Interreg
EUROPEAN UNION
Danube Transnational Programme
DanuP-2-Gas

Project main output O.T3.1

Transnational Strategy for Effective Sector Coupling

Activity A.T3.2: Strategy development

December, 2022

Project co-funded by the European Union funds (ERDF, IPA)
www.interreg-danube.eu/danup-2-gas

DOCUMENT CONTROL SHEET

Project reference	
Full title of the project	Innovative model to drive energy security and diversity in the Danube Region via combination of bioenergy with surplus renewable energy
Acronym	DanuP-2-Gas
Programme priority	Priority 3
Programme priority specific objective	SO 3.2 Improve energy security and energy efficiency
Duration	01.07.2020 – 31.12.2022
Project website	www.interreg-danube.eu/danup-2-gas
Project coordinator	TZE

Short Description
The strategy is a compilation of country-specific roadmaps and include concrete recommendations for sustainable economic operation of sector coupling hubs (specifically P2G plants) in the Danube region.

Document Details	
Title of document	Transnational Strategy for Effective Sector Coupling
Action	WP 3 Policy and Legal Framework
Main Output	O.T3.1
Delivery date	December 2022

Version	Date	Author	Organization	Description
V1	22.12.2022	Darja Markova	EI-JKU	Final version with inputs from country-specific roadmaps

IMPRINT

This document is issued by the consortium formed for the implementation of the DanuP-2-Gas project by the following partners:

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- ERDF PP1 Energy AGency of Savinjska, Koroška and Šaleška Region (SI)
- ERDF PP2 Tolna County Development Agency Nonprofit Public Ltd.(HU)
- ERDF PP3 Energy Institute at the Johannes Kepler University Linz (AT)
- ERDF PP4 Black Sea Energy Research Centre (BG)
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- ERDF PP11 Energy Institute Hrvoje Požar (HR)
- IPA PP1 Regional Agency for Socio – Economic Development – Banat Ltd (RS)

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Disclaimer

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

CONTENT

1. EXECUTIVE SUMMARY OF THE STRATEGY

Danube Region countries are particularly dependent on energy imports so that the security of supply became even more important in the year 2022. Additional intensive efforts are needed to increase the share of renewable energy production and thus to decarbonise industry and transport sectors. In order to achieve national and EU wide climate and energy targets, use of imported and fossil energy sources should be decreased. The replacement of fossil natural gas in the current energy system will be possible amongst others with increased electrification and use of renewable gases.

Big opportunities in the Danube region regarding untapped biomass residues and utilization of this potential as well as increase of renewable electricity production are essential steps, which are already taken to decrease energy dependency in the Danube Region. Production of biomethane, in biogas plants, and production of renewable hydrogen and renewable methane via electrolysis and methanation, is currently in development and shows big potential worldwide.

»The replacement of fossil natural gas in the current energy system will be possible amongst others with increased electrification and use of renewable gases.«

Power-to-gas plants combine eletcricity and gas sectors and will be essential part of the future energy system in Danube Region. The roll-out of such sector coupling hubs increases the energy security of the Region and helps to achieve decarbonisation targets. To successfully roll-out the Power-to-gas technology in the last years few demonstration projects have been funded mostly in Germany in Austria. The experience from plant construction and operation gives good possibility to exchange gained knowledge around the Danube Region and to inform and involve more interested stakeholders in the further roll-out of the technology. Cross-sector cooperation plays here an important role, as well as an awareness rising for such a technoogies for different stakeholder groups is indispensable.

»Power-to-gas plants combine electricity and gas sectors and are essential part of the future energy system in Danube Region.«

The main objective of the DanuP-2-Gas project was to support the diversification of energy ressources in the Danube Region, develop instruments for further successful deployment of sector couplung hubs and build a trans-national sectoral energy community to increase exchange of experience and strengthen the cooperation between responsible stakeholders. Analysis of legal framework in Danube countries and identification of existing barriers for wider developments in terms of energy independency and increased share of renewables, as well as development of needed actions for further P2G project deployment have been part of the project. In the following 5 main recommendations are summarised as an ouput of developed country-specific roadmaps.

RECOMMENDATIONS FOR ACTIONS TO FOSTER THE SECTOR COUPLING HUBS DEVELOPMENT IN DANUBE REGION:

1. **Development of legal framework and simplification of permission and administrative procedures**

In addition to the adjustment of the legal framework, starting with clear anchoring of the respective definitions till the elimination of double taxation should be (further) developed. Development of a supportive legal framework for sector-coupling hubs is required to allow investors to make long-term financial investment decisions. Simplification of permission and administrative procedures should be ensured, as well as very long permisssion acquiring time in all Danube countries should be reduced.

2. **Increase funding for demonstration projects**

In order to accelerate the roll-out of the technology, demonstration projects in different sectors and for different applications should be funded, in order to collect the broad knowledge from the operation of the systems under different system conditions. Targeted networking and experience exchange between demonstration projects owners and interested stakeholders/potential project developers should be intensified.

3. **Investments in commercialisation and roll-out of technologies**

Funding instruments designed for the long-term funding for technology expansion on a large industrial scale are essential and should be designed in such a way that there is long-term security for the operators. The necessary investments in retrofitting of infrastructure, e.g. for increased hydrogen volume in gas grids, and development of power grid, should be analysed in detail and necessary investment volume should be identified. Development of legal and financial possibilities that allows different players such as, for example, energy communities, to operate and own P2G projects should be fostered.

4. **Transnational cooperation within Danube region**

In order to intensify the experience exchange between Danube countries, transnational cooperation should be enhanced and specific information events organized. Within Danube region especially Germany and Austria are currently frontrunners in the development of P2G projects and can offer direct opportunities for experience transfer and capacity building to the other Danube region countries through delegation trips and on-site visits. Furthermore, the cooperation between investors, governments and public authorities should be intensified in order to foster the development of new projects.

5. **Awareness and acceptance rising**

In order to increase awareness about the P2G technologies of general public and thus enhance the acceptance level extensive and targeted information campaigns are necessary. Particular attention should be given to the potential direct neighbors of such a plants, to ensure high kowledge level about P2G technologies. Information campaigns and experience exchange activities should be organised also for public authorities, especially those, which are directly involved in development and operation of such plants.

2. INTRODUCTION

The project DanuP-2-Gas aims to advance transnational energy planning by promoting generation and storage strategies for renewables in the Danube Region by coupling power and gas sectors. The effective realisation of this project depends strongly on the legal and regulatory framework. During the work within the WP3 “Policy and Legal Framework” the legal and regulatory status concerning the construction and operation of hubs for coupling the electricity and gas sector was assessed and existing national barriers have been identified. These assessments are the basis for the development of country specific strategic roadmaps designed to foster energy storage through specific recommendations on different levels - for adjustments of the legal framework, reduce social, technical barriers as well as giving special insights on the potential of the sector coupling hubs in every country. Existing document is a combination of these roadmaps to a durable strategy to enhance sector coupling in the Danube Region.

The aim of this Deliverable is therefore to show identified barriers and needed actions for successful development of sector coupling hubs in Danube Region.

3. METHOD

This strategy is based on the developed country-specific roadmaps, where legal, techno-economic, socio-technic and overall barriers have been identified and respective needed actions and recommendations have been developed. These roadmaps have been discussed with respective national stakeholders and additional improvements have been made. The barriers and recommendations have been presented during national and international project workshops and distributed among interested stakeholders and political and policy making actors.

4. THEMATIC SCOPE AND GOAL OF THE STRATEGY

The goal of the strategy is to support the development towards increased energy security and efficiency in the Danube Region via storage of surplus renewable energy in the gas grid and contribute to the EU climate-neutrality by 2050. The strategy as a compilation of country-specific roadmaps identifies needed actions to overcome existing barriers for wider implementation of sector coupling hubs within the Danube region.

5. SPECIFIC GOALS OF EUROPEAN UNION

Before the national specifics are explained in more detail, the goals and objectives as well as the established procedures of the European Union should be outlined.

Reduction of greenhouse gas emissions – European Climate Law

With the adoption of Regulation 2021/1119[1], the so-called "European Climate Law", the European Union has established a union wide framework for achieving climate neutrality. Article 1 of the Regulation sets out the binding target of climate neutrality by 2050. Article 2 further specifies this target by prescribing the balancing of greenhouse gas emissions regulated by Union law and their removals by 2050 at the latest. This should lead to a net zero reduction of emissions by then. It is also stated that the Union will aim for negative emissions beyond this.

To ensure that climate neutrality is achieved by 2050, the EU has defined the interim target to reduce net greenhouse gas emissions within the EU by 55% by 2030 compared to 1990. Net greenhouse gas emissions are those that remain after subtracting the fraction removed by sinks, whereby a distinction can be made between natural sinks (natural ecosystems that absorb CO_2 such as forests) and technical sinks (technical means by which CO_2 can be absorbed from the atmosphere such as carbon capture and storage). Another goal is to further expand natural sinks and thus counteract the downward trend in the reduction of greenhouse gas emissions. Furthermore, it is to be ensured that sufficient mitigation measures are taken by 2030. As a result, the net reduction of greenhouse gases will be limited to 225 million tonnes CO_2-eq.[2] Under the "Fit for 55-package", the European Union has presented a number of measures which include proposals for revising EU legislation as well as new measures. These are intended to help achieving the climate targets.[3]

Reduction of greenhouse gas emissions – European Emissions Trading System

One measure to reduce greenhouse gas emissions is the EU Emissions Trading System which was established with Directive 2003/87/EC[4]. Here, the goal of reducing emissions in sectors which are covered by the EU ETS is 43% by 2030 compared to 2005. This has been set by the European Council and was taken up in recital 2of the Regulation (EU) 2018/841 (hereinafter LULUCF Regulation).[5]

Reduction of greenhouse gas emissions – Effort-Sharing sectors and LULUCF

Regulation (EU) 2018/842[6] (hereinafter Effort Sharing Regulation) plays an important role in the reduction of greenhouse gas emissions. It sets binding national annual targets to be achieved in the period from 2021 to 2030. This is intended to contribute to climate protection and to ensure that the commitments under the Paris Agreement are met.

[1] Regulation (EU) 2021/1119 of the European Parliament and of the Council of 30 June 2021 Establishing the Framework for Achieving Climate Neutrality and amending Regulations (EC) No 401/2009 and (EU) 2018/1999 ('European Climate Law'), OJ 2021 L 243/1.

[2] Cf. Article 4 (1) European Climate Law.

[3] Website of the Consilium of the EU, see https://www.consilium.europa.eu/de/policies/green-deal/fit-for-55-the-eu-plan-for-a-green-transition/#package (accessed 28.10.2022).

[4] Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC, OJ 2003 L 275/32 as amended by 2021 L 305/1.

[5] Regulation (EU) 2018/841 of the European Parliament and of the Council of 30 May 2018 on the inclusion of greenhouse gas emissions and removals from land use, land use change and forestry in the 2030 climate and energy framework and amending Regulation (EU) No 525/2013 and Decision No 529/2013/EU, OJ 2018 L 156/1 as amended by 2021 L 60/21.

[6] Regulation (EU) 2018/842 of the European Parliament and of the Council of 30 May 2018 on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Pa ris Agreement and amending Regulation (EU) No 525/2013, OJ 2018 L156/26.

The regulation sets a target of reducing each Member State's greenhouse gas emissions by 30% in the period 2021-2030 compared to their 2005 levels. It also lays down rules to determine the annual emission allocations for each Member State.[7]

Annex I also contains the specific percentages by which greenhouse gas emissions must be limited in 2030 (compared to 2005).[8] For Austria this means that it should have achieved a reduction of -36% in the burden sharing sectors. For the countries of the partners involved in the project, the targets result in the following table:

Country	Greenhouse gas emission reductions pursuant
AUSTRIA	-36%
BULGARIA	-0%
CROATIA	-7%
CZECH REPUBLIC	-14%
GERMANY	-38%
HUNGARY	-7%
ROMANIA	-2%
SLOVENIA	-15%
SLOVAKIA	-12%

The second legal basis relevant in this context is the LULUCF Regulation. It regulates the accounting of emissions and removals of GHG in the land use, land use change and forestry sectors.[9] It is an important instrument of climate and energy policy for the second period from 2021 to 2030. A no-debit rule is implemented, according to which Member States must ensure that, taking into account all relevant provisions (Articles 12 and 13 LULUCF Regulation), emissions do not exceed removals in the specific sector in the periods 2021-2025 and 2026-2030.[10]

Renewable Energy

Directive (EU) 2018/2001[11] (hereinafter RED II) is dedicated exclusively to promoting the use of energy from renewable sources and is intended to create a common framework for this. The binding overall target of the Member States is to have a share of energy from renewable sources of 32% in 2030, measured against gross final energy consumption.[12] The Directive does not specify individual targets for the individual Member States, but leaves it up to them to define these themselves (with a view to achieving the overall target), which are to be incorporated into the national energy and climate plans and submitted to the Commission.[13]

The RED II covers various sectors, including the heating and cooling sector. For this, it is stated that the member states should strive to increase the share of renewable energies in that sector. As an indicative benchmark, 1.3 percentage points compared to the 2020 share are specified. These determinations then

[7] Cf. Article 1 Effort Sharing Regulation.
[8] Cf. Article 4 (1) Effort Sharing Regulation.
[9] Cf. Article 1 LULUCF Regulation.
[10] Cf. Article 4 LULUCF Regulation.
[11] Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources, OJ 2018 L 328/82 as amended by 2022 L 139/1.
[12] Cf. Article 3 (1) RED II.
[13] Cf. Article 3 (2) RED II.

serve as an annual average for the periods 2021-2025 and 2026-2030. For those states in which waste heat is not used, the limitation of the increase is set at 1.1 percentage points.[14]

For the transport sector, it is stipulated that Member States must oblige fuel suppliers to bring the share of renewable energy in the sector's energy consumption to a minimum level. This minimum share is to be 14% in 2030. Specific methodologies for the calculation are given in Articles 26 and 27 of RED II.[15]

Energy Efficiency

EU law provides two different relevant standards on the subject of energy efficiency, Directive 2012/27/EU[16] and its amendment by Directive (EU) 2018/2002[17]. The aim is to ensure that the overarching energy efficiency targets are achieved by 2030, which provide a minimum improvement of 32.5%. Furthermore, improvements for the period after 2030 should already be prepared.[18] Here the EU does not specify individual targets, as each Member States has to set an indicative national energy efficiency target, taking into account certain predefined parameters[19] as the maximum energy consumption of 1128 Mtoe of primary energy and/or 846 Mtoe of final energy.[20]

Furthermore, the member states are obliged to make energy savings. They must save cumulatively 0.8% of annual final energy consumption (calculated over the most recent three-year period prior to 01.01.2019) in the period from 2021 to 2030. Annual savings of the same amount are also foreseen for the period after 2030, but the Commission can waive these after reviews if the savings are not necessary to achieve the climate targets for 2050.[21]

6. AUSTRIA

6.1 NATIONAL (SPECIFIC) GOALS

The Austrian government has set the goal of being climate-neutral by 2040 at the latest.[22] Austria aims at building, expanding and repowering plants that produce renewable electricity to the extent that the domestic renewable electricity production equals total domestic electricity consumption from 2030 onwards.[23] In order to achieve that, the annual electricity production from renewable sources should be increased by 27 TWh by 2030. These are to consist of 11 TWh photovoltaics, 10 TWh wind, 5 TWh hydro and 1 TWh biomass.[24]

[14] Cf. Article 23 (1) RED II.
[15] Cf. Article 25 (1) RED II.
[16] Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC, OJ 2012 L 315/1 as amended by 2019 L 158/125.
[17] Directive (EU) 2018/2002 of the European Parliament and of the Council of 11 December 2018 amending Directive 2012/27/EU on energy efficiency, OJ 2018 L 328/210.
[18] Cf. Article 1 (1) Directive 2012/27/EU.
[19] Cf. Article 1 (1) Directive 2012/27/EU.
[20] Cf. Article 5 Directive 2012/27/EU.
[21] Cf. Article 7 (1) Directive 2012/27/EU.
[22] Republic of Austria, Government Programme 2020-2024 (2020) pp. 72 (available under: https://www.bundeskanzleramt.gv.at/dam/jcr:7b9e6755-2115-440c-b2ec-cbf64a931aa8/RegProgramm-lang.pdf).
[23] § 4 (2) REEA.
[24] § 4 (4) REEA.

The Renewable Energy Expansion Act (in the following REEA, Erneuerbaren-Ausbau-Gesetz F.L.G. I No. 150/2021 as amended by F.L.G I No. 13/2022) also sets an objective regarding renewable gas, namely to increase the quantity of renewable gas produced in Austria to 5 TWh by 2030.[25]

The National Energy and Climate Plan (hereafter NECP) sets indicative target paths for the share of renewable energy in the gross final energy consumption for 2022, 2025 and 2027 in order to reach 46-50% by 2030. These are specified as follows:

- 2022: 36,2-36,9 %
- 2025: 39,2-40,9 %
- 2027: 41,8-44,4 %.[26]

Furthermore, Austria aims at improving primary energy intensity by 25-30% by 2030 compared to 2015. Over the period 2021-2030, Austria shall achieve cumulative final energy savings of approximately 11,878 ktoe.[27]

6.2 EXISTING BARRIERS

In the following chapter existing barriers and needed actions for the deployment of P2G projects in Austria are listed. These are based on the gained experience with P2G research and demonstration projects in Austria, findings from international projects and feedback received from the stakeholder workshop organised during Q4 2022. For a better overview, the barriers are divided into three subcategories, however all barriers are interconnected.

Legal barriers

- The appropriate legal and regulatory framework including funding possibilities for construction of P2G projects is still in development, which may hinder the faster deployment.

Socio-technical barriers

- A big variety of stakeholders should be involved in the implementation of P2G projects thus higher complexity in achieving sufficient acceptance for construction may occur.
- Low awareness of climate change and knowledge of clean technologies e.g. P2G, concentrated knowledge exist in small group of energy experts and industries.
- Ambivalence in public acceptance of wind farms and decrease of acceptance for construction of new power lines, but higher acceptance for solar farms and P2G compared to options without such technologies.[28]

[25] § 4 (1) (7) REEA.
[26] Republic of Austria, Integrated National Energy and Climate Plan for Austria 2021-2030 (2019) p. 80 (available under: https://ec.europa.eu/energy/sites/default/files/documents/at_final_necp_main_en.pdf).
[27] BMNT/BMVIT, #mission2030 - Die österreichische Klima- und Energiestrategie (2018) p. 18 (available under: https://www.bundeskanzleramt.gv.at/dam/jcr:903d5cf5-c3ac-47b6-871c-c83eae34b273/20_18_beilagen_nb.pdf) and Republic of Austria, Integrated National Energy and Climate Plan for Austria 2021-2030 (2019) pp. 86.
[28] V. Azarova, J. Cohen, C. Friedl and J. Reichl, 'Designing local renewable energy communities to increase social acceptance: Evidence from a choice experiment in Austria, Germany, Italy, and Switzerland' (2019) 132 Energy Policy 1176–1183, available at: https://doi:10.1016/j.enpol.2019.06.067.

- Local projects may face resistance from the local community. The general level of acceptance is decreasing when it comes to infrastructure implementation in the neighbourhood.[29]
- Complex and long permission procedures, also because of insufficient knowledge level of public authorities involved.

Techno-economic barriers

- Lack of appropriate infrastructure for hydrogen use in mobility and for injection into the gas grid.
- Readiness of gas infrastructure and appliances for higher shares of hydrogen is not identified; amount of additional investment to overcome this barrier is not identified.
- P2G projects with an aim to produce renewable hydrogen are often non-competitive with conventional fossil hydrogen production via steam reforming of natural gas in terms of costs of produced hydrogen. In comparison with fossil hydrogen produced at a big scale, renewable hydrogen production costs via electrolysis can be 3 to 5 times higher.
- The P2G process is not yet fully technologically mature, scaling up and R&D activities are still ongoing.
- The use of renewable gases in shipping and aviation is under development, therefore the use of hydrogen in these sectors is still a challenge.

6.3 ACTION ITEMS AND RECOMMENDATIONS

Taking into account the identified existing barriers, a variety of action items and needed steps, which should be taken to overcome these gaps and barriers and to achieve the goals of the roadmap, are summarised in this chapter.

Actions needed to overcome legal barriers

- Consideration of sector coupling technologies such as power-to-gas in the respective energy laws. A legal framework that provides legal certainty and incentives should be further developed. This would promote the implementation of such technologies.
- Increase the current allowable (up to) 10 % mol/mol hydrogen content in the gas network.[30] Pursuant to § 133a Gas Act 2011 (Gaswirtschaftsgesetz 2011 F.L.G. I. No. 107/2011 as amended by F.L.G I. No. 94/2022), the Federal Minister for Climate Action, Environment, Energy, Mobility, Innovation and Technology, together with the Federal Minister for Digital and Economic Affairs may determine by ordinance the technically maximum permissible proportion of hydrogen in the gas pipelines. An unrestricted feed-in of hydrogen into the existing natural gas grid is currently not possible. However, according to several studies, the feed-in of up to 17 vol-% is possible without causing problems.[31]
- Include energy storage as a market participant into the Austrian energy law framework according to the Electricity Market Directive 2019 (Directive 2019/944 as amended by 2022 L152/45).

[29] A. Veseli et al., 'Interdisciplinary challenges and opportunities for hydrogen projects in Austria and the EU' (2022) #32 European Energy&Climate Journal 60–63, available at: https://doi.org/10.4337/eecj.2022.02.05.
[30] ÖVGW (2021). Gasbeschaffenheit Richtlinie G B210.
[31] Haeseldonckx, D., & Dhaeseleer, W. (2007). The use of the natural-gas pipeline infrastructure for hydrogen transport in a changing market structure. International Journal of Hydrogen Energy, 32(10–11), 1381–1386. https://doi.org/10.1016/j.ijhydene.2006.10.018.

Actions needed to overcome socio-technical barriers

- Organization of public engagement events, to increase the acceptance levels of general public and specific stakeholders. The well-prepared information policy to satisfy potential opponents at an early project development stage is essential. Targeted information about system functionality, the general nature of hydrogen, involved benefits and opportunities of direct stakeholder feedback is very important.[32]
- Development of specific funding mechanisms for community-based local projects as the promotion of such projects would raise the awareness and acceptance in the hydrogen technologies, and will allow trying out technically and economically different approaches in real operation as well as will create demand.
- Guidelines for project developers on permission and admission procedures should be developed.

Actions needed to overcome techno-economic barriers

- Further development of financing mechanisms for demonstration projects and security of long-term funding is essential for achieving long-term decarbonisation goals.
- Intensified funding options for roll-out and commercialization of the respective technologies are needed.
- Further development of hydrogen mobility – construction of hydrogen refuelling stations and funding for hydrogen fuelled busses and heavy-duty trucks should be fostered.
- Readiness of gas infrastructure and appliances for higher shares of hydrogen should be proved as well as the amount of investment needed for adjustments of the infrastructure should be identified.
- As P2G business projects are often non-competitive, but, from the national economy point of view, projects for the generation, distribution and use of green gases as well as the maintenance of existing infrastructure have positive effects on GDP, jobs, import reduction, etc. Therefore, the stronger focus on these positive effects should be used to gain additional/alternative funding, and to increase public acceptance.
- To increase the maturity of the P2G technologies more demonstration and upscaling projects are needed worldwide.
- Constant market observation and targeted networking and experience exchange between demonstration projects owners and interested stakeholders / potential project developers can ensure that the technologies used and use cases implemented remain technologically "up-to-date". Innovations should be anticipated as soon as possible.
- As high investments for the P2G projects are needed, the examination whether projects can be designed in a modular way, so that investments or generation capacities can be adapted to the increasing demand over time, should be made.
- As green gas from local P2G plants would be produced at high costs the system service function (being able to create load balancing in the electricity grid and offering seasonal storage options for wind and PV) should be included in the business case and thus supported via additional financing mechanism to make local P2G more competitive also in comparison with the imported hydrogen and other green gases.

Further action items and recommendations

- The cooperation between investors, governments and public authorities should be intensified in order to foster the development of new projects.

[32] A. Veseli et al., 'Interdisciplinary challenges and opportunities for hydrogen projects in Austria and the EU' (2022) #32 European Energy&Climate Journal 60–63, available at: https://doi.org/10.4337/eecj.2022.02.05.

7. BULGARIA

7.1 NATIONAL (SPECIFIC) GOALS

The main objectives and measures for the implementation of Bulgaria's national energy and climate policies in the context of EU law are laid down in the National Energy and Climate Plan (NECP). It has been developed in accordance with the requirements of Regulation (EU) 2018/1999. According to the NECP, the following targets should be met by 2030:

- Share of renewables – 27.09%
    - Electricity – 30.33%
    - Heating and cooling – 42.60%
    - Transport – 14.20%

Bulgaria will make efforts to increase the share of energy from renewable sources in gross final energy consumption and reduce GHG emissions. Bulgaria has raised the level of ambition regarding the share of energy from renewable sources in gross final energy consumption from 25 % to 27.09%, in comparison with previous versions of the plan, and will thus aim to achieve the target set in Annex II to Regulation (EU) 2018/1999. To do so, Bulgaria will expand its generating capacity with an emphasis on wind and solar power. If necessary for achieving the targets set after 2025, tenders for additional renewable energy capacity may also be conducted, taking market conditions into account. Biomass use is projected to increase in all sectors — electricity, heat and cooling, and transport. The planned changes in transport will have a strong impact on the development of energy from renewable sources and GHG emissions reduction. More specifically, Bulgaria will promote the introduction and use of electric and hybrid vehicles in public and private transport and plans to create low-emission zones in large cities. These measures, among others, will contribute to the significant reduction of GHG emissions.

- Decrease in primary and final energy consumption with 27.89% and 31.67% respectively by 2030 as compared with the PRIMES 2007 reference scenario
    - Primary – 17 466 ktoe
    - Final – 10 318 ktoe

In reference to decreasse in energy consumption, Bulgaria will strive to achieve energy savings in final energy consumption, focusing on improvement of the energy performance of buildings and on energy generation, transmission and distribution.

In line with the EU's priorities for increasing energy efficiency, Bulgaria considers energy efficiency to be a top priority in view of its importance for improving energy security by lowering dependence on energy imports, for reducing energy costs for businesses and households, for creating more jobs, for improving air quality, for cutting GHG emissions and for improving the quality of life of citizens.

In line with Article 7 of Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, Bulgaria places emphasis on alternative policy measures to promote energy efficiency. Such measures include financial incentives for implementing energy efficiency projects, the promotion of energy performance contracts with guaranteed savings (ESCO contracts), and the renovation of the existing building stock with a view to increasing the number of nearly zero-energy buildings.

- Achieved interystem operability – 15%

Bulgaria's top priority is to diversify the sources of - and the routes for – its natural gas supply by implementing the following projects: building an interconnector between Bulgaria and Greece[33] (IGB project), building an interconnector between Bulgaria and Serbia (IBS project), participating in the construction of a liquefied natural gas (LNG) terminal in Alexandroupoli, and gas infrastructure development in connection with the plan to build a regional gas distribution center (Balkan Gas Hub). Bulgaria aims to increase its energy security by diversifying its energy supplies, making efficient use of domestic energy resources and further developing its energy infrastructure. In order to achieve these goals, efforts will be focused on grid development and enhancing the flexibility of the electricity system, e.g. by further developing the 400 kV and 110 kV transmission grid.

- Research, Innovation, and Competitiveness

Bulgaria is committed to promoting scientific progress in the area of innovative energy technologies, including clean power generation. Important projects promoting business innovations and digitalisation will be developed. Bulgaria plans to participate in a number of programmes in this area.

7.2 EXISTING BARRIERS

In the following chapter existing barriers and needed actions for the deployment of P2G projects in Bulgaria are listed. These are based on review of the Bulgarian legal framework and discussions with stakeholders.

Legal barriers

- In its current state of development, Bulgarian legislative system is unbalanced in reference to stipulations that incentivize electrical energy produced from renewable energy sources (RES) and ones that do the same for gas produced from renewable energy sources (GRES).
- Still absent preferential pricing for GRES despite provisions in art. 18, par. 4, point 5 of the Renewable Energy Sources Act (RES Act).
- Currently, art. 18, par. 4, point 1-2 (RES Act) stipulates that access to grid and transmission of GRES is guaranteed which is a good step forward albeit a higher level of engagement can be provisioned.
- The application of discriminatory fees for transmission and/or distribution for GRES is currently prohibited which does not provide any preferential treatment for GRES.
- The grid operators don't publish their tariffs for accession of GRS production facilities despite the presence of an imperative requirement that they must do so
- Methodologies for calculation of energy/CO_2 savings for the case when energy is delivered by GRES are not present in the Bulgarian regulation system. That prevents energy efficiency obligated parties from buying certificates for energy savings originating from usage of GRES. As a result, P2G hubs are excluded from the market for energy savings in Bulgaria.
- At present, there is no regulation that allows energy cooperatives/communities to be established in Bulgaria with the purpose of investing in and implementing P2G hubs.
- Lack of additional incentives for investments in coupling technologies due to absent obligation for operators of the gas/electrical grids to prioritize the use of balancing services provided by P2G facilities.

[33] In operation since September 2022

Socio-technical barriers

- Lack of political leadership and national support in reference to coupling technologies.
- Potential resistance may be expected from green organizations with the objective of protecting Bulgarian forests.
- Supply chains and waste biomass collection capacity are underdeveloped in Bulgaria, especially in reference to citizens and less so in the industrial sector.
- A big variety of stakeholders should be involved in the implementation of P2G projects thus higher complexity in achieving sufficient acceptance for construction may occur.
- Low awareness of climate change and knowledge of clean technologies e.g. P2G, concentrated knowledge exist in small group of energy experts and industries.
- Complex and long permission procedures, also because of insufficient knowledge level of public authorities involved.

Techno-economic barriers

- Entrepreneurs don't have the necessary incentive to take the risk and invest in innovative and unknown for the local market technology.
- Unbearable level of investments required for building gas and electricity grids that would enable a greater number of feasible locations for P2G hubs.
- Lack of appropriate infrastructure for hydrogen use in mobility and for injection into the gas grid.
- Readiness of gas infrastructure and appliances for higher shares of hydrogen should be proved as well as the amount of investment needed for adjustments of the infrastructure should be identified.
- P2G business cases are often non-competitive. However, from the national economy point of view, projects for the generation, distribution and use of green gases as well as the maintenance of existing infrastructure have positive effects on GDP, jobs, import reduction, etc. Therefore, the stronger focus on these positive effects should be used to gain additional/alternative funding, and to increase public acceptance.
- The P2G process is not yet fully technologically mature; there is a need for more demonstration projects. As well as constant market observation and targeted networking with demonstration projects can ensure that we remain technologically "up-to-date". Innovations should be anticipated as soon as possible.
- High production costs of domestic green gas from P2G applications. However, the system service function (being able to create load balancing in the electricity grid and offering seasonal storage options for wind and PV) can be used nationally and thus long-term support can be argued for. This is an important reason to develop P2G projects nationally, because through the import of green hydrogen from abroad, no possibility for nationally necessary system services will be available.
- As high investments for the projects are needed, the examination whether projects can be designed in a modular way, so that investments or generation capacities can be adapted to the increasing demand over time, should be made.

7.3 ACTION ITEMS AND RECOMMENDATIONS

Taking into account the identified existing barriers, a variety of action items and needed steps, which should be taken to overcome these gaps and barriers and to achieve the goals of the roadmap, are summarised in this chapter.

Action items needed to overcome legal barriers

- Adopting a same set of stimuli as the ones for the electrical energy produced from RES is expected to result in a big leap forward for the production of GRES. In that way GRES can experience the same level of proliferation as the one demonstrated by the electrical energy from RS in the past few years.
- Stipulations in the Renewable Energy Sources Act (RES Act) about adoption of preferential pricing for GRES have to be enforced.
- Grid operators can be obliged to provide preferential access for GRES; not just to guarantee it.
- In order to stimulate the penetration of sector coupling technologies, the accession and transmission fees should be set at preferential level. Putting GRES on equal footing with standard natural gas supply fees does not bring the necessary incentives for private investments in P2G hubs.
- The National Regulator should request the grid operators either to comply with the requirement for publishing their tariffs for accession of GRES production facilities or directly penalize them for non-compliance.
- Methodologies for calculation of energy/CO_2 savings for the case when energy is delivered by GRES should be developed and adopted by the Bulgarian regulation system.
- Introduction of regulation that allows energy cooperatives/communities to be established with the purpose of investing in and implementing P2G hubs. In addition, regional opportunities in communities for collection of waste biomass, needed for production of GRES, should be incentivized, e.g., sewage sludge, households' bio-waste, agricultural waste, etc.
- To provide additional incentives for investments in coupling technologies, operators of the gas/electrical grids should be obliged to prioritize the use of balancing services provided by P2G facilities.

Action items needed to overcome socio-technical barriers

- Political Leaders should express their support for coupling technologies and recognize them as a strategic national priority.
- Design of support programs that stimulate collection of waste biomass capacity, as well as development of waste biomass supply chains.
- Organization of public engagement events to increase the acceptance levels of general public and specific stakeholders.
- Development of specific financing mechanisms for better public involvement in the renewable energy production.

Action items needed to overcome techno-economic barriers

- Further development of financing mechanisms for demonstration projects such as the ones already present in the Bulgarian Resilience and Recovery Plan.
- Design of support programs that enable development of the gas and electricity infrastructure for the needs of P2G hubs, i.e., turning more locations as feasible options for production of GRES.
- The National Regulator should develop a detailed nomenclature of technologies and RES for GRES, accompanied by different preferential prices and guaranteed return on investment in the same manner as the one observed for electrical energy from RES.
- Intensified funding options for roll-out and commercialization of the respective technologies.

Further action items and recommendations

By the end of 2025 the above actions are feasible to be implemented mainly due to the expected start of the first P2G hub in Bulgaria and the demonstration of the benefits it can bring to the economy and its investors.

The hub will be supported by the Bulgarian Resilience and Recovery Plan – already in progress - which makes the probability of realization of that project pretty high. It is reasonable to be expected that after the proof of concept becomes a fact, additional motivation for further development of the national legislation in that direction will take over and necessary changes and improvements in regulation will be implemented.

8. CROATIA

8.1 NATIONAL (SPECIFIC) GOALS

- Before The Croatian Hydrogen Strategy until 2050 (Official Gazette no. 40/22) was adopted, the Croatian strategic framework had identified hydrogen and biogas (biomethane) associated with decarbonizing transport and heating sectors, but not as specific goals.
- The Croatian Hydrogen Strategy emphasizes the advantages of developing the potential related to the hydrogen economy and is aligned with the goals of the European Hydrogen Strategy, as well as with the National Development Strategy of the Republic of Croatia until 2030.
- 4 strategic goals have been recognized, namely: increasing the production of renewable hydrogen, increasing the utilization of RES potential for the production of renewable hydrogen, increasing the use of hydrogen, and encouraging the development of science, research and development of hydrogen technologies.
- Integrated National Energy and Climate Plan for the Republic of Croatia for the period from 2021 to 2030
- The Energy Development Strategy of the Republic of Croatia until 2030 with a view to 2050 (Official Gazette no. 25/20) was adopted in February 2020 with one of the planned goals be to build around 2 500 MW of installed capacity by 2030.
- The Strategy for Low-Carbon Development of the Republic of Croatia until 2030 with a view to 2050 (Official Gazette, No. 63/21).
- The Energy Development Strategy of the Republic of Croatia, like the Croatian Low-Carbon Strategy, foresees a reduction in greenhouse gas emissions of around 74 % in 2050 compared to 1990 emissions.
- The Energy Development Strategy of the Republic of Croatia recognizes hydrogen as an alternative fuel and foresees its use in traffic in order to achieve the aforementioned objectives.
- National Recovery and Resilience Plan 2021 — 2026: connect 1 500 MW of new RES electricity sources to the energy system by the end of 2024.
- Climate neutral scenario of the Republic of Croatia non-energy sectors: Scenarios for reduction of emissions by sectors (%), compared to 1990:

Table 1. Reduction of emissions by sectors

	2018	2030	2040	2050
Energetics	- 24,3	- 43,7	- 67,8	- 95,6
Industrial processes and product use	- 44,5	- 68,0	- 73,3	- 87,7
Agriculture	- 38,5	- 45,6	- 56,6	- 67,0
Waste	93,9	14,8	- 35,3	- 61,2
Total	- 25,4	- 45,6	- 66,0	- 89,3

Table 1. Trends in hydrogen consumption and production under the climate neutrality scenario

Year	Total energy consumption* GWh/year	Share of hydrogen in total energy consumption %	Amount of hydrogen required kt/year	Electrolyser capacity MW
2020	99.101	0,0	0,0	0
2025	101.786	0,1	2,6	35
2030	104.470	0,2	5,3	70
2035	97.358	1,5	37	480
2040	90.245	3,0	69	900
2045	83.359	6,5	138	1800
2050	76.473	11	214	2750

**Republic of Croatia, Ministry of Economy and Sustainable Development, Creation of Scenarios for achieving* higher emission reduction by 2030 and climate neutrality in the Republic of Croatia by 2050 for the energy sector, Zagreb 28th September 2020

However, given the growing potential of the hydrogen economy within the EU, as well as the potential expressed by Croatia with regard to RES, the above-mentioned objectives may be further increased as shown in Table 3, which is a scenario of accelerated development of the hydrogen economy. Table 3 shows the required electrolyser capacity that obtain the electricity needed to produce hydrogen exclusively from RES ensuring renewable hydrogen. In view of the variability of RES, the RES capacity factor was set at 0,242 over the 30-year observation period.

Table 2. Trends in the consumption and production of renewable hydrogen in accordance with the climate neutrality scenario (potential scenario for accelerated development of hydrogen-based economy)

Year	Total energy consumption* GWh/year	Share of hydrogen in total energy consumption %	Amount of hydrogen required kt/year	Electrolyser capacity MW
2020	99.436,50	0,0	0,0	0
2025	101.762,50	1,25	13,94	384,02
2030	104.468,80	3,75	46,20	1272,73
2035	97.357,06	8,125	106,14	2923,97
2040	90.245,30	12,50	172,60	4754,82
2045	83.358,03	13,75	216,86	5974,10
2050	76.470,74	15,00	266,03	7328,65

Yet, it needs to be considered that these goals and trends where determined before the current energy crisis, which requires their potential reconsideration. This should be done in accordance to existing situation on the EU-level and in extensive communication with stakeholders involved in every sector related to hydrogen and P2G implementation.

8.2 EXISTING BARRIERS

In the following chapter existing barriers and needed actions for the deployment of P2G projects in Croatia are listed.

Legal barriers

- In the energy laws, it is necessary, especially for connection to the network in terms of defining connection and network fees, to define more precisely which of category a P2G facility belongs (the Electricity Market Act differentiates between customers, supply, production, distribution, transmission and storage of energy). The article describing energy storage says: »energy storage facility as a facility which stores electrical energy by converting it into another form of energy, meaning reversible hydroelectric power plants, pumped hydroelectric power plants, electrical boilers with storage, heat pumps, batteries, electrolyzes with hydrogen storage and other devices which can store electric energy in a form, and deliver it to the transmission or the distribution grid later“. However, the definition of energy storage in the law, taken from the EU Directive 2019/944 on the common rules for the internal market for electricity defines: »deferring the final use of electricity to a moment later than when it was generated, or the conversion of electrical energy into a form of energy which can be stored, the storing of such energy and the subsequent reconversion of such energy into electrical energy or for use as another energy carrier«. According to the first definition, a P2G plant that does not use the produced gas for reconversion to electrical energy is considered an active consumer and not energy storage, but according to the second definition, a P2G plant that sends the gas into the gas system is also considered an energy storage facility. The classification of P2G plants is important as storage facilities have to pay the lesser connection fee, but on the other hand, have to obtain energy permit which adds another step to the grid connection process.
- In the energy laws (Network codes of HEP DSO and HOPS, Rules of Connection to electricity and gas distribution and transmission network, etc.) it is necessary to clearly define the possibility of connecting P2G plants to the energy infrastructure (electricity and gas network).
- P2G technology is recognized in the Energy Development Strategy of the Republic of Croatia, but it is insufficiently integrated into the energy system and the promotion of energy security, independence, and impact on the environment.
- The administrative part after projecting and before the connection and start of operation of RES usually requires many administrative procedures involving stakeholders from different areas which are time-consuming.
- Often changes of law can have a negative impact on the administrative procedure in the long-term process of project development and thus the need to finish or change the existing project.
- In the case of technologies with intensive development, including P2G, a long administrative procedure can cause a need for changes in planning and decisions to change technology, which can bring the project and needed permits to the start or additionally extend the administrative procedure.
- The spatial development strategy of the Republic of Croatia foresees the creation of guidelines for the choice of locations and planning of wind farms, solar plants, and small hydro plants, and based on that a document called „Analysis of spatial capacities and conditions for the use of renewable energy sources potential in the Republic of Croatia“. This document does not include an analysis of the potential of using P2G technology.
- Difficulty in connecting RES to the electrical network due to the network characteristics, eg. the unfavorable form of network (due to the form of Croatia’s territory the transmission grid is mainly radial

or meshed through neighboring countries), the problematic spatial distribution of RES, the age of the network and change of network user structure.

- The spatial plans of lower-level territorial units in the Republic of Croatia are often not aligned, especially considering the spatial classification of land use, so getting the needed permits and documents for the development of the RES project, and also future P2G facilities is more difficult.
- Uneven approach of including locations into spatial plans of certain counties considering the size of RES facilities (power plants of power of 20 MW and more are defined as energy buildings of state importance, power plants of power between 10 MW and 20 MW are defined as buildings of regional importance, but for the spatial plans of some counties different rules are used.
- The appropriate legal and regulatory framework including funding possibilities for the construction of P2G projects is still in development, which may hinder faster deployment.
- The act on thermal treatment of waste (NN 75/2016) does cover waste streams foreseen in this project, but P2G plant/technology is not mentioned as well as the usage of mentioned feedstock for hydrogen production, thus the implementation of P2G in case of this feedstock is not viable at the moment.

Socio-technical barriers

- Lack of communication between the private and public sectors (industry and legislative/strategic framework)
- Knowledge gap on P2G and hydrogen topics, and their implementation
- A big variety of stakeholders should be involved in the implementation of P2G projects thus higher complexity in achieving sufficient acceptance for construction may occur.
- Low awareness of climate change and knowledge of clean technologies e.g. P2G, concentrated knowledge exists in a small group of energy experts and industries.
- Local projects may face resistance from the local community. However, promotion for local, community-based projects is very important on the one hand to technically and economically try out different approaches in real operation and on the other hand to create demand.
- Complex and long permission procedures, also because of the insufficient knowledge level of public authorities involved.

Techno-economic barriers

- Lack of appropriate infrastructure for hydrogen use in mobility and for injection into the gas grid.
- Readiness of gas infrastructure for higher shares of hydrogen should be proved as well as the amount of investment needed for adjustments of the infrastructure should be identified.
- P2G business cases are often non-competitive. However, from the national economy point of view, projects for the generation, distribution, and use of green gases as well as the maintenance of existing infrastructure have positive effects on GDP, jobs, import reduction, etc. Therefore, a stronger focus on these positive effects should be used to gain additional/alternative funding and to increase public acceptance.
- The P2G process is not yet fully technologically mature; there is a need for more demonstration projects. As well as constant market observation and targeted networking with demonstration projects can ensure that we remain technologically "up-to-date". Innovations should be anticipated as soon as possible.
- High production costs of domestic green gas from P2G applications. However, the system service function (being able to create load balancing in the electricity grid and offering seasonal storage options for wind and PV) can be used nationally and thus long-term support can be argued for. This is an important reason to develop P2G projects nationally because, through the import of green hydrogen from abroad, no possibility for nationally necessary system services will be available.

- As high investments for the projects are needed, the examination of whether projects can be designed in a modular way so that investments or generation capacities can be adapted to the increasing demand over time should be made.
- In order to decrease additional losses in case of gas storage and later conversion into electricity requires P2G plants to be located near existing RES. The availability of additional space and profitability of building such plants near existing or planned RES due to the RES locations or in the case of RES parks must be considered.
- In case of injection of the produced gas from the P2G facility into the gas infrastructure, it is recommended to build P2G plants near the gas infrastructure, under the condition that the existing gas infrastructure has the technical ability for hydrogen transport. Due to poorly branched gas infrastructure in Croatia and the lack of gas infrastructure in areas with the greatest P2G plant potential (e.g. wind farms in the coastal part of Croatia, especially Lika, Dalmatia, and Dubrovnik area), there is a reduced potential for building P2G plants.

8.3 ACTION ITEMS AND RECOMMENDATIONS

Taking into account the identified existing barriers, a variety of action items and needed steps, which should be taken to overcome these gaps and barriers and to achieve the goals of the roadmap, are summarised in this chapter.

Action items needed to overcome legal barriers

- The existing legal framework concerning P2G and hydrogen should be more detailed and precise in determining goals and action plans.
- Further development of supportive legal framework for electricity (e.g. EES, …), waste management and heating sectors to implement faster uptake of P2G hubs and sector-coupling.
- Development of legal framework to support the uptake of hydrogen utilization and production.
- Change of the existing legislation in order to more precisely define P2G facilities and technology and their inclusion into the electrical and gas system.
- Reducing the number of unnecessary administrative procedures by merging multiple steps into one or decreasing the needed documentation by connecting the same information from multiple sources (state or local institutions).
- Depending on the importance of P2G technology, a system of incentives or another measures have to be made for the production and/or storage of hydrogen and subsequent reconversion into electrical energy has to be implemented in order to make the technology more profitable in the early stages, which would additionally encourage and accelerate further development of P2G technologies.
- Interministerial groups targeted to implementation of new technology outputs.
- Action plans that integrate hydrogen and power-to-gas with specific case scenarios.
- Inclusion of identified key stakeholders in the decision-making process.

Action items needed to overcome socio-technical barriers

- Organization of public engagement events, to increase the acceptance levels of the general public
- Development of specific financing mechanisms for better public involvement in the renewable energy production.
- Capacity building and proactive approach of key stakeholders (assistance from national associations and public institutions).

- Definition of social-techno-economic framework within Public Private Partnerships (PPP) on hydrogen and P2G topics.

Action items needed to overcome techno-economic barriers

- Further development of financing mechanisms for demonstration projects.
- Intensified funding options for roll-out and commercialization of the respective technologies.
- Intensified support for R&D projects.
- Uptake and transferability of knowledge and experience from EU-level stakeholders.
- While planning the electrical grid development and planning and connection of RES to the electrical grid, especially in the part of the grid where there are problems with the offtake of electrical energy from RES in certain time periods, the potential of building P2G plants in the vicinity has to be considered.
- Recognizing the benefits of the use of P2G plants in combination with RES, especially in parts where the electrical grid is not sufficient for new RES connection or if there is a need for storing the surplus of produced electrical energy and its use in periods of peak consumption.

Further action items and recommendations

- The cooperation between investors, governments, and public authorities should be intensified in order to foster the development of new projects.
- In terms of just and inclusive transition, immediate steps in research are required with emphasis on the integration of hydrogen and P2G.
- In order to achieve decarbonization goals through the utilization of hydrogen and P2G hubs immediate steps are required to move forward from BAU. This can be obtained through specific steps, focusing mainly on the legislative framework, where public stakeholders cooperate intensively with the private sector. Additional knowledge transfer is required, with the industry as a lead. This is only possible with a fast implementation of the Action plan developed on the national level which should be delivered by joint cooperation of the public and private sectors.

9. CZECH REPUBLIC

9.1 NATIONAL (SPECIFIC) GOALS

The following goals were set by National Energy and Climate Plan of the Czech Republic[1]:

- By 2030, reduce emissions of the Czech Republic by at least 44 Mt CO_2 eq. compared to 2005 (corresponding to a reduction of 30 % compared to 2005 and 10 % compared to real value of 88 Mt CO_2 eq in 2020).
- Quantitative increase in electricity production from renewable sources by 2030 compared to 2016:
  - 92 % photovoltaics
  - 243 % wind
  - 3% hydropower
  - 20% biomass.
- Quantitative increase in heat and transport production from renewable sources by 91595 TJ by 2030 compared to 2016:
  - - 33436 TJ solid biomass
  - - 23434 TJ wood chips
  - - 4067 TJ cellulose extracts
  - - 15622 TJ biofuels.[34]
- Renewable gas: Increase the share of nationally produced renewable gas in Czech Republic gas sales by 6626 TJ by 2030 based on the 2016 production.
- NECP: Indicative target paths for share of renewable energy in gross final energy consumption:
  - 2030: 20%
  - 2035: 23%
  - 2040: 26 %.
- NECP: Energy efficiency:
  - Cumulative savings for the period 2021-2030: 70 PJ.
- Renewable energy sources share 2020-2030 increase from 13 % to 22 %.

9.2 EXISTING BARRIERS

In the following chapter existing barriers and needed actions for the deployment of P2G projects in Czech Republic are listed. These are based on the long experience with P2G in Czech Republic and findings from international projects.

Legal barriers

- The appropriate legal and regulatory framework for production and energy transfer from renewable sources for P2G plant production is not considered in any energy price plan, i.e. direct selling of energy from producer to consumer is not possible.
- Even though from 2021 there is an option to store the overproduction of electricity by battery storage units, these must be driven on demand by the regulatory authority of the Czech Transmission System

[34] National Energy and Climate Plan of the Czech Republic (2019) Ministry of Industry and Trade, Prague, Czech Republic

Operator. It means that without the working and well developed P2G technology, incorporating of this technology is unlikely into the whole energy system of the Czech Republic.

- Extremely slow authorization of new technologies and slow building permit allowance (Czech Republic ranks around 150th place from 190 countries according to the World Bank).

Techno-economic barriers

- The production of hydrogen according to this project seems to be a viable alternative to utilize the rising renewable energy sources, however until further technological developments and robust solutions the hydrogen production will not be considered as possible solution.
- High energy consumption of hydrogen storage technologies and their technological immnaturance
- Non-existent hydrogen-related infrastructure.
- The P2G technology is not technologically mastered; further development and demonstration appliances are required to be brought into regular service.
- The high running price of hydrogen production is considered a significant barrier.
- The increased effectivity of hydrogen production and fuel cells efficiency is needed for the commercialization of P2G technology.

9.3 ACTION ITEMS AND RECOMMENDATIONS

Taking into account the identified existing barriers, a variety of action items and needed steps, which should be taken to overcome this gaps and barriers and to achieve the goals of the roadmap, are summarised in this chapter.

Action items needed to overcome legal barriers

- Constructing a reliable and economically effective power plant implying a Power-to-Gas technology to be considered as profitable energy source.
- Further development of a supportive legal framework for sector-coupling hubs.

Action items needed to overcome socio-technical barriers

- Organization of public engagement events, to increase the acceptance levels of general public and specific stakeholders.
- Development of specific financing mechanisms for better public involvement in the renewable energy production.

Action items needed to overcome techno-economic barriers

- Further development of financing mechanisms for demonstration projects.
- Intensified funding options for roll-out and commercialization of the respective technologies.

Further action items and recommendations

- Construction of pilot Power to Gas appliance to demonstrate the profitable technology.
- The cooperation between investors, governments and public authorities should be intensified in order to foster the development of new projects.

10. GERMANY

10.1 NATIONAL (SPECIFIC) GOALS

In the national Climate Protection Act, the German government set the goal to become a climate-neutral country by 2045. This shall be reached in two steps: The preliminary goal for 2030 is set for emission reduction of 65% compared with 1990 levels, the goal for 2040 is the reduction by 88%[35].

The 2022 revision of the Renewable Energy Act states that by 2035, almost all the electricity consumption shall be covered by renewable electricity. Measures to reach this goal include expansion pathways for renewable electricity production via wind and photovoltaics as well as an acceleration of planning and approval processes. Further, the electricity grid shall be expanded and more offshore wind power shall be installed. Municipalities shall be involved more in the expansion of onshore wind and PV production and the frameworks for PV on roofs shall be improved.

Further, the German government has committed to the Paris Agreement and all its contents.

10.2 EXISTING BARRIERS

In the following chapter existing barriers and needed actions for the deployment of P2G projects in Germany are listed. These are based on the findings from legal framework analysis and barriers identified during stakeholder discussions.

Legal barriers

- Missing or unclear definitions
    - "Power-to-Gas", "methanation" are not legally defined.
    - The definitions of certain terms, such as "biomethane", differ in the Renewable Energy Act and the Energy Industry Act.
    - The definition of "green hydrogen" is too narrow. "Green hydrogen" or "renewable hydrogen" is not defined in the Renewable Energy Act or in the Energy Industry Act.
    - "Renewable natural gas" and "synthetic natural gas" are not mentioned in the Renewable Energy Act.
- The definition of storage facilities, electricity production facilities, energy production facilities etc. do not directly include any kind of power-to-gas hubs (with/without methanation, with/without re-electrification). It is unclear as what a P2G hub qualifies. Thus, it is unclear which benefits and legal regulations apply for a certain plant.
- The unclear classification of P2G hubs leads to legal insecurities regarding unbundling regulations.
- The usage of biogenic waste and residuals does not lead to any privileges over the usage of plant biomass.

Socio-technical barriers

- Low awareness of P2G possibilities among the general public.

[35] https://www.bundesregierung.de/breg-de/themen/klimaschutz/klimaschutzgesetz-2021-1913672

- Low awareness regarding storage/electricity conversion technologies needed to enable the fast expansion of renewable electricity plants.
- The general public often does not differentiate between “natural gas” and “renewable natural gas”, as both gases are methane. “Methane” has quite a negative connotation in the German general public due to its high climate-damaging potential and methane leaking.
- Complex and long permission procedures, also because of the insufficient knowledge level of public authorities involved.

Techno-economic barriers

- Lack of financial support for investors.
- Lack of business cases for successful P2G installation.
- Natural gas prices are still too low to make P2G applications economically viable.
- Financial incentives to replace fossil natural gas with renewable substitutes are not high enough.
- The complex legal framework complicates and prolongs planning and building processes, thus increasing costs.
- Lack of financial incentives to use biogenic waste and residues.
- Lack of data to assess P2G potential.

10.3 ACTION ITEMS AND RECOMMENDATIONS

Taking into account the identified existing barriers, a variety of action items and needed steps, which should be taken to overcome these gaps and barriers and to achieve the goals of the roadmap, are summarised in this chapter.

Action items needed to overcome legal barriers

- Clear and uniform definition of the following terms:
    - Biomethane / Renewable Natural Gas
    - Synthetic natural gas
    - Biogas
    - Green hydrogen
    - Power-to-Gas
    - Biogenic waste and residual resources.
- Clear legal classification of different P2G applications as storage facilities or gas/electricity generators etc. Instructions on how to classify P2G hubs with different characteristics would be helpful. Inclusion of different P2G implementation scenarios and different operation modes in unbundling regulations.
    - Power-to-Gas with methanation
    - Power-to-Gas (electrolysis / green hydrogen production only)
    - Power-to-Gas with / without re-electrification
    - Direct usage / grid consumption of renewable electricity
    - Usage of different biogenic waste resources for gas production.
- Uniformization of definitions in different laws and ordinances.
- More privileges for the usage of biogenic waste and residues over plant biomass.
- More privileges for production of green hydrogen and renewable natural gas.

Action items needed to overcome socio-technical barriers

- Better communication on the difference of fossil natural gas and renewable natural gas, on methane leaking mitigation measures, on potentials for BECCS (biomethane pyrolysis), on climate-neutrality of biomethane (communication from science to the general public and to policy makers, communication from politics to the general public).
- Better communication on green hydrogen, risks and benefits.
- More dialogue with the general public to address concerns, perceived risks and costs and to highlight potential benefits.
- Policy support of energy cooperatives owned by the public (e.g. the population of a certain municipality) and share of revenues with the general public to increase acceptance of concrete projects.
- Better communication about the possibilities for publicly owned energy cooperatives to raise awareness of benefits and thus increase acceptance of the installation of concrete plants.
- Financial incentives to the general public to increase the perceived benefits of P2G hubs in order to increase acceptance.
- Inclusion of renewable energy systems and the benefits of green gases in scholar curriculums and general knowledge university courses.

Action items needed to overcome techno-economic barriers

- Financial incentives for the production of renewable natural gas, e.g. reduced tax on electricity consumption from the grid or omission of other levies. Especially financial incentives to make use of biogenic waste and residues (of other or own residues) should be installed.
- Simplification of the tax laws for electricity consumption, gas production and electricity production in P2G hubs in general.
- Faster approval procedures to reduce costs during planning processes. Privileges for renewable energy applications.
- Subsidies on the co-creation of a renewable electricity plant (PV or wind) and a P2G hub.
- Subsidies should not only apply for reconversion of produced gas, but also for the direct usage of renewable natural gas and renewable hydrogen.
- The prices paid for injection of renewable natural gas should be higher than for fossil natural gas.
- An increase of the CO_2 tax might support the economic competitiveness of renewable natural gas in comparison to fossil natural gas.

Further action items and recommendations

- A centralized system for data collection on biogenic waste / residues and surplus renewable electricity potential should be established.
- Better support for investors to find suppliers of biogenic waste and residues (match making coordinated by public bodies).
- Open and transparent communication about the currently valid laws and ordinances to provide the general public with basic understanding of the procedures in the renewable energy sector to foster general acceptance.

11. HUNGARY

11.1 NATIONAL (SPECIFIC) GOALS

- Our gas import share will fall to close to 70% by 2030 and below 70% by 2040.
- Gas consumption for heating will fall by 2 billion m^3 per year by 2030.
- While natural gas consumption in the power sector could exceed the current levels but could fall below 1 billion m^3 per year by 2040. Our total gas consumption will therefore fall from the current 10 billion m^3 per year to nearly 8.7 billion m^3 in 2030 and could fall below 6.3 billion m3 by 2040.
- The share of carbon-neutral domestic electricity generation increases to 90% by 2030.
- Domestic installed photovoltaic capacity will exceed 6000 MW by 2030, and close to 12000 MW by 2040.
- At least 1 million smart meters will be installed to increase the flexibility of the electricity sector.
- Our import share will stabilise below 20% by 2040.
- The key to this is to maintain nuclear capacity and to encourage and preparing the transmission and distribution network to meet the challenges of a decentralised and highly weather-dependent generation structure is a prerequisite for a rapid increase in renewable penetration.
- Our final energy consumption will not exceed the 2005 level of 785 PJ in 2030, while maintaining dynamic economic growth. If final energy consumption increases after 2030, the source will be carbon neutral.
- Our share of renewable energy use in gross final energy consumption to at least 21%.
- Our GHG emissions will be reduced by at least 40% compared to 1990.

Exploitation of alternative gas sources: estimated Hungarian biogas potential has a realistic potential to replace 1% of Hungarian natural gas consumption by 2030, which would be around 85 million m^3 per year. Further growth is expected by 2040, so that the domestic biogas potential could reach 100 million m^3. In addition to biogas, Hungary also sees hydrogen as an alternative, so the integration of hydrogen into the natural gas network is also being investigated. Our objective is to phase out low-utilisation (below 10%) distribution lines from the publicly funded system by offering low-carbon heating alternatives. The ability to feed hydrogen into the network could play a key role as an alternative to phasing out low-utilisation distribution lines and in meeting climate change objectives.

11.2 EXISTING BARRIERS

In the following chapter existing barriers and needed actions for the deployment of P2G projects in Hungary is listed. These are based on the long experience with P2G in Hungary and findings from international projects.

Legal barriers

- Although a number of Hungarian government documents deal with P2G technology, there are still significant gaps in the detailed regulation that need to be addressed.
- In Hungary, the only legal source which regulates the legal aspects of any type of gases appearing on the energy market is the Act XL of 2008 of natural gas supply (hereinafter: Natural Gas Supply Act). While the Natural Gas Supply Act does not include such provision which provides that the provisions of the act shall apply to other type of gases as well, regarding the absence of any applicable legal source, the gas-related stages of P2G technology and gas markets may fall under the scope of the Natural Gas Supply Act.

- As P2G technologies are not legally classified yet on the whole. In order to shed light on the current legislative environment, we shall examine the different technological stages, these processes comprise of and explain them in detail. Although this compartmentalizing approach might be the best available, it might not match the future legal solution, since the combination of the separate stages could result in a process which is different in essence.
- The installation of wind power is legally impossible, but this is expected to change in the coming years in view of the energy crisis.

Socio-technical barriers

- There are several initiatives to set up P2G centres in the country, but their social awareness is still low and the technology is not widely known. This would be necessary to allow sufficiently complex and comprehensive developments to enter the implementation phase.
- Low awareness of climate change and knowledge of clean technologies e.g. P2G, concentrated knowledge exist in small group of energy experts and industries.
- Public acceptance of wind farms is low and the supply of solar energy to the grid is temporarily limited.
- Complicated and lengthy authorisation procedures, where it is not always clear for the authorities concerned in particular what detailed rules apply to a given project, due to the incomplete legislative environment.

Techno-economic barriers

- Lack of appropriate infrastructure for hydrogen use in mobility and for injection into the gas grid.
- Readiness of gas infrastructure and appliances for higher shares of hydrogen should be proved as well as the amount of investment needed for adjustments of the infrastructure should be identified.
- P2G is not yet a commercially competitive technology. However, from a macro-economic perspective, projects for the production, distribution and use of green gases and the maintenance of existing infrastructure have positive effects on GDP, jobs, import reduction, etc. Therefore, by focusing more on these positive effects, additional/alternative financing should be obtained and public acceptance increased.

The P2G process is not yet a mature technology; more demonstration projects are needed. Continued market monitoring and targeted networking through demonstration projects can ensure this.

11.3 ACTION ITEMS AND RECOMMENDATIONS

Taking into account the identified existing barriers, a variety of action items and needed steps, which should be taken to overcome these gaps and barriers and to achieve the goals of the roadmap, are summarised in this chapter.

Action items needed to overcome legal barriers

- The rules and regulations that are established must be clear and unambiguous. They should provide a balanced and even playing field for different technologies and should not restrict or overly favor certain technologies. This will help to ensure that sector coupling can develop and grow in a way that is fair and open, and that allows for competition and innovation.
- In addition, the legislation should be designed in a way that promotes the growth and development of Reasearch&Development&Innovation activities. This can include providing incentives and support for

research and development, as well as fostering collaboration and partnerships between different stakeholders. By doing so, it is possible to create an environment that is conducive to innovation and the development of new technologies.

- It is important to engage in advocacy and policy dialogue with relevant authorities and decision-makers. This can involve participating in public consultations and policy debates, as well as engaging directly with lawmakers and regulators. Through these activities, it is possible to raise awareness of the P2G technology and its potential benefits, and to build support for policies and regulations that can help to overcome legal barriers and facilitate its development and deployment. By engaging in advocacy and policy dialogue, it is possible to promote the P2G technology and overcome the legal challenges and obstacles that may hinder its growth and adoption.
- Overall, there is a need for clear and effective legislation that allows for sector coupling but does not restrict or overly favor certain technologies. This legislation should provide a framework for the development and deployment of P2G and other sector coupling technologies and should support Research&Development&Innovation activities. By taking these steps, it is possible to create a legal framework that is conducive for the growth and success of the P2G technology.

Action items needed to overcome socio-technical barriers

- One way to overcome socio-technical barriers in building P2G hubs is to engage in stakeholder consultation and collaboration. This involves bringing together various stakeholders, including community members, local authorities, industry experts, and other relevant parties, to discuss the P2G technology and its potential impact. Through this process, it is possible to identify and address any concerns or issues that stakeholders may have, and to build consensus and support for the technology.
- Another way to overcome socio-technical barriers is to conduct demonstration projects and pilot studies. These projects can provide valuable data and information about the technical feasibility and effectiveness of the P2G technology, as well as its potential social and economic impacts. By conducting demonstration projects, it is possible to gather evidence and build a case for the technology, which can help to overcome any doubts or skepticism that may exist.
- In addition, it is important to engage in ongoing market monitoring and networking activities. This can help to ensure that the P2G technology is developed and deployed in a way that is aligned with market trends and needs and can help to build support and momentum for the technology.
- Overall, overcoming socio-technical barriers in building P2G hubs will require a combination of stakeholder engagement, demonstration projects, market monitoring, and networking activities. By taking these steps, it is possible to overcome the challenges and obstacles that may hinder the development and deployment of the technology.

Action items needed to overcome techno-economic barriers

- Conduct more demonstration projects. Demonstration projects are practical tests or trials of a technology that are carried out in a real-world setting. These projects can help to gather data, assess the effectiveness and feasibility of the technology, and identify any challenges or barriers to its deployment.
- By conducting more demonstration projects, it will be possible to gather more information and data about the P2G process, and to develop and refine the technology. This can help to mature the technology and make it more ready for widespread adoption.
- In addition, continued market monitoring and targeted networking through demonstration projects can help to ensure that the P2G process is developed and deployed in a way that is aligned with market needs and trends. This can help to ensure that the technology is successful and has a positive impact on the market.

- Overall, the solution to the problem of the P2G process not being a mature technology is to conduct more demonstration projects, as well as to engage in market monitoring and networking activities. This can help to advance the technology and prepare it for widespread adoption.

12. ROMANIA

12.1 NATIONAL (SPECIFIC) GOALS

Regarding Romania's energy goals and objectives, they are aligned both with European directives but also take into account the national energy context. These can be found in 2 of the key strategies regarding energy and climate neutrality: the Energy Strategy of Romania 2016-2030, with the perspective of 2050, respectively the Integrated National Plan in the field of Energy and Climate Change 2021-2030 (PNIESC) which also has important components and mentions about energy.

Among these objectives are

- The objective of reducing domestic greenhouse gas emissions by at least 40% by 2030 compared to 1990;[36]
- The objective regarding energy consumption from renewable sources of 32% in 2030;[37]
- The objective of improving energy efficiency by 32.5% in 2030;[38]
- The objective of interconnecting the electricity market at a level of 15% by 2030[39]

In addition to these objectives, the EU also made recommendations to Romania on various amendments from the national plans and strategies. The example would be the recommendation to increase the share of renewable energy to a minimum of 34% after the initially proposed share was 27.9%.[40]

Overview of the main objectives of PNIESC 2021 – 2030, at the level of 2030	
ETS emissions (% compared to 2005) -43.9%*	-43.9%*
Non-ETS emissions (% compared to 2005) -2%	-2%
Global share of energy from sources renewables ir	30.70%
Share of SRE-E 49.4%	49.40%
Share of SRE-T 14.2%	14.20%
Share of SRE-M&R 33.0%	33.00%
Energy Efficiency (% compared to the projection PRIMES 2007 at the level of 2030)	
Primary energy consumption -45.1%	-45.10%
Final energy consumption -40.4%	-40.40%
Primary energy consumption (Mtoe) 32.3	32.3
Final energy consumption (Mtoe) 25.7	25.7

Fig. 1. Objectives from PNIESC, page 13.

[36] Romania, Integrated National Plan in the field of Energy and Climate Change 2021-2030, 2020, (p.) 13, Bucharest
[37] Romania, Integrated National Plan in the field of Energy and Climate Change 2021-2030, 2020, (p.) 13, Bucharest
[38] Romania, Integrated National Plan in the field of Energy and Climate Change 2021-2030, 2020, (p.) 13, Bucharest
[39] Romania, Integrated National Plan in the field of Energy and Climate Change 2021-2030, 2020, (p.) 13, Bucharest
[40] Romania, Integrated National Plan in the field of Energy and Climate Change 2021-2030, 2020, (p.) 14, Bucharest

At the national level, among Romania's objectives listed in PNIESC are:

- Rapid implementation of the legal framework necessary for final investment decisions in the exploitation of natural gas resources in the Black Sea area.
- The development of new capacities on the Romanian Energy System and the integration with other markets in the region as well as the promotion of the use of hydrogen.
- Development/optimization of the existing infrastructure of electricity and natural gas networks, with a positive impact on the capacity to take over energy produced from RES and on the level of interconnectivity.
- Development of storage capacities.
- Development of high efficiency cogeneration projects; High-efficiency cogeneration is a way of producing electricity and heat, which allows reducing polluting emissions.
- Increasing the degree of interconnection plays an important role in the security of natural gas and electricity supply, as it will facilitate cross-border exchanges, especially in case of emergency.
- The implementation of the provisions of the legislative package "Clean Energy for All Europeans" will have the effect of promoting the use of energy from renewable sources, as they presuppose the adaptation of market conditions to facilitate the integration of energy from renewable sources into the National Energy System (SEN).
- The adoption of advanced technologies can contribute through the implementation of carbon capture solutions, the development of emission-free energy production capacities, new storage capacities. It will also facilitate the implementation of pilot and demonstration projects to promote the use of hydrogen in the production of electricity and in the industrial sector.
- Promoting clean energy and energy efficiency to support a low carbon economy. Specific objective 6.1 - Increasing energy production from less exploited renewable resources (biomass, biogas, geothermal).
- Increasing the share of bioenergy, broken down by thermal energy, electricity and transport, and regarding the supply of biomass, broken down by raw materials and origin (distinguishing between domestic production and imports). For forest biomass, an assessment of its source.
- Elaboration of new national strategies and objectives, including long-term or sectoral ones (for example, the share of energy from renewable sources in district heating, use of energy from renewable sources in buildings, energy from renewable sources produced by cities, energy communities and autonomous consumers, the energy recovered from the sludge obtained from waste water treatment).
- Promoting investments in new electricity production capacities, with low carbon emissions.

Regarding the strategic objectives strictly at the national level, Romania has 5 key orientation axes for the year 2030 and further for the year 2050:

- Energy security[41]
- Competitive markets[42]
- Clean energy[43]

[41] Romania, Energy Strategy of Romania 2016-2030,with the perspective of 2050, Ministry of Energy, 2018, (pg.) 1, Bucharest
[42] Romania, Energy Strategy of Romania 2016-2030,with the perspective of 2050, Ministry of Energy, 2018, (pg.) 1, Bucharest
[43] Romania, Energy Strategy of Romania 2016-2030,with the perspective of 2050, Ministry of Energy, 2018, (pg.) 1, Bucharest

- Modernization of the energy governance system[44]
- Reducing energy poverty and protecting the vulnerable consumer.[45]

Therefore, consulting the two documents and reviewing the objectives, it can be said that Romania has an integrated and holistic view, aligning itself with the objectives of the European Union, but also establishing internal objectives adapted to the national context in the field of energy.
Analyzing Romania's strategy at the national level for the period 2016-2030 with the perspective of 2050, it can be said that the point 2030 is an intermediate point, but with ambitious goals, following that until 2050 most of the values achieved in 2030 to be optimized or improved as much as possible.

12.2 EXISTING BARRIERS

Legal barriers

- Lack of information mentions and legislative regulation about power-to-gas technology.
- Lack of information mentions and legislative regulation about sector coupling.
- No clear and insufficient legislative frame regarding hydrogen.
- Delaying legislative processes that could improve the country's energy situation. The perfect example is the liberalization of the energy market, a process that has been talked about since 2020 but started only in 2021 even then with big problems and delays and many ambiguities. The same situation occurred in the case of the offshore law which involves the exploitation of gas deposits in the Black Sea (Romanian territorial waters), the law is delayed for more than a year.
- Administrative and political instability. Over the last 15 years, there have been very few cases in which a minister has been able to complete his term or a government has remained intact from the beginning without reshuffles and other procedures. Many times there have been entire governments that have not fulfilled their mandates. Thus, each minister came up with his own ideas, with a different team and there were several inconsistencies.
- Although there have been many examples of good practices in Western European countries regarding green energy since its use in transport or subsidizing green energy for households or non-household consumers (shopping centers, industry) they have not been adopted in Romania. Even if the economic and technical means were covered/assured, many technologies or practices are difficult to implement due to the lack of legislative framework.

Socio-technical barriers

- Lack of general, but also precise information about hydrogen, power-to-gas legislation, about the usefulness of different types of gas (biogas, biomethane) in the field of energy, energy production or the substitution of other methods to generate energy.
- Instability of the political environment. Governments, prime ministers and line ministers (implicitly also the minister in charge of energy) change very often so that many ideas do not get to be put into practice. The Ministry of Energy was moved (attached and broken) by other ministries or was a stand-alone ministry.

[44] Romania, Energy Strategy of Romania 2016-2030,with the perspective of 2050, Ministry of Energy, 2018, (pg.) 1, Bucharest
[45] Romania, Energy Strategy of Romania 2016-2030,with the perspective of 2050, Ministry of Energy, 2018, (pg.) 1, Bucharest

- Since 2017 no subsidy or other support scheme for new installed renewable energy capacities, and so, no new relevant investments have been done in this period.
- Insufficient use of green energy production facilities, so there is still a precedent and greater popularity of these sources.
- It has long relied on coal-fired electricity and nuclear power to the detriment of other renewable electricity sources.

Techno-economic barriers

- There are no measures to encourage the use of green energy in certain areas such as industry of any kind or transport (e.g. public transport). Measures could be taken to encourage smaller or larger factories and plants to be supplied with green electricity. Public transport could be encouraged to focus more on vehicles (buses, minibuses) with electric propulsion that use green energy. Trolleybuses and trams could also be encouraged.
- Measures that already exist and that promote green energy, although some of them are national programs that are insufficiently implemented, are insufficiently promoted whether it is the supply of green energy to a household, a block of flats or other buildings (malls, industrial halls, technology parks). The owners in question, investors must be encouraged with various benefits, possibly tax exemptions to make them opt for green energy.
- Directing funds and investments to wrong ends or investments made in inappropriate places - in the case of micro hydropower plants - that have been located on mountain rivers, sometimes in areas where this type of activity is not allowed. Many of them do not work, and those that do not pay off in terms of the amount of energy they produce. These have been described by environmental and energy specialists as inappropriate. Instead, they had a negative effect on ecosystems on fish fauna and flora.

12.3 ACTION ITEMS AND RECOMMENDATIONS

Action items needed to overcome legal barriers

- Creation of a new legislative framework for each of the following topics: hydrogen, sector coupling, power-to-gas.
- Modifying the existing legislative framework to eliminate ambiguities and make it clearer.
- The modification of the existing legislative framework in order to favour future investments or the introduction of new technologies.
- The grouping of laws in single documents (currently there are several laws that regulate the same subject, because they added and repealed articles from another legislature by another law, which causes the information to be dispersed in several documents from several years).

Action items needed to overcome socio-technical barriers

- Public campaigns to promote the means of clean and advantageous energy production that come with it.
- The encouragement and then the promotion of headquarters and buildings of public institutions that feed on green energy.
- Pilot projects and subsidies for homes in disadvantaged residential areas and beyond, for the installation of renewable energy production means.
- Campaigns to show the difference between an energy bill based only on conventional energy and a bill where renewable energy has a full or partial role.

- Encouraging large industries, but also small and medium enterprises to use renewable energy or even to produce it.
- The popularization of public transport that uses renewable energy or is friendly to the environment.

Action items needed to overcome techno-economic barriers

- The development and launch of programs and subsidies to develop new projects and investments in the field of renewable energy.
- The development of subsidies dedicated to hydrogen projects, those that provide sector coupling or power to gas.
- The development of training courses for professionals in the field on renewable techniques.
- Creating advantages for hydrogen-based energy producers.
- Following and replicating good examples from foreign countries. Their replication according to the national context.
- Encouraging small energy producers from renewable sources and protecting them from being absorbed by the big companies in the Romanian energy sector.
- Encouraging small- and medium- enterprises (SME) of any kind, but also industries to switch at least partially, if not totally, to renewable energy supply.

Further action items and recommendations

It is obvious that Romania is making progress in the field of energy and is trying to align itself with the directives of the European Union and to achieve all the objectives imposed by both the government and the European Commission.

However, this process, although it is taking place, has a slow course. This development, which does not occur so quickly, and the reasons why the Romanian state still lags behind the rest of the European Union, is the inconsistency of the Government. Energy has been the subject of several transitions either being a separate portfolio or ministry with its own relevant minister or being incorporated into other ministries - the Ministry of Economy (eg). Following the prioritization of energy as an independent ministry, there were several changes of ministers from different political parties, each starting projects that he could not complete, being replaced by another minister with a different vision. Therefore, consistency and continuity represented a problem in this case. Apart from the introduction of new production capacities, the Romanian state must also consider updating, modernizing and increasing the capacity of the already existing infrastructure. Currently there are examples of photovoltaic parks that produce energy, but cannot send it to the grid.

Promotion of renewable energy. This process takes place, but a more aggressive marketing in this sense would be more successful. Many times green energy is presented as something primarily beneficial for the environment, which is certain, but people regardless of whether we are talking about household owners, small businesses or large industrialists, are interested in the benefits that the use of green energy can bring them, how long the investment is covered, how much the investment amounts to, if they have any subsidies from the public authorities, etc. There is communication and transparency on this matter, but things could be done better.

Militancy for the introduction of new technologies and means of energy production. Power-to-gas, energy based on hydrogen and sector coupling. These things that are more popular in Central and Western Europe must be brought to Romania through advertising, through marketing, they must be promoted and justified. Subsequently, the creation and development of a legislative framework is needed to regulate the use of these new technologies.

Romania is on a good path in this path of energy development, but although there are still things that have not yet reached the national territory or issues that are happening, but are not being excelled at or are being

produced on a small scale, the Romanian state has in this moment every chance to reach its energy goals in the medium and long term.

13. SERBIA

13.1 NATIONAL (SPECIFIC) GOALS

According to the obligations stemming from the Energy Community Treaty and from the Sofia Declaration on the Green Agenda for the Western Balkans, the Republic of Serbia is preparing the Integrated National Energy and Climate Plan (NECP) from 2021 to 2030 with the vision until 2050 within the IPA project "Further Development of Energy Planning Capacity".

The purpose of the NECP is to set goals for the current decade – to 2030 and create the path for making Serbia climate neutral by 2050.

Government of Serbia presented the preliminary goals for the NECP[46] in July 2022 aiming to cut greenhouse gas emissions by 40.3% and achieve a share of 41% of renewables in gross final energy consumption by 2030. Provisional 2030 targets include:

- Cut greenhouse gas emissions from 1990 levels by 40.3%
- Reach a 41% share of renewable sources in gross final energy consumption
- Reach a 49.1% share of renewable sources in electricity production
- Reach a 50.9% share of renewable energy sources in heating and cooling
- Reach a 6.1% share of renewable sources in transportation
- Boost energy efficiency to lower primary energy consumption to 14.75 Mtoe
- Boost energy efficiency to lower final energy consumption to 9.528 Mtoe
- Add 1.54 GW in solar power capacity or 100 times more than the current level
- Add 3.51 GW in wind power or ten times more than the currently installed capacity in Serbia.

Within the process of the development of the NECP, alternative scenarios are modeled. Specific transportation targets in all scenarios include the use of electricity, green hydrogen, and bio-LNG in transport, and the target for green hydrogen is set at the level of 1% of the final energy consumption by 2030.

13.2 EXISTING BARRIERS

In the following chapter existing barriers and needed actions for the deployment of P2G projects in Serbia are listed. These are based on the findings from legal framework assesment and barriers identified during stakeholder discussions.

Legal barriers

- The appropriate legal and regulatory framework including funding possibilities for the construction of P2G projects is still in development, which hinders the faster deployment.
- It is important that sector coupling technologies, such as P2G, are taken into account accordingly in the respective laws. A legal framework that provides legal certainty and incentives should be further developed. This would promote the implementation of such technologies.

[46] https://mre.gov.rs/dokumenta/strateska-dokumenta/integrisani-nacionalni-energetski-i-klimatski-plan-republike-srbije-za-period-2021-do-2030-sa-vizijom-do-2050-godine

Socio-technical barriers

Low awareness of climate change and knowledge of clean technologies e.g. P2G, concentrated knowledge exists in a small group of energy experts and industries.

- Misconceptions surrounding the safety and use of hydrogen.
- Complex and long permission procedures, also because of the insufficient knowledge level of public authorities involved.

Techno-economic barriers

- Lack of appropriate infrastructure for hydrogen use in mobility and for injection into the gas grid.
- The acceptability of hydrogen to the current users of natural gas requires technical work to understand the technical limits of current appliances for the initial introduction of hydrogen, as well as the design for pure hydrogen use.
- P2G business cases are often non-competitive. However, from the national economy point of view, projects for the generation, distribution and use of green gases as well as the maintenance of existing infrastructure have positive effects on GDP, jobs, import reduction, etc. Therefore, the stronger focus on these positive effects should be used to gain additional/alternative funding, and to increase public acceptance.
- The P2G process is not yet fully technologically mature; there is a need for more demonstration projects. As well as constant market observation and targeted networking with demonstration projects can ensure that we remain technologically "up-to-date". Innovations should be anticipated as soon as possible.
- High production costs of domestic green gas from P2G applications. However, the system service function (being able to create load balancing in the electricity grid and offering seasonal storage options for wind and PV) can be used nationally and thus long-term support can be argued for. This is an important reason to develop P2G projects nationally because, through the import of green hydrogen from abroad, no possibility for nationally necessary system services will be available.

13.3 ACTION ITEMS AND RECOMMENDATIONS

Taking into account the identified existing barriers, a variety of action items and needed steps, which should be taken to overcome these gaps and barriers and to achieve the goals of the roadmap, are summarised in this chapter.

Action items needed to overcome legal barriers

- Finalize the legal and regulatory framework for the construction of P2G projects through the adoption of necessary by-laws and secondary and tertiary regulations.
- Further development of a supportive legal framework for sector-coupling hubs is required to allow investors to understand their cost and revenue basis and to reach a financial investment decision.

Action items needed to overcome socio-technical barriers

- The community uptake of hydrogen as a ‘green’ solution to energy delivery will need to be promoted through targeted engagement activities to proactively socialize the benefit of hydrogen to the public.
- Address the safety and use of hydrogen, as well as promote the environmental credentials of hydrogen as a means to decarbonize Serbia’s energy system.
- Increase the knowledge level of public authorities through learning from other regions, which have already begun the development of hydrogen industries, and apply best practices for streamlining and simplification of permitting procedures for the construction of P2G projects.

Action items needed to overcome techno-economic barriers

- Support the development of logistical infrastructure to transport the hydrogen from generation to consumption sites through blending hydrogen with natural gas and/or repurposing natural gas pipelines for hydrogen, and provide support for the construction of refuelling infrastructure for vehicles.
- Establishment of R&D programs aiming to provide evidence to understand any technical limitations of current users to accept hydrogen and address any technical challenges associated with the hydrogen market.
- Promote a valuable increase in GDP and employment stemming from the development of the hydrogen industry, and the development of strong domestic supply chains to replace import-intensive supply chains for oil and natural gas.
- Develop financing mechanisms and support both fundamental research/innovation and demonstration projects based on a collaborative approach with EU states, and participate in and access early-deployment markets and programs.
- Promote the ability of green hydrogen to match the seasonality of renewable energy generation and provide seasonal flexibility to the power system with high shares of solar and wind, and perform a cost-benefit analysis of different flexibility instruments.

Further action items and recommendations

- The cooperation between investors, governments, and public authorities should be intensified in order to foster the development of new projects.
- Provide long-term signals and commitments in the form of net zero emission targets, to attract private capital needed for scaling up green hydrogen production and use.
- Support development of technical standards and certification schemes compatible with electricity and gas schemes.
- Promote transparency and openness and link public support with requirements for the project data, to allow academia to analyse such data and work toward closing the gaps.

14. SLOVAKIA

14.1 NATIONAL (SPECIFIC) GOALS

The key document specifying the national goals in energy and climate sector is the: Integrated energy and climate plan for 2021-2030. The general approach of this document is in line with EU to move from fossil fuels to renewable sources.

The main quantified objectives of the NECP within the Slovak Republic until 2030 are to reduce greenhouse gas emissions for sectors outside of emissions trading (non-ETS) by 20% (the share was increased from the originally declared level of 12%). The use of RES in the final energy consumption is set in 2030 to be 19.2% with the fulfillment of the required goal of 14% of RES in transport. The energy efficiency goal is to reach 30,3% by 2030 and the interconnection of electrical systems 52%. The full Carbon neutrality is set to be achieved by 2050.

Considering the hydrogen activities in Slovakia, it is worth to mention the new National hydrogen action plan has been introduced and is still under evaluation in the interdepartmental commenting. While the main goal is to support the building of hydrogen production capacities directly connected to RES or other low-emission energy sources to cover the growing demand for clean hydrogen, the sectional goals are also to be mentioned:

- Total annual domestic production of green and blue hydrogen 45 000t
    - Production of hydrogen by electrolysis 25,000 t,
    - 300 MW of installed electrolysers,
    - At least 600 MW of RES and use of nuclear resources for hydrogen production
    - Production of hydrogen from waste and biomass 20,000 t
- Total annual domestic consumption of green and blue hydrogen 45,000 t
    - industry 30,000 t,
    - energy 5,000 t,
    - transport sector 10,000 t
        - 4,000 passenger cars
        - 260 buses
        - 600 light commercial vehicles
        - 600 heavy commercial vehicles, municipal vehicles and work machines
        - 12 regional train sets.

This is to be financed with planned expenditures for the implementation of hydrogen projects until the year 2030 from the state and direct European financial support totaling 0.954 billion Euro and also estimated private resources in the amount of 1.5 billion Euro.

To create a functional hydrogen market competitive to the rest of the EU, another goal must be met. The goal is to join the Slovak Republic in the European market with guarantees of hydrogen origin by establishing a register of renewable gases. As of November 2021, a draft law was introduced amending Act No. 309 2009 Coll. on the support of renewable energy sources that regulates the establishment of the Register of Renewable Gases for the purpose of recording the production of renewable gases and issuing guarantees of the origin of renewable gas. The founder and operator of the register is to be SPP distribúcia (the gas distribution system operator), and with the Amendment to the Act it is to be effective from 1 November 2022.

In 2009, only 6,8% of communal waste was energetically recovered. Since 2021, the key measure was adopted ordering the municipalities to separate the biodegradable municipal waste. Many municipalities still struggle with this task, however, it is clear that over 40% of the municipal waste is biodegradable and can be used for energetic purposes. More legislative updates are to be presented in 2023 and 2027 that will lead to prohibition of land-filling of other than inert waste. That means all other waste must be either separated and reused, or energetically used.

14.2 EXISTING BARRIERS

In the following chapter existing barriers and needed actions for the deployment of P2G projects in Slovakia are listed. These are based on the evaluation of the P2G related activities in Slovakia and the current legislative framework within the energy sector.

Legal barriers

- P2G are not clearly defined, as it is questionable if they are classified as consumer, producer or energy storage. This needs further legal assessment, due to linking provisions of energy law that is determined by category classification. It is necessary to assess who is also allowed to own, develop, manage and operate P2G plants.
- Proper legal classification and definitions of products is lacking.
- The main legal provision governing hydrogen 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 (hereinafter referred to as “biofuel”) means (i) biohydrogen, which is hydrogen produced from biomass”.
- Biomethane is defined as treated biogas, which has technical parameters comparable to the ones natural gas have, and therefore the legislation applicable to natural gas is also generally applicable to biomethane. However, this cannot be said for hydrogen, nor for renewable (green) hydrogen, and renewable natural gas, which is not yet really mentioned in the legislation, and if, then only as a fuel.
- Thus regulatory classification for the operations by Electricity and Gas Transmission System Operators, Electricity and Gas Distribution System Operators, Gas storage operators and producers needs to be developed. Also products (renewable hydrogen and renewable natural gas) need to be classified using gas quality standards and these points need to be answered for proper recognition by law. Question is also if general law coverage (definition) or a specification of every individual plant by its explicit corresponding provision should be assumed.
- Legal and regulatory framework including funding possibilities is under development. Since P2G technologies are reaching various fields of these frameworks, the whole process of identifying, describing, communicating and solving various situations might take longer than if the processes have some past development and accepted & tested solutions.
- The link between the law on the promotion of renewable resources and waste legislation is completely missing. Some biomethane production processes could recover waste. It is therefore necessary to amend the legislation so that financial resources for waste disposal and recovery can be better used in the production of biomethane.

Socio-technical barriers

- When building new biogas/biomethane production facilities, there is usually fundamental disagreement from the side of the population, as it is lacking correct insights and false concept imagination.

- Awareness about climate change is generally very low in the general public. Only a small group of experts have extended knowledge. The transformation is slow and requires time and combined effort of several departments.
- Long permission and status evaluation procedures are also an obstacle, as the public authorities don't possess enough expert knowledge.
- Very huge barrier is that Slovakia itself doesn't possess so much free and disponible capital to immediately power up the whole transformation of industry based on fossil fuels towards its green alternatives.

Techno-economical barriers

- It is important to determine gas quality standards and restrictions (also for feed-in into the grid), if it is possible directly or if some other requirements must be met. This also calls for an upgrade for the measuring technology to detect hydrogen higher than 6 % . The gas grid network technical improvements need to be set as well. For example, higher permeability of individual materials (both steel and plastic), fittings, seals, etc., due to the much smaller size of the H_2 molecule compared to the CH_4 molecules.
- The biomethane producer bears the costs of building a connection to the distribution network in the amount of 25% of the actual costs; however, not more than € 250,000 and no longer than 4km. Over 4 km the costs are taken by the producer. The connection becomes property of the distribution network operator.
- Taxes rates for electricity have been stated in 2010 at level 1.32 Euros/MWh. The electricity from renewable sources is exempt from excise duty. This could be applicable for the P2G production.
- P2G technology is not market competitive with current technologies in the short run, but in the long run they carry excessive advantages, both for the public as well as the industrial sector.
- Certifications for environmentally friendly ways of production (guarantees of origin) for renewable hydrogen should be in place in national legislation in 2022.
- Biomethane Register is being created (based on the model of Austrian Biomethane Model) and should be introduced November 2022.
- EU legal provisions should match national legal provisions, for example term "energy storage unit" introduced by EU in 2019 (Electricity Directive 2019).

14.3 ACTION ITEMS AND RECOMMENDATIONS

Action items needed to overcome legal barriers

- To define and anchor technological P2G solutions (products, by-products, derivatives, funding, investments, etc.) into a regulatory (energy) framework. This needs to be done also on a trans-national level.
- Establishing terms of P2G on all levels of terminology (scientific, academic, regulatory framework) to be clear what is what, and how it all works together. This needs to be done on both national and European level (English).
- To set up interdepartmental "P2G agency" that would concentrate all relevant types of data and would work as an advisory subject. It would also communicate with all stakeholders and participants, on both commercial and legislation-wise levels. We suggest it to be part of Slovak Energetic Innovation Agency (SEIA).

Action items needed to overcome socio-technical barriers

- To develop strategy for promotion of P2G related campaigns for the general public. State clear and understandable examples about why this technology has its future, what risks are met and why and how it is beneficial for the general public. P2G concept is quite new and lacks a sufficient amount of practical demonstrations.
- To anchor basics of energy and climate literacy into basic education, develop changes that will prepare society to be aware of its impacts.
- To create more effective ways to receive grants, funding and subsidies from the common European framework.
- At current state, and according to the prefeasibility study as well, we can conclude that P2G business cases are not competitive yet. On the other hand, they bring many other positive effects that from a long-term point of view they are a success. Lack of competitiveness should be balanced by additional extra funding possibilities.

Action items needed to overcome techno-economic barriers

- To anticipate innovations as soon as possible.
- To set up decent conditions for small scale producers, so the market is decentralized and focusing on disponible local potential.

15. SLOVENIA

15.1 NATIONAL (SPECIFIC) GOALS

The key documents in the field of national energy and climate policy of the Republic of Slovenia are represented by two legislative policy instruments, following the EU 2030 and 2050 climate change mitigation goals:

- National Energy and Climate Plan (NECP)[47]
- Resolution on long-term climate strategy of Slovenia until 2050[48].

NATIONAL ENERGY AND CLIMATE PLAN

The instrument was adopted by the Government of the Republic of Slovenia on 27th of February 2020, which in its structure clearly sets out 5 key objectives for the period up to 2030 (with a view to 2040), defining objectives, policies, and measures in the five dimensions of the Energy Union:

1. decarbonisation (GHG emissions and RES),

2. energy efficiency,

3. energy security,

4. the internal market; and

5. research, innovation, and competitiveness.

Among other things, the NECP makes it clear that the objective of Slovenia's energy and climate policy is to ensure a reliable, secure, and competitive energy supply in a sustainable manner by ensuring the much-needed transition to a climate neutral society and achieve the sustainable development objectives by enabling environment for economic development and the creation of jobs with high added value, to improve quality of life and increase environmental responsibility, and provide affordable energy services for citizens and the economy.

The key challenges for Slovenia in the area of energy and climate policy are:

- Progressively reducing energy consumption and increasing energy and material efficiency in all sectors.
- Accelerated development of the electricity distribution network to increase the intensity and resilience, to enable accelerated exploitation of flexibility of resources and load flexibility, integrating heat pumps, meeting the requirements of the accelerated deployment of e-mobility, and accelerated integration of generation of the electricity from renewable energy sources; financial resources will need to be secured for additional financial resources for additional capital investments by distribution companies and to ensure sustainable grid charging.
- Effective positioning of infrastructure projects contributing the key infrastructure projects that contribute to achieving a climate-neutral society.
- Phasing out fossil fuels in all sectors.
- Sustainable transport management and the transition to alternative fuels.
- Accelerated development of district heating and cooling systems.

[47] https://www.energetika-portal.si/fileadmin/dokumenti/publikacije/nepn/dokumenti/nepn_5.0_final_feb-2020.pdf
[48] https://www.energetika-portal.si/fileadmin/dokumenti/publikacije/redps50/redps50_dz_jul2021.pdf

- Decarbonisation of natural gas supply and integration of the gas and electricity sectors.
- Maintaining the efficiency and safe operation of nuclear facilities in Slovenia and preparing for providing guidance for a decision on the future use of nuclear energy and the possible construction of a new nuclear power plant.
- Technological development and commercial breakthrough of RES, advanced technologies, and services, including energy storage and energy efficiency.
- Reducing the implementation deficit for all actors and at all levels for a comprehensive and successful management and implementation of measures for the transition to a climate-neutral society.

KEY OBJECTIVES

Key objectives in the areas of energy change adaptation, RES implementation and energy efficiency are the following:

- By 2030, to reduce GHG emissions from sectors not covered by the scheme to a greater extent than the burden-sharing regulation for Slovenia, i.e. by at least 20% relative to the 2005 by meeting sectoral targets: transport 12%, broad use 76%, agriculture 1%, waste management 65%, industry 43%, energy 34%.
- Reduce the use of and dependence on fossil energy imports by: phasing out coal use (at least 30% by 2030 and a decision to phase out the use of coal in Slovenia according to the principles of a just transition by 2021), a ban on the sale and installation of new oil-fired boilers by 2023, support for the implementation of pilot projects for the production of synthetic methane and hydrogen (The indicative target is 10% of methane or hydrogen from renewable sources in the transmission and distribution network by 2030).
- Ensure that LULUCF sectors do not produce net emissions (after application of accounting rules) by 2030, i.e. emissions in the LULUCF sector do not exceed sinks.
- Aim for at least 27% renewables in final energy consumption by 2030, i.e. (indicative): At least 2/3 of energy use in buildings from RES by 2030, at least 30% of RES in industry, 43% in the electricity sector, 41% in the heating and cooling sector, 21% in transport (biofuels at least 11%).
- By 2030, improve energy efficiency by at least 35% compared to the 2007 baseline scenario (in line with the Energy Efficiency Directive).
- Ensure that the policies and measures adopted are systematically implemented to ensure that final energy consumption does not exceed 54.9 TWh (4,717 ktoe). Converted to a primary energy level, consumption in 2030 will not exceed 73.9 TWh (6,356 ktoe).
- Reduce final energy consumption in buildings by 20% by 2030 compared to 2005; and Ensure that GHG emissions from buildings are reduced by at least 70% by 2030 compared to 2005.

RESOLUTION ON LONG-TERM CLIMATE STRATEGY OF SLOVENIA UNTIL 2050

The National Assembly of the Republic of Slovenia adopted the Resolution on long-term climate strategy of Slovenia until 2050 at its regular session, convened on the 13th of July 2021. The policy instrument itself is a strategic document and does not contain concrete measures. The action plan for the implementation of the "climate strategy until 2030" is the NECP. The two documents were prepared in a coordinated manner and are based on the same expert basis. The orientations in the Resolution on long-term climate strategy of Slovenia until 2050 are based on projections in the expert backgrounds, which analyse possible approaches to achieve the objectives under certain assumptions. The projections take into account the state of the art of technologies, expected developments and information at the time the projections are made. On this basis,

projections of economic development, energy prices, technology prices and assumptions on the implementation of measures have been made.

VISION

In 2050, Slovenia will be a climate-neutral and climate-resilient society based on sustainable development. It will manage energy and natural resources efficiently, while maintaining a high level of competitiveness in a low-carbon circular economy. The society will be based on preserved nature, a circular economy, renewable and low-carbon energy sources, sustainable mobility and locally produced healthy food. It will be adapted and resilient to the impacts of climate change. Slovenia will be a society with a high quality of life and security, seizing opportunities in a changing climate. The transition to a climate-neutral society will be inclusive, taking into account the principles of climate justice. The costs and benefits of the transition will be shared equitably, including for the most vulnerable. Mitigation and adaptation measures will be made available to the most vulnerable groups of the population.

MAIN GUIDELINES

The main directive of the policy instrument is to reduce the GHG emissions. Other guidelines, which apply to all sectors, include increasing material efficiency, promoting low-carbon sources, energy efficiency, sustainable spatial development, sustainable construction and promoting digitalisation, and public administration as a role model. Slovenia will not adopt policies and measures or invest resources in a way that would undermine the commitments of the Paris Agreement. One of the cross-cutting themes is the fact that, in addition to the climate crisis, we are also facing a biodiversity crisis, and synergies between the two need to be sought in finding solutions. Any environmental interventions must be carried out with the least possible impact on the environment. To better integrate climate policy into sectoral policies, Slovenia will strengthen the checking of the consistency of documents, policies, regulations and other acts with climate policy, and further strengthen this component in the process of integrated environmental impact assessment or EIA. It will also develop criteria for assessing the consistency of documents with adaptation and mitigation policies.

15.2 EXISTING BARRIERS

In the following chapter existing barriers and needed actions for the deployment of P2G projects in Slovenia are listed.

Legal barriers

- Lack of P2G definition in national legislation.
- The clarity of definition of energy storage (facility) in electricity supply act 2021.
- Electricity and gas sector fragmentation from the legislative regulation perspective.

Techno-economic barriers

- Lack of transmission/distribution network analysis and quality standards related to feeding in the hydrogen and ‘renewable natural gas’.
- Gas system adjustment pace.

Socio-technical barriers

- Clear definition of charges that would apply specifically for a P2G plant.

- Lack of more defined specifications on exemptions regarding the payment of contributions that would apply for P2G.
- Double taxation/levies for P2G facilities.

15.3 ACTION ITEMS AND RECOMMENDATIONS

Taking into account the identified existing barriers, a variety of action items and needed steps, which should be taken to overcome these gaps and barrier and to achieve the goals of the roadmap, are summarised in this chapter.

Action items needed to overcome legal barriers

- The definitions of P2G hubs, hydrogen technologies, etc. should be clarified in the legislation of the Republic of Slovenia. It would also be necessary to amend all laws that touch on these areas and to clearly describe where all Slovenian legislation touches on the operation of the technologies studied in the DanuP-2-Gas project.
- It would be necessary to clarify the definition of energy storage (facility) in electricity supply act 2021.
- It would also be necessary to merge several law acts to make broader and clearer laws, so that there are fewer regulations and that the legislative instruments of the sector are not spread over several different legislations.

Action items needed to overcome socio-technical barriers

- Investing in the development of the transmission/distribution network analysis implementation and development of the quality standards related to feeding in the hydrogen and 'renewable natural gas'.
- Government investment in the development of the gas network and system, which should be more deliberate, faster, smoother, and more sustainable.

Action items needed to overcome techno-economic barriers

- The state should clearly define the definition of charges that would apply specifically for a P2G plant.
- The specifications of the contribution exemptions that would apply to P2G should be clearly defined by the State and the Government. Planning and installation of a pilot test plant with the possibility of testing and analysing the impact of injecting various renewable gases into the transmission system.
- Facilities using P2G technology should not be double-taxed, and they should even be exempt from certain taxes and be included in all kinds of CHP and RES support schemes available, this should be ensured by the State.

Further action items and recommendations

The rules for the operation, investment, and operation of Power-to-Gas and Power-to-X systems should be clearly defined in the relevant legislation acts. At the same time, the state should also provide non-repayable financial incentives and loans to the sector through various investment measures and channels to stimulate interest and investment in the sector.

LIST OF ABBREVIATIONS

BMNT Austrian Federal Ministry for Sustainability and Tourism (now: Federal Ministry for Agriculture, Forestry, Regions and Water Management)

BMVIT Austrian Federal Ministry for Mobility, Innovation and Technology (now: The Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology)

CHP Combined Heat and Power

GRES Gas produced from Renewable Energy Sources

IBS Gas Interconnection Bulgaria – Serbia

IGB Gas Interconnector Greece-Bulgaria

IPA Instrument for Pre-accession Assistance

LNG Liquefied Natural Gas

NECP Integrated National Energy and Climate Plan

P2G Power-to-Gas

PNIESC Integrated National Plan in the field of Energy and Climate Change 2021-2030 (Romania)

PPP Public Private Partnerships

RES Renewable Energy Sources

SEN National Energy System (Romania)

SME Small- and medium- enterprises