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Short Description
This document include country-specific political roadmaps, which are based on country-specific policy assessments and identified barriers and involves recommendations directed at political actors and energy planers.

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1. 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 the electric power and gas sector. The effective realisation of this project depends strongly on the legal and regulatory framework. During the work within the WP3 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. Further, these roadmaps will be combined to a durable strategy to enhance sector coupling in the Danube Region.

In order to obtain valuable results for the roadmaps from the legal analysis and identified barriers, it is imperative to identify which measures and steps are necessary to achieve the EU and national targets for decarbonization, increasing the share of renewable energies as well as increasing energy security in the region. It must be emphasized that there are some barriers that apply to all countries, however country-specific challenges with corresponding national climate targets will play an important role for the developed roadmaps. The roadmaps will be discussed during national stakeholder workshops and individual expert interviews and additional adjustments, based on the interviews, will be incorporated.

Deliverable 3.2.1 serves as a basis for all the above-mentioned objectives. The aim of this Deliverable is therefore to define the needed actions to promote and deploy the sector-coupling hubs in Danube Region countries.

2. METHOD

The objective of this Deliverable is to present the developed country-specific roadmaps, which are developed based on the conducted legal assessment in every involved country and, especially, taking into account the identified barriers. In the development of the national roadmaps work package the core team met twice to discuss the aims, timeline and needed actions. The roadmaps, which than were developed by the respective project partners were disseminated to the important stakeholders/political/policy representatives in each country and gained feedback was incorporated into the roadmaps.

3. GENERAL APPROACH

A roadmap is a strategic plan that describes the steps needed to take to achieve stated outcomes and goals. It clearly outlines links among tasks and priorities for action in the near,
medium and long term. A roadmap also includes metrics and milestones to allow regular tracking of progress towards the roadmap's ultimate goals. The IEA defines a technology roadmap as *"a dynamic set of technical, policy, legal, financial, market and organisational requirements identified by all stakeholders involved in its development."*[1]

The development of the roadmap in DanuP-2-Gas project relies on the general approach proposed by IEA in "Energy Technology Roadmaps. A guide to development and implementation", see Figure 1.

The results of analysis of biomass potentials, as well as infrastructural challenges made within the WP 2 are essential part of the roadmap, showing the existing situation with future scenarios. Evaluated use cases of sector coupling hubs within the WP2, highlight important findings for potential investors or other interested stakeholders, showing the possibilities and weaknesses of feasibility of such projects in every country.

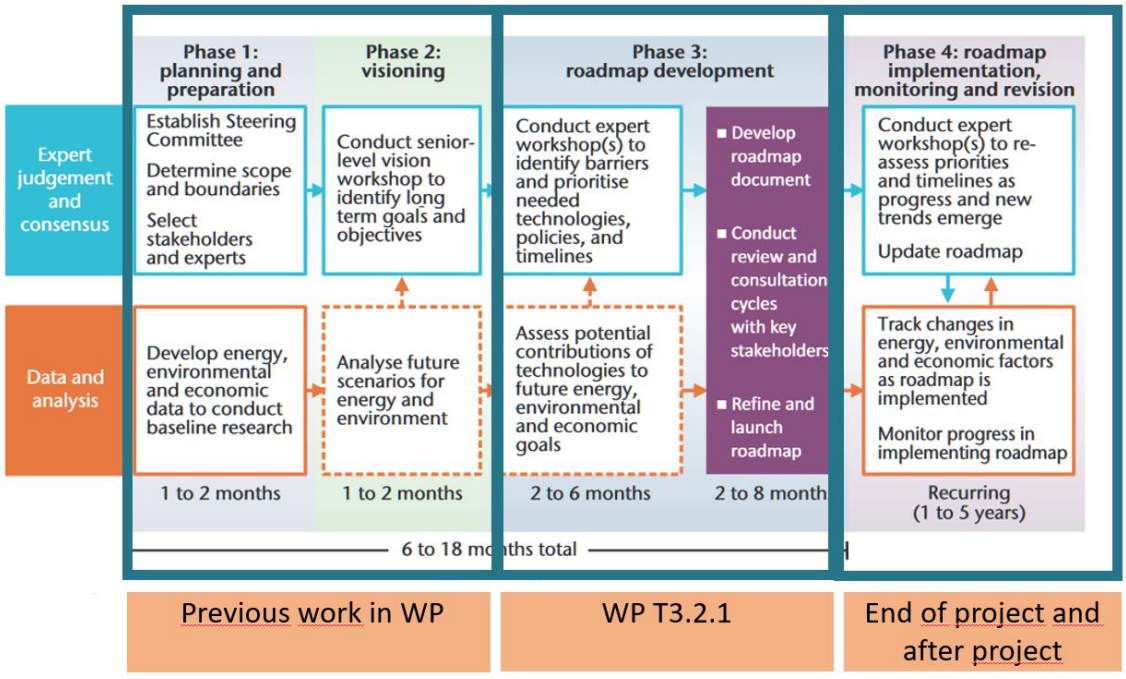

Figure 1. Roadmap process outline (Adjusted from IEA technology Roadmap Guide, 2014)

The analysis of the legal framework and identification of existing barriers is the core part of this roadmap. The further development of action items and needed steps to overcome the barriers, which are in line with the specific country goals, shows the step-wise plan to achieve the overall targets and aims of the roadmap.

4. THEMATIC SCOPE AND GOAL OF THE ROADMAP

The goal of the roadmap 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 roadmap identifies needed actions to overcome existing barriers for wider implementation of sector-coupling hubs within the Danube region. The roadmap focuses foremost on adjustments of legal framework, however overall interdisciplinary barriers and challenges are shown and further steps identified.

5. CZECH REPUBLIC

5.1 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 CO2 eq. compared to 2005 (corresponding to a reduction of 30 % compared to 2005 and 10 % compared to real value of 88 Mt CO2 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

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

- Renewable gas: Increase the share of nationally produced renewable Ga 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 22.0 %

5.2 OVERVIEW OF POWER-TO-GAS RELATED ACTIVITIES

No particular action leading to the fulfilling the goals of the Integrated National Energy and Climate Plan for Czech Republic are specified in the government documents[1,2]. Czech Republic proposes to increase country share of renewable sources in gross final energy consumption to a 22 % treshold by 2030, which is an increase of 9 percentage points compared to the Czech national target of 13 % for 2020. Renewable energy sources

However, the state of affairs in particular areas necessitate the change of the national energy plan. These are:

1) Coal phase out and particularly the end of coal mining at the territory of Czech Republic. Recent government decision declared the coal phase out in the year 2033, however the mining companies plan to mine coal up to the year 2038. Further prolongation is not possible due to the fact that there is no more available coal, which is possible to mine economically profitably within the Czech mining areas.
2) War at Ukraine necessitating diversion from natural gas.

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

[2] Energy Technology Roadmaps. A guide to development and implementation. IEA, 2014 Edition

Recently, Ministry of Industry and Trade of the Czech Republic announced a revision of National Energy and Climate Plan, which is supposed to undergo a significant revision. Renewable sources are supposed to be significantly increased from current ~ 15% to 30% in all-over energetic mix, however the main source will be probably considered solar energy. The document itself, the National Energy and Climate Plan consider hydrogen only as experimental energy source with no further plans for its development and usage. However, the new energetic policy introduced another instrument (which is currently prepared on legislative level). It is the increase of community energy sharing, "solar neighbourhood", which enable production, energy storage, and distribution of energy on neighbourhood basis instead of selling produced energy to national grid. Consequently, the share of energy between private partners would enable to sell the energy without extra charge by national electricity provider and make energy production more profitable for small producers. This fact might possibly introduce another means of electricity production including from gas generated bio-waste.

It must be also noted that the technologies for the use of hydrogen, primarily in heavy transport (trucks, busses, and potentially vans) are being developed and engineered by Czech branches of EU companies such as IVECO or Bosch. However, the source of hydrogen for transport usage is considered to be sourced by offshore wind farms.

The highly volatile energy market with a rapid expanse of solar farms, thus opens possibilities in the context of Power-to-Gas to promote biogas production as a viable alternative in the emerging debate on available energy sources, particularly for industry sectors utilizing gas as heating medium.

5.3 SECTOR-COUPLING POTENTIAL IN THE CZECH REPUBLIC

For Identification of the potential for sector-coupling hubs for the particular country it is important to take into account the following: biomass potentials, availability and suitability of gas and power infrastructure and energy system specification.

The optimization tool, developed during the project was used to evaluate different use cases in all participating countries, the results give a robust overview of the techno-economic feasibility of sector-coupling hubs. According to the findings, respective recommendations for potential investors are provided.

5.3.1 BIOMASS POTENTIAL

5.3.1.1 ELECTRICITY

Only around 12% of total 84 TWh of electricity production in Czech Republic comes from renewable sources. Five percent of the overall national electricity production is based on biomass making share of 55% on whole renewable electricity production (based on 2021 data) as shown in figure 1.

Biogas-based produced electricity accounts for 46% of total bio-electricity generation. The biogas plants operate mainly on purposely grown agricultural phytomass, such as corn supplemented by other agricultural wastes. As the biogas plants are widespread around the Czech Republic (Fig. 2), further increment of their capacity is highly improbable due to the lack of available biomass for their operation.

Wood chips accounted for 24% produced electricity. Wood chips for electricity generation originate mainly as waste from wood production in forestry. Wood chips are primarily used in combined electricity and heat production in town power stations or as coal supplements in power plants. Similarly, as in the case of biogas stations, the amount of electricity produced from wood chips will not significantly increase in the future, merely due to limited amount of tree harvesting and further available wood biomass.

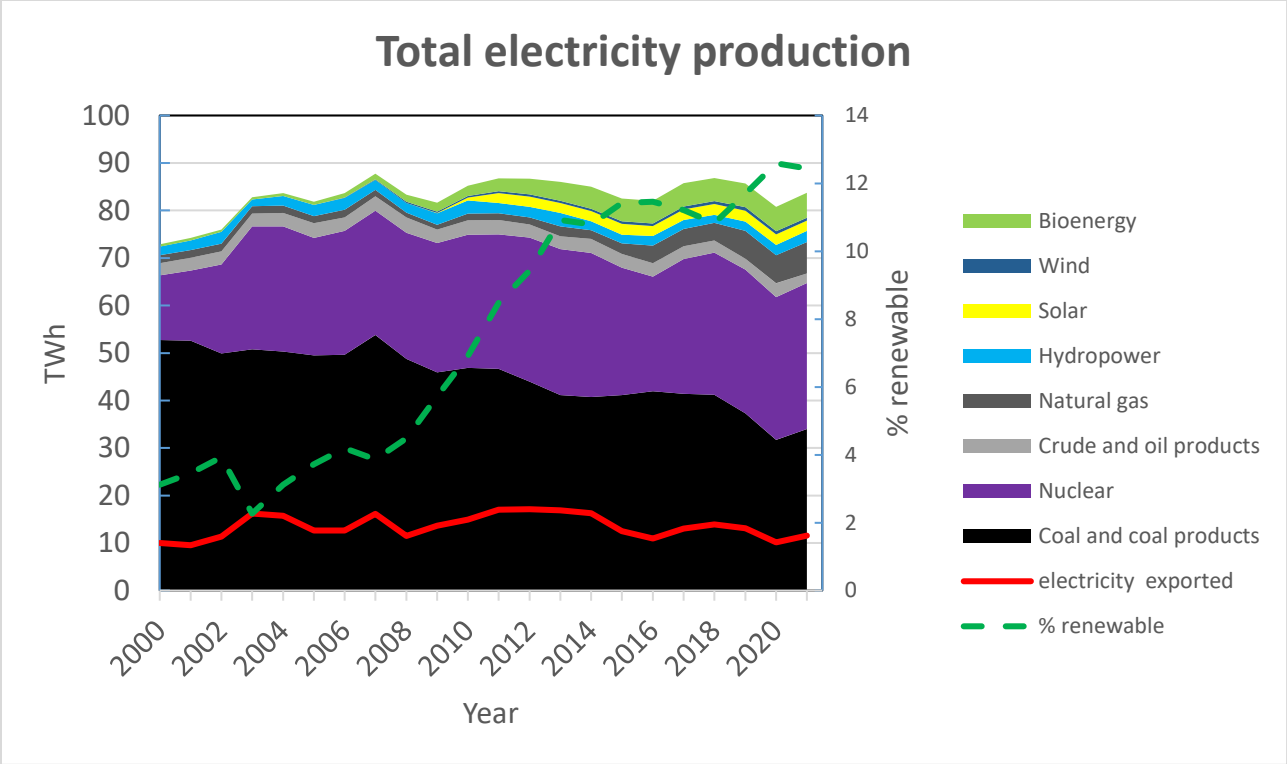

Figure 1 Production of electricity in Czech Republic. Source: Czech statistical office (https://www.czso.cz/)

The third major source of bioelectricity, 17%, is connected to the paper manufacturing process. Around 990 K t of paper is yearly produced in the Czech Republic whose waste products are energetically utilized. The all over supply of wood for the Czech paper industry comes from national sources. Similarly, as for two above mentioned cases the amount of feedstock is limited. Paper manufacture industry compete for sources with the energetic sector and household heat production. The production of electricity can potentially decrease in paper mill industry; however, it will increase reciprocally in the energy production from wood chips.

The remaining bioelectricity sources represent 12% of total bioenergy production, direct mill saw residues accounts for 5%, energy crops accounts for 2%, biogas from wastewater plants accounts for 2%, and landfill gas is used for generation of 1%.

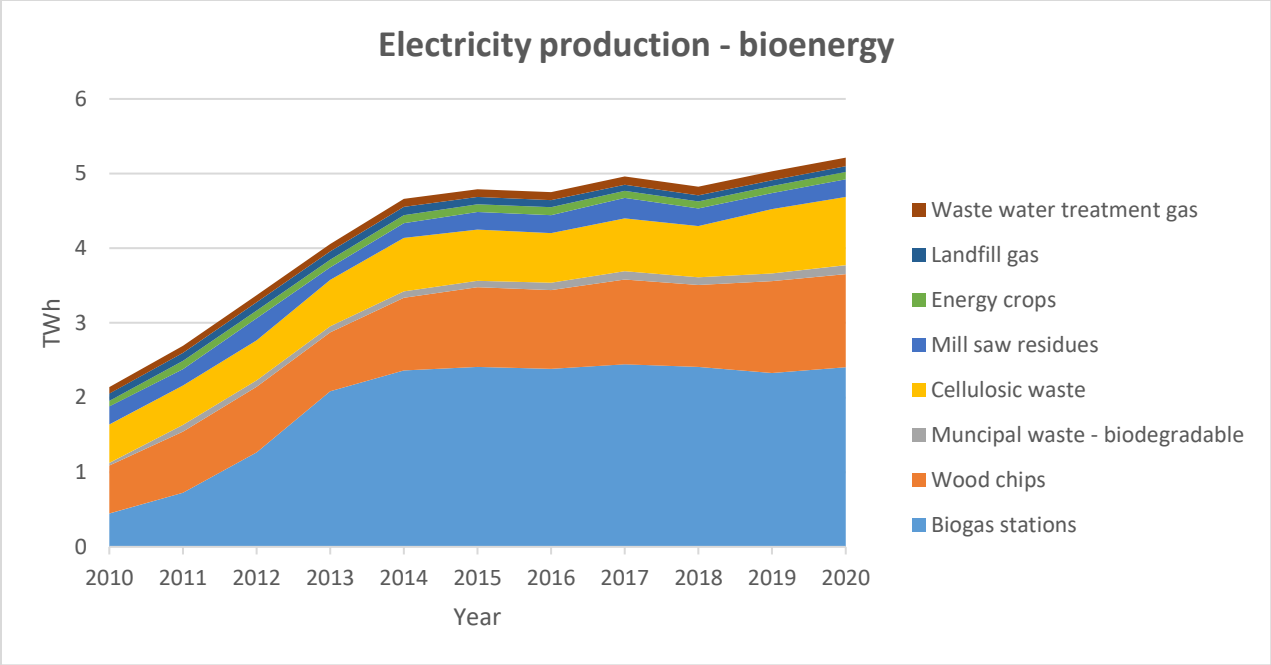

Figure 2 Figure 1 Production of electricity in Czech Republic form renewable biosources. Source: Czech statistical office (https://www.czso.cz/)

5.3.1.2 HEAT

In 2021, total heat production in Czech Republic reached 98 PJ. Approximately 60% of heat production in Czech Republic is produced from either brown or hard coal. Natural gas accounts for 13% and other fossil fuels accounts for <1%. The share of bioenergy on heat production is around 23%. Regarding the types of bioenergy, Czech Republic relies to a great extent on solid biofuels, which account for over 16% of the total bioenergy supply, comprising wood fuel, woodchips, wood pellets and bark, as well as sawmill by-products (Fig. 3).

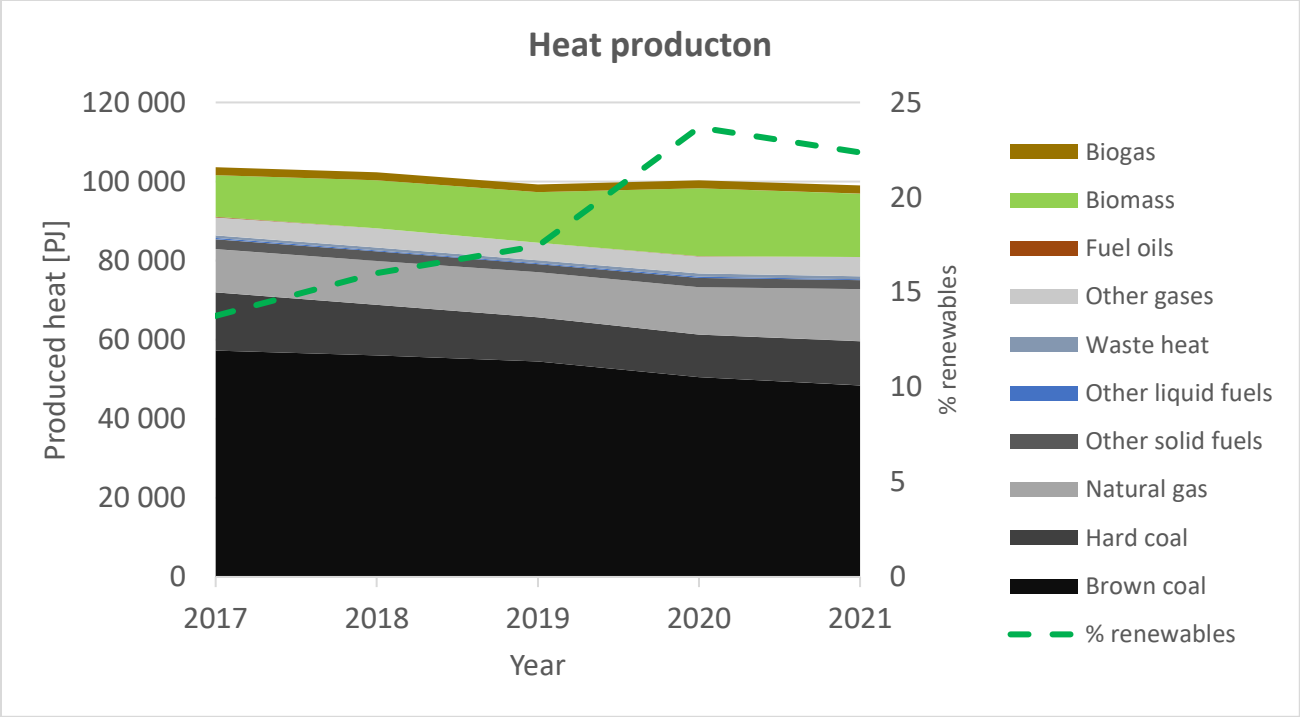

Figure 3 Production of heat in Czech Republic. Source: Czech statistical office (https://www.czso.cz/)

The major share of biomass in heat production is a direct residential heating (Fig. 4). It accounts for 66% with the largest part of the biomass used in private households. The wood from local sources is mostly used by private households' owners. The popularity of firewood use in heating particularly increased in connection to a bark beetle calamity in years 2017 – 2019 and overproduction of cheap firewood. However, the latest statistical data are available for a year 2018 (https://www.czso.cz/) and long-term trend of timber harvesting is rather unpredictable on national level. However, significant growth of wood production for household energetic purposes is highly unlikely.

The other main sources of bio heating are connected also to the wood production. The second major source of heat that accounts for 14%, wood chips are used mainly in municipal heating in cogeneration power plants. The potential of wood chips in energy production was already described above.

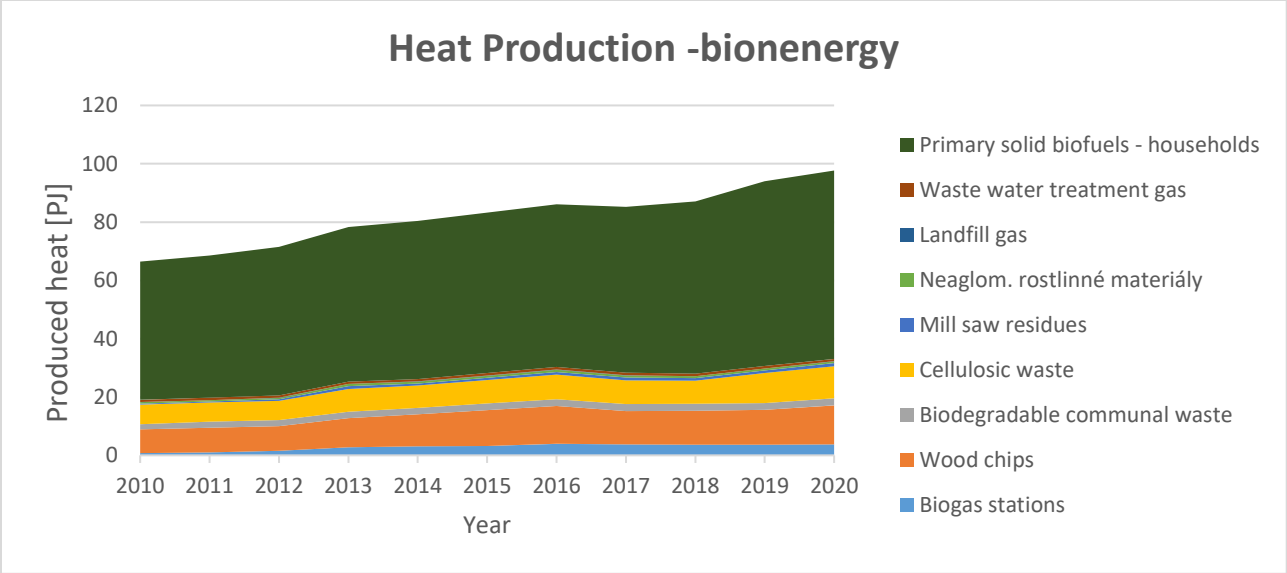

Figure 4 Production of heat in Czech Republic form renewable biosources. Source: Czech statistical office (https://www.czso.cz/)

The last significant source is connected to the paper manufacturing process, cellulosic waste is used mainly in cogeneration power plants and accounts for 11%. The rest of heat production as in biogas stations, waste biogas production or mill saw residues forms 9% of total bioheat produced.

In conclusion, data analysed for this report shows a clear trend for wide use of biomass in Czech Republic. However, the currently used resources (mainly based on wood and wood processing waste) are limited and almost entirely utilized. The growth of bioenergy use must be though further connected to other sources of biological materials.

Current situation connected with sharp decline of conventional gas supplies mainly from Russia, thus opens possibilities in the context of Power-to-Gas to promote the biogas production as viable alternative in an urgent search for alternative sources of expensive gas.

5.3.2 DESCRIPTION OF CZECH INFRASTRUCTURE LANDSCAPE

Czech infrastructure is well developed, electricity grid is in literally in every house, and the gas and water manifolds supply majority of municipalities. Czech bioenergy infrastructure reflects well the available production of biomass feedstock and its subsequent utilization for bioenergy. The bottle neck is the production of usable biomass for energetic use which is mainly constrained by available land area for its production.

Forests in the Czech Republic cover 33% of the country's land area. Of the total area of forests, the government owns 54.9%, municipalities 17.2%, regions 0.06%, religious entities 4.4%, corporations 1.2%, other legal entities 3.2% and individuals 19.3%. Over 70% of the forests are coniferous forests (50% spruce and 16% pine), over 27% are deciduous forests, among which beech (9%) and oak (7%) are the most represented. The average age of forest is 115 years. The Forest Act regulates forest management, and the performance of forest functions and protects the general use of the forest regardless of who owns it.

The bioenergy in Czech Republic is mostly generated from wood associated feedstocks such as wood, woodchips, or cellulose extracts. The demand for alternative energy sources grew during last ten years, and it was particularly driven by economic reasons, namely by search for cheaper energy sources than fossil fuels. If there was an unused biomass source, such as wood waste from forestry, the industry turned it into valuable source of wood chips for heat production[3-5]. The amount of available wood-based feedstock is thus limited and moreover a competition for wood rises due to energy crisis caused by war at Ukraine and stable industry applications as paper production.

Similar conclusions are applicable for biogas production, Biogas station are mainly fed by purposely grown corn and area of its production is constrained to fields having smaller economic potential for more valuable products such as cereals, colza (subsidized for biodiesel production), and others[6]. The total area of the agricultural land of the Czech Republic is 4,205,288 hectares. This includes activities on arable land, orchards, hop-growing areas, vineyards and permanent grassland. Arable land occupies 37,5 % of the total land fund. Most of the arable land (54 %) is of average fertility, 40 % is above average fertility.

Considering the P2G technology several alternative organic feedstock sources can be found. Wastes from food industry might provide a suitable alternative, however the amount is limited and even worse, the legislative flamework requires specific (expensive) handling of meat-containing waste. Moreover, food processing companies in the Czech Republic are usually owned by foreign corporations, making it difficult to implement any non-standard business agreements.

[3] Yearly report on the operation of Czech Heating Framework (2021) Energy regulation authority of Czech Republic

[4] Yearly report on the operation of Czech Heating Framework (2020) Energy regulation authority of Czech Republic

[5] Yearly report on the operation of Czech Heating Framework (2019) Energy regulation authority of Czech Republic

6 The final data on agricultural crops harvest (2022) Czech statistical office, Prague, Czech Republic

The most promising source for P2G technology is the sludge from wastewater plants. The other usage of sludge is very limited by its presumed composition requiring costly analyses for potential content of hazardous compounds. However, it represents a well-predictable source of biowaste, both in terms of quantity and quantity.

5.3.3 USE CASE ANALYSIS

There is a broad potential for P2G network construction in Czech Republic. The potential sources for unused biological waste is high (Fig. 5). The transport, gas, electricity and water infrastructure is well developed (Fig. 6).

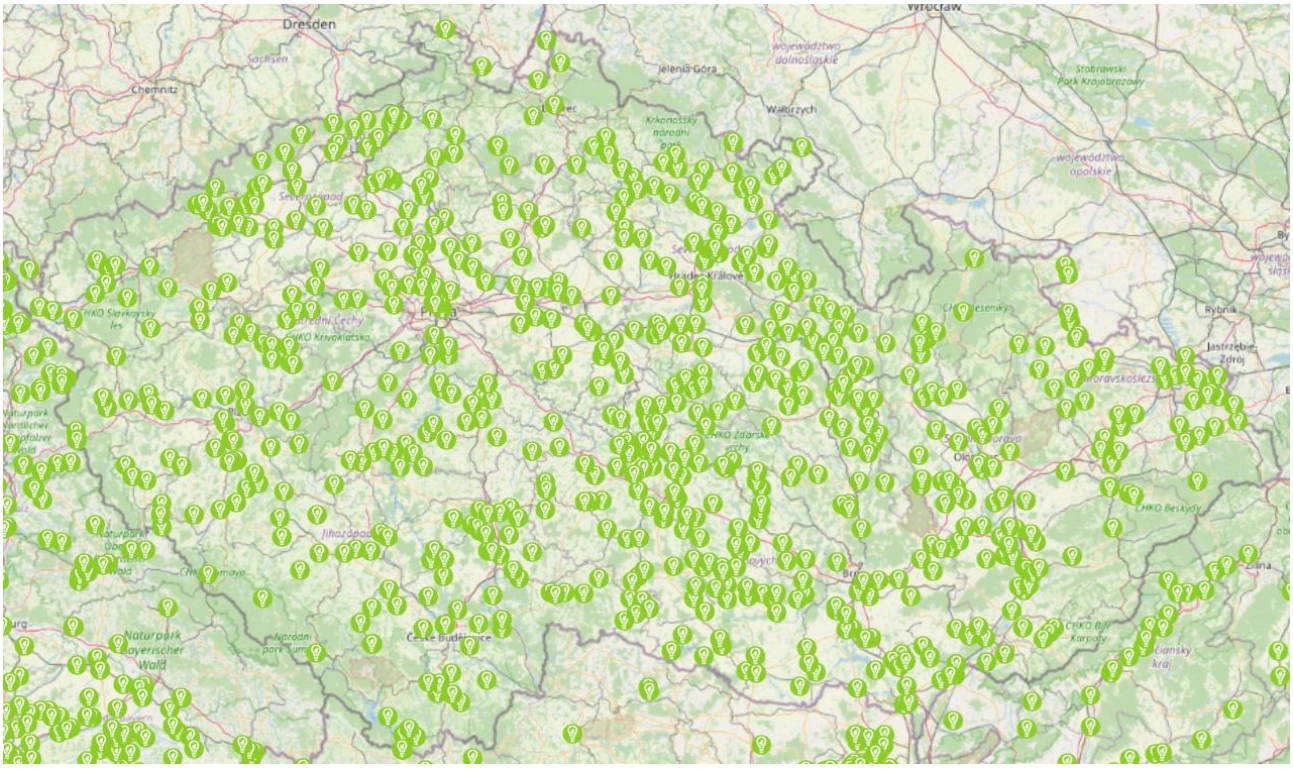

Figure 5 Sources of unused biowaste in the Czech Republic (source:https://www.danup2gas.eu/atlas-test)

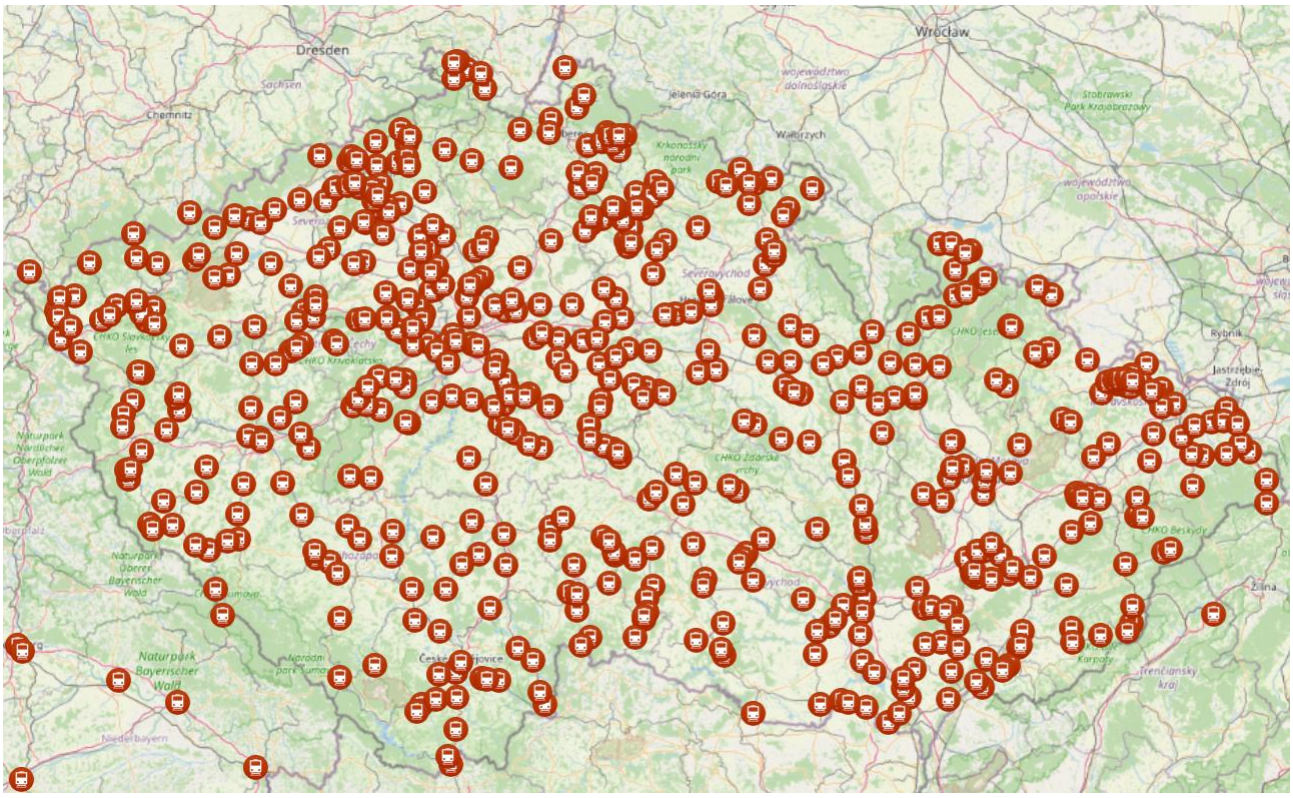

Figure 6 Transport hubs in the Czech Republic (source:https://www.danup2gas.eu/atlas-test)

The amount of otherwise unusable waste from the wastewater treatment plants is 220 000 t y-1. With 40% dry mass and 40% carbon content, more than 183 K m^3 of methane can be yearly produced.

The pre-feasibility study made in the frame of this project using the Atlas and DanuP2Gas Optimization Tool v2 revealed the well-defined scenario of the best scenario for P2G application. Under the no-war situation and summer daytime overproduction of electric energy, current trading prices of hydrogen, oxygen, and methane, the best investment option is to build an electrolysis production unit. The simulations clearly showed that any amount of energy produced could be consumed by the P2G plant for the production of hydrogen and oxygen.. The only limit is the size of the electrolysis unit and the market potential of produced gasses. Such a middle-sized electrolysis unit can make up to 500 t of hydrogen yearly, with a payoff period of 15-18 years, working 8 hours a day.

5.3.4 EXISTING FUNDING POSSIBILITIES

The major source of funding and the only appropriate one for industrial based projects in the Czech Republic is the grant provider Technology Agency of the Czech Republic (TACR) supported from the Ministry of Industry and Trade. TACR supports applied research, experimental development, and innovation; however, it limits the areas of research and development according to the yearly priorities specified by the government. We can only expect that current energetic crisis will open possibilities of further development connected to P2G technology.

Cooperation with a private and business sector is not well developed in Czech Republic mainly due to the ownership of vast amount of profitable businesses by foreign owners. Under our broad experiences, this feature effectively limits the cooperation possibilities.

5.4 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 Operator. It means that without the working and well developed P2G technology, incorporating of this technology is unlikely into the whole energetic 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)

Socio-technical barriers

- In recent days, every energy storage technology would be acceptable to the public. Then this point is not considered a barrier.

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 energetic 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.

5.5 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