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D1.2.1 – Report on legal analysis

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12	Municipality of Ulcinj	Crna Gora (ME)	

Danube Indeet: Integrated and decentralised concept rethinking energy and transport systems based on renewable energy in the Danube region - DRP0200088

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The following document is developed as a compilation of the analyses of the policy and legal situation by participating countries, which have been made by the respective partners with accompanying support of PP3 EI-JKU in the development of the reports. The EI-JKU assumes no liability for the correctness and completeness of these country-specific analyses.

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Executive summary

This deliverable provides a comprehensive analysis of the policy and legal frameworks related to renewable hydrogen and vehicle-to-X (V2X) technologies in the participating countries. The document aims to assess the progress of national legal systems in addressing these critical energy topics and to create a comparative overview that highlights key considerations.

The analysis reveals that EU member states show varying levels of progress in developing legal frameworks for renewable hydrogen and V2X technologies. While some have established robust policies with clear incentives, infrastructure plans, and integration into renewable energy goals, differences in national priorities and regulatory standards challenge harmonization and cross-border collaboration. The inclusion of non-EU countries broadens the perspective, showcasing innovative approaches, unique challenges and opportunities for cooperation through knowledge exchange.

Enhanced collaboration between EU and non-EU countries offers significant potential for innovation but necessitates overcoming issues such as differing regulations, infrastructure compatibility, effective incentives and governance challenges.

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1. Introduction

The European energy market is undergoing a transition towards renewable energy sources, which is expected to result in a substantial increase in demand for renewable electricity in the forthcoming years. This shift is set to encompass various sectors where electrification is feasible, with renewable hydrogen emerging as a significant contributor, particularly in the industrial sector.

The increased share of renewable energies, which is primarily attributable to renewable electricity, and the resultant decentralised electricity generation, will consequently lead to an increased requirement for more flexible electricity grids. Renewable hydrogen and bidirectional recharging (vehicle-to-x or vehicle-to-grid [V2G]) of electric vehicles offer a means to provide networks with the aforementioned flexibility while simultaneously reducing CO_2 emissions in the sectors.

As the generation of electricity from renewable energy sources can only be adapted to consumption to a limited extent, the grid is subject to fluctuations of variable intensity. For instance, if renewable hydrogen is increasingly produced during periods of overcapacity, the electricity grid is relieved and the need for re-dispatches is reduced, while simultaneously ensuring the supply of hydrogen to other sectors. A similar principle applies to V2G, provided that vehicles and recharging points are able to communicate with the public power grid. In periods of overcapacity, these vehicles can be repurposed as mobile storage solutions. This involves the transmission of information from the grid to the recharging point, with the objective of increasing capacity and thereby supplying greater amounts of electricity. In the event of a vehicle being connected for a period of several hours, for instance overnight, the grid has the capability to draw electricity back from the vehicle, depending on the necessity for loads. Conversely, during periods of undercapacity, the charging point can be adjusted to reduce recharging power, thereby enabling the grid to manage demand. These mechanisms empower the grid to effectively manage both peak loads and oversupply in the short term without compromising the continuity of power generation.

Despite the substantial potential of these technologies, it is imperative that the legal framework governing them is sufficiently specific to ensure smooth operational. It is therefore essential to ensure legal certainty for legal practitioners, thereby facilitating economic functionality by explicitly delineating the applicable regulatory framework.

2. Comparison Table

The comparison table contains answers to five key questions, which only can be answered with a yes or no. The aim of this table is to provide an initial overview and, above all, to compare the policy and legal situation of the respective countries in a very brief way. It provides a first impression of the direction the state is heading concerning hydrogen and/or V2X, detailed information on the status of the policy and legal situations is described in chapter 3.

The questions are listed below, together with a short explanation of why they are relevant for the project's scope.

- **Does the country have a hydrogen strategy?**
  The existence of a hydrogen strategy, and more importantly its content, shows that the state is considering hydrogen in its energy system or has even taken the first steps towards a hydrogen economy.
- **Are there national targets (strategic and/or legal) for hydrogen production?**
  If a country sets strategic or even legal targets for hydrogen production, this symbolises a commitment to this specific technology. In addition, it is possible to estimate the extent to which hydrogen should be used and the specific sectors where it can be used.
- **Is there a mobility strategy?**
  A mobility strategy provides information on how the specific state sees the design of future mobility. The existence of such a strategy often means that the state also sees potential for innovation in this sector.
- **If so, does it include alternative fuels (in the sense that there are specific plans for better implementation of alternative fuels)?**
  The inclusion of alternative fuels in the mobility strategy shows a government's ambition to reduce the share of CO_2 emissions in this sector as well as increasing the share of renewable energy sources.
- **Is there a definition of energy storage in the electricity law (or in any laws regulating the electricity market)?**
  Directive (EU) 2019/944 introduced the definition of energy storages into EU electricity law for the first time. This includes electrolysers, but also electric vehicles when performing bi-directional recharging processes. The classification as energy storage systems has a number of consequences, such as restrictions for grid operators in connection with energy storages. It is therefore relevant to know whether EU countries have implemented the directive and whether non-EU countries have similar regulations.
- **Is bi-directional recharging (vehicle-2-grid) mentioned within the law?**
  Bi-directional recharging is still a relatively new technology, but it can have a positive impact on the energy system. The mentioning of V2G in the law suggests that first steps are already being taken to implement this technology in the country and ensure the operation of it within the legal framework.

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Country	national hydrogen strategy	hydrogen specific targets (strategic and/or legal)	mobility strategy	including alternative fuels	definition of energy storage	bi-directional recharching mentioned
Austria	Yes	Yes	Yes	Yes	No (draft exists)	No (draft exists)
Bosnia and Herzegovina	No	No	Yes	No	Yes	No
Croatia	Yes	Yes	Yes (as part of other strategies and laws)	Yes	Yes	No
Czechia	Yes	Yes	Yes	Yes	No	No
Germany	Yes	Yes	No (but legal provisions)	Yes	Yes	Yes
Hungary	Yes	Yes	Yes	Yes	Yes	No
Montenegro						
Romania	Yes	Yes	Yes	Yes	Yes	No
Serbia	No (draft exists)	No (only in the strategy draft)	No	No	Yes	No
Slovakia	Yes	Yes	No (targets exist in other strategies)	Yes	No	No

3. Reports

After the table has given a first impression, the national reports are intended to provide a more detailed insight into the policy and legal situation of the countries. To this end, the content of relevant strategies in the fields of hydrogen (especially H2 used in industry) and mobility (especially vehicle-to-x) will be presented, followed by a more detailed examination of the laws that regulate these areas.

The policy and regulatory framework of the European Union will be examined first, followed by the national status quo (in alphabetical order of the participating countries). The aim is to provide an overview of the strategic orientation of the state on the one hand, and the legal framework on the other, in order to draw conclusions on how far it is developed to enable the integration of these technologies.

3.1. European Union

In recent years, the European Union has undertaken a comprehensive revision of numerous legal regulations in energy and climate matters. This process has been characterised by a notable commitment to the expansion of renewable energies. The legislative change is based on the fact that the implementation of renewable energies into the existing energy system requires a major legal adaptation process to remove legal barriers and obstacles and thus pave the way for the progressive application of renewables.

3.1.1. European strategies

The EU initiated this change through a series of strategies that have been further elaborated in subsequent documents. A portion of these strategies has already been integrated into legal norms.

The most significant strategic papers encompass the following:

- **Clean Energy For All Europeans**[1] (2016)
- **The European Green Deal**[2] (2019)
- **A hydrogen strategy for a climate-neutral Europe**[3] (2020)
- **Sustainable and Smart Mobility Strategy – putting European transport on track for the future**[4] (2020)
- **'Fit for 55': delivering the EU's 2030 Climate Target on the way to climate neutrality**[5] (2021)

3.1.2. European legal acts

The **"European Climate Law" (Regulation (EU) 2021/1119)** should act as a guarantor for progress towards the Paris climate goals and sets a target for the EU to achieve climate neutrality by 2050. On the way to climate neutrality, an interim target has also been set to reduce net greenhouse gas emissions by at least 55% by 2030 compared to 1990 levels.

[1] Communication from the Commission, Clean Energy For All Europeans, COM(2016) 860 final, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52016DC0860 (accessed 30.12.2024).

[2] Communication from the Commission, The European Green Deal, COM(2019) 640 final, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:52019DC0640 (accessed 30.12.2024).

[3] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, A hydrogen strategy for a climate-neutral Europe, COM(2020) 301 final, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:52020DC0301 (accessed 30.12.2024).

[4] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, Sustainable and Smart Mobility Strategy – putting European transport on track for the future, COM(2020) 789 final, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0789 (accessed 30.12.2024).

[5] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, 'Fit for 55': delivering the EU's 2030 Climate Target on the way to climate neutrality, COM(2021) 550 final, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:52021DC0550 (accessed 30.12.2024).

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One of the key instruments of European energy and climate policy is the **Renewable Energy Directive (Directive [EU] 2018/2001 – RED III)**. It aims to promote energy from renewable sources and sets overall and specific sectoral targets. It provides a common binding target for Member States to increase the share of renewable energy in the Union's gross energy consumption to 42,5% by 2030, with a view to reaching 45% (2,5% non-binding).

For the industrial sector, the Directive sets a non-binding target for increasing the share of renewable energy sources in final energy and non-energy consumption. Accordingly, there should be an annual increase of 1,6 percentage points, calculated as an annual average for the periods 2021-2025 and 2026-2030. A partial count concerning this target is foreseen for the use of waste heating and cooling. With regard to hydrogen used for the above-mentioned purposes in industry, it is stipulated that at least 42% must be renewable fuels of non-biological origin (e.g. renewable hydrogen) by 2030. This share is to be increased to 60% by 2030.

For the transport sector, member states shall oblige fuel suppliers to meet two different targets. The first target includes the option of either increasing the minimum share of renewable energy in the sector's final energy consumption to 29% by 2030 or reducing its greenhouse gas intensity by 14,5%. The second target sets a combined minimum share of advanced biofuels and biogas (e.g. produced from renewable fuels of non-biogenic origin) in the energy supply for transport of 1% by 2025 and 5,5% by 2030.

The **Delegated Regulation (EU) 2023/1184** establishes a harmonised methodology for the EU, introducing rules for the production of renewable fuels of non-biological origin. The method determines the conditions under which electricity utilised in the production process can be classified as renewable, which in turn determines the renewable nature of the produced fuels, particularly hydrogen. Two scenarios are considered: electricity obtained from a direct line or from the public grid. If the electricity is taken from the public grid, the regulation offers several options with corresponding requirements, with different connection points. This ensures that the methods can be chosen according to individual circumstances.

The connection points are as follows:

- more than 90 % average proportion of renewable electricity
- emission intensity of electricity lower than 18 gCO2eq/MJ
- system useful fuel production
- conditions of additionality, temporal correlation and geographical correlation

The method also regulates the verification requirements for these fuel units. The Delegated Regulation is supplementing Directive (EU) 2018/2001.

Directive (EU) 2019/944 regulates the **European internal electricity market**. Accordingly, it contains provisions on various aspects of the electricity market (such as market roles, unbundling, regulatory authorities, etc.). Of particular relevance is the Directive's definition of energy storage, which is likely to include both electrolysers and EVs in the case of bi-directional recharging. The European Commission confirmed this technology-neutral formulation of the definition in its

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Recommendation (2023/C 103/01) of 14 March 2023. The classification as energy storage is also accompanied by a prohibition for system operators to own, construct, manage or operate such facilities, unless member states define an exemption in accordance with the conditions of the Directive. A similar prohibition for system operators is found in the Directive for the ownership, construction, management or operation of recharging points.

The EU directive regulating the internal gas market has recently undergone a revision (**Directive [EU] 2024/1788**) and adoption under the motto 'Decarbonisation of gas markets', accompanied by the corresponding regulation (**Regulation [EU] 2024/1789**). The provisions for hydrogen have been comprehensively novelised. The objective is to establish a hydrogen market, inclusive of the associated infrastructure and network planning. In order to guide the gas industry towards renewable gas, the directive also contains provisions on renewable and low-carbon gases.

In 2023, the European Union revised Directive 2014/94/EU on the deployment of alternative fuels infrastructure, whereby the form of a regulation was chosen for the new legislation. This development can be attributed to a number of factors, but one of the most significant was the uneven development of infrastructure in the various EU countries up to that point. In order to facilitate a gradual increase in the number of vehicles equipped with alternative drive systems, it was essential to ensure seamless cross-border traffic flow, with infrastructure assuming a pivotal role in this regard.

Regulation (EU) 2023/1804 on the deployment of alternative fuels infrastructure, which is directly applicable in the Member States, aims to ensure that infrastructure is developed evenly across the EU. The regulation mentions a variety of fuels, including electricity and hydrogen.

For e-mobility, the targets are divided into those for light and heavy duty vehicles and a distinction is made between the TEN-T core network and the TEN-T comprehensive network. Targets are set for the years by which public recharging points must be available, the distances at which they must be provided and the charging capacity they must provide, with the targets for light-duty vehicles being "stricter" than those for heavy-duty vehicles. There are also provisions on how payment, invoicing and pricing must be carried out, as well as requirements based on the ability of recharging points to communicate with the grid in order to adjust charging power according to grid load.

The targets for hydrogen mobility do not distinguish between vehicle groups, but include targets for the development of refuelling infrastructure. Similar to the charging infrastructure, the targets are staggered over the years. There are also requirements for hydrogen refuelling operators related to various aspects of payment terms.

3.2. Austria

The Austrian government has committed itself to certain overarching climate goals in the **Government Programme 2020-2024**[6].In contrast to the targets set by the European Union, climate neutrality in Austria should be achieved by 2040, making Austria a European pioneer in climate protection. This also goes hand in hand with the rejection of nuclear power as an alternative and the focus on exclusively renewable energy sources.[7]

3.2.1. Hydrogen

The **Austrian hydrogen strategy**[8] sets a strategic orientation and was adopted in 2022 and aims, among other things, to build up 1 GW of electrolysis capacity by 2030, create a supporting framework for the production of renewable hydrogen, establish hydrogen production as an important part of the energy system and develop a suitable hydrogen infrastructure.[9] The potential of electrolysers as a sector-coupling technology is recognised and their promotion and targeted use in areas for which electrification is not a viable option, such as industry, is being attempted.[10]

As electricity is required to generate renewable hydrogen, the **Electricity Act 2010** (Elektrizitätswirtschafts- und -organisationsgesetz 2010), as the central regulation for the electricity sector, is also an important source in this application. It regulates a wide range of topics from electricity generation and supply, the operation of grids and unbundling, to system utilisation fees and customer rights. With regard to the production of hydrogen, the classification of the electrolyser as a market participant under electricity law and the corresponding rights and obligations (e.g. payment of system usage fees) are relevant in this context.

The Electricity Act 2010 is to be significantly revised in order to, among other things, meet the requirements of European legislation. To this end, the draft of the **revised Electricity Act** (Elektrizitätswirtschaftsgesetz) was presented by the federal government at the beginning of 2024. According to the draft, the provisions relating to energy storage (which includes electrolysers) would be relevant to hydrogen. In addition, changes are also planned to the facilitations for system utilisation fees, which in future should be linked to the condition of system usefulness.

The **Renewable Energy Expansion Act** (Erneuerbaren-Ausbau-Gesetz) implements with its provisions the RED II as well as the internal electricity market legislation. Specifically, it sets the goal of increasing the share of nationally produced renewable gas to 5 TWh by 2030. The REEA also sets a target for domestic renewable electricity generation to be equal to total domestic electricity consumption by 2030. Furthermore, guarantees of origin for renewable energy are also regulated, as are investment subsidies for renewable gases. Specifically, regarding electrolysers, there are

[6] Federal Chancellery of Austria, Out of responsibility for Austria – Government Programme 2020-2024 (2020), https://www.bundeskanzleramt.gv.at/dam/jcr:7b9e6755-2115-440c-b2ec-cbf64a931aa8/RegProgramm-lang.pdf (accessed 06.06.2024).

[7] Federal Chancellery of Austria, Government Programme 2020 – 2024, p. 72.

[8] Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology, Hydrogen Strategy for Austria (2020), https://www.bmk.gv.at/dam/jcr:0eb2f307-1e4d-41b1-bfd8-22918816eb1b/BMK_Wasserstoffstrategie_DE_UA_final.pdf (accessed 06.06.2024).

[9] Cf. Federal Ministry for Climate Action, Hydrogen Strategy, pp. 17, 18.

[10] Cf. Federal Ministry for Climate Action, Hydrogen Strategy, p. 24.

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also regulations on investment subsidies for plants that convert electricity into hydrogen or synthetic gas.

The draft of the **Hydrogen Promotion Act** (Wasserstoffförderungsgesetz) was presented by the Austrian government at the beginning of 2024 and entered into force in July 2024. Its aim is to increase the production of renewable hydrogen of non-biological origin by creating a legal basis for promoting the construction and operation of plants for the production of such gases. Funding will be provided through competitive auctions for the period of 2024 till 2026. A total of up to €820 million in federal funds will be made available for the promotion, although only newly constructed facilities for the production of renewable hydrogen from non-biogenic origin are eligible.

If hydrogen is fed into the public gas grid after production, the **Gas Act 2011** (Gaswirtschaftsgesetz 2011) applies. This Act, like the Electricity Act 2010 for the electricity market, is the central law for regulating the gas market. Since hydrogen may not be fed directly into the public gas grid in Austria, if methanation does not follow, natural gas must first be obtained from the gas grid, mixed with the renewable hydrogen produced, and then the natural gas-hydrogen mixture must be fed into the public gas grid. Among other things, the Act contains regulations for system utilisation fees and also exemptions from these in the case of hydrogen feed-in. In line with the new EU regulatory framework for the gas sector, the revision of the Gas Act 2011 is expected in the near future.

The **Renewable Gases Act** (Erneuerbares-Gas-Gesetz), which aims to increase sales of renewable gases on the Austrian gas market to 7.5 TWh by 2030, is also currently being developed. Alongside this, domestic consumption of fossil natural gas is to be reduced and a supply of nationally produced renewable gas is to be ensured by 2040. The draft provides mandatory green gas quotas that must be met by gas suppliers in order to substitute fossil gas volumes with renewable gases.

The **Gas Labelling Ordinance** (Gaskennzeichnungsverordnung) regulates the labelling of the origin and environmental impact of gases that are fed into or withdrawn from the public gas grid. The provisions include the labelling of primary energy sources, conversion and storage as well as international trade.

3.2.2. Vehicle-to-grid and the mobility sector

Austia's 2030 Mobility Master Plan (Mobilitätsmasterplan 2030)[11] is a strategic planning instrument for the transport sector in Austria, which was published in 2021 and is intended to help achieve climate neutrality by 2040. To this end, CO_2 emissions in this sector are to be reduced to almost zero by implementing a large number of targets and measures. In future, the most efficient and available technologies are to be used in a climate-neutral manner and the expansion of the necessary infrastructure is also to be driven forward.[12]

The **Immediate Action Programme** (Sofortprogramm: Erneuerbare Energie in der Mobilität)[13] from 2022 serves as a bridge between the national strategic goals from the Mobility Master Plan

[11] Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology, Austria's 2030 Mobility Master Plan – The new climate action framework for the transport sector: sustainable – resilient – digital (2021), https://www.bmk.gv.at/dam/jcr:6318aa6f-f02b-4eb0-9eb9-1ffabf369432/BMK_Mobilitaetsmasterplan2030_DE_UA.pdf (accessed 06.06.2024).

[12] Cf. Federal Ministry for Climate Action, Austria's 2030 Mobility Master Plan, pp. 8, 37.

[13] Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology, Immediate Action Programme: renewable energy in mobility – An implementation strategy for the Mobility Masterplan 2030 for the energy

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2030 and the European targets from the Fit for 55 package and thus the targets from the Alternative Fuels Infrastructure Regulation (AFIR).[14] However, some of the EU targets are also to be exceeded, for example by only registering new zero-emission cars from 2030. In addition, the expansion of the infrastructure should be increased by offering 95% of the population in Austria a fast charging station within a maximum distance of 15 km, which will lead to exceeding the AFIR targets by 2030.[15]

As vehicle-to-grid/home is about the possibility of supplying electricity from the electric vehicle to the public grid or to one's own home, the provisions of the **Electricity Act 2010** must be taken into account. The specific provisions relating to the consumption and supply of electricity and the associated rights and obligations as well as distribution of roles assigned to the vehicle in carrying out the activities are relevant. However, it must be noted that the EA does not explicitly address V2G and therefore there is a certain need for regulation.

According to the new **Electricity Act draft**, the provisions relating to energy storage (which includes battery electric vehicles) would be relevant for vehicle-to-grid. In addition, changes are also planned to the facilitations for system utilisation fees, which in future should be linked to the condition of system usefulness. This could also apply to BEV when they are connected to a charging station and the charging power and direction of electricity flow is optimised automatically according to the grid capacity. The proposal also contains provisions on the operation of charging infrastructure, particularly in relation to grid operators implementing the requirements of the Internal Electricity Market Directive.

transition in road transport (2022), https://www.bmk.gv.at/dam/jcr:39ca215f-71b4-422a-bfa0-5bf2efd1ef6b/BMK_Sofortprogramm_EEM_UA.pdf (accessed 06.06.2024).

[14] Cf. Federal Ministry for Climate Action, Immediate Action Programme, p. 7.

[15] Cf. Federal Ministry for Climate Action, Immediate Action Programme, pp. 13, 14.

3.3. Bosnia and Herzegovina

At the beginnig, it is important to emphasize the specific constitution of Bosnia and Herzegovina. Bosnia and Herzegovina consist of two Entities - Republika Srpska and the Federation of Bosnia and Herzegovina (Federacija Bosna i Hercegovina – hereinafter FBiH) and Brcko District. Besides this, Federation of Bosnia and Herzegovina is divided into ten cantons. Therefore, according to that, there are four levels of a governance in Bosnia and Herzegovina – State level, Entity level, Cantonal and municipal levels.

The Republika Srpska is one constitutional and legal entity comprising one level of local self-government with 8 Cities and 63 Municipalities, and has its own Government, Parliament, laws, bylaws and judicial powers.

On the other side, Federation of BiH is divided into ten cantons, which represent federal units of the FBiH. Each canton has its own parliament and government, as well as legislative and judicial powers. Moreover, the Federation of Bosnia and Herzegovina has the Federal parliament, and their own constitution, Government and legislations. In that sense, it is possible to say there are eleven governments, parliaments and legislators in FBiH. Cantons are divided into municipalities and cities, 79 in total. All municipalities and cities have their own self-government units, with legislative powers.

The third component, which is ownership of both Republika Srpska and FBiH, is Brcko District. According to decision of international arbitration tribunal in 1999, Brcko was established as a District. Thus, District Brcko (which is, in fact, a municipality) is condominium jointly owned by the Entities but not managed by either. Legislation from State level directly applies to the district and its fields of competence are nearly the same as the ones of the Entities (including executive, legal and judiciary authorities).

3.3.1. General

Having in mind complicated legal and political framework in Bosnia and Herzegovina, with combination of governance between several levels, it is important to emphasize that each entity has its own strategy for energy sector.

ENERGY DEVELOPMENT STRATEGY OF THE REPUBLIC OF SRPSKA UNTIL 2035[16] represents a set of goals and measures for the implementation of the policy of the Government of the Republic of Srpska in the energy sector. The Government's policy is expressed in strategic goals at the sectoral level, as well as specific goals for individual parts of the energy sector. The strategy defines five key strategic goals until 2035, namely: efficient use (exploitation) of resources; secure and affordable energy; efficient use of energy; energy transition and responsibility towards the environment and development and harmonization of the regulatory-institutional framework.

[16] Energy Development Strategy of the Republic of Srpska until 2035, https://vladars.rs/sr-SP-Cyrl/Vlada/Ministarstva/mper/std/Documents/StrategijaEnergetike2035Latinica.pdf (accessed 30.12.2024).

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FRAMEWORK ENERGY STRATEGY OF THE FEDERATION OF BOSNIA AND HERZEGOVINA UNTIL 2035[17] as the long-term goal of FBIH's energy sector consider the creation of a competitive and long-term sustainable energy system, within the framework of available capacities, resources and adequate dynamics. A stable energy system is necessary for the stability and start-up of other branches of the economy, as well as maintaining the competitiveness of the economy as a whole. In order to achieve the stated goal, five key priorities and related focus areas were defined: efficient use of resources, secure and affordable energy, efficient use of energy, energy transition and responsibilities towards the environment and development and alignment of the regulatory-institutional framework.

3.3.2. Energy efficiency and renewable energy sources

Both entities have their own laws related to energy efficiency and renewable energy sources.

Republika Srpska adopted the **Law on renewable energy sources** in February 2022 and also adopted the Program on the use of renewable energy sources in January 2024. The law and the program regulate: the overall goals of the Republic of Srpska on the share of energy from renewable sources until 2030; sector goals by year; total contributions expected from individual technologies; an overview of the types and methods of achieving incentives; the amounts provided for incentives by technology; as well as others issues of importance for achieving the goals set by the energy and climate plan of the Republic of Srpska. New Law enables market premiums and assumes full balancing responsibility for all projects above 500 kW. Preparation of secondary legislation is ongoing[18].

Law on the use of renewable energy sources and efficient cogeneration in Federation of BiH has been adopted in October 2023. The aim of this law is to promote and regulate the production of electricity, heating and cooling energy from RES and EC, as well as the use of RES in transport for consumption on the domestic market and to increase the share in total energy consumption, and to ensure the development of incentive measures, regulatory framework and technical infrastructure for RES and EC. The support scheme is based on administratively set feed-in tariffs in Federation of Bosnia and Herzegovina, where renewable energy producers under feed-in tariffs remain fully released from balancing responsibility as the adoption of the methodology for allocating balancing costs is still pending[19].

According to Bosnia and Herzegovina Annual Implementation report for 2023[20] (Energy Community Secretariat), overall implementation score on renewable energy for Bosnia and Herzegovina for 2023 is 44%, while for energy efficiency is 48%. Target for share of energy from renewable sources for 2030 is 43,6%.

[17]Framework energy strategy of Bosnia and Herzegovina until 2035, https://www.mvteo.gov.ba/data/Home/Dokumenti/Energetika/19042022_Framework_Energy_Strategy_of_BiH_until_2035_ENG_FINAL.pdf (accessed 30.12.2024).

[18]https://reers.ba/wp-content/uploads/2022/04/Zakon-o-obnovljivim-izvorima-energije-Sluzbeni-glasnik-RS-broj-1622.pdf (accessed 30.12.2024).

[19]https://advokat-prnjavorac.com/zakoni/Zakon-o-koristenju-obnovljivih-izvora-energije-i-efikasne-kogeneracije-FBiH.pdf (accessed 30.12.2024).

[20] Energy Community Secretariat, Annual Implementation Report (2023), https://www.energy-community.org/dam/jcr:3da7c4f8-ea23-4169-b1e9-66b0ed05fcb7/EnC_IR2023.pdf (accessed 30.12.2024).

3.3.3. Hydrogen

Bosnia and Herzegovina submitted the **INTEGRATED ENERGY AND CLIMATE PLAN OF BOSNIA AND HERZEGOVINA**[21] (draft version) in 2023. This document establishes links between the existing elements of the strategic framework and defines a new approach that introduces stronger cooperation between sectors, with the aim of establishing a clear and efficient implementation framework, based on an intersectoral approach. This new, linked strategic approach should ensure a smooth process of the energy sector decarbonisation in 2030, which aims for meeting the carbon neutrality criterion by 2050.

The pillars of this strategic approach are set according to the dimensions defined by the Energy Union Strategy (COM/2015/080)24[22], namely: Dimension 1A: Decarbonisation: Reduction and elimination of greenhouse gas emissions, Dimension 1B: Decarbonisation: Renewable energy sources, Dimension 2: Energy efficiency, Dimension 3: Security of supply, Dimension 4: Internal energy market, Dimension 5: Research, competitiveness and innovation.

Within the dimension 3, there are two points: 3-2.1.2 Reduce the consumption of oil and petroleum products by electrifying transport and using hydrogen, and 3-2.2.2 Reduce dependence on the import of natural gas by means of measures to convert fuel in industry to hydrogen and electricity.

These two operational objectives cover the set of measures related to hydrogen usage up to 2030. Unfortunately, the measures identified for these two points, related to future use of hydrogen to reduce the role of natural gas in electricity production or heating, or consumption of oil and petroleum, appear in very general way, like "Enact public policies with the aim of electrifying transport and using hydrogen", but they lack with concrete details and measurable planning.

3.3.4. Electromobility sector

Regarding electromobility sector, legislation in the field of transport does not recognize, sufficiently and in details, the necessary aspects of electro-mobility and usage of green hydrogen, although part of it already exists in by-laws, rulebooks etc. but mostly related to the import procedures, permits and registration procedures of such vehicles.

Besides previously mentioned operational objectives in the document INTEGRATED ENERGY AND CLIMATE PLAN OF BOSNIA AND HERZEGOVINA, which are related to transport and electromobility, there are also entity laws and regulations which define the overall conditions for electromobility sector.

According to the **Law on electricity in Republika Srpska** the entity regulator - Regulatory Commission for Energy of Republic of Srpska - defines the conditions for delivery of electricity to final customers, including the conditions and methods of issuing electric power permits for the connection of new users of the system, including places for charging or supplying for electric vehicles.

[21] Integrated energy and climate plan of bosnia and herzegovina (draft), https://www.energy-community.org/dam/jcr:fffa65bf-d137-454d-aad7-992eee783af6/NECP%20BiH%20v.7_ENG.pdf (accessed 30.12.2024).

[22] https://energy.ec.europa.eu/topics/energy-strategy/energy-union_en (accessed 30.12.2024).

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The Law on Electricity of the FBiH enter into force in august 2023, together with Law on Energy and Regulation of Energy Activities. The Law on Electricity of the FBiH introduced new legal framework for electromobility.

For the first time, the conditions for installation of public and private charging stations for electric vehicles and providing charging services for electric vehicles are defined by this law. According to the law, the operators of the grid have to cooperate with the companies, private or public, in installing or managing of charging stations. Charging stations will be available for public. On the other side, the service providers are obligated to have market, easily comparable and non-discriminatory prices for electric vehicle charging services.

3.4. Croatia

The **Government Programme 2024 – 2028**[23] outlines the key developmental priorities for the country in the coming years. These priorities include demographic revitalization, digital transformation, decarbonization, and education. The programme emphasizes the importance of renewable energy sources, aiming to increase energy independence and reduce CO2 emissions, in line with the European Green Plan. There is a strong focus on modernizing infrastructure, particularly in energy, transport, and urban development, including significant investments in renewable energy, the expansion of the LNG terminal, and the modernization of public transportation systems. The government also plans to focus on the unique needs of Croatian islands, climate change adaptation, and the development of sustainable urban mobility ecosystems.

3.4.1. Hydrogen

Croatia's Hydrogen Strategy[24] aligns with the country's broader goals for green and digital transitions, focusing on achieving climate neutrality and sustainable mobility. The strategy is based on four pillars that determine the main guidelines for the development of the hydrogen-based economy: 1) production of low (or zero) carbon and renewable hydrogen, 2) hydrogen storage and transport which includes conversion of existing infrastructure, 3) use of hydrogen with emphasis on industrial processes, agriculture, and transport, and 4) education, research and innovation ensuring the development and commercialization of new hydrogen technologies. The strategy also highlights the importance of establishing hydrogen clusters, implementing international standards, and creating a favourable regulatory environment to accelerate the adoption of hydrogen technologies.

The strategy sets specific goals for short-term (until 2026), medium-term (until 2030), and long-term periods (until 2050), with a focus on reducing greenhouse gas emissions, supporting clean energy transitions, and developing a robust hydrogen economy by 2050. The specific goals for long-term period include electrolyser capacity of 2750 MW, 11% share of hydrogen in total energy consumption, 100 hydrogen filling stations, and 50 patents related to the hydrogen-based economy. The strategy also lists implementation priorities where the first one is the use of renewable hydrogen in oil refinery for the processing of conventional fuels which contributes to increased share of RES in transport with a reduction in greenhouse gas emissions.

The macroeconomic impact assessment was carried out for two development scenarios, one corresponding to the scenario of climate neutrality, and the other scenario based on the assumptions of accelerated development of the hydrogen-based economy.

[23] Programme of the Government of the Republic of Croatia for the mandate 2024 - 2028 (2024), https://vlada.gov.hr/UserDocsImages/ZPPI/Dokumenti%20Vlada/2024/Program_16_Vlade_RH.pdf (accessed 19.08.2024).

[24] Hydrogen Strategy of the Republic of Croatia until 2050 (2022), https://mingo.gov.hr/UserDocsImages/UPRAVA%20ZA%20ENERGETIKU/Strategije,%20planovi%20i%20programi/Novi%20direktorij/ZA%20WEB%20Hrvatska%20startegija%20za%20vodik%20do%202050.%20godine.pdf (accessed 19.08.2024).

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The **Study of the Development Plan and Implementation of Croatia's Hydrogen Strategy**[25] outlines Croatia's approach to integrating hydrogen into its energy system as part of its transition to green energy. The strategy aligns with the broader European goals for climate neutrality by 2050 and focuses on developing a hydrogen-based economy. Key initiatives include expanding the production of renewable hydrogen, particularly from solar, wind, and hydropower sources, and adapting existing natural gas infrastructure for hydrogen storage and distribution.

The strategy also emphasises the development of a comprehensive hydrogen refuelling network to support hydrogen-powered public and private transport and highlights the importance of pilot projects and a robust regulatory framework. Hydrogen's applications in various sectors, including transport, industry, energy, and heating, are explored, with a focus on its role in decarbonisation, especially in areas where electrification is difficult.

In Croatia, hydrogen is currently produced and used only in the Rijeka Oil Refinery and in Petrokemija Kutina to produce ammonia. The study also notes that, while Croatia does not currently produce electrolysers, alternative hydrogen production technologies such as biomass pyrolysis and gasification are being developed domestically. Public awareness, education, and research and development are identified as crucial elements for the successful implementation of the hydrogen strategy.

The **National Recovery and Resilience Plan**[26] outlines substantial investments in hydrogen infrastructure as a critical element of Croatia's energy transition. This includes the construction of electrolysers and hydrogen refuelling stations to support the use of hydrogen in transport. The plan also aims to develop the hydrogen economy by financing projects focused on renewable hydrogen production and integrating hydrogen into the energy system, with a target to build an initial 30 MW of electrolysers.

One of the main goals of the **Energy development strategy**[27] is the construction of new infrastructure for alternative fuels in transport, including hydrogen, by 2030. The report highlights the importance of producing hydrogen using renewable electricity, particularly for sectors where direct electrification is difficult, such as aviation, maritime, and heavy-duty road transport, as well as certain industrial processes. The Strategy recognizes hydrogen as a crucial fuel for the future, with a potential role for CCS technology to achieve lower emissions.

The **Low-carbon development strategy**[28] presents the significant potential of hydrogen as a fuel. The document explains the need for substantial investments in the distribution network for hydrogen, which has been identified as one of the key means towards wider adoption of hydrogen as a fuel for transport. The use of hydrogen in vehicles does not require special adjustments regarding travel and refuelling habits. The advantage of hydrogen is that, due to its high energy value, it is suitable for use in freight vehicles and for powering ships. Its widespread use supports

[25] Study of the Development Plan and Implementation of the Croatia's Hydrogen Strategy until 2050 (2024), https://www.azu.hr/media/201nx0by/hr-h2-strategy-implementation_summary-study_final.pdf (accessed 20.08.2024).

[26] National Recovery and Resilience Plan 2021. – 2026 (2021), pp. 184-186, https://planoporavka.gov.hr/UserDocsImages/dokumenti/Plan%20oporavka%20i%20otpornosti%2C%20srpanj%202021..pdf?vel=13435491 (accessed 19.08.2024).

[27] Energy development strategy of the Republic of Croatia until 2030 with a view to 2050 (2020), https://mingo.gov.hr/UserDocsImages/UPRAVA%20ZA%20ENERGETIKU/Strategije,%20planovi%20i%20programi/Strategija%20energetskog%20razvoja%20RH%202030%20s%20pogledom%20na%202050.pdf (accessed 19.08.2024).

[28] Low-carbon development strategy of the Republic of Croatia until 2030 with a look at 2050 (2021), p. 41, https://ec.europa.eu/clima/sites/lts/lts_hr_hr.pdf (accessed 19.08.2024).

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the integration of renewable energy sources, as excess electricity from renewables can be stored by producing hydrogen.

Croatia's Plan for the Production and Use of Biofuels in Transport[29] outlines a specific measure (C7.1. R1-I1) that aims to enhance the use of hydrogen and new technologies in Croatia. This measure includes investments in renewable hydrogen production through the installation of electrolysers, the construction of hydrogen refuelling infrastructure, and technical studies on the potential for geological CO2 storage. Additionally, Measure C7.1. R1-I2 focuses on developing a hydrogen-based economy including the production, storage, transport and utilization of hydrogen, in line with the Croatian Hydrogen Strategy until 2050.

Zero scenario[30] envisions a substantial increase in the use of e-fuels between 2040 and 2050. These synthetic fuels, created by combining "green" or "e-hydrogen" (produced through electrolysis using renewable electricity) and captured CO2, are expected to play a key role in decarbonizing sectors where direct electrification is challenging. While currently expensive, the cost of e-fuels is projected to decrease due to advancements in technology and economies of scale, potentially reaching 1-3 EUR/l by 2050. The scenario also highlights the importance of hydrogen in heavy-duty road transport, potentially in combination with fuel cell technology, electric vehicles, biofuels, and synthetic fuels. The report identifies several challenges in transport sector, including optimizing the transport system, increasing the use of low-emission alternative energy, promoting demand for zero-emission vehicles, fostering research and innovation, and ensuring active participation from local communities.

The **Law on the Gas Market**[31] in Croatia regulates the production, trade, and distribution of natural gas and other gases like biogas and LNG, provided they can be safely integrated into the natural gas system. The law requires the transmission system operator to develop a ten-year plan for the gas network, aligned with the national energy strategy, and submit it for approval every two years. While the law generally applies to various types of gas, it does not specifically address the integration of hydrogen into the gas network.

3.4.2. Mobility sector

The **Energy development strategy**[32] outlines plan for building new infrastructure to support the use of alternative fuels in transport, including electric charging stations, by 2030. It also predicts an increase in the share of private electric vehicles and the electrification of public transport. According to this strategy, in the period up to 2030, the transport sector will focus on building new infrastructure for the use of alternative forms of energy in transport (LPG and CNG/LNG, electricity and hydrogen). An increase in the share of alternatively fuelled vehicles, especially electric ones, is

[29] Croatia's Plan for the Production and Use of Biofuels in Transport (2024), pp. 50-52, https://mingo.gov.hr/UserDocsImages/UPRAVA%20ZA%20ENERGETIKU/Plan%20proizvodnje%20i%20kori%C5%A1tenja%20biogoriva%20u%20prometu_Studija_5_04_2024.docx (accessed 19.08.2024).

[30] Zero scenario for the energy sector - draft for public discussion (2020), https://mingo.gov.hr/UserDocsImages/UPRAVA%20ZA%20ENERGETIKU/Strategije,%20planovi%20i%20programi/NULTI%20SCENARIJ%20za%20energetski%20sektor%20-%20nacrt%20za%20javnu%20raspravu.pdf (accessed 19.08.2024).

[31] Law on the Gas Market, https://www.hera.hr/hr/docs/SPKP/ZoTP-2018.pdf (accessed 19.08.2024).

[32] Energy development strategy of the Republic of Croatia until 2030 with a view to 2050 (2020), https://mingo.gov.hr/UserDocsImages/UPRAVA%20ZA%20ENERGETIKU/Strategije,%20planovi%20i%20programi/Strategija%20energetskog%20razvoja%20RH%202030%20s%20pogledom%20na%202050.pdf (accessed 19.08.2024).

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predicted, as well as the electrification of public transport, and an increase in the use of LPG in heavy freight, maritime and rail transport. The development of advanced networks should enable the transport sector to participate in the cost-effective provision of flexibility and balancing services to the power system.

The Environmental Protection and Energy Efficiency Fund in Croatia has been supporting the transition to cleaner transport since 2014 through the **Drive Economically**[33] project. This initiative provides grants to individuals and companies for purchasing energy-efficient vehicles, such as electric and hybrid cars. Between 2014 and 2024, Fund allocated significant funding to promote energy-efficient vehicles, resulting in increased adoption of electric and hybrid cars and latest 15 million euro initiative in 2024 is expected to cover more than 2,000 new vehicles. The expected benefits include energy savings and a significant reduction in CO2 emissions. Although the co-financing is extended to hydrogen cars, this benefit is still not consumed in Croatia.

The **Low-carbon development strategy**[34] outlines key measures in the transport sector aimed at reducing CO2 emissions. These include the use of low-emission fuels like electricity, natural gas, hydrogen, and biofuels, as well as promoting the electrification of personal vehicles. The strategy also emphasizes improving vehicle efficiency, discouraging diesel fuel use, and reducing the import of old diesel vehicles. Additionally, it advocates for sustainable integrated transport systems and the localization of production to minimize freight transport. Achieving significant emission reductions by 2050 will require the development of electric vehicles and the support of renewable energy sources in electricity production.

The strategic goals of **National Development Strategy**[35] focus on modernising Croatia's railway infrastructure, particularly within the core TEN-T network, and enhancing suburban rail services. There is a strong emphasis on promoting freight transport by rail and other low-emission transport modes, as well as advancing integrated urban transport systems. Additionally, the strategy prioritises the development of new transport processes and autonomous mobility systems.

The **Croatia's Plan for the Production and Use of Biofuels in Transport**[36] outlines several initiatives aimed at promoting cleaner transport and reducing greenhouse gas emissions. It includes a program (TR-2) to co-finance the purchase of new alternative fuel vehicles and the development of related infrastructure. It also highlights the importance of developing charging infrastructure for both light and heavy-duty vehicles along the Trans-European Transport Network (TEN-T). Additionally, the Modernization Fund supports investments that improve energy efficiency in the transport sector, further contributing to the decarbonization. The European strategy for the future of transportation focuses on three key pillars: making all forms of transportation more environmentally friendly, ensuring sustainable alternatives are readily available within a multi-

[33] Program of co-financing of electric vehicles in 2024, https://www.fzoeu.hr/hr/sufinanciranje-nabave-energetski-ucinkovitijih-vozila/7713 (accessed 19.08.2024).

[34] Low-carbon development strategy of the Republic of Croatia until 2030 with a look at 2050 (2021), p. 40, https://ec.europa.eu/clima/sites/lts/lts_hr_hr.pdf (accessed 19.08.2024).

[35] National development strategy of the Republic of Croatia until 2030. (2021), pp 57, https://narodne-novine.nn.hr/clanci/sluzbeni/2021_02_13_230.html (accessed 20.08.2024).

[36] Croatia's Plan for the Production and Use of Biofuels in Transport (2024), p. 40, https://mingo.gov.hr/UserDocsImages/UPRAVA%20ZA%20ENERGETIKU/Plan%20proizvodnje%20i%20kori%C5%A1tenja%20biogoriva%20u%20prometu_Studija_5_04_2024.docx (accessed 19.08.2024).

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modal transport network, and implementing incentives to encourage the shift towards greener travel options.

Other Croatia's mobility plans developed under the **National Recovery and Resilience Plan**[37], and **Strategy for Transport Development**[38] focus on expanding green mobility through investments in alternative-fuel vehicles, e-charging and hydrogen infrastructure, energy-efficient systems, and innovative solutions like e-bikes, aiming to reduce CO2 emissions and enhance sustainable transport. Local municipalities plans such as the **Development plan of Koprivničko-križevačka County**[39] includes the measure of the improvement of electromobility through the gradual replacement of vehicles in the public sector with electric vehicles and energy-efficient vehicles on alternative fuels.

The Croatian **Law on the Establishment of Infrastructure for Alternative Fuels**[40] mandates the deployment of a sufficient number of publicly accessible electric vehicle charging points, especially in urban areas and along the core TEN-T network. It also gives technical specifications for these charging points, emphasizing compatibility with Type 2 connectors. Low-power AC charging stations for motor vehicles must be equipped with at least Type 2 sockets or vehicle connectors in accordance with the HRN EN 62196-2 standard. Additionally, the law requires the establishment of a suitable number of publicly accessible hydrogen refuelling stations, adhering to specific technical standards regarding hydrogen purity, refuelling algorithms and equipment, and connector types.

The **Law on Biofuels for Transport**[41] in Croatia regulates the production, trade, and use of biofuels and renewable energy in transport. It sets targets for renewable energy use in transport, aiming for 14% by 2030. Obligated parties must submit plans and monitor the use of biofuels, electricity, and hydrogen. Public transport and the public sector must ensure that 70% of their vehicles use renewable energy or efficient alternatives, and electricity for public transport must be sourced from RESs.

3.4.3. Renewable energy sources

Government Programme 2024 – 2028 foresees and targets the installation of overall 2,500 MW of renewable electricity production facilities by 2028 whereas the **National Recovery and Resilience Plan**[42] recognizes that the current electrical grid is the bottleneck that slows down the connection permits issuing and the development of new projects. Investors have shown interest in connecting over 6,500 MW of renewable electricity facilities, highlighting the need for green transport

[37] National Recovery and Resilience Plan 2021. – 2026. (2021), pp. 350, 370, https://planoporavka.gov.hr/UserDocsImages/dokumenti/Plan%20oporavka%20i%20otpornosti%2C%20srpanj%202021..pdf?vel=13435491 (accessed 19.08.2024).

[38] Strategy for Transport Development of the Republic of Croatia (2017 – 2030) (2017), pp. 62, 210, https://mmpi.gov.hr/UserDocsImages/arhiva/MMPI%20Strategija%20prometnog%20razvoja%20RH%202017.-2030.-final.pdf (accessed 20.08.2024).

[39] Development plan of Koprivničko-Križevačka county 2021.-2027 (2021), p. 50, https://kzz.hr/dokumenti/plan-razvoja-krapinsko-zagorske-zupanije-2021-2027/ (accessed 23.08.2024).

[40] Law on the Establishment of Infrastructure for Alternative Fuels (2016), https://narodne-novine.nn.hr/clanci/sluzbeni/2016_12_120_2608.html (accessed 21.08.2024).

[41] Law on Biofuels for Transport (06/2009), https://www.hera.hr/hr/docs/SPKP/ZoBP-2009.pdf (accessed 21.08.2024).

[42] National Recovery and Resilience Plan 2021. – 2026 (2021), pp. 58-62, https://planoporavka.gov.hr/UserDocsImages/dokumenti/Plan%20oporavka%20i%20otpornosti%2C%20srpanj%202021..pdf?vel=13435491 (accessed 19.08.2024).

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infrastructure, including sufficient biofuels and renewable hydrogen production, distribution, and usage systems.

The **Energy development strategy**[43] sets targets for increasing the share of RES in the energy mix, aiming for a 42% to 93% increase by 2050 depending on the scenario. This increase should come from the development of commercially available technologies, particularly those using the power of water, sun, and wind. To achieve these goals, the strategy proposes financial support for bioeconomy development, sustainable waste management, research, and pilot/demonstration projects. It also advocates for risk mitigation funds for demanding and borderline commercial technologies in the renewable energy sector. A key objective is to achieve 100% domestic electricity production from renewable sources by 2050. The strategy also acknowledges the potential negative environmental impacts of RES projects and emphasizes the need for careful site selection and the use of advanced technologies to minimize these effects.

The **National Recovery and Resilience Plan**[44] prioritises the development of renewable energy infrastructure to meet European and national environmental goals. Key initiatives include the revitalisation, construction, and digitalisation of the energy system, the promotion of energy efficiency, and the integration of renewable energy sources across various sectors. A significant focus is placed on stimulating electricity production from renewable sources by introducing a new system of market premiums.

The **Development plan of Zagreb County**[45] focuses on improving energy efficiency and promoting renewable energy by supporting local resource development, offering advisory services, and encouraging sustainable energy adoption to reduce consumption and boost competitiveness.

The **Law on Renewable Energy Sources and High-Efficiency Cogeneration**[46] establishes support mechanisms to promote the generation of electricity from renewable sources and high-efficiency cogeneration plants. The Ministry ensures that any available support for electricity production from cogeneration plants is contingent upon the electricity being generated from high-efficiency cogeneration and the waste heat being used efficiently to achieve primary energy savings. Under the market premium system, eligible producers can enter into contracts with the energy market operator to receive a premium for the net electricity supplied to the grid from renewable energy sources or high-efficiency cogeneration plants. The feed-in tariff system guarantees a fixed price for the net electricity supplied to the grid from eligible plants.

The **Law on the Electricity Market**[47] prioritizes electricity from renewable sources and cogeneration. It requires the Ministry to align energy permits with national and EU renewable

[43] Energy development strategy of the Republic of Croatia until 2030 with a view to 2050 (2020), see https://mingo.gov.hr/UserDocsImages/UPRAVA%20ZA%20ENERGETIKU/Strategije,%20planovi%20i%20programi/Strategija%20energetskog%20razvoja%20RH%202030%20s%20pogledom%20na%202050.pdf(accessed 19.08.2024).

[44] National Recovery and Resilience Plan 2021. – 2026. (2021), pp. 58-62, https://planoporavka.gov.hr/UserDocsImages/dokumenti/Plan%20oporavka%20i%20otpornosti%2C%20srpanj%202021..pdf?vel=13435491 (accessed 19.08.2024).

[45] Development plan of Zagreb County for the Period 2021-2027 (2022), pp. 69-73, https://www.zagrebacka-zupanija.hr/media/filer_public/ae/cd/aecd1f89-7a9c-4aae-b37f-e97422d3b54d/11_privitak_-_plan_razvoja_zagrebacke_zupanije_za_period_2021-_2027.pdf (accessed 23.08.2024).

[46] Law on Renewable Energy Sources and High-Efficiency Cogeneration (2021), https://www.hera.hr/hr/docs/SPKP/ZoOIEiVUK-2021.pdf (accessed 21.08.2024).

[47] Law on the Electricity Market (10/2021), https://www.hera.hr/hr/docs/SPKP/ZoTEE-2021.pdf)accessed 20.08.2024)

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energy goals, and distribution system operators to prioritize renewable energy facilities. Suppliers must support renewable energy programs, and the Croatian Energy Regulatory Agency oversees the development of an advanced, efficient grid with regular evaluations and reports.

3.4.4. Climate change

The **National Development Strategy**[48] and **Strategy and Action Plan for Nature Protection**[49] outline key development directions and strategic goals to guide Croatia's growth. The strategies focus on green and digital transitions, aiming for climate neutrality through renewable energy, energy efficiency, and sustainable mobility, while addressing biodiversity challenges by integrating renewable energy development with habitat protection and fostering innovative financing for conservation projects.

The **Low-carbon development strategy**[50] discusses the requirements of the EU Governance Regulation, which mandates member states, including Croatia, to prepare an integrated national energy and climate plan by 2030 and a long-term low-carbon strategy by 2050. The purpose of Croatia's Low-Carbon Strategy is to drive societal changes that will reduce greenhouse gas emissions and enable economic growth to be decoupled from emissions. The strategy's general objectives include promoting sustainable development through a low-carbon economy, enhancing energy security and sustainability, fulfilling international obligations, and reducing air pollution to improve public health and quality of life. The strategy outlines around one hundred measures for emission reduction across various sectors such as energy production, transport, industry, agriculture, and waste management. These measures are organised into three scenarios: the Reference Scenario (NUR), the Gradual Transition Scenario (NU1), and the Strong Transition Scenario (NU2), each representing different levels of commitment to reducing emissions.

The **Strategy for Climate Change Adaptation**[51] is a document that provides an assessment of climate change impacts and vulnerabilities in Croatia up to 2040 and 2070. The strategy proposes 83 adaptation measures, including three general measures focused on climate modelling, capacity building, and developing monitoring indicators. In the energy sector, the strategy focuses on the production facilities, distribution, and transmission networks through energy storage and increased renewable energy capacity. It also highlights the importance of a supportive legal framework and rapid response capabilities to mitigate the negative effects of climate change on the energy system.

Achieving the goals of the **Integrated national energy and climate plan**[52] of the Republic of Croatia for the period from 2021 to 2030 (12/2020) will be achieved through five key dimensions

[48] National development strategy of the Republic of Croatia until 2030. (2021), pp. 13-15, https://narodne-novine.nn.hr/clanci/sluzbeni/2021_02_13_230.html (accessed 20.08.2024).

[49] Strategy and Action Plan for Nature Protection of the Republic of Croatia for the period from 2017 to 2025 (2017), https://narodne-novine.nn.hr/clanci/sluzbeni/2017_07_72_1712.html (accessed 20.08.2024).

[50] Low-carbon development strategy of the Republic of Croatia until 2030 with a look at 2050 (2021), p. 40, https://ec.europa.eu/clima/sites/lts/lts_hr_hr.pdf (accessed 19.08.2024).

[51] Strategy for Climate Change Adaptation in the Republic of Croatia for the period up to 2040, with a view to 2070 (2020), https://narodne-novine.nn.hr/clanci/sluzbeni/2020_04_46_921.html (accessed 22.08.2024).

[52] Integrated national energy and climate plan of the Republic of Croatia for the period from 2021 to 2030 (2020), https://mingo.gov.hr/UserDocsImages/UPRAVA%20ZA%20ENERGETIKU/Ostali%20dokumenti/NECP_HRV_final_30_12_2020%20UE.pdf (accessed 22.08.2024).

of the energy union: energy security, internal energy market, energy efficiency, decarbonization and research, innovation and competitiveness. Plan outlines key energy and emissions targets for 2030. It sets a reduction of greenhouse gas emissions by at least 43% for the ETS sector and 7% for sectors outside the ETS, both relative to 2005 levels. The share of renewable energy sources (RES) is targeted to reach 36.6% in gross final energy consumption and 14.0% in the transport sector. Additionally, primary energy consumption is aimed to be 344.4 PJ (8.23 Mtoe), while final energy consumption is targeted at 286.9 PJ (6.85 Mtoe).

The **Development plan of Zagreb County**[53] emphasizes integrating climate change adaptation into all development processes by identifying risks, designing proactive measures, and focusing on key sectors like water management, agriculture, forestry, energy, and health to ensure sustainable and resilient growth.

The **Law on Energy Efficiency**[54] establishes a framework for improving energy efficiency across various sectors. It mandates the creation and implementation of national and regional energy efficiency plans, sets energy savings targets for 2014-2030, and outlines obligations for energy suppliers. The law aims to reduce environmental impact, enhance energy security, and meet international emissions commitments. Multiple incentives are provided for projects using renewable energy and efficient cogeneration systems within the Environmental Protection and Energy Efficiency Fund website[55]. Some of the incentives in the past years include co-financing installation of photovoltaic power plants in family homes, investment in energy efficiency measures and high-efficiency cogeneration in the processing industry and investment for the production of electricity from renewable sources in the processing industry. The ministry responsible for energy oversees the planning, evaluation, and reporting of these initiatives.

[53] Development plan of Zagreb County for the Period 2021-2027 (2022), pp. 73-75, https://www.zagrebacka-zupanija.hr/media/filer_public/ae/cd/aecd1f89-7a9c-4aae-b37f-e97422d3b54d/11_privitak_-_plan_razvoja_zagrebacke_zupanije_za_period_2021-_2027.pdf (accessed 23.08.2024).

[54] Law on Energy Efficiency (04/2021), https://www.hera.hr/hr/docs/SPKP/ZoEU-2014.pdf (accessed 20.08.2024).

[55] Environmental Protection and Energy Efficiency Fund: National public calls and tenders https://www.fzoeu.hr/hr/nacionalni-javni-pozivi-i-natjecaji/1367 (accessed 13.11.2024).

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3.5. Czechia

Hydrogen has been enshrined in Czech legislation[56] as an energy gas since 2024. The amendment to the Energy Act, effective from January 1st of 2024, for the first time in the history of the Czech Republic, has classified hydrogen among the gases that can be distributed to consumers via the public gas network. There are no specific targets for renewable energy for gas or energy as a whole. Hydrogen is now placed within the same legal framework as natural gas. The method of hydrogen production is not yet distinguished here. The hydrogen producer is required to provide the market operator with complete information about the origins of hydrogen production. The legislation thus allows for the distribution of not only a mixture of natural gas and hydrogen but also 100% pure hydrogen. Already, our gas pipelines can handle a 20% hydrogen blend with natural gas. A mixture above 20% requires adjustments to the gas infrastructure. The share of hydrogen is expected to increase in the medium and long term, eventually reaching 100%.

3.5.1. Hydrogen

In 2021, the Czech Republic introduced its Hydrogen Strategy (Vodíková strategie)[57], which is a key document for the development of hydrogen technologies in the country. This strategy is part of a broader framework aimed at achieving climate goals and transitioning to a low-carbon economy. Following the European Hydrogen Strategy and the goals of the European Green Deal, this strategy focuses on the period from 2021 to 2050, by the end of which we aim to achieve climate neutrality.

The new strategy builds upon the original Hydrogen Strategy approved by the government in 2021. The relatively early update was necessitated by the revision of several key policies at the European level as part of the Fit for 55[58] package—whether it concerns the Renewable Energy Directive and Regulation (EU) 2023/1804 on the deployment of alternative fuels infrastructure.

The revised strategy outlines the current state and barriers to the development of the hydrogen economy and sets specific goals, which are further detailed in the so-called “task cards” in the document's appendix. The strategy envisions three overlapping phases, referred to as local islands, global bridges and new technologies. These phases are characterized by different methods of hydrogen production, distribution, usage, and projected production costs. In the local islands phase, the focus is on local production primarily to meet obligations arising from European legislation and to develop hydrogen economies within so-called hydrogen valleys. The global bridges phase, around 2030, anticipates the completion of the repurposing of gas transmission infrastructure and the potential import of hydrogen from abroad. The new technologies phase envisions the emergence of innovative production technologies that will significantly reduce the cost of hydrogen production and facilitate its expansion into other sectors.

[56] Act No. 469/2023 Coll., on the Conditions for Doing Business and on the Performance of State Administration in the Energy Sectors and on Amendments to Certain Acts (Energy Act).

[57] Ministry of Industry and Trade, https://mpo.gov.cz/assets/cz/prumysl/strategicke-projekty/2024/7/Vodikova-strategie-CR-aktualizace-2024.pdf (accessed 28. 08. 2024).

[58] The "Fit for 55" package is a set of European Union policies aimed at reducing greenhouse gas emissions by 55% by 2030 compared to 1990 levels. This initiative is part of the broader EU Green Deal, which seeks to make Europe the first climate-neutral continent by 2050. The "Fit for 55" package was proposed by the European Commission in July 2021 and includes various legislative measures and targets across different sectors.

The main goals of the strategy for the purposes of our project:

- Build at least 400 MWe of electrolyzer capacity with priority by 2027 and ensure appropriate support.
- In the 2025-2026 timeframe, establish a comprehensive legislative and regulatory framework for the hydrogen economy, including a framework for guarantees of origin, certifications, technical standards, etc.
- In the 2024-2028 timeframe, prepare the gas infrastructure for blending hydrogen with natural gas; (usage: as fuel for combustion engines and gas turbines, transitioning to the use of pure hydrogen in energy production.).
- Incorporate the Czech Republic's infrastructure into European hydrogen corridors – support the inclusion of Net4Gas projects on the PCI list, and provide political support for European financing.
- In the 2025-2026 timeframe, create a regulatory framework that enables the repurposing of the existing gas transmission infrastructure.

3.5.2. Vehicle-to-grid and the mobility sector

National Action Plan for Clean Mobility (Národní akční plán pro čistou mobilitu)[59] is a key strategic document of the Czech Republic that focuses on supporting and developing clean mobility, meaning transportation with low or zero emissions (electric mobility, CNG, LNG, and to a limited extent hydrogen technology, i.e., fuel cell technology). This plan is part of a broader effort to decarbonize transportation, reduce dependence on fossil fuels, and improve air quality.

The document was created in response to the core strategic documents of the Czech government in the areas of energy, transportation, and the environment (State Energy Concept, Transportation Policy of the Czech Republic for 2014-2020 with a view to 2050, State Environmental Policy of the Czech Republic 2012-2020, Strategy for Regional Development of the Czech Republic 2014-2020, National Program for Emission Reduction) with the aim of fulfilling these fundamental energy, environmental, and transportation policy goals of the Czech Republic.

The document expresses the Czech government's commitment to actively support the development of alternative fuels in transportation, thereby achieving the previously defined goals of the Czech Republic in the fields of energy, transportation, and the environment. The overarching goal of the National Action Plan for Clean Mobility is to create a sufficiently favorable environment for the broader adoption of selected alternative fuels and drive technologies within the Czech Republic, and to achieve conditions comparable to those in other advanced European Union countries. In the long term (post 2030), the aim is for electric mobility to be considered a standard technology, natural gas to be regarded as a standard fuel, and hydrogen technology to advance from the research and development phase to a stage comparable to current electric mobility. This means implementing essential measures to develop this technology in the medium to long term.

[59] Ministry of Industry and Trade, https://www.mpo.gov.cz/assets/cz/rozcestnik/pro-media/tiskove-zpravy/2024/8/Aktualizace-Narodniho-akcniho-planu-ciste-mobility.docx (accessed 30. 08. 2024).

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In the document, hydrogen is already considered a highly monitored energy source for transportation in the medium to long term perspective.

Hydrogen production through electrolysis is considered energy-intensive; however, due to the rapid expansion of electricity production from clean but intermittent sources (solar power, wind turbines), it is being considered whether it might still be a viable method for energy storage and transportation.

3.5.3. Conclusio

- **Hydrogen** has been enshrined in Czech legislation as **an energy gas**.
- The Czech Republic has developed and approved it within its legislative framework the **hydrogen strategy**. Strategy is a key document for the development of hydrogen technologies in the country.
- The Czech Republic has developed a **National Action Plan for Clean Mobility.** The key strategic document of the Czech Republic focusing on the support and development of clean mobility. This plan outlines goals and measures to support the transition to more environmentally friendly transportation modes, including the development of electric and alternative propulsion systems, and aims to improve air quality and reduce emissions in the transportation sector.

Shortcomings in hydrogen legislation:

- There is a lack of a certification system, ČSN standards (Czech Technical Standards) and a licensing system for manufacturers (including for low-carbon hydrogen).
- It is unclear which approval rules will apply to hydrogen (such as EIA, etc.), and there is a lack of methodologies for the regional authorities.
- The tax framework for hydrogen is not clarified—specifically, whether the taxation of RFNBO (Renewable Fuels of Non-Biological Origin) / low-carbon hydrogen will differ from that of the currently used gray hydrogen.
- In the transportation sector, there is a lack of methodology for using RFNBO hydrogen as an intermediate product for decarbonizing conventional fuels due to supplier obligations.
- The greatest uncertainty is associated with the implementation process of RED III, which will take place in 2024.

3.6. Germany

Germany's legal framework for renewable energy is deeply rooted in its commitment to climate neutrality. Germany has established clear and ambitious goals for climate neutrality, aiming to reach net-zero greenhouse gas (GHG) emissions by 2045. The Climate Protection Act[60] sets legally binding reduction targets, including a 65% reduction in emissions by 2030 compared to 1990 levels. This transition is part of the Energy Transition, which promotes decarbonization across all sectors—energy, industry, transport, and buildings. The key legislative tool for renewable energy expansion is the Renewable Energy Act, which provides financial incentives like feed-in tariffs and market premiums to support the development of renewable energy technologies (solar, wind, biomass).

Germany's energy policy[61] is in line with EU objectives, including the European Green Deal and the Paris Agreement, aiming to reduce carbon emissions, increase energy efficiency, and integrate renewable sources into the energy mix. Additionally, Germany's commitment to faster permitting processes and sector-specific climate targets reflects the influence of EU directives like Renewable Energy Directive (RED) II and III (Directive [EU] 2018/2001), which ensure a legally binding framework for the energy transition. The Net Zero Industry Act (NZIA) also supports the expansion of clean technology sectors, such as electrolysers and fuel cells. The German government is currently preparing the national implementation of the NZIA in Germany.

As of 2023, over 40% of Germany's electricity supply comes from renewable sources, primarily wind and solar. This shift is driven by the **Renewable Energy Act**, which ensures that renewable energy producers have guaranteed grid access and benefit from feed-in tariffs. The Renewable Energy Act has set an ambitious target for 80% of Germany's gross electricity consumption to be met by renewable sources by 2030, making it a cornerstone of Germany's energy transition. The Federal Network Agency oversees the achievement of this target through regulatory mechanisms, ensuring compliance and supporting integration of renewables into the grid.

Germany's industrial sector, a major contributor to carbon emissions, is gradually moving toward renewable energy use through electrification and the adoption of green hydrogen. The **Climate Action Programme 2030**[62] and Germany's **National Hydrogen Strategy**[63] provide financial incentives and support for industries to decarbonize. These initiatives focus on sectors that are challenging to electrify, such as steel and chemicals, encouraging the use of hydrogen as an alternative energy source. Additionally, the **Federal Emission Control Act** sets emission limits for industries, while the Renewable Energy Act offers reduced tariffs for electricity generated from renewable sources if efficiency criteria are met. Together, these policies aim to promote a shift to renewable energy and significantly reduce industrial emissions.

[60] https://www.bmuv.de/fileadmin/Daten_BMU/Download_PDF/Gesetze/191118_ksg_lesefassung_bf.pdf (accessed 30.12.2024).

[61] https://www.bmuv.de/fileadmin/Daten_BMU/Pools/Broschueren/klimaschutzplan_2050_en_bf.pdf (accessed 30.12.2024).

[62] https://www.bundesregierung.de/breg-en/issues/climate-action (accessed 30.12.2024).

[63] https://www.bmwk.de/Redaktion/DE/Publikationen/Energie/die-nationale-wasserstoffstrategie.html (accessed 30.12.2024).

3.6.1. Vehicle-to-grid and the mobility sector

Traditionally reliant on fossil fuels, Germany's transportation sector is undergoing a transformation with increasing adoption of electric vehicles (EVs) and biofuels. The **Federal Climate Protection Act** mandates substantial reductions in GHG emissions in the mobility sector to meet national climate goals. The **Electric Mobility Act** and the **Federal Funding Guideline for Electric Mobility** support the expansion of EV infrastructure, promoting the use of electricity from renewable sources in transportation. Additionally, the **Biomass Sustainability Ordinance** and other biofuel regulations are encouraging the use of sustainable bioenergy, helping to decarbonize the transport sector. These policies[64] provide the legal framework for increasing the share of renewables in the mobility sector, enabling Germany to facilitate the adoption of renewable fuels and electric vehicles, paving the way for a cleaner, more sustainable mobility system.

The Electric Mobility Act and the **Regulation on recharging point infrastructure** regulate the expansion of charging infrastructure for battery EVs. The law sets binding targets for the number of public charging points and includes provisions for fast-charging stations along highways. FinanVVcial incentives and legal obligations for new buildings to include charging infrastructure are also part of this framework.

Vehicle-to-Grid (V2G) technology is defined legally as the bidirectional exchange of electricity between electric vehicles and the power grid. This allows EVs to store energy and feed it back into the grid, supporting grid stability and energy management. Under German law, V2G systems are classified as energy storage devices, with specific provisions concerning their role in the energy market. EVs engaged in V2G activities are treated as both energy withdrawers (when charging) and feeders (when discharging back to the grid), regulated under the **Energy Industry Act**. Special provisions for V2G systems include requirements for grid compatibility, cybersecurity, and data protection. The Energy Industry Act and the Renewable Energy Act provide the legal framework for integrating V2G into the energy system. These provisions aim to encourage the integration of V2G into the broader energy system while ensuring that it contributes to grid stability and the efficient use of renewable energy. The implementation of V2G faces several legal and regulatory challenges, including the need for updated grid infrastructure to handle bidirectional energy flows, the development of new business models for energy providers, and the protection of consumer rights, particularly concerning battery life and data privacy. These issues are being addressed through pilot projects and ongoing regulatory adjustments.

3.6.2. Hydrogen

The German law does not provide any legal definition for the term Power-to-Gas (P2G) or P2G plants. However, definitions in different laws can be applied to the P2G technology, and this is mentioned in some laws, notably the Renewable Energy Act and the Energy Industry Act. These laws define and regulate energy plants broadly, which can sometimes encompass P2G facilities, but they do not explicitly address P2G. Different terms and classifications can apply to P2G depending on the specific operational features of each plant.

[64] The Electric Mobility Act and the Biomass Sustainability Ordinance.

According to the Renewable Energy Act, biomass plants are defined as plants that produce electricity from biomass. Therefore, this definition does not apply for a number of P2G plants if they convert electrical energy into biomethane or hydrogen without converting it back to electricity.

The Energy Industry Act provides the term "energy storage plant". All facilities that consume electrical energy for the purpose of electrical, chemical, mechanical, or physical intermediate storage and generate it as electrical energy or release it in another form of energy are summarized under this term, which applies to P2G plants as well. In the Energy Industry Act, the term is only used for unbundling measures and therefore does not impact the financial and other legal regulations of P2G plants. But exactly that is an issue: The definition for Unbundling is quite relevant as the general provisions for the energy industry apply to other legal issues. According to the definition of end users, P2G facilities are, in general, defined as end users and are therefore obliged to pay end user fees (e.g., grid fees, electricity taxes, etc.). This applies especially in those cases where the converted electrical power is not reconverted but used in a different energetic form (gas, LNG, etc.).

If a plant stores electrical energy from renewable sources in the form of biogas, biomethane, or hydrogen in order to reconvert the stored gas into electricity, the plant is treated as an electricity storage facility. According to the Energy Industry Act, electricity storage facilities are generally treated as end users of the electricity they store. In case of reconversion into electrical power, the storage facilities can also be considered as generator.

Another term in the Energy Industry Act is "energy plant". Since they include all "installations for the generation, storage, transmission or delivery of energy," the term applies to P2G plants. The term is mainly connected to § 49 Energy Industry Act, which provides regulations for technical security and security standards of the plants, as well as information on how to implement and prove compliance with the regulations.

The German law distinguishes between consumers of electrical power, which are defined as "end users" of the electricity, "producer" and "storage facilities". Depending on the classification, different fees and taxes or financial incentives apply. A plant can be defined as a storage facility and producer or as a storage facility and end-user at the same time. The classification of a plant has to be assessed individually since many different factors impact the classification. In some cases, there are privileges which can lead to a remission of end-user fees. Electricity generators profit from financial incentives for the production of renewable electricity.

The Energy Industry Act (§ 3 No. 19c) defines Gas Storage Facilities, with exclusions for facilities involved in a process described in the law as “Gewinnung” which means production or extraction. The interpretation of this term affects whether P2G plants might be eligible for tax exemptions, as some legal interpretations suggest P2G facilities could qualify as “gas production facilities” under the **Energy Tax Law**.

Although the German law does not provide a precise term or unified classification for P2G, multiple terms (e.g., energy storage plant, end user, gas storage facility) can apply depending on the specific configuration and operation of the plant. With the increasing importance of P2G technologies for energy storage and hydrogen production, clearer legal definitions and standardizations are needed to streamline regulations, clarify tax implications, and support the broader integration of P2G in Germany's energy system.

3.6.3. Greenhouse gas emission savings and decarbonisation

Germany's sustainability and GHG emissions savings calculations align with the EU's RED II and RED III, ensuring consistency across member states. By incorporating these sustainability criteria into national law, Germany ensures compliance. These provisions include the calculation of GHG emission savings, ensuring that biofuels and bioliquids contribute at least 65 % in GHG savings compared to fossil fuels by 2026. Additionally, Germany adheres to strict sustainability criteria, which ensure that renewable energy production does not harm biodiversity, ecosystems, or food security. The Biomass Sustainability Ordinance further specifies sustainability criteria for bioenergy, requiring that biomass used in energy production must not come from areas converted from forests or other high-biodiversity landscapes.

Going on with the topic of hydrogen, Germany's National Hydrogen Strategy[65] outlines the production of hydrogen primarily through electrolysis using renewable electricity, resulting in green hydrogen. The strategy aims to establish a domestic market for green hydrogen, positioning Germany as a leader in hydrogen technology and production. The strategy sets ambitious targets for hydrogen production, aiming to establish 5 GW of electrolysis capacity by 2030 and 10 GW by 2040.

The produced hydrogen is legally mandated to be used in sectors identified as crucial for the energy transition, including steel production, chemical industries, and heavy-duty transport. The hydrogen strategy also encourages the integration of hydrogen into the power sector for grid balancing and energy storage.

While domestic production is prioritized, Germany acknowledges that it will need to import green hydrogen to meet its long-term goals. The hydrogen strategy outlines plans for establishing international partnerships and import routes, particularly from regions with abundant renewable energy resources, such as North Africa and the Middle East.[66]

The National Hydrogen Strategy and the **Climate Protection Act** establish binding targets for the integration of hydrogen into the energy system. By 2030, a significant portion of hydrogen used in Germany must be renewable, with specific quotas set under the Renewable Energy Act for green hydrogen production and consumption.

Under German law, renewable hydrogen is defined as hydrogen produced via electrolysis using electricity from renewable sources. Low-carbon gases, i.e. grey or blue hydrogen, include hydrogen produced from natural gas with carbon capture and storage (CCS). The German law does not classify any other kind of carbon-neutral hydrogen as “green”. This can be considered a shortcoming, as for example bioenergy with carbon capture and storage provides viable pathways to gain renewable hydrogen. One example is the production of hydrogen via pyrolysis of biomethane, which even results in carbon-negative hydrogen. Revisions in the German law and hydrogen strategy should be considered to grant benefits for production pathways other than electrolysis.

As for mobility, Germany's strategy is centred around decarbonization and the promotion of alternative fuels. The Climate Protection Act and the Electric Mobility Act provide the legal

[65] https://www.bmwk.de/Redaktion/DE/Publikationen/Energie/die-nationale-wasserstoffstrategie.html (accessed 30.12.2024).

[66] https://www.bmwk.de/Redaktion/DE/Publikationen/Energie/importstrategie-wasserstoff.html (accessed 30.12.2024).

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framework for reducing emissions in the transport sector, focusing on increasing the adoption of EVs, promoting hydrogen fuel cell vehicles, and developing the necessary infrastructure.

Germany's National Hydrogen Strategy emphasizes the expansion of hydrogen refuelling infrastructure to support the adoption of hydrogen fuel cell vehicles. The strategy highlights the importance of establishing a network of hydrogen refuelling stations, particularly for commercial vehicles, in line with market development by 2030[67].

As of 2023, Germany has made progress in this area, with 91 hydrogen filling stations operational across the country[68].

[67] https://www.bmwk.de/Redaktion/EN/Publikationen/Energie/national-hydrogen-strategy-update.pdf?__blob=publicationFile&v=2&utm_source=chatgpt.com (accessed 30.12.2024).

[68] https://www.statista.com/statistics/1291945/hydrogen-filling-stations-germany/?utm_source=chatgpt.com (accessed 30.12.2024).

3.7. Hungary

3.7.1. Hydrogen strategies

The **Hungarian National Hydrogen Strategy**[69] established a variety of strategic goals upon its adoption in 2021 and identified four main pillars in its outlook to 2030. The basis of the hydrogen ecosystem is the production of low-carbon and carbon-free hydrogen while creating the foundations for decentralized hydrogen-production based on electrolysis and renewables. The strategy also acknowledges the interdependent nature of hydrogen with other sectors, such as industry, where decarbonization should be aided by the supply of green/blue/turquoise hydrogen avoiding a total of 95 thousand tons of CO_2 emissions. 4,8 thousand HFC vehicles, 20 hydrogen fuel stations and 40 charging points will lead to an estimated 130 thousand CO_2 emission to be avoided. By adding 2% by volume to the natural gas grid a sector coupling capability up to 60MW should appear on the electricity market as well.[70] The establishment of a supporting and more comprehensive regulatory framework is also a specific goal identified in the Strategy. It has to be said however that other strategical document, such as the Alternative Fuels infrastructure national policy framework program[71] foresees a very slow spread of hydrogen fuel even in public transport. The Strategy was adopted by the **1372/2021. (VI. 10.) Government decision on the adoption of the National Hydrogen Strategy 2030. The National Energy and Climate Plan** also indicates a move towards hydrogen in general terms as a tool for achieving greater reduction of emissions in the transport sector or in industrial sectors but mainly refers to the Hydrogen Strategy.

3.7.2. Electricity, natural gas and hydrogen

The Act No LXXXVI of 2007 on electricity is the core regulation for the electricity sector. This fundamental law regulates most of the electricity market, determines basic concepts, is constantly updated and modified to follow current challenges in the energy market, however it does not deal with hydrogen in detail. Detailed provisions about the implementation of the regulations are introduced in specific Government Decrees and Ministerial Decrees.

Act No. XL of 2008 on natural gas supply and **Governmental Decree No. 19 of 2009 (I.30.) implementing the provisions of the Act** create an efficient natural gas market, regulate transportation, distribution, storage, consumption and trade among others. In terms of hydrogen, the law effectively regulates the provisions related to the quality of natural gas complying with EU-level and also national regulation (based on physical and chemical parameters).

Act No. XLIV. of 2020 on climate protection sets specific goals regarding carbon emissions and renewables, such as a 40% percent reduction compared to the 1990 levels in 2030, and aims to a 21% share of renewables in gross final energy consumption[72]. There are several Government Decrees that created important branches of support schemes for RES, such as **Government Decree No. 299/2017. (X. 17.) on the feed-in tariff for renewable electricity and the premium**

[69] https://cdn.kormany.hu/uploads/document/6/61/61a/61aa5f835ccf3e726fb5795f766f3768f7f829c1.pdf (accessed 30.12.2024).

[70] Hungarian National Hydrogen Strategy, p. 3.

[71] https://2015-2019.kormany.hu/download/a/0c/e0000/A%C3%9CINK_fin.pdf (accessed 30.12.2024).

[72] https://net.jogtar.hu/jogszabaly?docid=A2000044.TV (accessed 30.12.2024).

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tariff, setting the amount of the feed-in tariff as well as the premium tariff ("green premium) for plants not subject to obligatory tendering procedures (between 50 kW and 1 MW, except for wind power plants), and for operations with a capacity of 0.5-1 MW are obliged to apply for a premium tariff, installations with 50 kW-0.5 MW can indicate whether they choose the feed-in or the market premium tariff. **Act No. CXVII of 2010 on the promotion of renewable energy in the transport sector and the reduction of greenhouse gases in the transport sector** contributes to the reduction of greenhouse gas emissions in the transport sector. One other important policy is the **Government Decree No. 273/2007 (X. 19.) Household-sized power installations (HMKE)** with a capacity of maximum 50 kVA are eligible for net metering in case that the power plant connects to the low-voltage grid. **Gov. Decree 309/2013. (VIII. 16.) on the certification of the origin of electricity generated from renewable sources or produced by high-efficient co-generation** regulates the issue, transfer, cancellation, supervision and control of Guarantees of Origin for RES or CHP electricity.

There is no regulation at the moment for the promotion of hydrogen, nor the certification of hydrogen, however the strategical framework at this stage is sufficient to support the current volume of hydrogen production and the ongoing pilots will provide information for further legis

There are two pilot projects for hydrogen, the Bükkábrány Energy Park electrolyzer[73], and the Akvamarin project for hydrogen feed in into the gas grid[74], however there is no commercial application at the moment. There is only one commercial hydrogen fuel station in Hungary. The Hungarian **RePowerEU**[75] plan identifies the need for a *"legal and administrative environment, which encourages and supports the establishment of a renewable-based hydrogen ecosystem in Hungary"* however there has been no such provision created to date.

Regarding the vehicle-to-grid technologies, there is one available electric bus charger in Hungary that allows V2G however it is a part of an energy community in Bábolna, Komárom-Esztergom County. Recent strategical document, such as the Jedlik Ányos Plan 2.0, the Hungarian Electromobility Strategy[76] identified the need for further pilot activities and subsequently creating a supportive legislative environment.

[73] https://bukkabranyienergiapark.hu/ (accessed 30.12.2024).

[74] https://mfgt.hu/hu-HU/Akvamarin (accessed 30.12.2024).

[75] https://archive.palyazat.gov.hu/download.php?objectId=1098140 (accessed 30.12.2024).

[76]https://2015-2019.kormany.hu/download/f/a9/a1000/Hazai%20elektromobilit%C3%A1si%20strat%C3%A9gia.pdf (accessed 30.12.2024).

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3.8. Montenegro

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3.9. Romania

3.9.1. Hydrogen

Romania is in the process of developing a comprehensive hydrogen strategy that aligns with European Union directives and national energy goals. Although there is no standalone hydrogen strategy as of yet, several laws and regulations address the production, storage, and utilization of hydrogen within broader energy and environmental policies.

Key Legislation

Law no. 220/2008[77] sets the foundation for promoting renewable energy sources in Romania. It includes provisions for the certification and incentivization of renewable energy, which encompasses the production of renewable hydrogen. This law aims to support the integration of renewable energy into the national grid and includes mechanisms for guarantees of origin, green certificates, and investment subsidies for renewable energy projects, including hydrogen production. it does not specifically address the certification of renewable hydrogen as detailed in the EU Delegated Regulation 2023/1184.

Law no. 34/2017[78] focuses on the development of infrastructure for alternative fuels, including hydrogen, and was initially aligned with the EU's directive on alternative fuels infrastructure. However, with the adoption of the Alternative Fuels Infrastructure Regulation (AFIR) in 2023, which is directly applicable across EU member states, Law No. 34/2017 may require reassessment. It is possible that the law will be either updated to reflect the newer EU targets and requirements or repealed in favor of direct compliance with AFIR

Law no. 123/2012[79] is a comprehensive regulation governing the electricity and natural gas markets in Romania. It includes provisions relevant to the production and use of hydrogen, particularly regarding the integration of renewable hydrogen into the electricity grid. This law addresses the roles and responsibilities of market participants, the operation of transmission and distribution networks, and the rights and obligations related to system usage fees and market access.

Law no. 237/2023[80], recently enacted, provides additional support and regulatory clarity for the hydrogen sector. It outlines the legal framework for the production, storage, and distribution of hydrogen, aiming to enhance Romania's capacity for renewable hydrogen production. The law includes specific provisions for the certification of hydrogen production facilities, safety standards, and financial incentives to promote investment in hydrogen technologies. This law outlines measures for fuel providers and industrial hydrogen consumers to integrate hydrogen from renewable sources and reduce carbon emissions into the industrial and transportation sectors. It defines terms like renewable fuels of non-biological origin, renewable hydrogen, and hydrogen with reduced carbon emissions. The law mandates fuel providers to ensure a minimum percentage

[77] Law no. 220/2008 for establishing the system for promoting the production of energy from renewable sources.

[78] Law no. 34/2017 on the installation of infrastructure for alternative fuels.

[79] Law no. 123/2012 on electricity and natural gas.

[80] Law no. 237/2023 on the integration of hydrogen from renewable and low-carbon sources in the industry and transport sectors.

of energy from renewable sources in the fuels they supply, starting from 2030. It also imposes obligations on industrial hydrogen consumers to gradually increase their use of renewable fuels or hydrogen with reduced carbon emissions. Additionally, it establishes reporting requirements for industrial hydrogen consumers and fuel providers to track their compliance with these regulations.

This legislation is significant as it provides a legal framework to promote the use of hydrogen from renewable sources, contributing to Romania's efforts to combat climate change and reduce carbon emissions. By establishing clear obligations for both fuel providers and industrial consumers, it creates incentives for the transition towards cleaner energy sources. However, effective implementation and enforcement will be crucial to ensure the law's success in achieving its environmental objectives.

Sector-Coupling and Infrastructure Development

The Romanian legislation recognizes the importance of sector-coupling technologies, such as electrolysers, for the efficient integration of hydrogen into the energy system. By promoting the use of electrolysers for hydrogen production, the laws aim to support industries where direct electrification is not feasible. The installation of hydrogen refuelling stations under Law no. 34/2017 also contributes to the development of a robust hydrogen infrastructure. The Romanian legislation provides support for sector-coupling technologies like electrolysers through regulatory measures, infrastructure development, and potential financial mechanisms, including grants and subsidies.

Compliance with European Union Directives

Romania's hydrogen-related legislation aligns with several EU directives, including the Renewable Energy Directive II (RED II) and the Clean Energy for All Europeans package. These directives mandate member states to adopt policies that facilitate the integration of renewable energy sources and the reduction of greenhouse gas emissions. Romania's legal framework supports these goals by promoting renewable hydrogen production and the development of alternative fuel infrastructure.

Law No. 237/2023 establishes a comprehensive legal framework for the production, storage, transport, and utilization of hydrogen in Romania. In line with the Austrian model, the law aims to facilitate the transition towards a hydrogen-based economy, emphasizing safety, sustainability, and market development. Through clear definitions and licensing procedures, the law sets the groundwork for a regulated hydrogen sector, ensuring that all stakeholders adhere to stringent safety and environmental standards. Provisions for incentives, particularly for green hydrogen production, demonstrate a commitment to promoting renewable energy sources and reducing carbon emissions in line with global climate goals. The law also addresses key aspects such as storage, transport, and utilization, providing guidelines for infrastructure development and market regulation.

While Law No. 237/2023 represents a significant step towards harnessing the potential of hydrogen in Romania, certain challenges and limitations remain. One critical aspect is the need for effective enforcement mechanisms to ensure compliance with the law's provisions, particularly regarding safety and environmental standards. Additionally, the success of the hydrogen sector depends heavily on investment in infrastructure and technology, which may require substantial financial

resources and long-term planning. Furthermore, the law should continuously adapt to technological advancements and evolving market dynamics to remain effective and relevant. Overall, while Law No. 237/2023 lays the foundation for a thriving hydrogen economy in Romania, its implementation and ongoing evaluation will be essential for realizing its full potential and addressing emerging challenges.

Moreover, the delay in enacting comprehensive legislation concerning hydrogen until the summer of 2023 underscores a significant gap in Romania's regulatory framework. Prior to this, mentions of hydrogen in existing laws, particularly in the context of alternative fuels, were vague and insufficient. This lack of clarity and specificity hindered the development and integration of hydrogen technologies in Romania's energy landscape. The absence of a dedicated legal framework for hydrogen further exacerbated uncertainties for stakeholders, including investors, researchers, and industry players, impeding the potential growth of the sector.

The inclusion of the hydrogen framework law in the National Recovery and Resilience Plan highlights its strategic importance in addressing pressing issues such as climate change and global warming. By recognizing the necessity of integrating hydrogen into Romania's energy mix, policymakers acknowledge the role of clean energy alternatives in achieving environmental sustainability targets. However, the reliance on external pressures, such as the requirements of the National Recovery and Resilience Plan, to prompt legislative action underscores a broader need for proactive policymaking and long-term strategic planning to address emerging challenges effectively. Moving forward, ensuring the coherence and timeliness of regulatory measures will be crucial for facilitating the transition towards a hydrogen-based economy and mitigating the impacts of climate change in Romania.

3.9.2. Vehicle-to-grid and the mobility sector

E-mobility has gained significant traction in Romania in recent years, driven by state-level incentives and benefits for electric vehicle (EV) owners. Key measures include substantial subsidies for purchasing electric and hybrid cars when exchanging an old internal combustion vehicle. Initially, vouchers for electric cars reached approximately EUR 10,000, and for hybrid cars EUR 4,000-5,000. In 2024, these subsidies were halved due to budget constraints and high demand. The current incentives are:

- 25,500 lei for a new fully electric or hydrogen fuel cell vehicle.
- 13,000 lei for a new hybrid electric vehicle emitting a maximum of 80 g CO_2/km.
- 13,000 lei for an electric motorcycle.

These subsidies are capped at 50% of the vehicle's selling price, with a maximum vehicle price of 70,000 euros, including VAT. Additionally, EV owners benefit from tax exemptions, free parking in major municipalities, and the option for green registration plates.

As a result of these policies, over 42,000 electric cars have been registered in Romania, with around 16,800 registered in 2023 alone, a 35% increase from 2022. The country had approximately 5,000 charging stations by the end of 2023. In 2024, over 5,000 units were registered in the first four months.

Romania aligns with EU targets and directives for e-mobility, contributing to the acquis commanditaire. By the end of 2025, Romania aims to have a charging station every 60 kilometres on main roads. For hydrogen vehicles, the target is a station every 200 kilometres by 2030.

Vehicle-to-Grid (V2G)

Currently, V2G is not regulated in Romania, despite being recognized in the media as a beneficial practice. Legislative and financial frameworks are needed to allow users to benefit from supplying energy from their car batteries to the grid. The only alternative, V2H (Vehicle to Home), is feasible for individual households but not integrated into the national grid.

To implement V2G effectively, legislation must evolve to match technological advancements. Users should be compensated for the energy supplied to the grid, similar to the compensation system for solar panel energy contributions. This would require laws enabling payments or easy-to-apply compensation systems for V2G users.

Romania is in the process of developing its strategic and legislative framework to support the transition towards sustainable mobility and energy systems, aligning with EU directives and global sustainability goals. Key documents include Romania's Sustainable Development Strategy 2030 and various national strategies focusing on energy and climate.

The National Sustainable Development Strategy 2030[81] sets the overarching framework for achieving the Sustainable Development Goals (SDGs) by incorporating economic, social, and environmental dimensions. This strategy aims to create a sustainable future for Romania, with specific goals including affordable and clean energy, industry innovation and infrastructure, and climate action. It provides a roadmap for sustainable practices and policies across various sectors, including transportation and energy (UNEP LEAP).

Romania's Integrated National Energy and Climate Plan[82] (NECP) for 2021-2030 outlines the country's objectives and policies to meet its climate and energy targets. It emphasizes reducing greenhouse gas emissions, increasing energy efficiency, and promoting renewable energy. The NECP highlights the importance of developing infrastructure for electric vehicles (EVs) and integrating renewable energy sources into the grid, laying the groundwork for vehicle-to-grid (V2G) technologies.

Romania's focus on promoting electric mobility is part of its broader strategy to reduce emissions in the transport sector. The development of EV infrastructure, including charging stations, is a critical component of this strategy. While specific legislative provisions for V2G are still under development, existing policies encourage the adoption of EVs and support the necessary infrastructure expansion.

Romania's **Electricity and Natural Gas Law**[83] provides the legal foundation for the country's energy sector, including provisions for the development and integration of renewable energy sources. Although V2G-specific regulations are not yet explicitly detailed, the existing legal framework supports the growth of renewable energy and the modernization of the energy grid, which are essential for V2G implementation (UNEP LEAP).

[81] Romania's Sustainable Development Strategy 2030. UNEP Law and Environment Assistance Platform.

[82] Integrated National Energy and Climate Plan (NECP) 2021-2030. Ministry of Energy, Romania.

[83] Law no. 123/2012 on electricity and natural gas.

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Future developments

Romania is expected to further develop its legislative framework to explicitly address V2G technologies as part of its commitment to sustainable development and EU directives. The ongoing expansion of EV infrastructure and renewable energy sources will play a crucial role in facilitating the adoption of V2G solutions, contributing to the overall goals of reducing carbon emissions and enhancing energy efficiency.

3.10. Serbia

While not yet an EU member state, Serbia has aligned its energy policies with European Union regulations as part of its EU accession process. The push for decarbonization and adopting green technologies, including hydrogen and electric mobility, plays a critical role in Serbia's environmental policy. These shifts are particularly significant in Serbia's efforts to modernize its energy infrastructure, reduce greenhouse gas emissions, and foster sustainable economic growth.

3.10.1. Hydrogen

Hydrogen energy is increasingly viewed as a cornerstone of the European Green Deal and a potential solution to decarbonize industries that are difficult to electrify, such as heavy transport, steel production, and chemical manufacturing. Serbia's legal and policy framework regarding hydrogen is still in its infancy but reflects a growing interest in exploring this technology.

National Strategy and Legal Framework

Serbia's legal framework on hydrogen energy is primarily shaped by its obligations to the Energy Community Treaty[84] (signed with the EU) and the EU Clean Energy for All Europeans package. However, Serbia has not adopted specific national laws dedicated solely to hydrogen technology. Hydrogen policies are currently integrated into broader energy strategy documents and climate action plans[85, 86, 87], prioritizing renewable energy sources like solar, wind, and hydropower.

In 2024, Serbia's National Energy and Climate Plan (NECP)4 highlighted hydrogen as a potential part of its decarbonization strategy. This plan outlines Serbia's intentions to reduce its carbon intensity and increase the share of renewable energy in the energy mix, aiming to reach climate neutrality by 2050. Within the framework of NECP, through pilot projects, new innovative RES technologies for electricity production will be promoted, such as small wind turbines, the use of renewable hydrogen production to store electricity from variable RES, etc., to assess their performance. In addition, the further use of RES in district heating networks will be achieved mainly through biomass (2.7 ktoe), and the gradual exploitation of other renewable energy sources, such as biomethane, hydrogen, and geothermal energy, is envisaged.

Challenges and Opportunities

The lack of a clear regulatory framework for hydrogen poses challenges for investments and technological development in this sector. Nonetheless, Serbia can benefit from regional cooperation within the Western Balkans on hydrogen technology development and the EU's

[84] https://www.energy-community.org/legal/treaty.html (accessed 30.12.2024).

[85] The Energy Law (Official Gazette of the RS, no. 62/2023), https://www.paragraf.rs/propisi/zakon_o_energetici.html.

[86] The Law on Renewable Energy Sources (Official Gazette of the RS, no. 40/2021 and 35/2023), https://www.paragraf.rs/propisi/zakon-o-koriscenju-obnovljivih-izvora-energije.html (accessed 30.12.2024).

[87] Integrated national energy and climate plan of Republic of Serbia by 2030 with a vision for 2050 (Official Gazette of the RS, no. 70/2024), http://demo.paragraf.rs/demo/combined/Old/t/t2024_08/SG_070_2024_002.htm (accessed 30.12.2024).

significant investments into hydrogen infrastructure under the Hydrogen Strategy for a Climate-Neutral Europe (2020).

Hydrogen Pilot Projects

Serbia has initiated small-scale projects in hydrogen production, but these are still in pilot phases. The future of hydrogen in Serbia depends mainly on the alignment of domestic policies with EU-level frameworks, the development of infrastructure, and private-sector involvement in technology and project financing.

3.10.2. Vehicle-to-grid and the mobility sector

Electric mobility is a key focus of Serbia's push toward a greener future, as it aims to reduce air pollution, reliance on fossil fuels, and greenhouse gas emissions. Serbia's legal framework for electric vehicles (EVs) is evolving, with several initiatives and legislative steps in place.

Electric Vehicle Incentives and Policies

- Serbia has introduced several policies and incentives to promote electric mobility:
- In 2021, the Serbian Government adopted a Green Agenda for 2021-2030[88], focusing on sustainable development, energy efficiency, and clean transport.
- The "Green Economy Program"[89] offers subsidies and tax incentives for electric vehicle purchases. These incentives are part of Serbia's commitment to reducing carbon emissions from the transportation sector.
- Serbian authorities also provide subsidies for EV charging stations as part of efforts to establish a nationwide network that would make EV adoption more attractive and feasible.

Legal Instruments:

- Law on Air Protection (2016)[90]: A critical legal instrument that supports Serbia's efforts to tackle air pollution, indirectly encouraging the use of electric vehicles.
- Regulation on Charging infrastructure (2020)[91]: This regulation governs the installation of public charging stations, ensuring compatibility and safety standards for electric vehicle infrastructure.

[88] SERBIA AND 2030 AGENDA, Mapping the National Strategic Framework, vis-a-vis the Sustainable Development Goals, https://rsjp.gov.rs/wp-content/uploads/Serbia-and-2030-Agenda_November-2021.pdf (accessed 30.12.2024).

[89] EU for Green Agenda in Serbia, https://www.undp.org/serbia/projects/eu-green-agenda-serbia (accessed 30.12.2024).

[90] List of regulations in the field of environmental protection in the Republic of Serbia, https://www.ekologija.gov.rs/sites/default/files/inline-files/List_of_regulations.pdf (accessed 30.12.2024).

[91] Conditions for the provision of the service of charging vehicles with electricity, https://www.paragraf.rs/100pitanja/trgovina/uslovi-za-pruzanje-usluge-punjenja-vozila-elektricnom-energijom.html (accessed 30.12.2024).

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- Incentives for EV Purchases: A subsidy program for electric cars provides direct financial assistance to individuals and companies purchasing electric vehicles, although the budget for these programs remains limited compared to EU standards.
- EU Alignment: Serbia's transport policies are closely aligned with the EU's Green Deal, which sets ambitious targets for developing zero-emission vehicles. Serbia has signed the European Agreement on Road Transport[92] and participates in the Energy Community[93], which promotes cleaner energy and transport options in the Western Balkans.
- In addition, the EU Alternative Fuels Infrastructure Regulation has influenced Serbia's development of charging stations, particularly in major cities like Belgrade. Serbia's commitment to harmonizing with EU standards allows it to participate in cross-border EV networks within the region.

Challenges and Gaps

Despite these efforts, the legal framework for electric mobility in Serbia faces several challenges:

- Insufficient infrastructure: While the number of charging stations has increased, it is still limited, particularly in rural areas. Expanding this network is critical to support widespread EV adoption.
- High Initial Costs: Despite government subsidies, the high upfront cost of electric vehicles remains a barrier.
- Public Awareness and Education: There is a need for better public awareness programs to encourage the adoption of electric mobility.

[92] European Agreement concerning the work of crews of vehicles engaged in international road transport (AETR), https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A21978A0408%2801%29 (accessed 30.12.2024).

[93] https://www.energy-community.org/ (accessed 30.12.2024).

Political and Economic Implications

The intersection of hydrogen and electric mobility in Serbia offers significant opportunities and challenges in both the political and economic spheres:

- **Geopolitical Considerations:** Serbia's energy policies are influenced by its relationships with the EU, Russia, and China. While Serbia is aligning its energy policies with the EU, it also maintains strong ties with Russia regarding energy supplies, particularly natural gas. Developing hydrogen as a clean energy alternative could reduce Serbia's dependency on fossil fuels, although this would require substantial investment and regional cooperation.
- **Economic Opportunities:** The hydrogen and electric mobility sectors present opportunities for Serbia to attract international investment, create jobs, and develop new industries. However, the legal framework must be more designed to unlock these opportunities fully. Key sectors that could benefit include manufacturing, research and development, and infrastructure development.
- **EU Accession Process:** As Serbia seeks EU membership, meeting EU standards for environmental sustainability, energy transition, and clean transport will be crucial. This would require harmonizing national legislation with EU directives and investing significantly in green technologies.

3.11. Slovakia

The EU's targets, which affect Slovak climate policy, are gradually becoming more ambitious. Slovakia's share of reaching this figure is not yet final (GHG emissions in non-ETS countries are expected to fall by 20% since 2005), but the process has been strongly shaping the national strategic framework for climate change mitigation and adaptation[94]. The main vision and strategic document in the field of climate change policy is the adopted **Low Carbon Development Strategy of the Slovak Republic until 2030 with a view to 2050**. The Strategy was approved by the Slovak Government in 2020 and represents Slovakia's response to its climate change commitments[95]. The goal of Slovakia will be to establish terms for production of hydrogen in order for Slovak economy to be as independent as possible in terms of its import. The priorities will be aligned with the updated Strategy for Smart Specialisation for Research and Innovations (RIS3) for the programming period of 2021 – 2027. Based on the sources at hand, at the production of Blue Hydrogen, Slovakia will focus on use of electricity from nuclear power plants as the preferred low-carbon renewable energy source[96].

3.11.1. Hydrogen

The main legal provision governing hydrogen in the Slovakia is § 2 (4) Act No. 309/2009 Coll. on the Promotion of Renewable Energy Sources and Highly Efficient Cogeneration and on Amendments to Certain Acts, which recognises hydrogen as a source of renewable energy: "for the purposes of this Act, a fuel produced from renewable energy sources. According to the National Hydrogen Strategy, the Slovak Government will aim to accelerate the creation of the legislative framework and financial conditions for the implementation of hydrogen technologies. "**National Hydrogen Strategy: Prepared for the future**" [97] (National Hydrogen Strategy – hereafter referred to as NHS) can provide valuable insight into the developments in the field. Measures defined in the **Action Plan** are proposed to meet the strategy's goals and will facilitate investments in the economically sustainable value chain of renewable and low-carbon hydrogen, i. e. in its production, transport, distribution, storage, and use in industry, energy, and transport, especially where direct electrification is not possible, or will be cost-ineffective. The goal of the Slovak government is to support production and use of Green Hydrogen, as well as the necessary infrastructure to implement those activities. They will also support production of Blue Hydrogen[98]. Based on the current hydrogen use, it can be assumed that by 2030, Slovakia will consume 200 kilotons of hydrogen a year. We anticipate that with intense usage of hydrogen, the consumption will reach

[94] Integrated national energy and climate plan for the years 2021 – 2030 (processed in accordance with Regulation EU No. 2018/1999 on Energy Union governance and climate action), 2019.

[95] TOWARDS ACHIEVING CLIMATE NEUTRALITY FOR SLOVAKIA IN 2050: ANALYSIS OF THE SITUATION AND KEY CHALLENGES. DOI:10.31577/PPFAR.2023.15.004, https://www.prog.sav.sk/wp-content/uploads/TOWARDS-ACHIEVING-CLIMATE-NEUTRALITY-FOR-SLOVAKIA-IN-2050.-ANALYSIS-OF-THE-SITUATION-AND-KEY-CHALLENGES.pdf.

[96] DRAFT RESEARCH AND INNOVATION STRATEGY FOR SMART SPECIALISATION OF THE SLOVAK REPUBLIC 2021-2027. Ministry of investment, regional development and informatization of the Slovak Republic, https://mirri.gov.sk/wp-content/uploads/2018/10/Research-and-innovation-strategy-for-smart-specialisation-of-the-Slovak-Republic-2021-2027.pdf.

[97] National Hydrogen Strategy: Ready for the Future, https://nvas.sk/NVS_EN.pdf.

[98] National Hydrogen Strategy: Ready for the Future, https://nvas.sk/NVS_EN.pdf.

400-600 kilotons by 2050 – 90% of which will be covered by low-carbon sources[99]. The action plan for the successful implementation of the National Hydrogen Strategy up to 2026 will create conditions for the implementation of hydrogen technologies in line with the National Hydrogen Strategy. Targets for hydrogen production and consumption for 2030 will be analysed and quantified within Measure 1. Implementing this measure will create the prerequisites for the second phase of the Action Plan implementation. The financing method and the estimated costs of implementing measures will be clarified in chapters (B and C of the second stage of the Action Plan). In 2025, the Action Plan will be updated to take into account significant changes to the policy of the Slovak Republic and the EU and any revision of the Integrated National Energy and Climate Plan for the years 2021 – 2030. Infrastructure for Hydrogen use in transport will support the construction of basic infrastructure in the regions of the Slovak Republic via specific financial schemes. Refuelling stations and fuel systems will be located based on an analysis of hydrogen requirements for fleets of hydrogen vehicles and mobile technology on major transport routes, operations at urban nodes and airports, and in the hydrogen valleys. Within the pilot phase of building hydrogen infrastructure, the Action Plan anticipates the establishment of at least three hydrogen refuelling stations by 2026. The stated investment will be financed via the approved Aid Scheme from the Recovery and Resilience Plan funds within Component 3 and is in line with the accepted milestones and objectives of supporting infrastructure construction for alternative fuels[100].

3.11.2. Vehicle-to-grid and the mobility sector

There were close to 500 EVs registered in Slovakia at the end of 2017. While not a considerable number, this represents a substantial (40%) increase on the 355 EVs registered in 2016. Currently there are 35 fast charging stations and around 100 normal charging points. To put this in context, over 100,000 vehicles (including more than 95,000 cars) are sold each year in Slovakia, most with a combustion engine. Thus, provided the market share level improves, EVs are considered to potentially have a big and promising future. In September 2015, the Slovak government adopted the **Strategy for the Development of Electric Mobility in the Slovak Republic** and its impact on the National Economy of the Slovak Republic ("the Strategy"). Measures considered by the Strategy[101] include:

- stimulation of growth in the sale of electric cars and plug-in hybrids in Slovakia via direct or indirect support (by subsidising certain costs),
- low emission zones for cities (and legislation to allow local authorities to declare such zones in their territory),
- simplification of the administrative process for the construction of charging infrastructure (with the aim of only requiring project documentation of the electrical installation and an inspection report for the placement of a charging station),

[99] Prognosis of hydrogen consumption and production in Slovak economy by 2050 will be part of the Action Plan of Measures for Successful 25 Implementation of the National Hydrogen Strategy.

[100] SEVA-Slovak elecric vehicle association, https://seva.sk/en/data-statistics/ (accessed 30.12.2024).

[101] Strategy for the development of Electric Mobility in the Slovak Republic.

- providing public parking spaces in place of residence. Electric car owners shall automatically acquire the possibility of the reservation of one parking space in the immediate vicinity of their home,
- providing public parking spaces. This includes the possibility of limited parking reservation spaces for electric car owners,
- introducing legislative conditions for the mandatory construction of charging infrastructure when constructing parking spaces,
- building a National Network of Charging Centres. This will allow universal use of EVs, including on long-distance routes,
- ensuring subsidies for local authorities to build a publicly available rechargeable charging infrastructure,
- favouring parking and access to narrower city centres and pedestrian zones for EVs. This will facilitate transport and supply in pedestrian zones to be carried out exclusively by EVs.

Actual historical trend suggests that the number of EVs in Slovakia may reach 28 thousand to 41 thousand vehicles by 2030[102]. The electricity demanded by these electric vehicles to travel 12,000 km to 15,000 km in a year could reach 220-710 TJ or 90-200 GWh in 2030, which is less than 1% of total electricity consumption in Slovakia in 2018 (111 PJ or 31 TWh). Should the growth of EVs in Slovakia become more progressive, then for example 116,000 EVs (5% of current passenger cars fleet) would consume up to 2 PJ or 0.56 TWh of electricity.[103]

The development in the area of vehicle powertrains indicates that application of fuel cells is becoming a real alternative to combustion engines and battery (accumulator) based electromobility. However, due to technical reasons, they are inter-connected . In order to use hydrogen in transportation, Slovakia will build a network of refuelling station based on the transportation concentration and the expected consumption of hydrogen in the given region[104].

The gaseous hydrogen can be blended into the natural gas distribution network, which is well-developed in Slovakia. It will be possible to repurpose it and use it to transport and distribute hydrogen. Before that, it will undergo a detailed expert analysis of its technical condition. Use of hydrogen and various forms of hydrogen-containing gas mixtures will play a crucial role at decarbonisation of heat economy[105].

[102] Growth potential of electric vehicles and their impact on transport fuels and electricity demand in the Slovak Republic, https://www.mhsr.sk/uploads/files/3VWIDqf1.pdf (accessed 30.12.2024).

[103] Executive Summary of the Centre of Economic Issue. Ministry of Economy of the Slovak Republic, https://www.mhsr.sk/uploads/files/3VWIDqf1.pdf (accessed 30.12.2024), p. 2-4.

[104] Strategy of Electromobility Development in SR and Its Impact on National Economy of SR, UV-29689/2015, https://www.mhsr.sk/uploads/files/QeKrkpWz.pdf (accessed 30.12.2024).

[105] Revision and update of National Political Framework for Alternative Fuel Market Development, UV 557/ 2019, https://www.mhsr.sk/uploads/files/8Hvhoqz5.pdf (accessed 30.12.2024).

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