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POLICY PAPER

# European launch vision for Electric Road Systems

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## European launch vision for Electric Road Systems

Electric Road Systems can become a key instrument to decarbonize the road transport sector in Europe. Only a European, interoperable implementation approach can exploit ERS' full potential. The following paper illustrates which impact EU legislation has on ERS, which barriers Member States face in regard to ERS and outlines a launch vision based on national strategies, policies and EU requirements.

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# Glossary

# Glossary

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| **AFID** | Alternative Fuels Infrastructure Directive:<br><br>Each EU Member State was requested to submit a National Policy Framework (NPF) and also National Implementation Reports (NIR) for alternative infrastructures and vehicles, which serve as the data basis for the report AFID Implementation report. |
| **BEV** | Battery electric vehicle are electric cars powered by rechargeable battery packs, with no secondary source of power. They plug into an electricity source to recharge. |
| **Biofuels** | Fuels that are produced over a short time span from biomass. |
| **CEF** | Connecting Europe Facility for Transport is the funding instrument to realise European transport infrastructure policy. It aims at supporting investments in building new transport infrastructure in Europe or rehabilitating and upgrading the existing one. |
| **CNG** | Compressed natural gas is a fuel gas mainly composed of methane. |
| **EU Directive** | A "directive" is a legislative act that sets out a goal that all EU countries must achieve. However, it is up to the individual countries to devise their own laws on how to reach these goals. |
| **EV** | Electric vehicles (also battery electric vehicles (BEVs)), have an electric motor instead of an internal combustion engine. |
| **ESR** | Effort Sharing Regulation. |
| **ERS** | Electric Road System(s) enable dynamic power supply to vehicles while driving. They comprise catenaries, conductor rails and inductive systems. |
| **ERS-BEV** | Battery electric vehicles with the technical components to use ERS. |
| **ETS** | Emissions Trading System: Process of buying and selling permits and credits that allow the permit holder to emit carbon dioxide. |
| **FCEV** | Fuel cell electric vehicle use electricity to power an electric motor. In contrast to other electric vehicles, FCEVs produce electricity using a fuel cell powered by hydrogen. |
| **GDP** | Gross domestic product is a monetary measure of the market value of all the final goods and services produced and sold in a specific time period by countries. |
| **GHG** | Greenhouse Gas. |
| **HDV** | Heavy Duty Vehicle. |
| **HGV** | Heavy Goods Vehicle. |
| **HEV** | Hybrid electric vehicles comes with both a traditional combustion engine and a battery. |
| **Ktoe** | Kilotonne of oil equivalent. A tonne of oil equivalent (toe) is a unit of energy defined as the amount of energy released by burning one tonne of crude oil. |
| **LEV** | Low Emission Vehicle does emit less pollutants than a vehicle with a traditional combustion engine. |
| **LNG** | Liquefied natural gas is natural gas (predominantly methane. |
| **MCS** | Megawatt Charging System. |
| **NAP** | National Action Plan. |
| **NIR** | National Implementation Report. |
| **NPF** | National Policy Framework. |
| **PHEV** | Plug in Hybrid Electric Vehicle comes with both a traditional combustion engine and a battery. |
| **RED** | Renewable Energy Directive. |
| **EU Regulation** | A "regulation" is a binding legislative act. It must be applied in its entirety across the EU. |
| **RES** | Renewable Energy Sources, e.g. Solar, Wind or Geothermal Energy. |
| **STF** | Sustainable Transport Forum |
| **SEPU** | National Energy and Climate Plan Update (of the Czech Republic). |

| | |
|---|---|
| **TCO** | Total cost of ownership is a financial estimate intended to help buyers and owners determine the direct and indirect costs of a product. |
| **TEN-T Network** | Trans-European Transport Network (TEN-T) policy addresses the implementation and development of a Europe-wide network of roads (among others). The current TEN-T policy is based on Regulation (EU) No 1315/2013. The Core Network includes the most important connections, linking the most important nodes, and is to be completed by 2030. The Comprehensive Network covers all European regions and is to be completed by 2050. |
| **TFEC** | Total Final Energy Consumption. |
| **TFES** | Total Final Energy Supply. |
| **TRL** | Technology readiness levels are a method for estimating the maturity of technologies. |
| **WtW** | Well-to-wheel analysis is a method to quantify the impact of transportation fuels and vehicles regarding energy and climate change. |
| **ZEV** | Zero-emission vehicles do not emit any kind of pollutants. |

# Executive summary

In the context of Electric Road Systems, EU Member States can be divided into three groups: “ERS-pioneers” (e.g. Germany, Italy and France), “Second-Movers” (e.g. Austria, Netherlands) and “Observers” (e.g. Poland, Czechia and Hungary). This analysis takes a closer look at these countries while exemplary focusing on Poland, Czechia and Hungary (hereinafter referred to as the "focus countries").

ERS are dependent on sustainably produced electricity. The climate impact of electricity-powered trucks is invalidated if the electricity is generated from fossil fuels. The transition from conventional energy to renewable energy sources is accompanied by challenges in the electricity grid sector. According to the authors of this paper, Electricity-based drives, in particular ERS and fast charging (Megawatt charging System (MCS), are the most promising approach to decarbonize the road-based heavy duty transport sector in Europe. The initiation of ERS infrastructure expansion by the private sector will not take place. Therefore, Member States have to take technology path decisions if ERS are to be deployed on a larger scale in Europe. According to its national strategy, Germany will take its path decision concerning overhead catenary systems between the years 2024 and 2026.

The legal analysis shows that the Emission Trading System II (EU-ETS II), the Effort Sharing Regulation (ESR), the Regulation regarding $CO_2$ standards for heavy-duty vehicles and the Renewable Energy Directive (RED II/III) support the decarbonization process of the transport sector in general. They do not focus on ERS in particular. However, once path decisions towards ERS are taken by Member States, EU instruments, e.g. funding mechanism can be utilized in order to support ERS in particular. The Alternative Fuels Infrastructure Regulation poses the most relevant legal act for ERS in the near future. The EU negotiations’ outcome will set a review process in motion (by 2024 or 2026) marking a significant milestone for ERS.

The policy analysis exemplary focuses on Poland, Czechia and Hungary (“Focus countries”) and illustrates that these countries, regarding heavy duty transport, only formulated vague decarbonization visions so far in which ERS play a minor role. However, due to significant shares in the TEN-T Core Network and a high number of resident logistics companies, it is particularly important to closely include the focus countries in ERS decision processes. Security of supply and economic growth as primary national goals are perceived as largely incompatible with decarbonisation in these countries. Therefore, EU-legislation is the main instrument to decarbonize the transport sector in the focus countries. Also, an ERS-stakeholder forum should be implemented on EU level to coordinate ERS activities and prepare the next AFIR review process.

- The best case scenario, in which all Member States start scaling up ERS simultaneously, is not likely to occur. Instead, it is more likely that ERS will be implemented gradually on a larger scale within Europe.

- Especially observer countries are not likely to agree on strict ERS deployment requirements as they exist e.g. for charging points in the AFIR.

- National commitment and coordination play a major role in the deployment of ERS. Member States and ERS-stakeholders should organize themselves on a regular basis on EU level before the AFIR review process is initiated. In this regard, EU institutions should provide a platform for ERS-stakeholders and support ERS by increasing its acceptance and encouraging an understanding between Member States which ERS-technology should be deployed for long-haul road transport.

- The German and French technology path decisions are especially relevant since Second Mover-countries will only decide on ERS if at least one larger Member State is opting for ERS in the first place. In this regard, AFIR functions as an instrument to declaratively codify the Member States’ political will to deploy ERS on a larger scale and to provide planning security for Second Movers and Observers.

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# Introduction

# 1 Introduction

## 1.1 Aim of the Study

The severe impacts of climate change and its risks must be mitigated worldwide. Policy frameworks, such as the "Fit for 55" package in the EU, support a rapid transformation and decarbonization of all economy sectors. Emissions from the transport sector have been stagnating in the EU for many decades.[1] Road based heavy goods transport poses a challenge in this regard. Efficient and quickly applicable solutions are thus necessary, especially for heavy duty vehicles (HDVs). Electric Road Systems (ERS) can be part of the solution, as they are economically efficient and sustainable, especially in combination with battery solutions.[2]

As many logistic providers operate across borders, it is particularly important that a cross-border infrastructure network is set up to ensure seamless operations. Therefore, the focus concerning these use-cases lies on the most frequented highway routes on the Trans-European Transport Network (TEN-T) on which the majority of HDV traffic is circulating.[3] However, the market ramp-up of new, transformative technologies forms a sensitive phase, as both publicly accessible infrastructure and matching vehicles must be developed.

The political path decision towards a large-scale deployment of ERS has not been made yet – neither on an European, nor on a national level. While some Member States have been researching and/or demonstrating ERS technology for years or play an important role in the decision process (Sweden/Germany/Italy, France - hereinafter ERS-pioneers), some Member States are conducting first feasibility studies by now but will likely wait for ERS-pioneers to take a decision (e.g. Netherlands, Austria) (hereinafter "Second-Movers"). At the time being, most Member States act as "Observers" regarding ERS technologies. This analysis takes a closer look at these countries while exemplary focusing on Poland, Czechia and Hungary (hereinafter referred to as the „focus countries").

**This paper intends to**

- **show the impact of European Law on the implementation process of ERS,**
- **analyse Energy and Mobility Policies of the focus countries in order to identify further potential for the sustainable operation of ERS and to**
- **outline an European decision and introduction scenario for ERS.**

## 1.2 Structure and Method

First, three preliminary considerations are made: General information on the relationship between renewable energy sources and power grids is provided (2.1), the paper's premise that electrification via a combination of charging points and ERS constitutes the most effective and fastest option to decarbonise heavy duty transport is defined (2.2) and the importance of a political path decision for the heavy duty transport sector and ERS is illustrated (2.3).

The legal examination analyses several EU legal acts and their (potential) impact on the decarbonisation of the road transport sector and ERS (3).

In the policy analysis (4), the previous design of the Energy and Mobility policies of the focus countries is examined and contextualized within the framework of a qualitative content analysis. In particular, scientific studies, official documents on the decarbonization strategies and current newspapers are analyzed. A special focus lies on the AFID Implementation Report, in which EU Member States presented their goals and methods for decarbonizing the transport sector. Furthermore, an interview with a representative of the Ministry of Transport of Czechia is analyzed. A policy cycle visualizes the policy adopting process concerning ERS.

Finally, the information from the legal and policy analysis will be translated into an ERS deployment scenario/timeline (5). The conclusion sums up the papers findings in two main assumptions (6). Furthermore, the authors hosted a consecutive meeting of the European Networking Group on ERS in June 2022 in Berlin, where different ERS related topics were discussed with international stakeholders. Findings deriving from the meeting were also incorporated into the paper. The next meeting of the European Networking Group on ERS will take place in 2023.

1 European Energy Agency, 'GHG Emissions by Sector in the EU-28', 2018, https://www.eea.europa.eu/data-and-maps/daviz/ghg-emissions-by-sector-in#tab-chart_1.

2 Patrick Plötz et al., 'Infrastruktur für Elektro-Lkw im Fernverkehr', 2021, https://www.ifeu.de/fileadmin/uploads/BOLD_Truck_charging_discussion_paper.pdf.

3 Simon Suzan and Lucien Mathieu, 'Unlocking Electric Trucking in the EU: Recharging along Highways. Electrification of Long-Haul Trucks' (Brüssel: Transport & Environment, 2021), https://www.transportenvironment.org/wp-content/uploads/2021/07/202102_pathways_report_final.pdf.

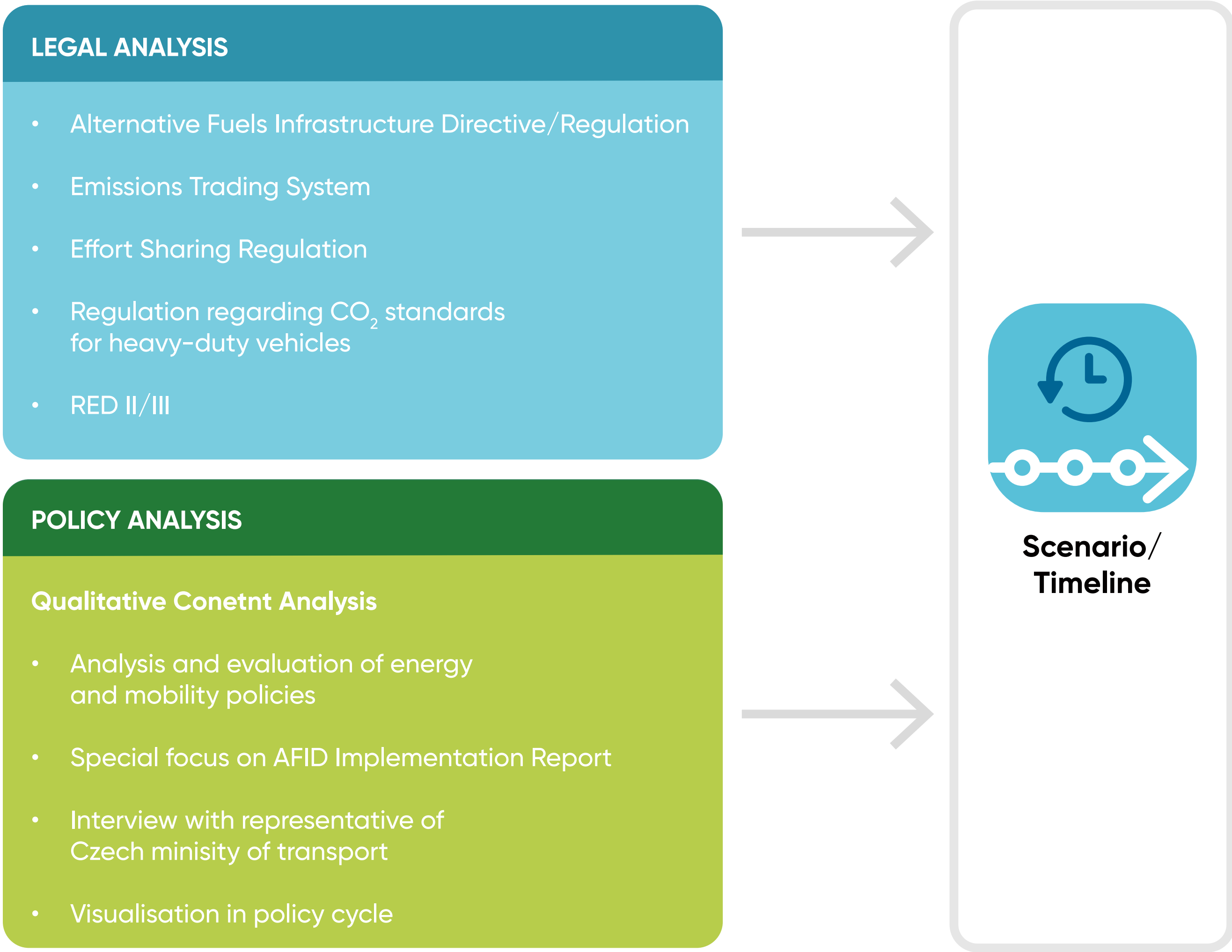


*Figure 1 - Thematic structure of the analysis. Source: Own Depiction.*

02

# Preliminary considerations

# 2 Preliminary considerations

ERS are dependent on sustainably produced electricity. The climate impact of electricity-powered trucks is invalidated if the electricity is generated from fossil fuels. The transition from conventional energy to renewable energy sources is accompanied by challenges concerning the electricity grid. A combination of ERS and fast charging systems (e.g. MCS) is considered to be the most promising approach to decarbonize the road-based heavy goods transport sector in comparison with hydrogen-based drives and biofuels. According to its national strategy, Germany will take its path decision concerning overhead catenary systems (ERS-technology) between the years 2024 and 2026.

## 2.1 Renewable energy sources (RES) and power grid

As a potential building block of future decarbonization concepts, ERS are dependent on sustainably produced electricity. Ultimately, the climate impact of electricity-powered trucks is invalidated if the electricity is generated from fossil fuels. However, the transition from conventional energy to RES is accompanied by enormous challenges, especially in the electricity grid sector.

The transformation of the energy sector is therefore complex. In addition to the mere construction of PV and wind units, the electricity grid must also be expanded and adapted. Modern, digital control systems must be developed and implemented, installations for sector coupling must be built on a large scale and further storage options must be taken into account. A transformation of this scale requires tremendous investments.

## 2.2 Alternative fuels in heavy-duty transport

In the following, an overview of different alternative fuels for heavy commercial vehicles will be given. The most relevant fuels for this study include hydrogen-based drives, especially fuel cell electric vehicles (FCEV) and electricity-based drives such as ERS and fast charging systems like megawatt charging (MWC). The particular relevance of a gapless European infrastructure must be pointed out here. On the one hand, continuous infrastructure coverage is particularly relevant for logistics companies operating cross-border; on the other hand, a particularly large market also offers economies of scale through mass production, which significantly increases the economic viability of alternative drives.

### 2.2.1 Hydrogen

Green hydrogen is produced using an electrolysis process with sustainably produced electricity and is therefore climate neutral. There are many other ways of producing hydrogen[4] that are less or not at all sustainable. Green hydrogen from electrolysis production used as fuel is currently comparably expensive and energy inefficient. A large share of energy is lost during production, transport and use of hydrogen, so that Fuel Cell Electric Vehicles (FCEV) only achieve a Well-to-Wheel (WtW) efficiency[5] of approx. 30%.[6] Various experts conclude that the total cost of ownership (TCO) for logistics companies[7],[8],[9], the infrastructure costs[10],[11] and the GHG abatement costs are disadvantageous or not advantageous compared to direct electricity use. This is particularly noticeable in GHG abatement costs, which are estimated to be almost 3 times higher than for electric drives.[12] With TRL 6-7, the fuel cell-powered truck can be considered operational in the foreseeable future. However, it is

4 Marcus Newborough and Graham Cooley, 'Developments in the Global Hydrogen Market: The Spectrum of Hydrogen Colours', 2020, https://www.magonlinelibrary.com/doi/abs/10.1016/S1464-2859%2820%2930546-0.

5 WtW-efficiency is the overall efficiency from the extraction process of resources to the utilisation in kinetic energy in the vehicle.

6 M. Prussi et al., 'JEC Well-To-Wheels Report', in JRC Science for Policy Report, 5th ed. (EU Science Hub, 2020), 89–90, https://www.concawe.eu/wp-content/uploads/jec_wtw_v5_121213_final.pdf.

7 Julius Jöhrens et al., 'Roadmap OH-Lkw: Einführungsszenarien 2020-2030', 2020, 31, 83–85.

8 Martin Wietschel et al., 'Machbarkeitsstudie zur Ermittlung der Potentiale des Hybrid-Oberleitungs-Lkw', 2017, 91–92, 141–42, 160–64, https://www.bmvi.de/SharedDocs/DE/Anlage/G/MKS/studie-potentiale-hybridoberleitungs-lkw.pdf?__blob=publicationFile.

9 Florian Hacker et al., 'StratON Bewertung Und Einführungsstrategien Für Oberleitungsgebundene Schwere Nutzfahrzeuge', Endbericht (Berlin: Öko-Institut, HS Heilbronn, Fraunhofer IAO, Intraplan Consult GmbH, February 2020), 150–57, 170–71, https://www.oeko.de/fileadmin/oekodoc/StratON-O-Lkw-Endbericht.pdf.

10 Philipp Rose, Martin Wietschel, and Till Gnann, 'Wie Könnte Ein Tankstellenaufbau Für Brennstoffzellen-Lkw in Deutschland Aussehen?', Working Paper Sustainability and Innovation (Karlsruhe: Fraunhofer ISI, 2020), https://www.econstor.eu/bitstream/10419/225286/1/1735638625.pdf.

11 Plötz et al., 'Infrastruktur für Elektro-Lkw im Fernverkehr'.

12 NPM, 'Werkstattbericht Antriebswechsel Nutzfahrzeuge - Wege Zur Dekarbonisierung Schwerer Lkw Mit Fokus Der Elektrifizierung', 2020, 20, https://www.plattform-zukunft-mobilitaet.de/wp-content/uploads/2020/12/NPM_AG1_Werkstattbericht_Nutzfahrzeuge.pdf.

lower than the TRL of e.g. Overhead Catenary System (Lvl 8). Since enormous supply gaps with green hydrogen were already calculated for many European countries, even when considering significant import shares, it is important to utilize efficient electrification options where they are available.[13] According to a study by Fraunhofer UMSICHT, Germany, for example, will only be able to cover approx. 14% of its Hydrogen demand by itself by 2030. The study also points out that import options are limited until 2030 and beyond, and that the energy and political conditions of promising importing countries such as Chile, Morocco or Spain would not be able to close such a supply gap, even if Germany was their only trading partner. Moreover, they show that the only realistic transport method for green hydrogen up to 2030 and beyond are heavy-duty trucks. This creates a notable transport impact and as long as supply trucks still use diesel, hydrogen also has a non-negligible carbon footprint.[14] It is further highlighted that the import potential is massively overestimated in current political framework plans. Consequently, the so-called hard-to-abate sectors such as shipping, aviation and many industries, should be supplied with green hydrogen with priority, while any electrification potential, also in heavy duty transport, should be utilized.[15] In this context, it must also be taken into account that Europe is currently strongly dependent on energy imports. The Ukraine-Russia war in particular has highlighted the disadvantages of a highly outsourced energy structure and the (cluster) risk of being tied to external suppliers and the associated potential economic losses.[16] Accordingly, the risk of additional dependency should be well considered.

### 2.2.2 Biofuels

Biofuels are derived from biomass and can be used in transport. There are different processes, which are also referred to as generations. The first generation of biofuels consists of edible food. The accompanying need for land and water use, as well as the fertilizer used in the process, drive land erosion, water use, and food prices alike. Moreover, they offer little GHG savings over fossil fuels, as they require a large amount of energy (from fossil fuels) to grow, collect and process.[17] Second generation biofuels consist of agricultural by-products or cellulosic materials, such as wood, leaves and grass. They can provide for a sustainable alternative on a limited scale, especially when organic waste, which is produced anyway, is used. Third-generation biofuels consist of aquatic cultivated feedstocks, mostly algae. Fourth-generation biofuels consist of bioengineered microorganisms such as algae or fungi. In general, third- and fourth-generation biofuels in particular, and with certain restrictions also second-generation biofuels, are considered sustainable. However, further research, especially on third- and fourth-generation biofuels is necessary, as no marketable, cost-effective processing methods have yet been found to extract biofuels from the respective sources.[18] Accordingly, biofuels from the second generation onwards can contribute to a sustainable mobility transition. Nevertheless, biofuels are not considered as efficient and rapid decarbonization method for the heavy-duty transport sector on a large scale.

### 2.2.3 ERS and Megawatt Charging Systems

Electric road systems enable dynamic power supply to vehicles while driving. They comprise catenaries, conductor rails and inductive systems. Catenary, conductor rail systems are characterised by high WtW-efficiency.[19] In the future, the combination of megawatt charging and ERS can be considered a cost-efficient option.[20] The Catenary System is also characterised by a high level of technical maturity and is currently classified at Technology Readiness Level 8.[21] Many studies forecast an economic advantage in TCO of ERS trucks compared to diesel trucks in the medium term of about 10 years and see it well positioned compared to other alternative drives as well, given advanced infrastructure expansion.[22], [23], [24], [25] The most frequented highway routes on the TEN-T are particularly suitable for this, as the ma-

13 Adrian Odenweller et al., 'Probabilistic Feasibility Space of Scaling up Green Hydrogen Supply', 2022, https://www.nature.com/articles/s41560-022-01097-4.

14 Bärbel Egenolf-Jonkmanns et al., 'Wasserstoffimporte - Bewertung Der Realisierbarkeit von Wasserstoffimporten Gemäß Den Zielvorgaben Der Nationalen Wasserstoffstrategie Bis Zum Jahr 2030' (Fraunhofer UMSICHT, 2021), 52–54, https://www.umsicht.fraunhofer.de/content/dam/umsicht/de/dokumente/pressemitteilungen/2021/Bereitstellung%20von%20Wasserstoff%20bis%202030.pdf.

15 Suzan and Mathieu, 'Unlocking Electric Trucking in the EU: Recharging along Highways. Electrification of Long-Haul Trucks'.

16 Mark Flanagan et al., 'How a Russian Natural Gas Cutoff Could Weigh on Europe's Economies', 2022, https://www.imf.org/en/Blogs/Articles/2022/07/19/blog-how-a-russias-natural-gas-cutoff-could-weigh-on-european-economies#:~:text=Dependence%20on%20Russia%20for%20gas,gas%20deliveries%20since%20June%202021.

17 Anwar Khan et al., 'Investigation of Biofuel as a Potential Renewable Energy Source', 2021, 3,6, https://www.mdpi.com/2073-4433/12/10/1289.

18 Khan et al., 17.

19 Prussi et al., 'JEC Well-To-Wheels Report', 89–90.

20 Plötz et al., 'Infrastruktur für Elektro-Lkw im Fernverkehr'.

21 Matthias Hartwig, Anna Bußmann-Welsch, and Michael Lehmann, 'Leitbilder für den Aufbau von elektrischen Straßensystemen in Europa', 15 October 2020, 1, https://doi.org/10.5281/ZENODO.4327277.

22 Jöhrens et al., 'Roadmap OH-Lkw: Einführungsszenarien 2020-2030', 31, 83–85.

23 Wietschel et al., 'Machbarkeitsstudie zur Ermittlung der Potentiale des Hybrid-Oberleitungs-Lkw', 91–92, 141–42, 160–64.

24 Hacker et al., 'StratON Bewertung Und Einführungsstrategien Für Oberleitungsgebundene Schwere Nutzfahrzeuge', 150–57, 170–71.

25 Hasan Huseyin Coban, Aysha Rehman, and Abdullah Mohamed, 'Analyzing the Societal Cost of Electric Roads Compared to Batteries and Oil for All Forms of Road Transport', Energies 15, no. 5 (January 2022): 1925, https://doi.org/10.3390/en15051925.

jority of HDV traffic is located there.[26] For catenary trucks it is possible to use electricity that is (temporarily) stored in a small battery to bridge sections without overhead lines, which can then be recharged while driving underneath the overhead line. Overall, technology assessments indicate that ERS-BEV have the lowest life cycle emissions of GHG among ERS-BEV, BEV, Combustion Engine Vehicles and FCEV.[27]

However, ERS are facing a lack of awareness and serious consideration as a decarbonization method among the general population and policy makers, compared to hydrogen. ERS are not as strong represented on an European level as hydrogen and many manufacturers focus their business on BEV's and Hydrogen solutions at the moment. Acceptance-studies from Germany have also shown a neutral to slightly negative attitude of the population towards the technology.[28] Nevertheless, ERS form a valuable technology that has to be considered by all Member States in order to develop comprehensive policy strategies for the transport sector.

There are several ERS pilot projects.[29] Currently, three systems of 13 km length are used in Germany by 15 trucks. The United Kingdom aims to trial a catenary system for heavy-duty trucks[30] and Sweden is planning the first permanent ERS-facility in Örebro which will cover approximately 21 km.[31] Some European countries, e.g. France[32], the Netherlands[33] and Austria[34] have commissioned studies on the economic viability and environmental impacts of electric road systems. Last October, France launched a call for tenders under the fourth Future Investment Programm (PIA-Programme d'investissement d'avenir) to begin experimenting with ERS technologies.[35]

## 2.3 Importance of a path decision – Germany

Whether Electric Road Systems will play a larger role in decarbonizing the heavy-duty transport sector in Germany and the EU, depends on political will. The initiation of ERS infrastructure expansion by the private sector is very unlikely, since it involves high risks that are unlikely to be taken by one or a few private actors under uncertain conditions. Therefore, initiatives by the state are crucial. In contrast to the heavy-duty transport sector, the electrification of private vehicles has already been decided on a national level. Within the next couple of years the numbers of charging points and electric vehicles will increase drastically in Germany according to national expansion plans.[36] Nevertheless, concerning the heavy-duty transport sector, two fundamental decisions still have to be taken: The much cited "An Overall Approach to Climate-Friendly Commercial Vehicles"[37] by the German government (hereinafter "Approach") schedules a window of opportunity for decision on a pathway concerning overhead catenary systems for HDV between the years 2024 and 2026. This means, that according to the Approach other Electric Road Technologies won't be considered for a large scale roll-out. For Hydrogen this path decision window is scheduled shortly after. BEV's as a solution for regional and long-distance operations are already decided on according to the Approach. As a preparation for the roll-out phase, Adhoc Task-Forces (including one on dynamic and stationary charging by means-of overhead catenary technology) were established. In addition, three so called "Innovationscluster"[38] were established of which two projects (one in Bavaria[39] and one in the Rhein-Main/Rhein-Neckar region[40]) are expected to equip highways with catenaries in combination with stationary charging and hydrogen refuelling stations.

26 Suzan and Mathieu, 'Unlocking Electric Trucking in the EU: Recharging along Highways. Electrification of Long-Haul Trucks'.

27 CollERS 2, Ready to go? Technology Readiness and Lifecycle Emissions of Electric Road Systems, 2022, https://electric-road-systems.eu/e-r-systems-wAssets/docs/publications/CollERS-2-Discussion-paper-1-Technology-assessment.pdf.

28 Burghard, Catenary trucks: Electric highways in Germany require broad social acceptance, 2020, https://www.isi.fraunhofer.de/content/dam/isi/dokumente/cce/2020/Policy_Brief_e_highway_oberleitung_lkw.pdf.

29 Coban, Rehman, and Mohamed, 'Analyzing the Societal Cost of Electric Roads Compared to Batteries and Oil for All Forms of Road Transport', 8–9.

30 https://www.powerelectronicsnews.com/uk-trial-to-electrify-30km-of-motorway-with-overhead-catenary- power/.

31 https://www.worldhighways.com/wh12/news/sweden-create-permanent-electric-road.

32 https://www.ecologie.gouv.fr/lautoroute-electrique.

33 'Verkenning Electric Road Systems' (Nederlande: Movares, 2022), https://open.overheid.nl/repository/ronl-850ffb2c-44a7-4122-9173-0c04c4e64bf6/1/pdf/bijlage-2-rapport-movares-electric-road-systems.pdf.

34 https://www.energyagency.at/energyroads – Study not yet published (10.10.2022).

35 https://www.techniques-ingenieur.fr/actualite/articles/la-france-souhaite-experimenter-les-systemes-de-routes-electriques-107295/.

36 The goal are 1 Million charging points until 2030.

37 BMDV, 2020, https://www.bmvi.de/SharedDocs/EN/publications/overall-approach-climate-friendly-commercial-vehicles.pdf?__blob=publicationFile.

38 https://bmdv.bund.de/SharedDocs/DE/Anlage/K/presse/104-karte-innovationscluster.pdf?__blob=publicationFile.

39 https://www.stmb.bayern.de/med/pressemitteilungen/pressearchiv/2021/177/index.php.

40 https://wirtschaft.hessen.de/Presse/Wirtschaftsminister-Al-Wazir-zum-Innovationscluster.

03

# Legal Analysis

# 3 Legal Analysis

The legal analysis shows that the Emission Trading System II (EU-ETS II), the Effort Sharing Regulation (ESR), the Regulation regarding $CO_2$ standards for heavy-duty vehicles and the Renewable Energy Directive (RED II/III) support the decarbonization process of the transport sector in general. They do not focus on ERS in particular. however, once path decisions towards ERS are taken by Member States, EU instruments, e.g. funding mechanisms, can be utilized in order to support ERS. The AFIR poses the most relevant legal act concerning ERS. The EU negotiations' outcome will set a review process in motion (by 2024 or 2026) marking a significant milestone for ERS.

The new European Climate Law sets out the EU's climate target to cut greenhouse gas emissions by at least 55% in 2030 compared to 1990 levels. In order to implement the climate goals the European Commission proposed a number of legislative revisions under the "Fit for 55" package in July 2021. EU legislation constitutes an important lever to facilitate EU-wide decarbonization of the (goods) transport sector. Even though EU law holds precedence over national law it does not lead to a situation in which contrary national law is null and void. Still, national law is not applicable as far EU law is relevant. European legal acts often represent the lowest common denominator among Member States. Nevertheless, the EU Member States are always permitted to exceed the minimum legal requirements of EU regulations.

In the following, an analysis of the EU legal framework of climate protection efforts in heavy goods road transport is carried out. Selected legal acts are evaluated with regard to their general impact on heavy goods traffic and ERS. This analysis especially focuses on the ongoing EU negotiations in regard to the Alternative Fuels Infrastructure Directive/Regulation (AFIR). Other evaluated EU policies are the Emission Trading System (EU-ETS), the Effort Sharing Regulation (ESR), the Regulation regarding $CO_2$ standards for heavy-duty vehicles and the Renewable Energy Directive (RED II/III).

Concerning ERS, several other legal acts play an important role. This paper ties in with the considerations made in the CollERS2-Discussionpaper.[41]

## 3.1 Alternative Fuels Infrastructure Directive/Regulation

As part of the "Fit for 55"-package, the Commission submitted a proposal[42] to amend the Alternative Fuels Infrastructure Directive, taking into account the development of the market for electric vehicles, in order to ensure that an additional number of recharging points accessible to the public are put in place in each Member State by 31 December 2025.

ERS are also mentioned in the proposal. However, deploying ERS is not mandatory as they are only mentioned as a potential future technology option. As such, they are mentioned in the preface: „Moreover, emerging technological developments, such as Electric Road Systems (‚ERS') have to be accounted for." They are also defined in Art. 2 of the proposal: „(…) ‚electric road system' means a physical installation along a road that allows for the transfer of electricity to an electric vehicle while the vehicle is in motion." Furthermore, ERS must be mentioned in the progress report in accordance with Art. 14 AFIR, if countries decide to establish them according to Annex I Nr. 3. Besides, AFIR supports the approach to ensure interoperability through standardization by specifying provisions for common technical specifications for ERS. Already existing common technical specifications are therefore complemented with a set of new areas for which the Commission will be entitled to adopt new delegated acts, Art. 19 in conjunction with Annex II, 1.14./1.15. Status Quo of the revision process

The counsel's general approach[43] concerning the AFIR proposal states that "by 31 December 2024, the Commission shall review the provisions of this Regulation related to heavy-duty vehicles, and, where appropriate, submit a proposal to amend this Regulation." When conducting the review, "technological and standard developments achieved by that date and those

41 Matts Andersson, 'Regulating Electric Road Systems in Europe - How Can a Deployment of ERS Be Facilitated?', 2022, https://electric-road-systems.eu/e-r-systems-wAssets/docs/publications/CollERS-2-Discussion-paper-2-Regulatory-issues.pdf.

42 The legislative procedure is launched when the European Commission submits a legislative proposal to the Council and the European Parliament. At the same time it sends the proposal to national parliaments, https://www.consilium.europa.eu/en/council-eu/decision-making/ordinary-legislative-procedure/#:~:text=The%20European%20Commission%20submits%20a,a%20conciliation%20committee%20is%20convened.

43 The Council sometimes uses a ‚general approach' to give the Parliament an idea of its position on the proposal. European Council, ed., 'Dossier Interinstitutionnel: 2021/0223(COD)', 2022, 73, https://data.consilium.europa.eu/doc/document/ST-9111-2022-INIT/x/pdf.

expected in the short term, in particular regarding […] technologies such as […] electric road systems (ERS)" […] shall be considered." The Commission's proposal only envisaged a review process for the Regulation as a whole at the end of 2026 (Art. 22). The general approach enables the launch of the interinstitutional negotiations (trilogues)[44].

In addition, the Committee on Transport and Tourism, the responsible entity within the European Parliament, proposed in particular that the review process shall take place by 31 December 2026 (Commission's original proposal) but added that, "as part of this review, the Commission shall particularly consider the technological advancement of electric road systems such as contactless inductive charging or overhead line technology and whether the deployment of such infrastructure may impact the deployment of publicly accessible recharging infrastructure and, if appropriate, any consequential adjustment is required of the charging infrastructure deployment targets of this Regulation. As part of this assessment, the Commission shall specifically consider the possibility for Member States to account electric road systems towards the achievement of the total power output targets for light commercial vehicles set out in Article 3 and for heavy commercial vehicles set out in Article 4."[45]

The upcoming trilogue will show which AFIR review timeframe is going to be adopted.

## 3.2 EU ETS Directive and Effort Sharing Regulation

### 3.2.1 Status Quo

EU climate policy consists of three columns sorted by sectors. Main instruments are the Emissions Trading System (EU-ETS) and Effort Sharing.

1. Roughly 40% of all GHG emissions generated in the EU are covered by the EU-ETS, which currently includes electricity and heat generation, energy-intensive industry, as well as air traffic in the European economic area. The ETS requires EU producers to buy allowances for their GHG emissions. The prices on the European carbon market reached for the first time the amount of €100/t of $CO_2$ in spring 2022.[46]

2. The Effort Sharing Regulation (ESR) forms the second column and establishes legally binding emission reduction targets for each EU Member State based on their economic performance for the sectors transport, buildings and agriculture.[47] The ESR legislation was adopted in 2018 to deliver a 29% reduction in emissions covered by 2030 compared to 2005.

3. (The third key EU instrument for climate action is the LULUCF Regulation[48] which establishes for the first time a target for the land use sector and creates the framework for emissions and removals from this sector.)

Currently, the sectors of the first column are exclusively addressed by an European leveled instrument (ETS), while the remaining sectors are decarbonized by measures on a national level. The ESR merely sets out targets. The Member States can decide on concrete measures to achieve them.

### 3.2.2 Revision

The "Fit for 55" package aims to translate the Green Deal goals into law. It includes also revisions of the EU ETS-Directive and the Effort Sharing Regulation.

#### 3.2.2.1 EU Emissions Trading System for Transport

The following legal analyses focuses especially on the proposal to establish an ETS for buildings and road transport. According to the proposal the new ETS is to be established as a separate self-standing system from 2025 (EU-ETS II). Entities that have to trade allowances are those who release fuels which are used for combustion in the sectors of buildings and road transport. The emissions cap for EU ETS II will be set from 2026 and decrease to reach emission reductions of 43 % in 2030 compared to 2005 for the targeted sectors.

Carbon pricing in itself cannot overcome all barriers to the deployment of low- and zero-emissions solutions in road transport. Therefore, the Effort Sharing Regulation is going to be still applicable. This means that the road transport sector will be decarbonized by the ETS II instrument as well as through national policies that are based on the ESR. Some Member States (Ger-

44 The Council, the Parliament and the Commission can organise informal interinstitutional meetings, known as ‚trilogues', to help them reach an agreement, https://www.consilium.europa.eu/en/council-eu/decision-making/ordinary-legislative-procedure/#:~:text=The%20European%20Commission%20submits%20a,a%20conciliation%20committee%20is%20convened.

45 Committee on Transport and Tourism, 'AMENDMENTS 001-274, Proposal for a Regulation (COM(2021)0559 – C9-0331/2021 – 2021/0223(COD)) - Deployment of Alternative Fuels Infrastructure - A9-0234/2022', 2022, 114, https://www.europarl.europa.eu/doceo/document/A-9-2022-0234-AM-001-274_EN.pdf.

46 Elisabeth Cornago, 'The EU Emissions Trading System after the Energy Price Spike', 2022, 2, https://www.cer.eu/sites/default/files/pbrief_ets_EC_4.4.22.pdf.

47 Caterina Salb et al., 'Klimaschutz in Zahlen (2018) – Fakten, Trends und Impulse deutscher Klimapolitik', 2018, 21.

48 Regulation (EU) 2018/841 of the European Parliament and of the Council of 30 May 2018 on the inclusion of greenhouse gas emissions and removals from land use, land use change and forestry in the 2030 climate and energy framework, and amending Regulation (EU) No 525/2013 and Decision No 529/2013/EU.

many, Sweden, Denmark and France)[49] already established national ETS for road transport and buildings that will have to be coordinated with the new EU ETS II. The focus countries don't have a national ETS for the transport sector which means that the EU ETS II gains in importance in this regard.

#### 3.2.2.2 Effort Sharing Regulation

The general objective of the ESR's revision is to contribute to the new climate ambition in a cost-effective and coherent way. To align the contribution of the sectors covered by the ESR to the new EU-wide climate targets, the Commission proposes reducing the emissions from these sectors by at least 40 % compared to 2005 levels. Targets per country range from -10 % (Bulgaria) via -17,7% (Poland), -18,7% (Hungary), -26% (Czechia) and -50 % (e.g. Germany and Sweden).[50]

### 3.2.3 Potential effects of ETS II and ESR on Electric Road Systems

The question is to what extent the new proposals concerning the EU ETS II and the ESR can support heavy goods road transport and Electric Road Systems in particular. Both legal acts can be applied as indirect levers to support new mobility technologies by specifically utilizing EU funds/national policies for this sector.

#### 3.2.3.1 Potential effects of the ETS-funding schemes

Auctioning revenues of ETS and other sources flow into different funds. If Member States consider the a roll-out of Electric Road Systems they should be able to take first steps by utilizing already existing funding and policy structures established, e.g. by the ETS. In the following, relevant current and new funding schemes of the ETS are described and analyzed in this context.

Modernization Fund: To overcome the low-carbon innovation investment gap and to address distributional effects of emission trading, the Commission proposes to increase the size of the already operating Modernization Fund by 2.5% allowances from the total quantity. The funding program supports 10 lower-income EU countries in their transition to climate neutrality by helping to modernize their energy systems and improve energy efficiency, e.g. in the transport sector.[51] The beneficiary EU countries are among others Czechia, Hungary and Poland. The fund prioritizes among other fields the modernization of energy networks, including grids. As already emphasized, also by fellow researchers from the CollERS 2-project, assumptions for total electric power demands and grid connections along European roads are a vital component in order to electrify the heavy duty transport sector, irrespectively whether of static or dynamic charging will be deployed.[52] Therefore, it would be beneficial to utilize this existing and well accepted[53] fund system by explicitly listing the modernization of electricity grids for the purpose of electrification of heavy transport as a "priority investment".

Innovation Fund: The European Commission acknowledges that innovation and development of new low-carbon technologies in the sectors of buildings and road transport are crucial for ensuring the cost-efficient contribution of these sectors to the expected emission reductions.[54] Therefore, 150 million allowances from the new EU-ETS II sectors are also added to the already existing Innovation Fund, which funds businesses, that want to invest in new technologies. To be eligible for funding as a (large-scale) demonstration project via the Innovation Fund, technologies must be sufficiently developed. Pure research and development projects or pure market launch measures are not targeted. Research and development projects are primarily funded by the Horizon Europe program and market launch measures are more eligible for CEF funding. ERS have been studied in depth in several EU Member States for more than a decade. Nevertheless, only a few Member States set up ERS-test tracks so far.[55]

49 DEHSt, 'Questions about National Emissions Trading.', 2021, 4, https://www.dehst.de/SharedDocs/downloads/EN/nehs/nEHS-10-questions-paper.pdf?__blob=publicationFile&v=4.

50 European Commission, 'COM(2021) 555 Final. 2021/0200(COD), Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL Amending Regulation (EU) 2018/842 on Binding Annual Greenhouse Gas Emission Reductions by Member States from 2021 to 2030 Contributing to Climate Action to Meet Commitments under the Paris Agreement', 2021, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2021:555:FIN Annex .

51 European Commission, 'COM(2021) 551 Final, 2021/0211 (COD), Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL Amending Directive 2003/87/EC Establishing a System for Greenhouse Gas Emission Allowance Trading within the Union, Decision (EU) 2015/1814 Concerning the Establishment and Operation of a Market Stability Reserve for the Union Greenhouse Gas Emission Trading Scheme and Regulation (EU) 2015/757', 2021, 20, https://ec.europa.eu/info/sites/default/files/revision-eu-ets_with-annex_en_0.pdf.

52 Andersson et al. CollERS 2, Regulating Electric Road Systems in Europe - How can a deployment of ERS be facilitated?, 2022, p. 6.

53 Half the beneficiary Member States decided to transfer additional allowances to the MF, demonstrating their preference for this instrument compared to solidarity or Article 10c derogation, SWD(2021) 601 final PART 4/4, p. 67.

54 European Commission, 'COM(2021) 551 Final, 2021/0211 (COD), Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL Amending Directive 2003/87/EC Establishing a System for Greenhouse Gas Emission Allowance Trading within the Union, Decision (EU) 2015/1814 Concerning the Establishment and Operation of a Market Stability Reserve for the Union Greenhouse Gas Emission Trading Scheme and Regulation (EU) 2015/757', 38.

55 E.g. Sweden, Germany and Italy.

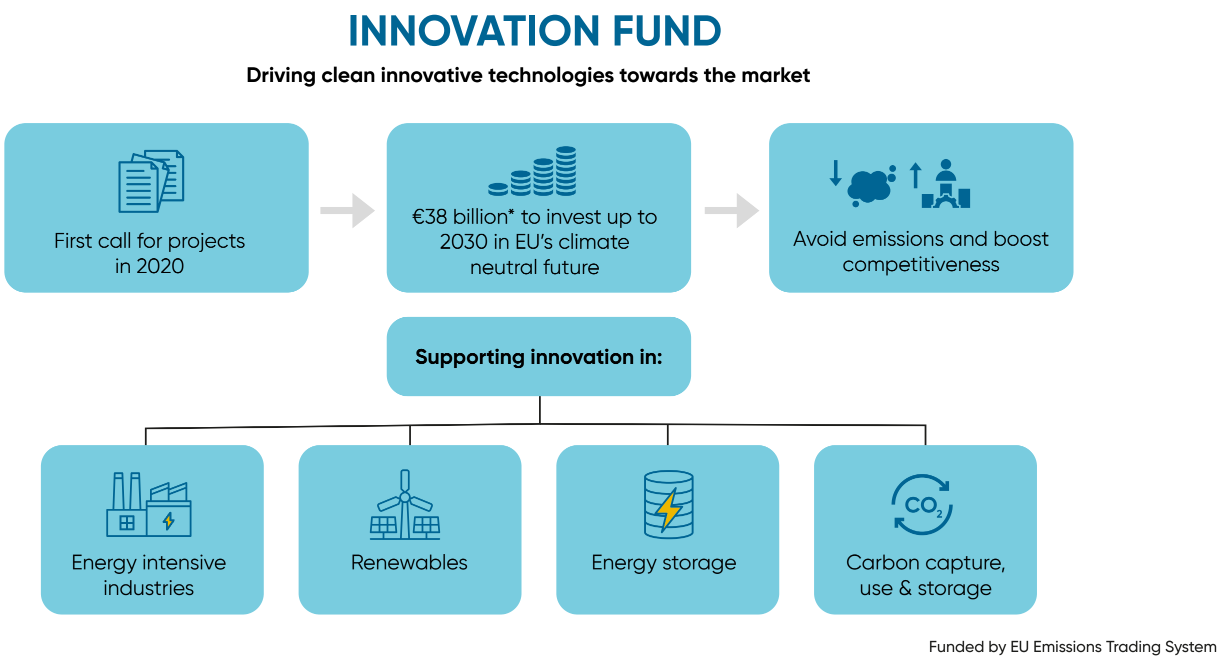


*Figure 2 - Organisation of the innovation fund. Source: European Commission*[56].

Even though the Technology Readiness Level of overhead catenary systems for road transport is already quite high (see 2.2.3), other aspects (e.g. Market Readiness Level, Member states specific aspects, operation processes[57]) might be further looked at from the perspective of Member States that haven't been engaged in ERS yet. Nevertheless, it depends on the individual project, which funding scheme (Innovation Fund, Horizon Europe or CEF) is more fitting.

### 3.2.3.2 Effects of the ESR reduction targets

In which GHG sectors Member States achieve the reductions is irrelevant, provided that the national GHG targets of the respective Member State are met in sum.[58] The sectors in which reductions are cost efficient can also vary among Member States. In the context of decarbonization technologies in heavy goods transport, and ERS in particular, Member States with a higher GDP have a greater interest in promoting decarbonization technologies in heavy goods transport at an earlier state, as their GHG saving targets are higher and they have more financial options available for implementation measures. Also, differences in the economic structure of Member States lead to different abatement costs for specific ESR sectors and thus to different preferences regarding decarbonization strategies in general. The aim is often not to select the alternative that saves the most $CO_2$, but to identify the measures that have the most favorable ratio between costs and saved ton/$CO_2$.[59] Since a climate-neutral EU is targeted by 2050, in the medium term, each Member State has to decarbonize heavy goods transport eventually. Some Member States (depending on their individual abatement costs and GDP) will most likely tackle this sector after a certain time lag compared to other states.

### 3.2.3.3 Indirect support by ESR and ETS

As shown, Member States have many liberties in their decision which projects, sectors and technologies they want to support primarily when applying for ETS funds or developing national policies according to the Effort Sharing Regulation. Therefore, those EU legal acts have no direct influence on the Member States' decision to deploy ERS. Even if ESR and ETS do not constitute direct instruments to support Electric Road Systems, they can still function as facilitating factors once the technology decision was taken and Member States want to take action. Consequently, existing funding schemes as the Modernization and Innovation Fund and the CEF Transport can serve as incentivizing tools.

56 https://climate.ec.europa.eu/eu-action/funding-climate-action/innovation-fund/what-innovation-fund_en.

57 Matts Andersson et al., 'Ready to Go? Technology Readiness and Lifecycle Emissions of Electric Road Systems.', 2022, 9, https://publica-rest.fraunhofer.de/server/api/core/bitstreams/dcc6e1c5-d73c-414e-ae54-e2c1dd4654a0/content.

58 'Implementation of the Effort Sharing Decision', accessed 14 February 2022, https://ec.europa.eu/clima/eu-action/effort-sharing-member-states-emission-targets/implementation-effort-sharing-decision_en.

59 Wissenschaftlicher Dienst des Deutschen Bundestages, 'Emissionsausstoß Und $CO_2$-Vermeidungskosten von Elektro Und Emissionsausstoß Und $CO_2$-Vermeidungskosten von Elektro- Und Plug-In-Hybrid-Auto', 2022, 15, https://www.bundestag.de/resource/blob/905894/f93a609aa329673bcdbc2daaa1f8b94d/WD-5-067-22-pdf-data.pdf.

## 3.3 $CO_2$ Emission Standards for HDV

The Regulation[60] aims to set $CO_2$ emission standards for new heavy-duty vehicles in currently most relevant HDV-classes and was introduced in 2019. The regulation requires all manufacturers of HDV fleets to emit on average 15% less $CO_2$ emissions from 2025 and 30% less from 2030. The average specific $CO_2$ emissions of a manufacturer are calculated and compared with the reference period mid-2019 to mid-2020. It should be noted that a tank-to-wheel approach and not a well-to-wheel approach is used, so that upstream emissions are not included and the carbon footprint is "better on paper" than in reality. This regulation constitutes an important supplement to the ETS II and the ESR that both target the transport sector in general but are not targeting the heavy duty road transport in particular. The Commission will initiate a review process on the effectiveness of the Regulation and report on this to the European Parliament and the Council by 2022.

In sum, the influence of the regulation may be quite significant from a pan-European perspective, but has does not target specific technologies. This poses the risk of a temporal delay in the introduction of alternative propulsion technologies in heavy goods transport, such as ERS, in different European regions. But as long Member States coordinate their ERS strategies, a certain time-delay in deploying ERS in different Member States appears manageable.

## 3.4 Renewable Energy Directive (RED)

RED II is the main EU instrument dealing with the promotion of energy from renewable sources and was adopted in 2018. The Commission's proposal for a revision of the Renewable Energy Directive (RED III) increases the renewable energy target from the current 32% to 40%. The Parliament rapporteur aims to increase the EU's renewable energy target to 45% by 2030[61]. Each Member State has  to set an obligation on fuel suppliers to ensure that the amount of renewable electricity (and renewable fuels) supplied to the transport sector leads to a greenhouse gas intensity reduction of at least 13 % by 2030.  Also, the proposal increases the ambition level for advanced biofuels to 2.2% of the transport sector's energy consumption.[62] Furthermore, it introduces new incentives for the deployment of the infrastructure needed by EVs as it requires the Member States to introduce a credit mechanism which allows charging point operators to contribute towards the reduction target.

RED III does not have a particular effect on the road transport sector or ERS. Since it promotes advanced biofuels and stationary charging, RED III could even have a negative effect on ERS at some point as a study from Sweden shows: Swedish policies aim to steadily increase the biofuel admixture in the existing fossil fuel mix until 2030 for fossil fuels. A recent Swedish analysis[63] indicates that the rapid development on BEV, primarily for local and regional operations, combined with the policy of an increased biofuel admixture can have a negative impact on the socio-economical profitability of ERS in Sweden. In the same analysis, it is deemed to be possible to achieve up to 85 % of GHG reduction in the heavy transport sector by combining stationary charging and a gradually higher share of renewable fuels in the existing fuel mix.[64] This case shows, that it is crucial to examine in time and in detail which use-cases for ERS in which Member States are most promising. ERS are especially interesting for long haul transport but can also function in e.g. shuttle operations or as a public stationary solution along highways. As fossil fuels will gradually disappear, the heavy transport sector can't rely anymore on only one propulsion solution for all trucks and use-cases.

60 REGULATION (EU) 2019/1242 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 20 June 2019 setting $CO_2$ emission performance standards for new heavy-duty vehicles and amending Regulations (EC) No 595/2009 and (EU) 2018/956 of the European Parliament and of the Council and Council Directive 96/53/EC.

61 This was also proposed by the Commission in its Communication on the REPowerEU plan (COM/2022/230 final) https://eur-lex.europa.eu/resource.html?uri=cellar:fc930f14-d7ae-11ec-a95f-01aa75ed71a1.0001.02/DOC_1&format=PDF.

62 https://ec.europa.eu/commission/presscorner/detail/en/qanda_21_3544.

63 Trafikverket, 'Regeringsuppdrag - Analysera Förutsättningar Och Planera För En Utbyggnad Av  Elvägar', 2021, http://trafikverket.diva-portal.org/smash/get/diva2:1524344/FULLTEXT01.pdf.

64 Widegren et al., CollERS 2, Ready to go? Technology Readiness and Lifecycle Emissions of Electric Road Systems, 2022, p. 3 https://electric-road-systems.eu/e-r-systems-wAssets/docs/publications/CollERS-2-Discussion-paper-1-Technology-assessment.pdf.

04

# Policy Analysis

# 4. Policy Analysis

The policy analysis exemplary focuses on Poland, Czechia and Hungary ("Focus countries") and illustrates that these countries, regarding heavy duty transport, only formulated vague decarbonization visions so far in which ERS play a minor role. However, due to significant shares in the TEN-T Core Network and a high number of resident logistics companies, it is particularly important to closely include the focus countries in ERS decision processes. Security of supply and economic growth as primary national goals are perceived as largely incompatible with decarbonisation in these countries. Therefore, EU-legislationis the main instrument to decarbonize the transport sector in the focus countries. Also, an ERS-stakeholder forum should be implemented on EU level to coordinate ERS activities and prepare the next AFIR review process.

In order to form a scenario concerning ERS that includes the focus countries, their individual energy and transport policy background has to be taken into account. The development and modification of policies will be visualised and explained within the framework of the policy cycle model. In a next step, both the energy and mobility policies of the focus countries will be analyzed. As ERS are an electricity-based technology, special attention will be paid to the electricity mix and the electricity grid in addition to a mere examination of the mobility sector. In order to do so, a qualitative content analysis will be conducted for each of the focus countries. Special focus will be put on the evaluation of the AFID Implementation Report, in which all EU Member States provide information on their decarbonization strategies in the transport sector. Furthermore, an interview with a representative of the Czech Ministry of Transport will be assessed. Finally, the policies will be evaluated.

## 4.1 Policy Cycle

Policy is defined as „(...) action implemented by the government body which has the legislative, political and financial authority to do so."[65] Stakeholders influencing policies can be manifold. The interest structure, which forms the national policy, is subdivided here into economic influence, civil society influence and supranational influence. The common policy cycle consists of six steps: 1. Problem Definition/Agenda Setting, 2. Constructing Policy Alternatives, 3. Choice of Solution, 4. Policy Design, 5. Policy Implementation and 6. Monitoring and Evaluation (Figure 10, Annex).

First, a policy issue must be considered relevant by stakeholders and placed on the government‘s agenda. The second step is to analyse which processes already exist and which alternative concepts could be used to change them. When choosing a solution in step 3, relevant factors comprise economic and social cost-benefit assessments, a fair distribution of costs and benefits, the feasibility within the current regulatory environment, and the possibility of subsequent modification. A corresponding policy approach can be formulated in step 4, implemented and monitored in step 5, and evaluated in step 6.

### 4.1.1 Supranational Influence

The supranational EU influence regarding decarbonization is reflected in the EU legislation described in Chapter 3. At the same time, different associations influence European Policy making.

In the context of ERS, the Sustainable Transport Forum (STF) is particularly relevant. The STF "was set up to assist the European Commission in implementing the Union's activities and programmes aimed at fostering the deployment of alternative fuels infrastructure to contribute to the European Union energy and climate goals. It serves as a platform for structural dialogue, exchange of technical knowledge, cooperation and coordination between EU Member States and relevant public and private stakeholders."[66] At the moment, Members of this Forum (Type C)[67] are mainly European associations or French/German companies., e.g. Alstom, Transport & Environment, European Association for Electromobility (AVERE), Hydrogen Europe or VDE. The Forum is divided into sub-groups, e.g. Sub-group on the Implementation of Directive 2014/94/EU. The European Commission is currently renewing the membership of the Forum (for members Type C) and invites interested expert-organisations to reply to this open call for applications. Up to 30 expert organisations will be selected. The deadline for applications is 15 November 2022. ERS-related stakeholder could seize this possibility now and apply. Nevertheless, ERS-stakeholder also have the possibility to become part of associations (such as AVERE) to strengthen their influence in the forum. Furthermore, a sub-group specialized on ERS seems recommendable.

As only a limited number of "Type C Members" can be accepted, STF represents more of a technical working sphere. However, ERS require a more prominent presence on EU level in general, it could be useful to additionally implement an EU Strategic Stakeholder Dialogue on Electric Road Systems. In spring 2023, Sweden (an ERS-pioneer) will hold the Presidency of the Council of the European Union for 6 months. This means that Sweden will lead the work in the Council and can place emphasis on certain topics. Sweden has been working on ERS for years. Therefore, it could be recommendable to initiate such a Strategic Stakeholder Dialogue on ERS within the Swedish presi-

65 Eóin Young and Lisa Quinn, 'Writing Effective Public Policy Papers - A Guide for Policy Advisers in Central and Eastern Europe', 2002, 7, https://www.icpolicyadvocacy.org/sites/icpa/files/downloads/writing_effective_public_policy_papers_young_quinn.pdf.

66 https://ec.europa.eu/transparency/expert-groups-register/screen/expert-groups/consult?lang=en&groupId=3321&fromMembers=true&memberType=3&memberId=58152.

67 Type C - Organisation (30), Type D - Member State Authority (27), Type E - Other public entity (6).

dency, where all ERS-stakeholder (incl. Member States representatives) could form an EU leveled forum to discuss several ERS-related issues on a regular basis. In order to place ERS as key technology within the EU, it appears to be purposive for the Member States to closely coordinate a strategy for ERS before AFIR is reviewed for the first time. Members could exchange study results and information on a regular basis, decide on a possible TEN-T ERS-network and discuss openly which ERS are suitable for which use-cases (technology decision among ERS). It would be important to include ERS-pioneers, Second Movers and Observers alike. ERS don't have the same "presence" as hydrogen on an EU level yet. Thus, a forum on EU level could give the technology a broader standing and recognition. In this regard, also European associations as the "Alliance for Logistics Innovation through Collaboration in Europe (ALICE)" and "European Logistics Association" (ELA) have to be approached and included in an EU Stakeholder Dialogue on ERS. It would be an advantage that all ERS-interested parties could take part without any participants limitations.

Additionally, observer countries should be encouraged to conduct their own investigations (e.g. (ERS-corridor-) feasibility studies[68]) whether ERS pose a valid technology for their country. Also, co-funding measures for those studies should be provided on an EU level to give the right incentives.

### 4.1.2 Economic Influence

Economic stakeholders influence policy making in different ways. Usually, companies or interest groups in economic sectors, such as trade unions, represent their point of view by lobbying policy-makers.

In the context of ERS, the manufacturers of heavy trucks who are active in the European market are particularly relevant. Their product portfolio is defined by their market expectations and at the same time forms the basis of the propulsion options available for logistics companies. Important companies in this context are MAN and Scania (both subsidiaries of Volkswagen), Daimler, DAF, IVECO and Volvo.[69] Of these, however, only Scania is involved in ERS projects and is positively associated with the technology.[70] Mercedes is focusing on MWC-BEVs and FCEVs.[71] IVECO is focusing on BEVs and FCEVs in cooperation with Hyundai and Nikola,[72] as is DAF.[73] Volvo was involved in an ERS pilot in Sweden in 2018,[74] but published a critical article about ERS and sees the technology in a niche role in 2020.[75] Siemens is building an ERS overhead line infrastructure called eHighway and is involved in related projects together with Scania.[76] Besides Siemens, Alstom has also been involved as an infrastructure manufacturer in ERS projects, such as the Swedish project with Volvo mentioned above.[77] IVECO, together with ABB and Electreon, has been involved as an infrastructure supplier in an inductive ERS pilot project in Italy, the "Arena del Futuro", which, however, is not specifically aimed at heavy trucks, but electric vehicles in general. In summary, the position of many OEMs is predominantly sceptical about ERS, and the current focus is primarily on FCEVs and BEVs for heavy-duty transport. However, some are also involved in ERS pilot projects, which implies at least a certain interest in the technology.

### 4.1.3 Civil Society Influence

Since the focus countries can be categorized as ERS observer countries, the technology remains largely unknown. In this respect, the position of civil society towards the technology cannot be examined here. In order to assess the civil society influence, an evaluation of the acceptance of the technology from other countries, such as Germany, where the technology is already more established, as well as an evaluation of the general position of civil society towards climate change in the focus countries can be insightful.

In a German study on acceptance of ERS, newspaper articles and citizen inquiries were evaluated. They found, that the media response toward the technology remained largely neutral, while the perception of locals was mostly negative. Most discussed

68 Possibly together with German partners since Germany has a special interest in the deployment of ERS in its neighbor countries.

69 Wietschel et al., 'Machbarkeitsstudie zur Ermittlung der Potentiale des Hybrid-Oberleitungs-Lkw', 225.

70 Volkswagen, 'Umweltfreundliche CO2-Bilanz, Leisere Fahrzeuge, Gutes Fahrverhalten Und Keine Abgase: Das Kontinu-ierliche Laden Auf Der Straße Birgt Ein Enormes Potenzial Für Den Güterverkehr', 2019, https://www.volkswagenag.com/de/news/stories/2019/07/electrified-highway.html.

71 Daimler Trucks, 'IAA Transportation 2022: Daimler Truck Enthüllt Batterieelektrischen Fernverkehrs-Lkw EActros LongHaul Und Erweitert E-Mobilitätsangebot', 2022, https://media.daimlertruck.com/marsMediaSite/de/instance/ko/IAA-Transportation-2022-Daimler-Truck-enthuellt-batterieelektrischen-Fernverkehrs-Lkw-eActros-LongHaul-und-erweitert-E-Mobilitaetsange-bot.xhtml

72 IT Times, 'Nikola Und IVECO Bringen Emissionsfreien Tre (BEV) LKW Auf Den Markt', 2022, https://www.it-times.de/news/nikola-und-iveco-bringen-emissionsfreien-tre-bev-lkw-auf-den-markt-145097/.

73 DAF, 'Alternative Fuels and Drivelines On the Road to Even Cleaner Road Transport', 2022, https://www.daf.com/en/about-daf/sustainability/alternative-fuels-and-drivelines.

74 Volvo Group, 'Volvo Is Planning to Build Electric Roads in Western Sweden', 2018, https://www.volvogroup.com/en/news-and-media/news/2018/sep/volvo-plans-to-build-electric-roads.html.

75 Lars Mårtensson, 'Electric Roads: A Niche Solution for Confined Areas?', 2020, https://www.volvotrucks.com/en-en/news-stories/insights/articles/2020/jul/electric-roads-a-niche-solution-for-confined-areas.html.

76 Siemens Mobility, 'EHighway – Die Elektrifizierung Des Straßengüterverkehrs', 2022, https://www.mobility.siemens.com/global/de/portfolio/strasse/ehighway.html.

77 Alstom, 'Alstom Presents APS for Road, Its Innovative Electric Road Solution', 2017, https://www.alstom.com/press-releases-news/2017/11/alstom-presents-aps-for-road-its-innovative-electric-road-solution.

and criticized were the costs, economic viability and possible competition to rail. It was also noticeable that the climate contribution was questioned. However, according to the authors of the study, the sceptical attitude could be reduced if the positive aspects of the technology are clearly communicated and future projects on larger scales operate successfully.[78]

In the context of the societal relevance of decarbonization, a Eurobarometer survey[79],[80],[81] found that Poland and Czechia, and to a lesser extent Hungary, rated climate change issues as less important than the EU average. When asked about the single most important current global problem, personal action against climate change and whether the respective national government is doing enough against climate change, Poland and Czechia were mostly 10-15% below the EU average. Hungary was mostly slightly below EU average. In addition, the topic of climate change is much less present in the Polish media and is associated with much more scepticism in European comparison.[82] However, awareness is increasing in Poland and the younger generation in particular is becoming increasingly sensitive to the subject.[83] In comparison, Czech society is more sensitive to the topic. Still, a significant proportion of the population is in favour of postponing concrete far-reaching measures and only implementing them in several years.[84] Further surveys in Hungary have shown that climate protection in Hungary is not given enough attention by politicians. The majority of the population considers it a serious problem and would welcome more commitment from companies and political stakeholders.[85]

Overall, studies on the acceptance of ERS identified a certain degree of societal scepticism. Societally, climate protection is taken comparatively seriously in Hungary and the Czech Republic. However, many Czechs are not in favour of comprehensive short-term measures. In Poland, climate change plays a lesser role and is primarily addressed by the younger generation. This societal scepticism must should be taken into account in a potential future introduction of ERS.

### 4.1.4 Adapted Policy Cycle Model

The national interest structure is formed by the individual interests described above. If the national interest structure diverges from the interest structure of other member states, a clash of interest can occur in the EU legislative process. Due to the influence of the member states in the legislative process, laws can be watered down or blocked depending on political majorities.

In the following, it will be shown that there is a conflict of interests between the climate protection targets of the EU and the focus countries. In this context, agenda setting is considered largely externally motivated and contrary to national goals such as security of supply and economic efficiency. Policy modification is therefore not necessarily aimed at effective climate protection, but at ensuring security of supply and economic efficiency while at the same time meeting minimum EU requirements. This is visualized in Figure 3. The resulting policies will be analysed in the following.

78 Uta Burghard and Aline Scherrer, 'Der eHighway aus gesellschaftlicher Perspektive', 2020, https://publica-rest.fraunhofer.de/server/api/core/bitstreams/013106a8-38d9-49c7-9a08-90d7901a83bc/content.

79 European Commission, 'Special Eurobarometer 513 - Climate Change - Poland', 2021, https://europa.eu/eurobarometer/api/deliverable/download/file?deliverableId=75890.

80 European Commission, 'Special Eurobarometer 513 - Climate Change - Czech Republic', 2021, https://europa.eu/eurobarometer/api/deliverable/download/file?deliverableId=75873.

81 European Commission, 'Special Eurobarometer 513 - Climate Change - Hungary', 2021, https://europa.eu/eurobarometer/api/deliverable/download/file?deliverableId=75882.

82 Zbigniew Kundzewicz, Rasmus Benestad, and Andrzej Ceglarz, 'Postrzeganie Zmian Klimatu i Jego Ochrony – Porównanie Polski i Norwegii, Cz.2', 2018, 2, https://naukaoklimacie.pl/aktualnosci/postrzeganie-zmian-klimatu-i-jego-ochrony-porownanie-polski-i-norwegii-cz-2-330/.

83 Next Newspaper, 'Licznik Dla Klimatu Tyka Nieubłaganie. Już Tylko 9 Lat Na Odejście Polski Od Węgla', 2021, https://next.gazeta.pl/next/7,172392,27756761,licznik-dla-klimatu-tyka-nieublaganie-juz-tylko-9-lat-na-odejscie.html.

84 Tereza Jindrova, 'Průzkum: Češi Jsou pro Ochranu Klimatu, i Když to Bude Bolet', 2021, https://www.seznamzpravy.cz/clanek/pruzkum-cesi-jsou-pro-ochranu-klimatu-i-kdyz-to-bude-bolet-169521.

85 Adam Koloszi, 'A Magyarok Nagy Többsége Szerint Sokkal Többet Kellene Foglalkozni a Klímaváltozással', 2019, https://index.hu/techtud/2019/09/16/klimatudatossag_szorongas_klimavaltozas_indexes_kerdoiv_zavecz_kozvelemeny-kutatas/.

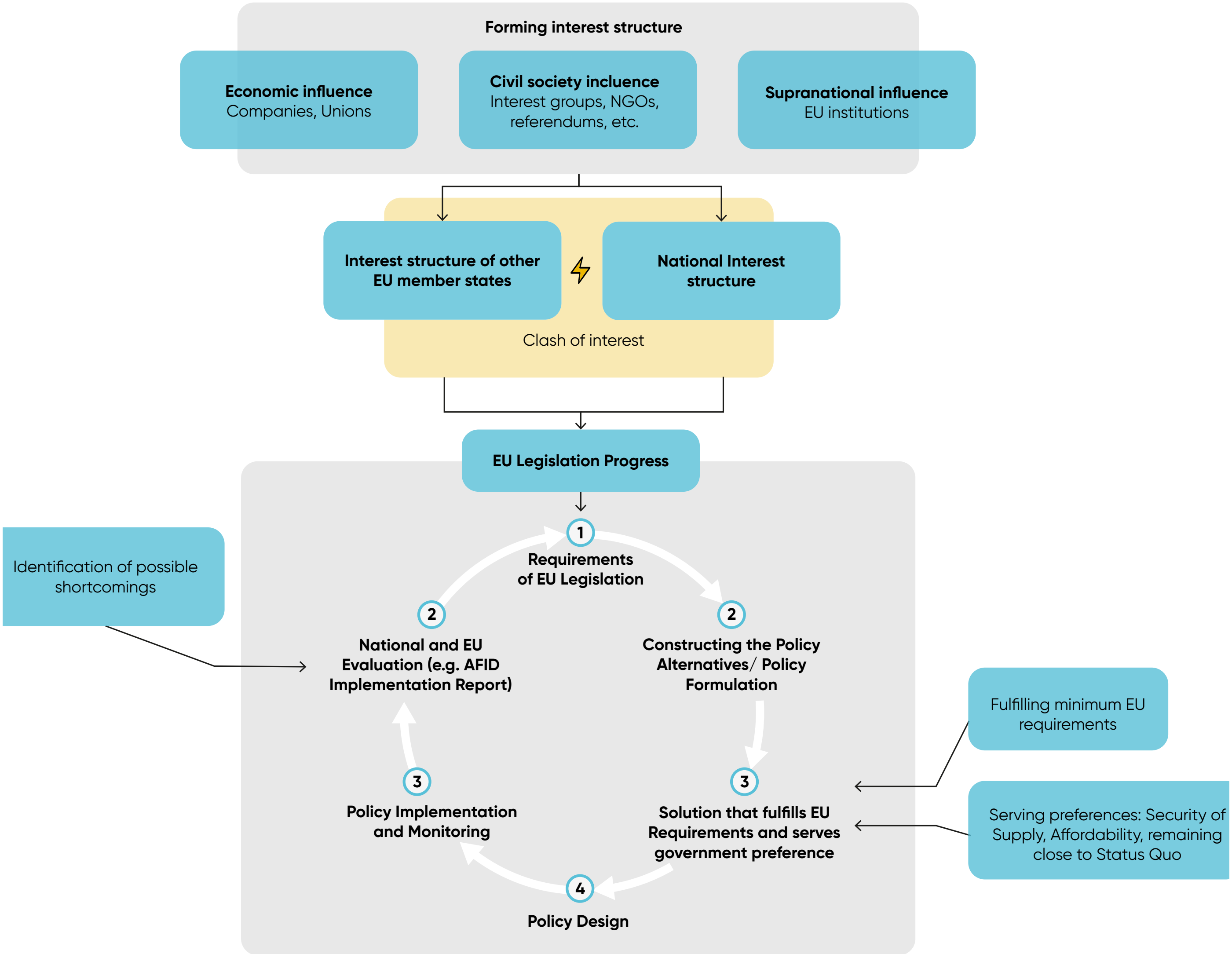


*Figure 3 - Modified Version of the Policy Cycle - Clash of Interest in EU Legislation. Bold: Changes made to the policy cycle regarding the specific case. Source: Own Depiction.*

## 4.2 Energy and Mobility Policies of the focus countries

In this chapter, the policy frameworks of the focus countries are examined with reference to the energy and mobility transition and ERS. This enables an assessment of barriers and starting points for future decarbonization methods, such as the introduction of ERS.

### 4.2.1 Poland

**8.5%** Share of EU Population

**10.5%** Share of EU GHG Emissions

**17.7%** ESR GHG reduction target 2030 vs. 2005

| | | |
|---|---|---|
| ENERGY | **2019** RES TFEC Share: | **16%** |
| | **2030** RES Target Share: | **21-23%** |
| | **2019** Primary electricity generation source: | **Coal** (80%) |
| | **2030** Planned primary electricity generation source: | **Nuclear** (37.5-56%) |
| TRANSPORT | Transport emission share as % of total emissions: | **17%** |
| | Transport emission increase 2005-2019: | **84%** |
| | Transport emission reduction target 2030 vs. 2005: | **37.5%** for new cars<br>**31%** for new vans |
| | RES share in fuels: | **7.5%** in 2020 |
| | Primary RES in transport: | **Biofuels** (92%) |
| | 2030 planned primary RES in transport: | **14%** |
| | ERS mentioned in mobility strategy: | **No** |

In the context of polish energy policy, a RES share of 21-23% by 2030 is foreseen.[86] A summary of the projected renewable energy consumption by sector until 2040 can be found in Figure 4. The remarkably low share of renewable energies in the transport sector (in grey) is particularly striking.

In this context, the historically important role of the coal sector should be mentioned, which is still responsible for almost 100,000 jobs in the country and is seen as a central solution for energy security, especially against the background of Russian oil and gas imports prior to the Ukraine war. This is also reflected in the electricity sector, where about 80% of electricity was generated by coal in 2021. Energy security is generally a high priority for the Polish government, both at national and EU level. Since a high number of coal companies are also (partly) state-owned, there are close ties to politics. The historically strong trade unions in the sector are an influential political interest group.[87] In addition, the strong position of the government in the Polish political system has a strong influence on the political agenda. In this respect, one aspect of Polish energy policy against the background of increasing decarbonisation targets is reducing the reliance on coal. "However, a large amount of financial support is given to the coal sector, for both mining and generation. Analysis from the European Commission and the OECD show that Poland's fossil fuel sub-sidies have increased substantially and are approaching EUR 1.8 billion per year, with most of them going to coal."[88]

Regarding the transport sector, Poland is obliged by EU regulations to reduce transport emissions by 14%[89] by 2030.[90] To achieve these targets, primarily biofuels and electromobility are mentioned, whereby electromobility only refers to passenger cars, buses and vans.[91] There are no precise quantified plans for the decarbonisation of heavy goods transport.

86 European Commission, 'Executive Summary of Poland´s National Energy and Climate Plan for the Years 2021-2030', 2020, https://energy.ec.europa.eu/system/files/2020-01/pl_final_necp_summary_en_0.pdf.

87 Julian Schwartzkopff and Sabine Schulz, 'Climate & Energy Snapshot: Poland - The Political Economy of the Low-Carbon Transition', 2017, 2, https://www.jstor.org/stable/resrep17776#metadata_info_tab_contents.

88 International Energy Agency, 'Poland 2022 - Energy Policy Review', 13.

89 It is likely that this number will have to be increased in order to support the EU-wide 55% reduction target.

90 Polish Ministry of Climate and Environment, 'Energy Policy of Poland until 2040', 2021, https://www.gov.pl/attachment/b1febd0c-e544-412d-a0d7-f6bff01707c1.

91 Beside EU funds, national funds exist for this area, including the Law on electro-mobility and the Low Emission Fund.

Regarding electrification, this is reflected in both the plans for the expansion of charging infrastructure[92] and EV rollout,[93] which focus on passenger cars and correspondingly lower charging capacities. However, the special relevance of the economic efficiency of vehicles and in particular cost parity with fossil drives are pointed out. For heavy duty transport, hydrogen is envisaged as a solution. "The Polish Hydrogen strategy (...) includes targets for 32 hydrogen fuelling stations and 250 hydrogen buses by 2025; 1 000 hydrogen buses by 2030; and goals for the use of hydrogen or hydrogen based synthetic fuels in heavy trucks, trains, ships and aviation."[94] This is also described in the NECP, which refers to the relevance of developing fuel cells as a transport solution.[95]

According to SRT2030, electrification in line with AFID goals as well as creating a "network of stations for charging or replacing electric batteries, and refueling with natural gas and hydrogen where cost efficiency is achieved" is foreseen.[96] EV-take-up and RES expansion significantly accelerated in 2021 due to national and EU regulatory changes, financial incentives and increased acceptance of EVs by Polish companies. However, “the share of EVs in all new registrations is only at around 4% compared to more than 15% across the EU. The government still lacks a comprehensive strategy for decarbonisation and electrification of the transport sector [...]”.[97]

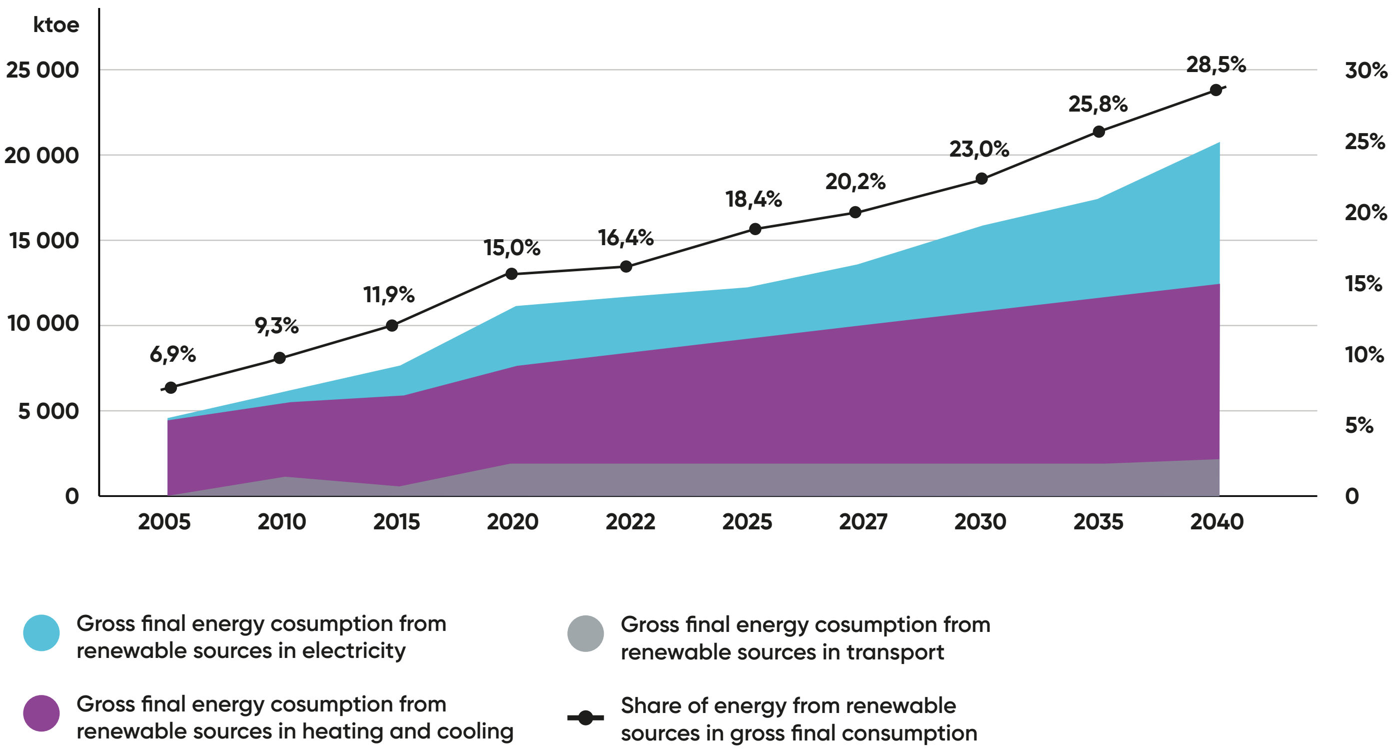


*Figure 4 - Projection of gross final energy consumption from RES in Poland by sector. Source: Polish NECP.*[98]

92 International Energy Agency, ‘Poland 2022 - Energy Policy Review’, 62.

93 Polish Ministry of Energy, ‘Electromobility Development Plan in Poland’, 2017, 18, https://climate-laws.org/geographies/poland/policies/electromobility-development-plan.

94 Polish Ministry of Climate and Environment, ‘Energy Policy of Poland until 2040’, 63.

95 Polish Ministry of Climate and Environment, ‘The National Energy and Climate Plan for 2021-2030 - Objectives and Targets, and Policies and Measures’, 2019, 34, https://energy.ec.europa.eu/system/files/2020-08/pl_final_necp_part_1_3_en_0.pdf.

96 Polish Ministry of Climate and Environment, ‘Sustainable Transport Development Strategy to 2030’, n.d., 148, https://www.gov.pl/attachment/8ca82ea2-ddf5-4cff-8bfc-b7d7bfb1237b. This document exists only in polish and was translated to English. The original page in the polish version might thus differ.

97 Rafal Bajczuk, ‘Polish Market for EVs Is Quickly Catching up with the Rest of Europe’, 2022, https://www.transportenvironment.org/discover/polish-market-for-evs-is-quickly-catching-up-with-the-rest-of-europe/.

98 European Commission, 5.

### 4.2.2 Czech Republic

| | | | |
|---|---|---|---|
| **2.4%** Share of EU Population | ENERGY | 2019 RES TFEC Share: | **16%** (92% of this are biofuels) |
| | | 2030 RES Target Share: | **22%** |
| | | 2019 Primary electricity generation source: | **Coal** (46%) |
| | | 2030 Planned primary electricity generation source: | **Nuclear** (46-58%) |
| **3.5%** Share of EU GHG Emissions | TRANSPORT | Transport emission share as % of total emissions: | **16%** |
| | | Transport emission increase 2005-2019: | **23%** |
| | | Transport emission reduction target 2030 vs. 2005: | **14%** |
| **26%** ESR GHG reduction target 2030 vs. 2005 | | RES share in fuels: | **4% in 2019** |
| | | Primary RES in transport: | **Biofuels** (~98%) |
| | | 2030 planned primary RES in transport: | **Biofuels** (94%) |
| | | ERS mentioned in mobility strategy: | **Yes** |

Regarding the energy sector, coal also plays an important role as energy source in Czechia. In 2019, 33% of total final energy consumption (TFEC), 46% of electricity and 25% of residential heating was generated by coal. The Czech Coal Commission therefore recommended a phase-out by 2038. The emerging gap is to be filled primarily by nuclear energy. At 16%, the share of RES in TFEC in 2019 was higher than Poland's, but almost entirely composed of bioenergy, with a 92% share. Wind and solar each account for only about 1%, as can be seen in Figure 9 (Annex).

In electricity consumption, the share of RES is supposed to reach 18-25% until 2040, while nuclear power is supposed to account for 46-58%, as can be seen in Table 1 (Annex). So, while the phase-out of coal seems to be accounted for, the predominance of nuclear energy sources derive in particular from the original draft of the State Energy Policy Update[99] of 2014. In this document, which became the cornerstone of the country´s energy policy, energy mix scenarios were developed, with the result that nuclear energy is clearly preferable. Its footprint is clearly visible in all post-2015 energy policy documents.[100]

The Czech transport sector remains heavily dominated by fossil fuels. In 2020, out of 8.5 million vehicles, only 7500 were EVs. The RES share of ~8% can be attributed almost entirely to biofuels, as shown in Figure 5. To achieve the target of 14% emission reduction by 2030, Czechia targets first-generation biofuels (7%), second-generation biofuels (6.2%), consisting of 4.5% biomethane and 1.7% used cooking oils, and 0.8% renewable electricity.[101] Even if more freight is to be shifted to rail according to the NECP,[102] it is expected that the share of road freight will still be the most relevant mode of transport by 2050 with more than 80%, as shown in Table 2 (Annex).

In order to decarbonize road freight, LNG and CNG are identified as the most promising medium-term decarbonization option and hydrogen and Biofuels as promising long-term options.[103] According to the Czech Hydrogen Strategy, about half of the hydrogen will be consumed in the transport sector, and more than 80% of this will be used by trucks.[104] The Transport Policy of Czechia also includes targets for the electrification of road transport. In addition to FCEVs and BEVs, it mentions direct power supply from the trolley and the electrification of motorways for

99 Czech Ministry of Industry and Trade, 'State Energy Policy of the Czech Republic', 2014, https://www.mpo.cz/assets/en/energy/state-energy-policy/2017/11/State-Energy-Policy-_2015__EN.pdf.

100 Jan Osicka et al., 'Sugarcoating Nuclear Energy in the Czech National Energy Strategy', 2021, 2, https://www.sciencedirect.com/science/article/abs/pii/S2214629620304400.

101 The data from this document refers to the old ESR target of -14% for Czechia. The new target is -26%.

102 European Commission, 'National Energy and Climate Plan of the Czech Republic', 2019, 75, https://ec.europa.eu/energy/sites/ener/files/documents/cs_final_necp_main_en.pdf.

103 European Commission, 76.

104 Czech Ministry of Industry and Trade, The Czech Republic´s Hydrogen Strategy, 2021, 28, https://www.mpo.cz/assets/cz/prumysl/strategicke-projekty/2021/9/Hydrogen-Strategy_CZ_2021-09-09.pdf.

road freight, but no concrete information is provided.[105] Table 3 (Annex) shows goals for alternative fuels vehicles in 2030. These goals were not classified by vehicle type, but it can be assumed that primarily passenger cars will be electrified and primarily CNG and hydrogen are planned for freight vehicles.

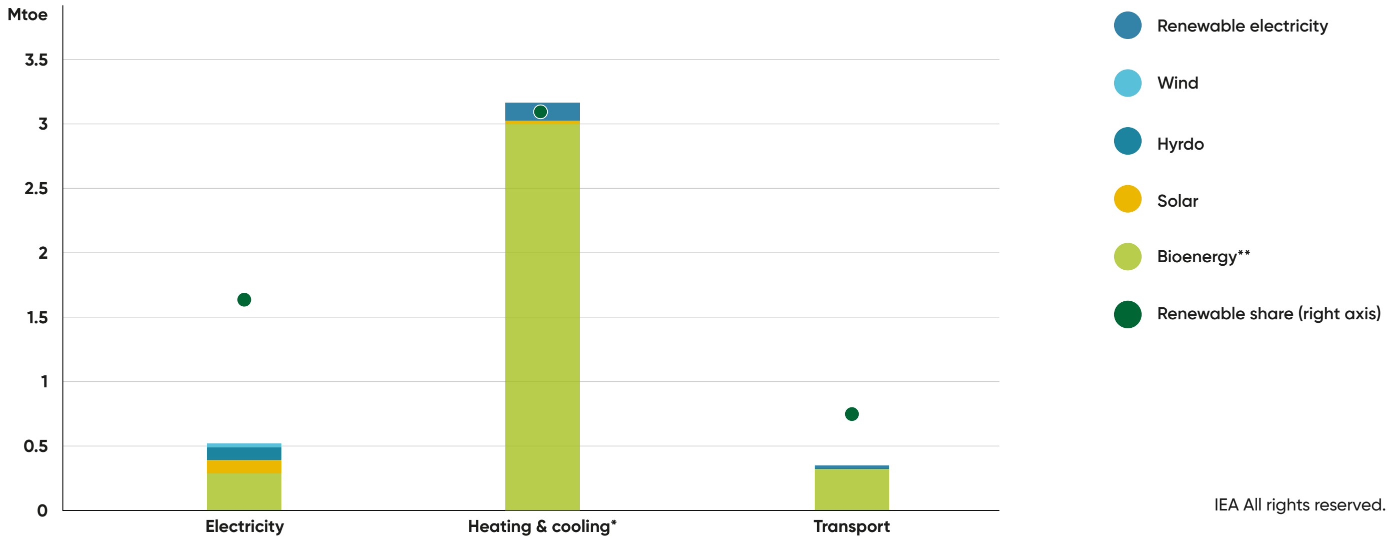


*Figure 5 - Renewable energy in different sectors in Czechia in 2019. Source: International Energy Agency.*[106]

105 Czech Ministry of Transport, 'Transport Policy of the Czech Republic Period of 2021 - 2027, with an Outlook until 2050', 2021, 39–40, https://www.mdcr.cz/getattachment/Dokumenty/Strategie/Dopravni-politika-a-MFDI/Dopravni-politika-CR-pro-obdobi-2014-2020-s-vyhled/Dopravni_Politika_CR_ENG.pdf.aspx.

106 International Energy Agency, 'Czech Republic 2021 Energy Policy Review', 2021, 78, https://iea.blob.core.windows.net/assets/301b7295-c0aa-4a3e-be6b-2d79aba3680e/CzechRepublic2021.pdf.

### 4.2.3 Hungary

**2.2%**
Share of EU Population

**1.7%**
Share of EU GHG Emissions

**18.7%**
ESR GHG reduction target 2030 vs. 2005

| | | |
|---|---|---|
| ENERGY | **2019** RES TFEC Share: | **12.6** |
| | **2030** RES Target Share: | **21%** |
| | **2019** Primary electricity generation source: | **Nuclear** (46%) |
| | **2030** Planned primary electricity generation source: | **Nuclear** (~50%) |
| TRANSPORT | Transport emission share as % of total emissions: | **22%** |
| | Transport emission increase 2005-2019: | **19%** |
| | Transport emission reduction target 2030 vs. 2005: | **14%** |
| | RES share in fuels: | **~7.5%** |
| | primary RES in transport: | **Biofuels** (~98%) |
| | 2030 planned primary RES in transport: | **Biofuels** (53%) |
| | ERS mentioned in mobility strategy: | **No** |

Regarding the energy sector, the RES share is 12.6% in TFEC 2019, which is higher than in Czechia and Poland, but is also primarily based on biofuels. A target of 21% RES is set for 2030. Hungary has made considerable progress in the expansion of solar plants, so RES electricity generation is no longer primarily from bioenergy. However, nuclear energy has a significant share in the country's low GHG emissions with 46% in 2020 and is planned to remain at this level, as can be seen in Figure 6. Coal is to be phased out until 2025.[107]

A special focus lies on energy security, low overall costs and the high relevance of nuclear energy. This is emphasized in the first sentence of the Hungarian NECP: "The main objective of the NECP is to strengthen energy sovereignty and energy security, to maintain the results of reduced overhead costs, and to achieve the decarbonisation of energy production, which is possible only through the combined use of nuclear energy and renewable energy. (...) Carbon neutral energy production is inconceivable and unfeasible without nuclear energy."[108]

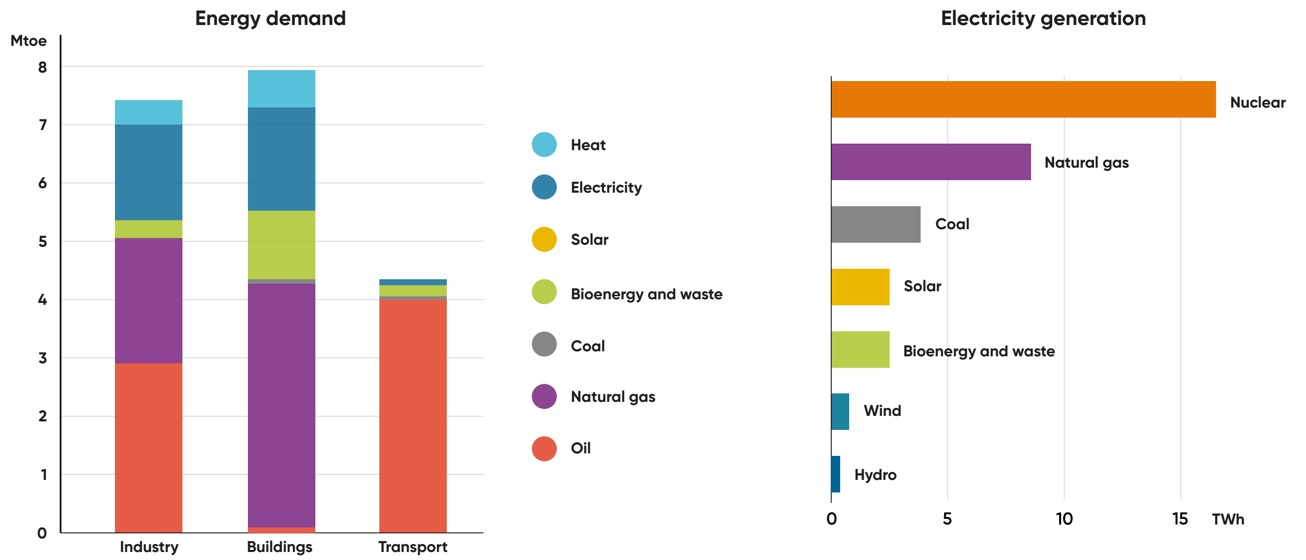


*Figure 6 - TFEC per sector and fuel and electricity generation by fuel 2020. Source: Hungarian Energy Policy Review 2022.*[109]

107 Europe Beyond Coal, 'Hungary Brings Coal Phase out Forward by Five Years to 2025', 2021, https://beyond-coal.eu/2021/03/03/79874/.

108 Hungarian Ministry of Innovation and Technology, 'Hungarian National Energy and Climate Plan', 2020, 1, 22, https://energy.ec.europa.eu/system/files/2022-08/hu_final_necp_main_en.pdf.

109 IEA, 'Hungary 2022 - Energy Policy Review', 2022, 22, https://iea.blob.core.windows.net/assets/9f137e48-13e4-4aab-b13a-dcc90adf7e38/Hungary2022.pdf.

Reference is also made to the necessary support of the EU: "The European Union expects Member States to operate overall climate neutral economies by 2050. (...) The Government of Hungary holds the view that Hungary can meet this target, but not without substantial financial contribution from the European Union. Hungary can make specific commitments only after careful consideration of the means and costs."[110]

The transport sector covered its TFEC in 2019 with 92% oil, 4% biofuels, and 2% electricity and gas respectively. The goal is to use at least 14% RES by 2030. Similar to Czechia, 7% is to be covered by first generation biofuels and another 3.5% by second generation biofuels. The remaining 3.5% is to be covered by electrification and the beginning ramp-up of hydrogen.[111] Measures for the rapid ramp-up of e-mobility have been taken in the form of the "Green bus programm" and the so-called Jedlik Ányos Plan (e-mobility plan), but mainly cover passenger cars and buses but not heavy trucks. Overall, it is planned to prioritize biofuels in the short and medium term in order to then increasingly promote large-scale electrification and the use of hydrogen in the transport sector from 2030. Second-generation biofuels will also continue to be used to a certain extent, as can be seen in Figure 7. However, it is also evident here that only 20% of the transport sector is to be decarbonized by 2035 and only 30% by 2040, which limits the scope for climate neutrality in 2050. In particular, the high relative share of electrification by 2040 can be considered positive based on the paper's premise, though.

ERS are listed in the national clean development strategy in a table under "innovative infrastructure" with TRL 8. Thus, even though no official expansion plans are described, the general option for the applicability of the technology has been identified.[112]

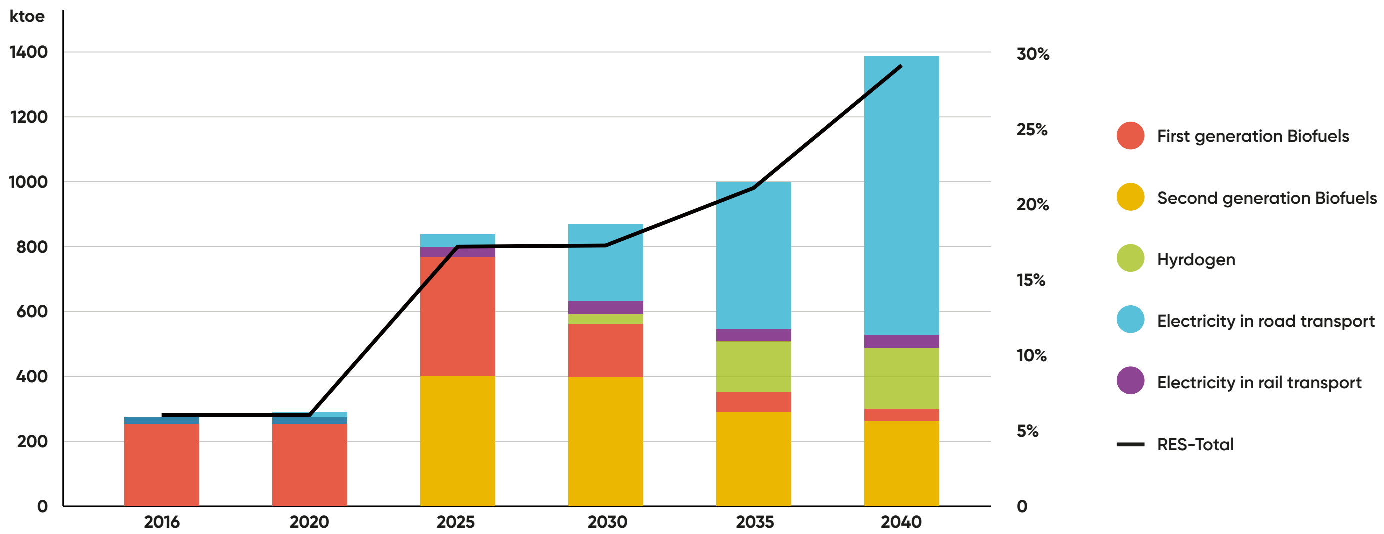


Figure 7 - Renewable energy consumption in Hungarian transport sector by energy source from 2016-2040. Source: Hungarian NECP[113]

[110] Hungarian Ministry of Innovation and Technology, 24.

[111] Hungarian Ministry of Innovation and Technology, 25.

[112] Hungarian Ministry for Innovation and Technology, 'National Clean Development Strategy 2020-2050', 2020, 107, https://unfccc.int/sites/default/files/resource/LTS_1_Hungary_2021_EN.pdf.

[113] Hungarian Ministry of Innovation and Technology, 273.

## 4.3 AFID Implementation Report

In the following, the AFID Implementation Report (IR)[114] will be analyzed with regard to the focus countries. The Commission's report collects and analyses the plans and efforts of the Member States in the construction of alternative infrastructure and the introduction of alternative vehicles. The specification of the vehicle type is optional, so only some member states have specified which vehicle types (passenger cars, LCVs, HDVs, etc.) are to be equipped with which alternative propulsion systems. Even without the specification of HDVs, the report offers relevant insights into the transport decarbonization policies and strategies of the member states.

Each EU Member State was requested to submit a National Policy Framework (NPF)[115] and National Implementation Reports (NIR)[116] for alternative infrastructures and vehicles, which serve as the data basis for the report. Methodologically, progress is considered adequate or good if the implementation in the NIR at least meets or exceeds the requirements of the NPF. The report provides a qualitative assessment of the progress made by the member states, based on legal, political and technical aspects, as well as a quantitative assessment of the fuels used and the anticipated EVs and CPs by 2030. In the following, the focus will be on the quantitative assessment of the document.

Regarding the quantitative analysis, in Czechia, there were 3.169 EVs out of 7.6 mil. total vehicles and 749 CPs in 2018. The plan was to have around 217.000 EVs and 19.000 CPs by 2030.[117] Hungary targeted about 390.000 EVs out of 4.4 mil. total vehicles and 35.000 CPs, while 9240 EVs and 671 CPs existed in 2018.[118] In Poland 3.338 EVs out of 30 mil. total vehicles and 769 CPs existed in 2018. The plan for 2030 was to have 1.9 mil. EVs. No information was given on the planned number of CPs.[119] The anticipated EV shares for 2030 for the focus countries are thus 2%, 5% and 7%, which puts them in 14th, 16th and 17th place among the 23 EU member states examined. More information and contextualization of this data can be found in Table 7 (Annex).

Regarding the ambition to introduce electric vehicles and charging infrastructure, the countries are mostly rated as "adequate" according to the methodology. However, in the final remarks of the assessment, all three countries are referred to the fact that "taking into account the current situation and expected trends, this level of ambition does not appear to be fully compatible with the pace of deployment of electric vehicles considered necessary for a full transition to carbon neutrality by 2050".[120]

In view of assessments of anticipated fossil fuel consumption for 2030, that Czechia and Hungary appended to their NIR, this criticism can be considered an understatement. As shown in Table 4 (Annex) for Hungary, combined oil consumption (diesel and petrol) should be reduced from 94% to 86% in 2030. Electricity with 4% and LNG/CNG with 3% were supposed to compensate for the gap. In the case of Czechia, oil consumption was supposed to be reduced from 97.5% to 91.5%. Electricity remains negligible at 0.73% by 2030, and CNG should compensate for the lower consumption of oil at 5.5%, as can be seen in Table 5. This indeed leaves potential for more ambitious decarbonization and puts the assessment as adequate into question.

A more comprehensive overview of the targeted EV fleets of the Member States in 2030, their economic power, their TEN-T core length and the HGV use of the TEN-T network can be found in Table 6. The table shows that there is a clear correlation between the gross domestic product per capita and the approx. EV shares targeted for 2030 in the AFID Implementation Report. The correlation coefficient between these two sets of variables is 0.83 and can thus be classified as very strong.[121] According to this, wealthy countries seem to be more inclined towards a rapid electrification of transport. Although correlation is not equivalent to causality, financial capabilities and cost parity with conventional vehicles can be considered highly important. Thus, the special relevance of targeted financial support for member states with a GDP below EU average shall be highlighted here.

The table also shows the relevance of road-based heavy goods transport for the focus countries. While data for Czechia on the TEN-T use of HGVs was not available, it is evident for Hungary and Poland that heavy goods transport plays one of the most important roles in European comparison. This is true both for the entire TEN-T network, which is referenced in the table, and the TEN-T core network, which is particularly relevant for ERS. HGVs use the TEN-T core network in Poland and Hungary intensively in European comparison.[122] With about 1100 km and about 3800km of TEN-T core length, they also both operate comparatively long sections of the transport network. Also, with around 1.1 million HGVs, Poland has almost as many HGVs

[114] Art. 10 (3) AFID.

[115] According to Art. 3 AFID.

[116] Art. 10 (1) AFID: For the first time: by 18 November 2019 and then every three years thereafter.

[117] 'Implementation Report AFID 2021 3/4', 2021, 132, https://eur-lex.europa.eu/resource.html?uri=cellar:e6afa54f-8003-11eb-9ac9-01aa75ed71a1.0001.02/DOC_3&format=PDF.

[118] 'Implementation Report AFID 2021 3/4', 403.

[119] 'Implementation Report AFID 2021 4/4', 2021, 493, https://eur-lex.europa.eu/resource.html?uri=cellar:e6afa54f-8003-11eb-9ac9-01aa75ed71a1.0001.02/DOC_4&format=PDF.

[120] This quote is addressed to Hungary, but Czechia and Poland were addressed similarly. 'Implementation Report AFID 2021 3/4', 418.

[121] Correlation coefficients can range between 1 and -1 and describe the correlation of variables. At 0 there is no correlation, at 1 there is a completely positive correlation (if A increases, B also increases), at -1 a completely negative correlation (if A increases, B decreases).

[122] Pettersson et al., 'Trans-European Road Network, TEN-T (Roads): 2019 Performance Report', 40.

as Germany and France together and by far the most in the EU, as can be seen in Table 7. Considering the fact that high shares of the TEN-T core network and a high share of the total number of trucks in the EU are accounted for by the focus countries, a timely decarbonization in heavy goods transport in these countries, but also in other observer countries, is urgent. So, while the analysis of AFID IR emphasizes the limited ambition for transport electrification in the focus countries, it appears to be particularly worthwhile in heavy goods transport.

## 4.4 Interview Czech Ministry of Transport

Concerning ERS, an interview with a representative of the Czech Ministry of Transport was conducted. Also, the authors had an exchange with representatives from Poland who pointed out that ERS are currently not a priority in the decarbonization strategy for heavy goods transport, as especially the Polish freight sector shows limited interest in the solution. In the interview with a representative of the Czech Ministry of Transport,[123] general questions were first asked about the decarbonization strategy in heavy goods transport and AFID/AFIR. Furthermore, the interview focused on the introduction perspectives of ERS in Czechia and possible effects of the current crises.

Regarding AFID, the numbers on EVs and charging infrastructure were considered to be too low in the context of the developments in the last years. The figures are expected to increase in future policies. It was assumed that they would be set higher in the future, but a quantification could not be made. Further quantified plans for the concrete decarbonization of HDVs were not known. With regard to AFIR, it could be found that the EU Member States are politically divided on the issue of further infrastructure expansion. Czechia belongs to the group that considers AFIR targets to be too ambitious and advocates lower expansion targets or longer timeframes. Many Czech companies operating in the sector also see these processes as critical and cannot identify a market for themselves in the medium future, especially if there is no planning security. Moreover, they suggest that infrastructure- and vehicle roll-out need to happen simultaneously, as an underutilization of either could be costly and slow down the further process. Regarding the security of supply, it was emphasized that a reduction of fossil fuel consumption is vital. However, the central question remains: whether there is sufficient electricity and whether the grid is able to cope with future demand. RES alone are too insecure; new nuclear power plants, in particular, could help to cope with the needed electricity volumes and the stability of the electricity grid.

In connection with the attractiveness of ERS corridors in Czechia, particularly the activity of larger neighbouring countries were mentioned as relevant. As transit country, Czechia relies on those and acts more as a trend follower. In addition, EU funds were mentioned as being relevant for investments of this magnitude. Moreover, a large part of the roads in Czechia had been modernized some time ago, which could make further work politically difficult, at least in connection with traffic restrictions. Planning security was considered important as well, which could be achieved in particular through a transparent political framework plan.

As further barriers to the introduction of ERS in Czechia, the scepticism of the public and the economic viability of the system were highlighted. Both the introduction of e-mobility in general and ERS in particular are viewed sceptically by parts of society. The economic efficiency of the system must be given in any case and must also be attractive compared to diesel. The volatile electricity prices as a result of the current crises also represent a major hurdle in this context.

## 4.5 Evaluation

In this chapter, the energy- and mobility policies of the focus countries will be assessed and evaluated. An evaluation of the achievement of EU climate targets, the envisaged energy sources for the energy and mobility sector with regard to their sustainability and their strategic advantages and disadvantages will be pursued. As ERS only play a peripheral role in the policies of the focus countries, it will also be noted to which extent they could complement the selected policies and what advantages they could bring.

### 4.5.1 Poland

The Polish decarbonisation efforts in energy policy are considered insufficient by the EU Commission,[124] stating that further significant measures need to be introduced to reach the 7% GHG target,[125] that the plans and policy descriptions (e.g. low carbon transition fund) are too unspecific and under-quantified, that the 21-23% target for RES until 2030 is too unambitious, and that electric vehicles are climatically obsolete with a low RES quota.

Schwartzkopff and Schulz[126] criticize subsidies for the coal sector, active prevention of renewable expansion and blocking or watering down ambitious climate regulations, both at national and EU level. They also criticize Poland for using its influence in the Visegrad Group[127] to convince other states to water down

123 Fynn Claes, 'Leitfadeninterviews Im Projekt AMELIE 2', 2022, https://usercontent.one/wp/www.ikem.de/wp-content/uploads/2022/07/Zusammenfassung-der-Leitfadeninterviews-im-Projekt-AMELIE-2-Final-1.pdf?media=1654600944.

124 European Commission, 'Assessment of the Final National Energy and Climate Plan of Poland', 2020, https://energy.ec.europa.eu/system/files/2021-01/staff_working_document_assessment_necp_poland_en_0.pdf.

125 This number refers to the old ESR target. The new target is -17.7%.

126 Schwartzkopff and Schulz, 'Climate & Energy Snapshot: Poland - The Political Economy of the Low-Carbon Transition'.

127 The Visegrad Group includes the countries of Poland, Czechia, Hungary and Slovakia. The group aims to coordinate their political positions in the EU.

EU regulations. At the same time, they stress the relevance of EU funds, which account for 60% of total public investments in Poland. While they also confirm that climate protection has a comparatively low status among the Polish population, this is less true for younger generations. Accordingly, RES are becoming more popular among the population and the public debate is increasingly opening up to a sustainable transition.

Muszyński and Kocur-Bera[128] show great potential for RES in Poland, especially for wind energy, but criticize the lack of formal and legal acts as the main factors for the slow development of RES in Poland. With current electricity prices of free-standing PV systems below 4ct./kWh and wind energy prices from 4ct./kWh, renewable energies are the cheapest and, according to estimations of Fraunhofer institute, will continue to fall to around 2-3ct./kWh by 2040, and remain as the cheapest and a favourable option for energy generation.[129]

With regard to Poland's mobility policy, which primarily plans with hydrogen in heavy goods transport, some critical aspects can be identified. As described in chapter 2.2, ERS and fast-charging infrastructure are much more efficient and cost-effective than hydrogen-based drives and can be deployed soon, as they have a high TRL. In light of strong supply gaps with green hydrogen, it is important to utilize electrification options where they are available. Overall, a decarbonization strategy for heavy transport that relies primarily on hydrogen is viewed critically here.

### 4.5.2 Czech Republic

The Czech approach in energy policy is criticized for lacking ambition as well.[130] Among others, this is reflected in the EU Commissions evaluation of the National Energy and Climate Plan for Czechia, which considers the GHG reduction target and the share of RES as too low.[131] In contrast to Poland, however, the targets are missed by a much smaller margin, which is why the criticism is less pronounced. The way in which the targets are supposed to be achieved is criticized, though.

On the one hand, this refers to nuclear energy, which can come with certain challenges.[132] This was noticeable this summer, when many French plants caused problems due to an exceptional drought and electricity had to be imported from other countries,[133] and in Ukraine, where the Zaporizhia plant played a dangerous key role.[134] Regarding the dominant role of nuclear power in Czech policy, the State Energy Policy Updates narrow approach is criticised in particular, which assumes notably favorable prices for nuclear power and distinctively high prices for other energy sources and emphasizes that "[…] the plan's scenario model is preoccupied with presenting the circumstances in a way that supports the preexisting decision to expand [nuclear power]."[135] This also aligns with other studies that find that RES are viewed by a majority of Czech policymakers as a risky investment that disrupts the status quo in the energy sector and security of supply, largely due to concerns about grid stability.[136]

On the other hand, it refers to the Czech mobility policy, which focuses strongly on biofuels. Czechia plans to cover 7% (max. allowed under EU legislation)[137] until 2030 in the transport sector this way. The EU Commission concludes in its assessment of the Czech NECP: "The plan only provides details of support measures for biomethane in transport. The policies and measures discussed appear to rely too much on bioenergy, at the expense of the electrification of the transport sector. Increasing bioenergy would increase pressure on land use, and would not help initiate a structural transformation of the transport sector."[138]

At the time of the publication of the AFID Implementation Report, only a marginal shift away from fossil fuels such as diesel and petrol was planned until 2030. Regarding electromobil-

128 Robert Muszyński and Katarzyna Kocur-Bera, 'Opportunities and Barriers to the Development of Poland in the Field of Renewable Energy Sources as Compared to the European Union', 2020, https://www.researchgate.net/publication/343154488_Opportunities_and_Barriers_to_the_Development_of_Poland_in_the_Field_of_Renewable_Energy_Sources_as_Compared_to_the_European_Union.

129 Christoph Kost et al., 'Stromgestehungskosten Erneuerbare Energien' (Fraunhofer ISE, 2021), 17, 29, https://www.ise.fraunhofer.de/content/dam/ise/de/documents/publications/studies/DE2021_ISE_Studie_Stromgestehungskosten_Erneuerbare_Energien.pdf.

130 International Energy Agency, 'Czech Republic 2021 Energy Policy Review', 24.

131 European Commission, 'Assessment of the Final National Energy and Climate Plan of Czechia', 2020, 2, https://ec.europa.eu/energy/sites/ener/files/documents/staff_working_document_assessment_necp_czechia.pdf.

132 Nele Steinbrecher, 'WWF Hintergrundpapier - Ohne Atomkraft in Die Zukunft', 2022, https://www.wwf.de/fileadmin/fm-wwf/Publikationen-PDF/Klima/hintergrundpapier-ohne-atomkraft-in-die-zukunft.pdf.

133 Paul Brown, 'Failing French Nuclear Plants Drive Up Electricity Costs as Heat Waves Cut Production', 2022, https://www.theenergymix.com/2022/08/07/failing-french-nuclear-plants-drive-up-electricity-costs-as-heat-wave-cuts-production/.

134 Tagesschau, 'IAEA-Chef Grossi Besorgt Über Beschuss', 2022, https://www.tagesschau.de/ausland/europa/akw-saporischschja-125.html.

135 Osicka et al., 'Sugarcoating Nuclear Energy in the Czech National Energy Strategy', 6.

136 Ewelina Kochanek, 'The Energy Transition in the Visegrad Group Countries', 2021, 4, https://www.researchgate.net/publication/350916587_The_Energy_Transition_in_the_Visegrad_Group_Countries/fulltext/6079c1222fb9097c0cec9b62/The-Energy-Transition-in-the-Visegrad-Group-Countries.pdf.

137 This data refers to RED II. Updates may come in RED III.

138 European Commission, 'Assessment of the Final National Energy and Climate Plan of Czechia', 11.

ity, there are already some approaches in the National Action Plan for Clean Mobility.[139] However, these relate primarily to the electrification of passenger vehicles and buses. There are no concrete, quantified proposals for decarbonizing road freight transport via electrification. This is to be achieved primarily via biofuels, LNG/CNG and hydrogen. However, as argued, electrification potential should be utilized where it is possible.

### 4.5.3 Hungary

Similar to Czechia, the EU Commission criticizes the weak overall expansion of RES and climate policies of Hungary, which are rated as lacking ambition. Regarding the energy policy of Hungary, even though the ESR target of 18.7% is expected to be exceeded, the EU Commission considers Hungary's energy policy to have more potential than 21% reduction until 2030. [140] Nevertheless, the overachievement is considered a positive development. The solar potential is supposed to be utilized with a tenfold increase from 680MW to 6500MW, but a stagnation in wind energy was seen as a missed opportunity.[141] The early phase-out of coal is also appreciated by the Commission.

In the context of the evaluation of Hungarian mobility policy, the intensive use of first-generation biofuels is viewed critically as well. However, it must be noted positively that there is a clear plan to phase out first generation biofuels and that neither hydrogen nor biofuels are supposed to play a primary role in the transport sector in 2040. This is intended for electricity. ERS do not yet play a role in this context, but have been identified as a decarbonization option. In this respect, Hungary's mobility policy can be evaluated as rather positive from an electrification perspective.

### 4.5.4 Key Results

To conclude, the evaluation illustrates the clash of interest between EU requirements that were set out and national interests. Quick decarbonization is perceived as incompatible with national goals by most policy makers. In the short term, the external circumstances of energy scarcity will make measures necessary, that are undesirable for quick decarbonization, such as the reactivation and intensive use of coal-based power plants. However, it is important to focus on long-term investments, without which relevant climate goals cannot be achieved in time. Therefore, current efforts on EU level are highly welcomed: Member States are, among other measures, supported by the Modernization Fund (see 3.2.3.1) to update their grids and the Renewable Energy Directive requires an increased expansion of renewable energies by the Member States. In this context, it is particularly important to find fair burden-sharing mechanisms so that states with GDPs below EU average are not overburdened. Financial support plays an important role in this regard and incentivizes national action.

Furthermore, electricity as an energy source in transport was negligible in the focus countries. This is reflected in the EV and charging point data, which was comparatively low. However, the progress in this regard is particularly relevant in the focus countries due to the high shares of TEN-T core network and high HDV traffic volume. Both the AFID IR and most other documents show limited ambitions for rapid decarbonization of the transport sector. Although most recent developments show more progress, plans for HDVs remain vague. Regarding ERS as a decarbonization option for HDVs, it is particularly noteworthy that they are not mentioned at all or only peripherally. Therefore, EU law can be a valuable tool to gradually transition national energy and mobility policies towards more ambitious targets in general and shift the focus to decarbonize the heavy transport sector as well. However, as the EU legislative process is geared towards consensus, it is also important to transparently reduce the scepticism of economic and societal stakeholders towards decarbonisation technologies in order to reduce clash of interest.

The analysis identified the following general barriers which can affect the introduction of ERS negatively: a neutral to sceptical position of some societal and market actors towards ERS technology, a high initial investment requirement both in the energy sector and mobility sector, a high degree of required planning security and challenges regarding the expansion of the electricity grid and the roll-out of reliable storage options. For the focus countries, the hesitation of relevant stakeholders towards decarbonization in general, the particular focus on security of supply and economic growth and the high age of grids represent further challenges.

139 Czech Ministry of Industry and Trade, 'National Action Plan for Clean Mobility', 2015, https://www.eafo.eu/sites/default/files/npf/1%20CZECH%20REPUBLIC%20NPF.en.pdf.

140 Hungarian Ministry of Innovation and Technology, 'Hungarian National Energy and Climate Plan', 2.

141 European Commission, 'Assessment of the Final National Energy and Climate Plan of Hungary', 2020, 8, https://energy.ec.europa.eu/system/files/2021-01/staff_working_document_assessment_necp_hungary_en_0.pdf.

05

# ERS Path Scenario

# 5 ERS Path Scenario

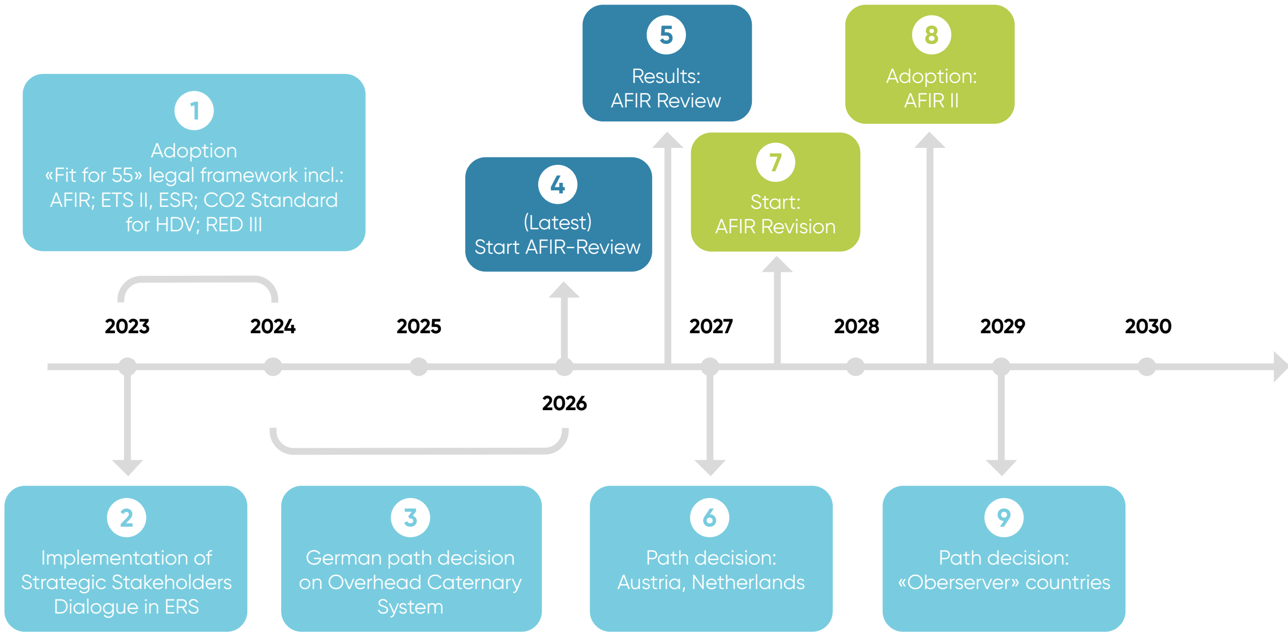


Figure 8 - ERS-Timeline scenario. Source: Own depiction.

In this analysis, the importance of a political path decision, especially by the ERS pioneer countries, has been emphasized as vital for the further success of the technology. The following timeline illustrates a scenario on how ERS could become a key decarbonization technology for the heavy transport sector in the EU. In its centre lies the political path decision each Member State needs to take, as shown in Figure 8.

1. (2023-2024): In 2023 the "Fit for 55" legal acts will be adopted, including the Alternative Fuels Infrastructure Regulation (AFIR), the EU Emission Trading System II (EU-ETS II), the Effort Sharing Regulation (ESR), the Regulation regarding $CO_2$ standards for heavy-duty vehicles and the Renewable Energy Directive (RED III).
   EU legislation is the main lever for several EU Member States to decarbonize their economies, including the road transport sector. Still, concerning ERS, no EU legal act targets the deployment of the technology in particular. If Member States consider to design the deployment of ERS as mandatory, AFIR would pose the adequate instrument to do so. Therefore, AFIR can be considered the most relevant EU legal "tool" regarding ERS.

2. Beginning of 2023: In order to place ERS as key technology within the EU, it appears to be purposive for ERS-stakeholder (incl. all Member States) to closely coordinate a strategy for ERS before AFIR is reviewed for the first time (4.). Member States could exchange study results and information on a regular basis (e.g. in a Strategic Stakeholder Dialogue on ERS, see 4.1.1), decide on a possible TEN-T ERS-network and discuss openly which ERS are suitable for which use-cases. Additionally, observer countries (especially from central Europe) should be encouraged to conduct their own ERS-investigations. Taking into account the hesitant targeting of decarbonization measures towards the heavy duty transport sector in general by many Member States (incl. the focus countries) and the fact that ERS face (mostly unjustified) acceptance challenges among policy makers and societies, it is crucial that the Member States exchange their scientific findings, clear up misunderstandings and develop strategies on how to identify and include all Member States where ERS could play a larger role. A revision of the AFIR concerning ERS could codify any found agreements. The next AFIR review process might represent the last chance for ERS to play a bigger role in the EU.

3. According to the German strategy (see 2.3), the German path decision will be taken between 2024 and 2026. In this regard, Germany coordinated its decision with other ERS-pioneers.

4. As AFIR negotiations are still ongoing, two review time slots (end of 2024 - Council/2026 -COM/EP) are being discussed at the moment. If the AFIR is to be reviewed already by the end of 2024 a prior coordination process between ERS-Stakeholder/Member States becomes even more crucial.

5. End of 2025: The results of the review process are the key element for ERS. If those are too vague to form concrete

recommendations on how ERS should be implemented in the EU and for which use-cases, ERS-technologies probably missed their window of a timely implementation. By this time, ERS-pioneers have taken a decision which ERS is the one to deploy. In this scenario, they concluded on the catenary system.

6. Beginning 2027: Once Germany, as ERS-pioneer country, has taken its path decision, it is likely that other neighbor countries (Second Mover) such as the Netherlands or Austria follow shortly after.[142]

7. Mid 2027: After the review results are definite and state that ERS are a valid technology approach to decarbonize European TEN-T corridors, the AFIR revision process is initiated by the Commission in order to implement ERS more prominently within *AFIR II*.

   In the following, three scenarios for a new *AFIR II* proposal are illustrated:

   - **Scenario 1**: From a legal point of view, it would be possible to set out mandatory ERS targets for each Member State (as it is done for charging points and refuelling stations in the AFIR right now). But this approach would only be successful if all Member States are entirely convinced by ERS. In this regard, an EU-level coordination on ERS becomes even more important.

   - **Scenario 2**: ERS are not considered a valid option for an EU-wide deployment and no ERS-targets are set out in AFIR II. Still, some Member States deploy ERS on a larger scale.

   - **Scenario 3**: The third scenario, which is assumed within the timeline, categorizes EU Member States:
     For Member States that are willing to commit on an EU level, concrete ERS-targets could be set out by AFIR II. This would be an important signal for Member States that did not yet take a path decision and provide planning security for those Member States.

     For those Member States that don't want to commit by the time the AFIR is revised, the possibility to account electric road systems towards the achievement of the total power output targets for light - and for heavy commercial vehicles[143] could be an appropriate approach.

8. Mid 2028: The revised AFIR II enters into force. By this time, EU wide several 100 km of ERS are operating (German Innovationcluster, Örebro, French ERS-section) and cross-border ERS deployment projects are implemented.

9. Beginning 2029: First observer countries take ERS path decisions. Since Member States, such as the focus countries, initially might have different priorities (grid modernization, decarbonization of other sectors) they will act delayed - and only if sufficient (financial) support on an European level is provided to establish ERS.

[142] This assumption derives from several conversations the authors had with Dutch and Austrian researchers and representatives during the last couple of months are only personal estimates.

[143] AMENDMENTS 001-274 by the Committee on Transport and Tourism, Amendment 261 Proposal for a regulation Article 22 – paragraph 1, p. 114, https://www.europarl.europa.eu/doceo/document/A-9-2022-0234-AM-001-274_EN.pdf.

06

# Conclusion

# 6 Conclusion

In conclusion, two main assumptions can be made:

1. The best-case scenario, in which all Member States start scaling up ERS simultaneously, is desirable, but not likely to occur. Instead, it is more likely that ERS will be implemented gradually on a larger scale in Europe. Especially observer countries might be sceptical about strict ERS deployment requirements as they exist e.g. for charging points in AFIR. The focus on Central and Eastern Europe is particularly important, as large parts of the TEN-T core network and especially many logistics companies are based there. The examples of the focus countries showed that they face challenges which ERS-pioneers do not face to the same extent. This should be taken into account when revising AFIR for the first time.
2. National commitment and coordination play a major role in the deployment of ERS. ERS-pioneer countries have to take national path decisions and should coordinate their strategies with all Member States on a regular basis on EU level before the AFIR review process is initiated. EU institutions should provide a platform for ERS-stakeholders and support the technology itself to increase its acceptance. The German/French path decision is especially relevant since Second Mover-countries, like Austria or the Netherlands will only decide on ERS if at least one larger Member State is opting for ERS in the first place. AFIR is therefore likely to function merely as an instrument to declaratively codify the Member States political will to deploy ERS on a larger scale and to provide planning security for observer countries.

The next 4-5 years decide if ERS will become a key technology to decarbonize the road transport sector. First ERS have to reach a better standing among European stakeholders. Pioneer countries have to work together to achieve this. Thereafter, it has to be decided which ERS-technology fits best for which use-case. In the end, its only about decarbonizing the transport sector in the most efficient way. ERS cannot be overlooked.

# Annex

## Tables

| | 2016 level | 2040 target level |
|---|---|---|
| Coal and other solid non-renewable fuels | 50 % | 11–21 % |
| Nuclear energy | 29 % | 46–58 % |
| Natural gas | 8 % | 5–15 % |
| Renewable and secondary energy sources | 13 % | 18–25 % |

*Table 1 - Share of individual fuels in gross electricity generation. Source: Czech NECP .*[144]

| | Year | MT statistics | | DSS2 results | | |
|---|---|---|---|---|---|---|
| | | 2000 | 2010=100% | 2020 | 2035 | 2050 |
| Ton kilometres | Rail transport | 126% | 13 770 million tkm=100% | 123% | 133% | 146% |
| | Road transport | 75% | 51 832 million tkm=100% | 128% | 166% | 174% |
| | Domestic water transport | 114% | 679 million tkm=100% | 170% | 215% | 234% |
| | Air transport | 169% | 22 million tkm=100% | 105% | 118% | 132% |
| | Total | 86% | 66 304 million tkm=100% | 127% | 160% | 169% |
| Modal split | Year | 2000 | 2010 | 2020 | 2035 | 2050 |
| | Rail transport | 30.5% | 20.8% | 20.0% | 17.3% | 17.9% |
| | Road transport | 68.1% | 78.2% | 78.6% | 81.2% | 80.6% |
| | Domestic water transport | 1.3% | 1.0% | 1.4% | 1.4% | 1.4% |
| | Air transport | 0.1% | 0.0% | 0.0% | 0.0% | 0.0% |
| | Total | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |

*Table 2 - Traffic forecast for Czechia. Source: National Action Plan for Clean Mobility.*[145]

| Type of vehicle | 2020 | 2025 | 2030 |
|---|---|---|---|
| **Electric vehicles** | 17 000 | 101 000 | 250 000-500 000 |
| **Public charging stations** | 1 300 | | 19 000-35 000 |
| **CNG vehicles** | 49 820 | 130 000 | 250 000 |
| **Refuelling stations** | 200 | 300 | 340-400 |
| **LNG vehicles** | 180 | 500 | 1 300 |
| **Refuelling stations** | 0 | 5 | 14/30 |
| **Hydrogen vehicles** | | 95 | 40 000-50 000 |
| **Refuelling stations** | | 15 | 80 |

*Table 3 - Targets for alternative fuels vehicles and infrastructure in Czechia. Source: Czech Energy Policy Review.*[146]

144 European Commission, 'National Energy and Climate Plan of the Czech Republic', 14.

145 Czech Ministry of Industry and Trade, 'National Action Plan for Clean Mobility', 29.

146 International Energy Agency, 'Czech Republic 2021 Energy Policy Review', 63.

| MODE OF TRANSPORT | FUEL | Fuel use [%] | | | Estimated fuels use [%] | | |
|---|---|---|---|---|---|---|---|
| | | 2016 | 2017 | 2018 | 2020 | 2025 | 2030 |
| Road | Gasoline | 33% | 32% | 31% | 36% | 32% | 35% |
| | Diesel | 61% | 64% | 64% | 58% | 60% | 51% |
| | Electricity | 0% | 0% | 0% | 0% | 1% | 4% |
| | CNG | 0% | 0% | 0% | 1% | 1% | 1% |
| | LNG | 0% | 0% | 0% | 0% | 1% | 2% |
| | Hydrogen | 0% | 0% | 0% | 0% | 0% | 0% |
| | LPG | 1% | 1% | 1% | 1% | 0% | 0% |
| | Biofuels | 5% | 4% | 4% | 4% | 5% | 5% |
| | Other AF | 0% | 0% | 0% | 0% | 0% | 0% |
| | **Total Road** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** |

*Table 4 - Anticipated changes in Hungarian fuel use in transport sector 2016-2030. Source: Implementation Report AFID 2021 3/4, 415.*

| MODE OF TRANSPORT | FUEL | Fuel use (%) | | | Estimated fuels use [%] | | |
|---|---|---|---|---|---|---|---|
| | | 2016 | 2017 | 2018 | 2020 | 2025 | 2030 |
| Road | Gasoline | 27.14% | 27.61% | 27.51% | 27.13% | 25.40% | 23.46% |
| | Diesel | 70.42% | 69.81% | 69.82% | 69.88% | 69.53% | 68.08% |
| | Electricity | 0.00% | 0.01% | 0.02% | 0.05% | 0.26% | 0.73% |
| | CNG | 0.75% | 0.83% | 0.92% | 1.22% | 3.11% | 5.52% |
| | Hydrogen | | | | 0.00% | 0.06% | 0.64% |
| | LPG | 1.69% | 1.73% | 1.73% | 1.71% | 1.64% | 1.57% |
| | Other AF | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| | **Total Road** | **100.00%** | **100.00%** | **100.00%** | **100.00%** | **100.00%** | **100.00%** |
| Inland waterway | Marine diesel oil | 100% | 100% | 100% | 100% | 100% | 100% |

*Table 5 - Anticipated changes in Czech fuel use in transport sector 2016-2030. Source: Implementation Report AFID 2021 3/4, 142.*

| Nr. | Country | Approx. EV Share 2030* | GDP/Capita 2018 | GDP/Capita in relation to EU average | TEN-T Core Length in km | TEN-T (All roads) HGV network use (Average) |
|---|---|---|---|---|---|---|
| 1 | Luxembourg | 33,29% | 98.640 € | 261% | 69 | 14,2% |
| 2 | Ireland | 29,24% | 66.670 € | 191% | 478 | 6,7% |
| 3 | Belgium | 15,80% | 40.240 € | 117% | 828 | 18,4% |
| 10 | France | 13,38% | 34.980 € | 104% | 5283 | - |
| 4 | Slovenia | 12,53% | 22.080 € | 87% | 446 | - |
| 5 | Germany | 12,52% | 40.340 € | 122% | 6363 | 15,1% |
| 8 | Lithuania | 12,52% | 16.170 € | 80% | 665 | 17,4% |
| 6 | Austria | 12,30% | 43.640 € | 127% | 1084 | 11,6% |
| 7 | Spain | 11,68% | 25.730 € | 91% | 5706 | 14,0% |
| 11 | Netherlands | 10,25% | 44.920 € | 129% | 671 | 13,7% |
| 9 | Malta | 10,23% | 25.490 € | 98% | 20 | - |
| 13 | Sweden | 8,48% | 46.310 € | 121% | 3034 | 14,4% |
| 14 | Denmark | 8,29% | 52.010 € | 128% | 813 | 12,3% |
| 15 | Hungary | 7,17% | 13.690 € | 71% | 1090 | 17,6% |
| 12 | Finland | 6,55% | 42.490 € | 111% | 1071 | 10,0% |
| 16 | Poland | 5,11% | 12.920 € | 70% | 3834 | 20,7% |
| 17 | Czech Republic | 2,32% | 19.530 € | 92% | 1017 | - |
| 18 | Bulgaria | 1,57% | 7.980 € | 51% | 1507 | - |
| 19 | Slovak Republic | 0,90% | 16.470 € | 73% | 832 | - |
| 20 | Latvia | 0,68% | 15.080 € | 69% | 835 | - |
| 21 | Romania | 0,44% | 10.510 € | 63% | 2564 | - |
| 22 | Greece | 0,15% | 17.210 € | 68% | 1815 | - |
| 23 | Cyprus | 0,08% | 24.290 € | 89% | 156 | - |

*Table 6 - Key data related to electrification efforts, economic power and the TEN-T network of EU Member States. Data for 5 EU member states insufficient. Blue: Focus countries. Source: AFID Implementation report, Transeuropean Road Network – Performance Report.*[147]
**These are approximated numbers with data from the AFID Implementation report.*[148]

[147] Jan Pettersson et al., "Trans-European Road Network, TEN-T (Roads): 2019 Performance Report" (Conference of European Directors of Roads, 2020), 40, 104.
[148] For more information on vehicle types and how the approx. EV share for 2030 was calculated, see Table 7.

| Country | Total vehicles 2018 | Passenger cars | As % of total | LGVs | As % of total | HGVs | As % of total | Busses/Coaches | As % of total | Anticipated vehicles 2030* | Anticipated EVs 2030 | **Anticipated EV Share 2030** | Number of inhabitants |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Luxembourg** | 492.481 | 415.145 | 84,30% | 34.833 | 7,07% | 10.161 | 2,06% | 2.042 | 0,41% | 608.610 | 202.600 | **33,29%** | 602.000 |
| **Ireland** | 2.590.989 | 2.182.920 | 84,25% | 317.798 | 12,27% | 37.871 | 1,46% | 12.500 | 0,48% | 3.201.953 | 936.363 | **29,24%** | 4.838.000 |
| **Belgium** | 7.406.933 | 5.853.782 | 79,03% | 759.406 | 10,25% | 146.920 | 1,98% | 16.125 | 0,22% | 9.153.512 | 1.446.286 | **15,80%** | 11.413.000 |
| **France** | 41.895.886 | 32.034.000 | 76,46% | 6.179.771 | 14,75% | 547.604 | 1,31% | 100.511 | 0,24% | 51.775.075 | 6.929.700 | **13,38%** | 67.221.000 |
| **Slovenia** | 1.376.012 | 1.143.150 | 83,08% | 89.000 | 6,47% | 15.928 | 1,16% | 2.834 | 0,21% | 1.700.480 | 213.007 | **12,53%** | 2.066.000 |
| **Germany** | 54.915.724 | 47.095.784 | 85,76% | 2.616.118 | 4,76% | 750.303 | 1,37% | 80.519 | 0,15% | 67.865.034 | 8.500.000 | **12,52%** | 82.850.000 |
| **Lithuania** | 1.606.222 | 1.430.520 | 89,06% | 64.345 | 4,01% | 61.332 | 3,82% | 7.925 | 0,49% | 1.984.974 | 248.563 | **12,52%** | 2.808.000 |
| **Austria** | 6.316.320 | 4.978.852 | 78,83% | 422.745 | 6,69% | 72.486 | 1,15% | 10.037 | 0,16% | 7.805.729 | 960.395 | **12,30%** | 8.822.000 |
| **Spain** | 34.630.709 | 24.074.151 | 69,52% | 4.637.954 | 13,39% | 568.899 | 1,64% | 64.905 | 0,19% | 42.796.745 | 5.000.000 | **11,68%** | 46.659.000 |
| **Netherlands** | 11.471.308 | 8.530.584 | 74,36% | 914.766 | 7,97% | 143.041 | 1,25% | 9.717 | 0,08% | 14.176.281 | 1.453.300 | **10,25%** | 17.118.000 |
| **Malta** | 375.634 | 300.140 | 79,90% | 36.571 | 9,74% | 12.223 | 3,25% | 2.100 | 0,56% | 464.210 | 47.488 | **10,23%** | 475.000 |
| **Sweden** | 6.145.560 | 4.869.979 | 79,24% | 570.252 | 9,28% | 79.652 | 1,30% | 14.377 | 0,23% | 7.594.703 | 644.148 | **8,48%** | 10.120.000 |
| **Denmark** | 3.237.751 | 2.594.469 | 80,13% | 389.461 | 12,03% | 42.663 | 1,32% | 13.158 | 0,41% | 4.001.223 | 331.749 | **8,29%** | 5.781.000 |
| **Hungary** | 4.398.832 | 3.641.823 | 82,79% | 444.588 | 10,11% | 125.887 | 2,86% | 19.134 | 0,43% | 5.436.091 | 389.900 | **7,17%** | 9.778.000 |
| **Finland** | 4.728.980 | 3.470.507 | 73,39% | 465.024 | 9,83% | 171.182 | 3,62% | 18.467 | 0,39% | 5.844.089 | 382.790 | **6,55%** | 5.513.000 |
| **Poland** | 30.061.644 | 23.429.016 | 77,94% | 2.649.198 | 8,81% | 1.108.075 | 3,69% | 119.471 | 0,40% | 37.150.280 | 1.900.000 | **5,11%** | 37.976.000 |
| **Czechia** | 7.582.962 | 5.747.913 | 75,80% | 441.303 | 5,82% | 269.319 | 3,55% | 22.027 | 0,29% | 9.371.050 | 217.179 | **2,32%** | 10.610.000 |
| **Bulgaria** | 3.413.371 | 2.773.325 | 81,25% | - | - | 438.328 | 12,84% | 21 | 0,00% | 4.218.255 | 66.200 | **1,57%** | 7.050.000 |
| **Slovakia** | 3.141.103 | 2.321.608 | 73,91% | 318.000 | 10,12% | 358.832 | 11,42% | 9.363 | 0,30% | 3.881.786 | 34.900 | **0,90%** | 5.443.000 |
| **Latvia** | 854.737 | 707.841 | 82,81% | 57.146 | 6,69% | 32.065 | 3,75% | 4.885 | 0,57% | 1.056.287 | 7.200 | **0,68%** | 1.934.000 |
| **Romania** | 7.665.962 | 6.452.536 | 84,17% | 753.029 | 9,82% | 281.295 | 3,67% | 51.802 | 0,68% | 9.473.621 | 42.148 | **0,44%** | 19.523.000 |
| **Greece** | 8.236.900 | 5.236.000 | 63,57% | - | - | - | - | 26.300 | 0,32% | 10.179.188 | 15.000 | **0,15%** | 10.738.000 |
| **Cyprus** | 704.221 | 550.695 | 78,20% | 98.533 | 13,99% | 12.509 | 1,78% | 3.084 | 0,44% | 870.279 | 700 | **0,08%** | 864.000 |
| **Average** | 10.576.097 | 8.253.684 | 79,03% | 1.059.992 | 9,23% | 240.299 | 3,19% | 26.578 | 0,33% | 13.069.976 | 1.303.027 | **9,37%** | 16.095.739 |

*Table 7 - Evaluation of the data on vehicle classes from the AFID Implementation report (Annex and summary of member states) and the resulting EV share for 2030.*[149] **The documented number of anticipated vehicles 2030 was calculated with the average vehicle growth of the years 2017-2021*[150] *(1.78%, see ACEA Reports) over 12 years until 2030. Formula used: (Number of total vehicles 2018)*(1,0178^12). Sources: AFID Implementation Report, ACEA Reports 2017-2022 , Eurostat.*[151]

149 This only serves as a rough approximation to assess the targeted number of EVs in 2030 and therefore does not claim to be a concrete prediction of the individual number of vehicles in EU member states in 2030.

150 'ACEA Report - Vehicles in Use 2017', 2021, https://www.acea.auto/files/ACEA_Report_Vehicles_in_use-Europe_2017.pdf. https://www.acea.auto/uploads/statistic_documents/ACEA_Report_Vehicles_in_use-Europe_2018.pdf. https://www.acea.auto/files/ACEA_Report_Vehicles_in_use-Europe_2019.pdf. https://www.acea.auto/files/report-vehicles-in-use-europe-january-2021-1.pdf. https://www.acea.auto/files/ACEA-report-vehicles-in-use-europe-2022.pdf.

151 'First Population Estimates - EU Population up to Nearly 513 Million on 1 January 2018', 2.

# Figures

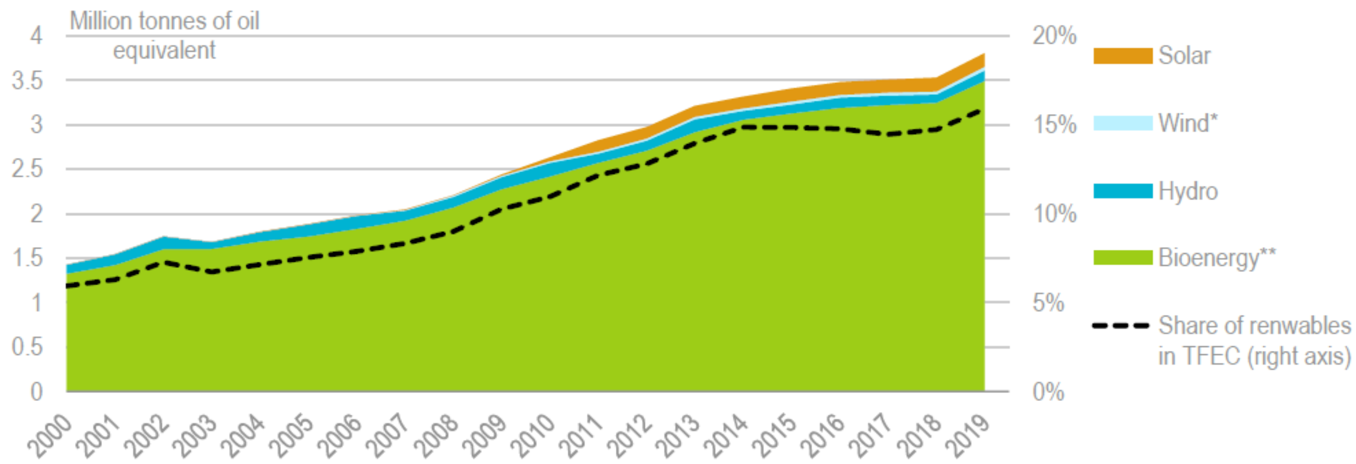


*Figure 9 – Renewable energy in TFEC in Czechia from 2000- 2019. Source: Czech Energy Policy Review 2021.*[152]

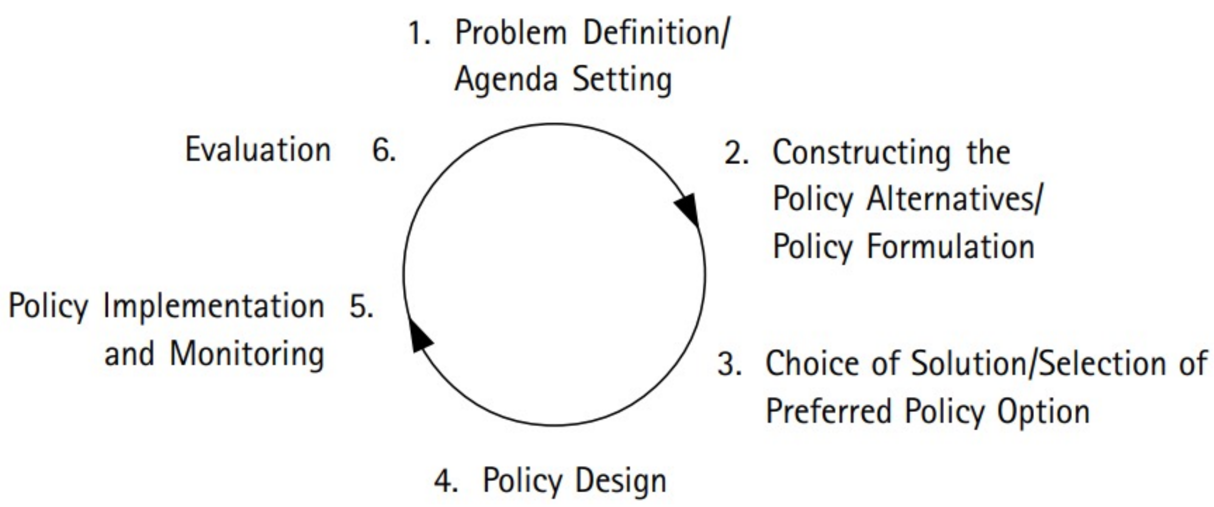


*Figure 10 - The policy Cycle. Source: Young and Quinn, p. 12.*

[152] International Energy Agency, 'Czech Republic 2021 Energy Policy Review', 78.

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