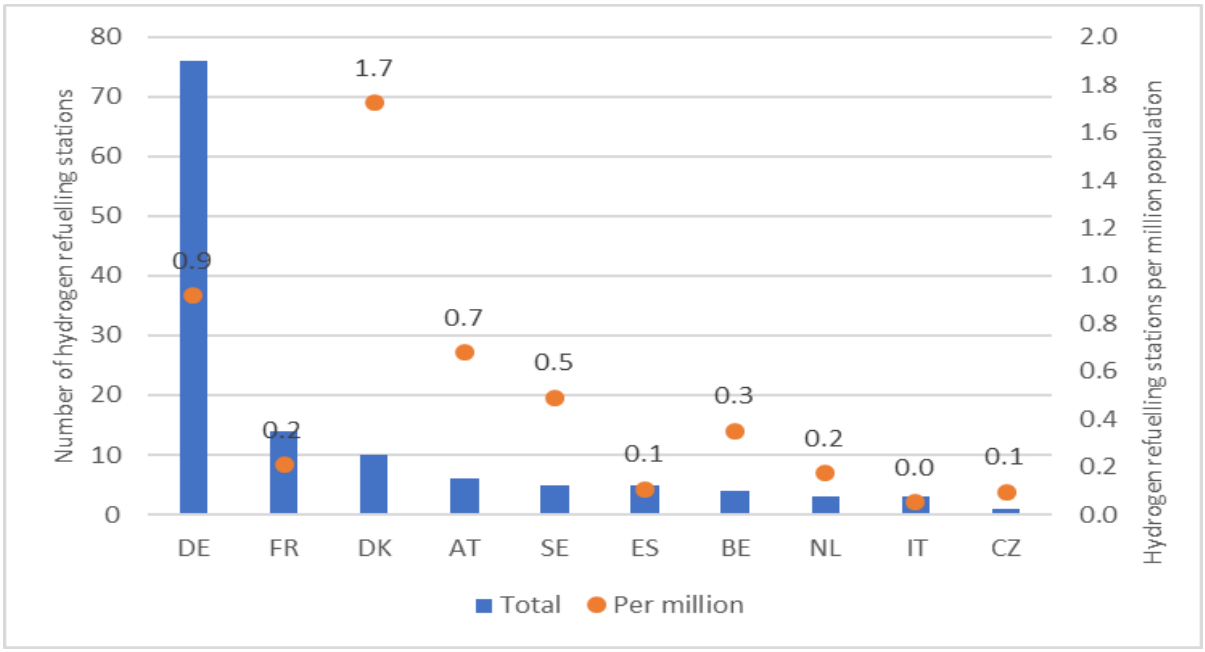
lower ratio of vehicles to refuelling stations) and the total number of vehicles is still very small (1200 at the end of 2019).

Table 8: Evolution of hydrogen vehicles and fuelling infrastructure for road transport in EU27

Indicator	2014	2015	2016	2017	2018	2019
Number of filling stations	n.d.	n.d.	35	39	39	127
Number of MS with stations	n.d.	9	10	10	10	10
per 100 km highway	n.d.	n.d.	0.05	0.05	0.05	0.15
Number of FCEVs	59	229	431	630	817	1,203
Vehicle per filling station (average)	n.d.	n.d.	12.3	16.2	20.9	9.5

The network of H2 infrastructure is concentration in a small number of MS. More than half of the H2 filling stations in 2019 (60%) were located in Germany (76), followed by France (14). In relative terms, Denmark has the most refuelling stations (1.7 per million population). In total, only 10 MS had at least one filling station in operation at the end of 2019. Most common types of hydrogen refuelling stations are the high pressure (700 bar) stations for road vehicles (108 according to EAFO). At EU level, the number of refuelling stations remained fairly constant until 2019 where there was threefold increase, with over 70% of new refuelling stations deployed in Germany.

Figure 29: Hydrogen infrastructure in MS that have at least one refilling station, by Member State and million population (2019)

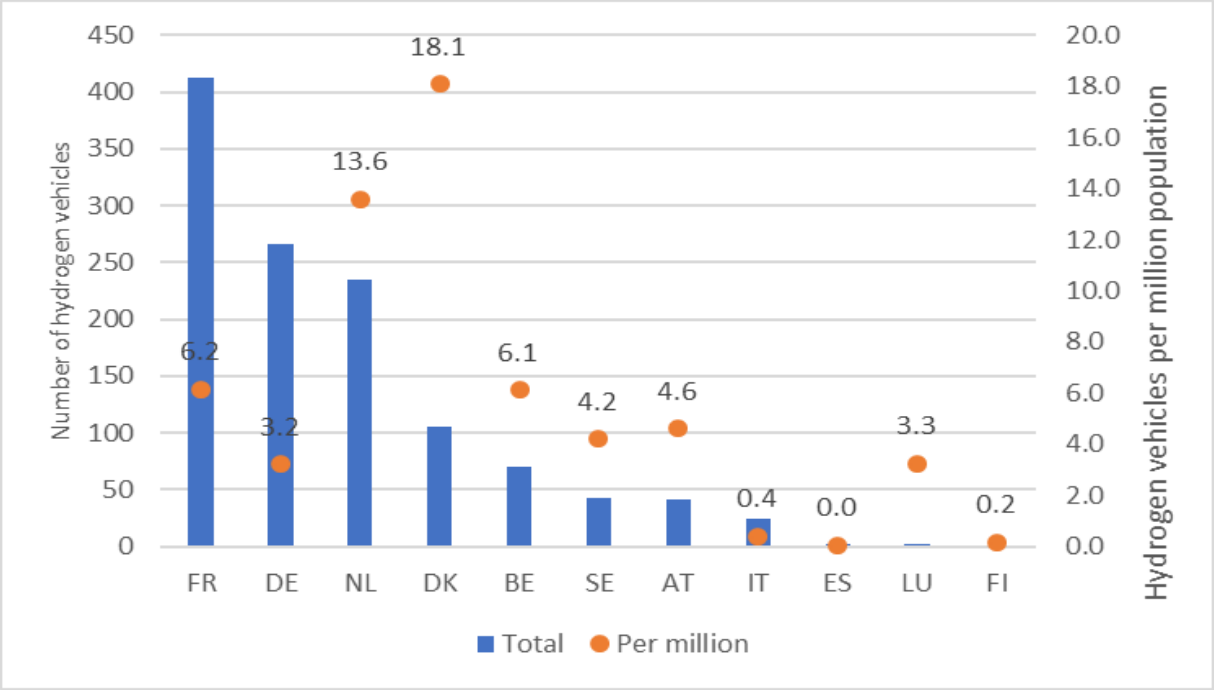


Source: EAFO

The number of hydrogen vehicles has seen a steadier increase at EU level since 2014. In total, 11 countries had registered hydrogen vehicles in 2019, compared to 7 Member States in 2015. At the end of 2019, France had the greatest number of hydrogen vehicles (413) followed by Germany (266). Adjusting for population, Denmark and Netherlands

have the most hydrogen vehicles with 18.1 and 13.6 vehicles per million population, respectively.

Figure 30: Hydrogen infrastructure in MS with at least one hydrogen vehicle, by Member State and million population (2019)



Source: EAFO

4.2 Hydrogen for waterborne transport

In recent years, there has been early adoption of hydrogen for waterborne transport, although the number of vessels powered by hydrogen is still extremely low. For maritime transport, there are three hydrogen vessels in operation and on order. In addition, the Commission funded a retrofit of an inland freight vessel, which features a diesel-electric powertrain and can be powered by hydrogen. In terms of infrastructure, there is no data to report on.

5. OTHER FUELS

5.1 LPG

In terms of infrastructure and vehicles, LPG was established as a fuel for road transport before the adoption of the AFID. There was a total of 8 million LPG vehicles in 2019, up from 7.3 in 2014 and the number of filling stations also increased along similar lines. However, year on year increase of LPG vehicles has decreased, with the number of new registrations of LPG vehicles representing only 0.9% in 2020 of total vehicle registrations, down from 3.5% in 2014.

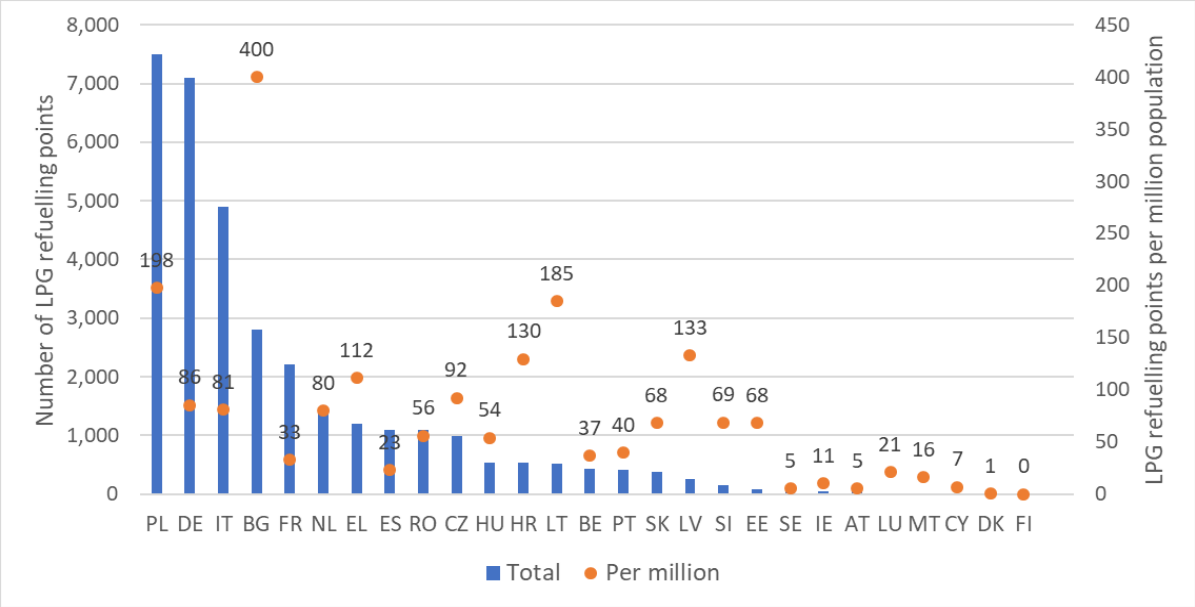
Table 9: Evolution of LPG vehicles and fuelling infrastructure for road transport in EU27 by type

Indicator	2014	2015	2016	2017	2018	2019
Number of filling stations	29,343	29,733	29,969	31,174	32,196	33,724
Number of MS with stations	25	25	25	25	26	26
per 100 km highway	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Number of vehicles	7,282,036	7,607,215	7,737,726	7,847,447	7,936,844	8,011,479
% share of new M1 registrations	1.9%	1.9%	1.8%	2.0%	1.3%	1.5%
Vehicle per filling station (average)	248.2	255.9	258.2	251.7	246.5	237.6

Source: EAFO

At national level, LPG refuelling stations are present in all Member States but Finland. Poland, Germany, Italy, Bulgaria and France are the countries with higher number of LPG fuelling stations and Bulgaria has the highest number when adjusting for population. However, while the overall number of refuelling points has increased in the EU from 2015 to 2019, several Member States that have reduced the number of refuelling points in this period, including Bulgaria, Romania, Czech Republic and the Netherlands.

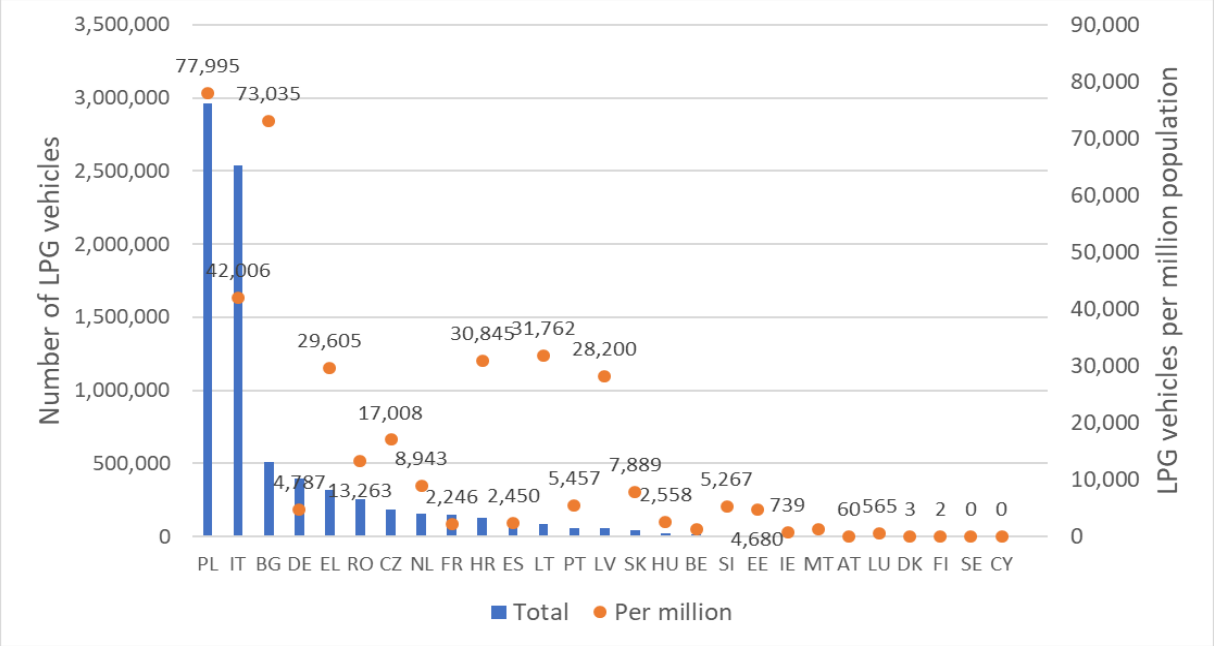
Figure 31: LPG infrastructure in EU27 by Member State, type and million population (2019)



Source: EAFO

In terms of vehicles, at the end of 2019, Poland and Italy had the greatest LPG vehicle stock, accounting for almost 70% of all LPG vehicles in the EU. Since 2015, Italy has seen the greatest increase in the number of vehicles, while Poland's LPG fleet has reduced. Romania, Spain and Greece have also seen a large increase in the vehicle number during this period but in almost half of the Member States there has been a reduction to the LPG vehicle fleet.

Figure 32: LPG vehicles in EU27 by Member State, type and million population (2019)

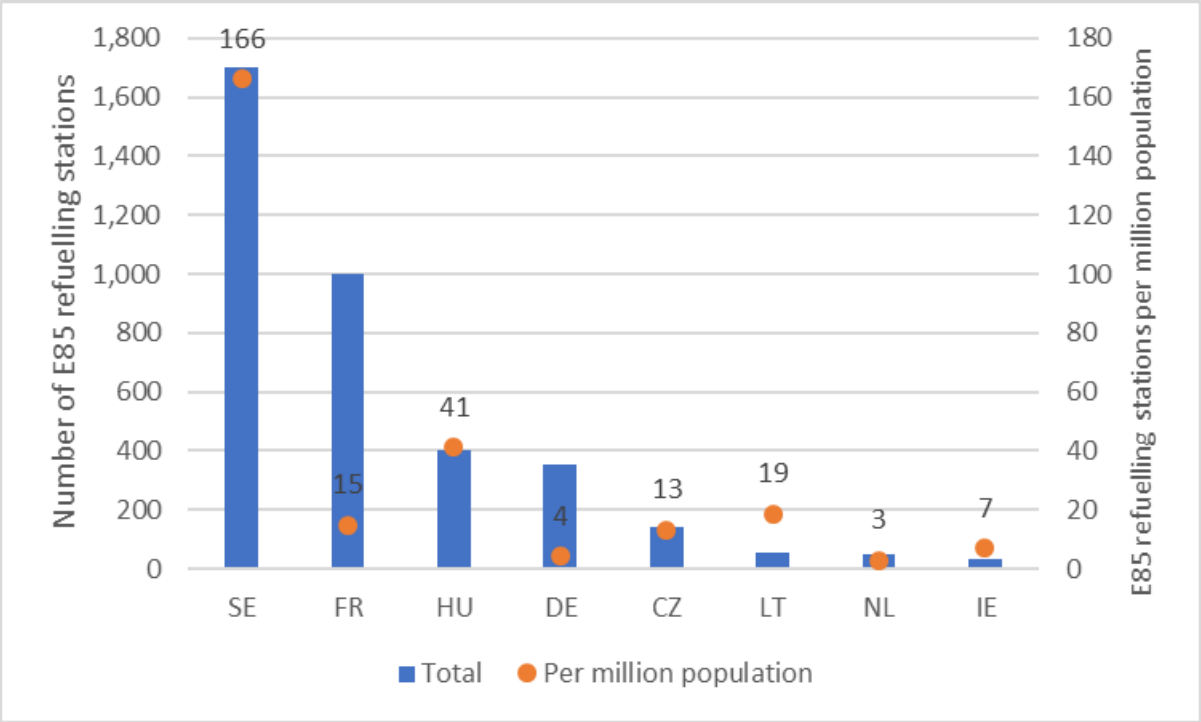


Source: EAFO

5.2 Biofuels

Data on the use of biofuels in transport are sparse and infrequently reported. Low blend bioethanol (e.g. E5, E10) is supported by traditional refuelling infrastructure, thus is widely available across the EU. However, high bioethanol blends (e.g. E85, E100) require adaptations to refuelling infrastructure, which has led to a more fragmented market, with some countries (e.g. Sweden) showing a clear preference for their use. Of the high blend bio-gasolines, E85 is the most prominent and is available in 8 Member States, according to EAFO. Sweden has the greatest number of E85 refilling stations (1700), followed by France (1000) and Hungary (403). There is an emerging market for ED95 in Finland, France and Sweden, although no specific data on the number of equipped refuelling points is available. In terms of biodiesel, there are 9 refuelling stations available for rapeseed methyl ester (European Commission, 2020).

Figure 33: E85 refuelling points in EU27 by Member State and per million population



Source: EAFO