Czech-Austrian Spring and Summer School

Revaluation of biomass potential under the perspective of the new sustainability challenges

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SUMMARY

1. Abstract

This work focuses on the potential and the competitiveness of biomass as a renewable energy source alternative to fossil fuels, and in general on the importance of a rapid shift towards emission-free economies and energy systems. The aim is to re-evaluate biomass potential under the new eyes of the sustainability challenges and projects, supporting and promoting bioenergy under different perspectives.

The main problem is the evaluation of potential in terms of future energy use, in a complex system embedded with economy, society, climate, geography, both qualitatively and quantitatively. An introduction of biomass uses for energy purpose and their classification is presented, followed by a description of the present and future role of biomass in the European Union, in Czech Republic and in Austria. After a qualitative analysis of different factors (forest and arable land surface, urbanization, energy intensity) to explore their impact on biomass potential, it is compared the potential with other renewable energy sources, and between the two countries of Czech Republic and Austria.

Results show that biomass, except for transportation and treatment of the matter, wins the comparison in terms of dispatchability, provision of ecological services and land recovery, creation of many more job places in different sectors.

Furthermore, the more mountainous geographical conformation of Austria guarantees a long-term availability of wood, but its limited arable land surface hinders the integration of agriculture by-products with respect to Czech Republic. The ex-soviet country history hindered the development, but the ongoing urbanization process offers many opportunities, in addition to the new inclusive EU policies. Since the compared characteristics apply to the countries in question, the results are specific and not fully generalizable.

It is concluded that bioenergy should be a cardinal point of the transition towards a green economy and energy system since its potential goes far beyond zero net-emission. Biomass deployment is the backbone of the transition and should deserve as much social awareness, investments and technological development as wind and solar energy do.

2. INTRODUCTION

Motivation:

In the last decades, environmental degradation and climate crisis increasingly attracted social and political awareness, reflecting the danger of the rapid change the planet is going through. Excessive greenhouse effect requires a concrete, effective and prompt response in shifting the global economy and supply chain towards a sustainable and emission-free one. Furthermore, it is essential to make up for the air, water and soil pollution and land degradation by implementing measures to stop causes of pollution and to recover the soil and environment in general. In this framework, the keyword is *sustainability*, which is acquiring global recognition thanks to projects and policies that are stressing and applying the concept, first among all the United Nation's Sustainable Development Goals (SDGs).

Biomass use for energy purpose has been adopted for centuries, providing basic energy services (heating, lighting, cooking) in a practical and economical way. After being substituted by fossil fuels for their technological and physical advantages (gaseous, liquid or powdered), biomass has been lately revalued as a more ecological alternative, since its carbon footprint is absorbed and released in the short lifecycle of the plant or living organism.

Furthermore, in the sustainability framework described above, the use of biomass for energy purpose shows an added value in terms of potential and competitiveness with respect to other energy vectors: it can provide an answer to two both the reduction of emissions and the recovery from environmental degradation. On one hand, it can ensure an emission-free power generation and on the other hand, especially the land use for energy crops, can perform the functions of increasing nutrients content and water storage and improving its resistance to erosion.

Therefore, the motivation for this work is to provide a re-evaluation of the potential of biomass under the perspective of sustainability, showing the added value with respect to other renewable technologies for energy production, and providing a qualitative assessment and comparison of the potential in the nations of Austria and Czech Republic. Critical aspects of this research are the availability of indexes and methods to evaluate the potential in the complex geographical, agronomical, and economical system in which biomass operates. If successful, this work will support the development of biomass for energy purpose by spreading awareness on its potential and providing a technical overview to the policy makers, to be used as roots for sustainability projects.

Overview on biomass for energy purposes:

Biomass is generally a substance of biological origin, either intentionally generated by production activities or as waste from agricultural or forestry production, food processing, municipal management, etc. Biomass can be considered as one of the renewable energies sources and has a noticeable energy potential even though its use is currently limited by many factors, mainly costs of production, conversion and transportation and the existence of economically viable treatment processes.

In the context of the use of energy biomass, plant biomass means mainly wood and various wood wastes or other energy crops suitable for combustion in thermal plants, such as agricultural products and their residues or purpose-grown species. Energy use of biomass is, for example, heating to create human thermal comfort, domestic hot water and production of other types of energy or energy conversion, for example as a biofuel for powering the engines of mobile energy vehicles and other appliances (CELJAK, 2008).

First and foremost, the existing predominant sources of biomass (wood, grass, straw) need to be better utilized. In addition to the existing sources of raw materials and energy, to fulfill the demand and the sustainability goals it is necessary to introduce the cultivation of so-called energy crops, especially in marginal areas which in the future will be excluded from food production (Pastorek, 2004).

Classification of biomass:

1. Primary residues: by-products of food crops and forest products (wood, straw, grain, etc.).
2. Secondary residues: By-products of processes that produce food or biomass materials (wood and paper sawdust, food and beverage industry, seeds, etc.).
3. Tertiary residues: by-products of biomass used as raw material (waste and wood, etc.)
4. Energy crops when meeting sustainability criteria

Furthermore, processing phytomass for energy use can generally be divided into the dry route (biomass has a moisture content below 50%) - combustion or gasification of plant matter and the wet route (biomass has a moisture content greater than 50%) - anaerobic fermentation using special bacteria without access to air, which releases methane as a product of metabolism that is used for the combined production of electricity and heat – cogeneration. In the field of interest of this work, some further definitions are given:

Agricultural harvest residues, especially cereal straw, have a wide range of applications. Depending on the water composition and the heating value, it can be either used to produce biofuels or for direct combustion with mid-high energetic yield. With a calorific value of 15-17,5 GJ/t on a dry basis, rapeseed straw is close to the better types of brown coal, and there is practically no other use for it in the energy sector (HAVLÍČKOVÁ et al., 2006).

Another promising source is waste woody biomass from educational and clearing logging in forest stands. Although its potential is very high, it is not exploited to such an extent because forestry companies that carry out logging are usually unable to clear this biomass from the forest in an economically viable way (HAVLÍČKOVÁ et al., 2007).

Regarding organic waste from industrial production, instead, the most common source is sawmills and wood processing plants, which often provide sawdust, offcuts, shavings, and bark as a waste product. This form of biomass is slowly being fully exploited, especially to produce biofuels such as compressed wood pellets and briquettes (HAVLÍČKOVÁ, WEGER et al., 2006). Also, solid residual from water treatment plant filtering can be used, solid households disposal and other types of urban waste as classified as biomass for energy purpose.

Intentionally produced energy crops:

A relatively new source of biomass are stands of so-called energy plants. This term refers to botanical species of trees, perennials and herbs, their cultivars and varieties, natural and intentional hybrids. Their growth, and especially volume production (t/ha/year), in intensive cultivation significantly exceeds the average values of other crops in the studied area (HAVLÍČKOVÁ, WEGER et al., 2006).

In general, it is more economically and energy efficient to grow perennial crops than traditional annuals (unless the by-product is straw cereals or oilseeds). Growing non-traditional perennial crops can effectively reduce the total cost of producing a unit of biomass and substantially increase the ratio of energy output to input by up to 4–10 x. For instance, with proper cultivation practices fodder sorghum (Rumex) could provide sufficient phytomass as a suitable fuel for several consecutive years, starting from the 2nd year after sowing, without the need to re-establish the crop (MOUDRÝ, SOUČKOVÁ et al., 2006). Nonetheless, it is recognized to have several criticalities - such as weather sensitivity, that make it not much suitable.

Not only ligno-cellulosic energy crops are grown: the main advantage of non-woody energy plants is that they produce high yields and are harvested with conventional agricultural machinery, implying a low investment from farmers who want to use part of their arable land for energy purposes. These crops differ from food crops as they are generally grown for yield of matter and not nutrients, with exception for multipurpose crops such as hemp. Many of them are perennial, as sorrel, Chinese ornamental, or Jerusalem artichoke, and are produced with lower production costs (HAVLÍČKOVÁ et al., 2007).

Finally, the so-called Fast-Growing tree Species (FGS), or Short Rotation Coppice (SRC), or clones of tree species that are capable of high yields of aboveground biomass in a short season of 3-6 years with a lifespan of 20-35 years (HAVLÍČKOVÁ et al., 2007).

Taxonomy for sustainable acitivites

Directing investment towards sustainable projects and activities is essential to meet the EU's 2030 climate and energy targets and to achieve the objectives of the European Green Deal.

The EU Taxonomy is a classification system that creates a list of environmentally sustainable economic activities. The EU Taxonomy is an important tool for increasing sustainable investments and for the implementation of the European Green Deal.

The Taxonomy Regulation establishes six environmental objectives:

1. Climate change mitigation
2. Climate change adaptation
3. Protection of water and marine life
4. Biodiversity
5. Transition to circular economy
6. Pollution prevention

Biomass and carbon production

Forest biomass is often mistaken for a carbon-neutral source of renewable energy. This is particularly true in the context of the 2015 Paris Agreement, which aims to significantly reduce the EU's greenhouse gas emissions by 2030. The EASAC (Expert Council of European

Academies) report seeks to alert politicians to rethink their approach to the use of forest biomass.

Until now, the prevailing view has been that burning biomass produces the same amount of CO_2 that the plant then consumes as it grows. This may be true in the long term, but it takes a long time for the new vegetation to absorb the carbon dioxide. Scientists describe that this return of carbon dioxide to nature can take decades, in some cases even hundreds of years. And all the while, carbon contributes to climate change as much as burning coal or oil.

Although current legislation does not address CO_2 emissions, the actual CO_2 emission factors were measured during combustion. It is usually stated that the same amount of carbon dioxide produced by burning biomass is absorbed by the biomass during growth. This implies that even if the CO_2 emission factor during combustion is not zero, it can be considered as zero.

3. Methodology

The section is structured in the presentations of the role of biomass in the energy mix, its presence and its future perspectives in the EU, the Czech Republic and Austria. Furthermore, for the latter it will be described an overview of the natural and climatic context as a basis for the comparison of their respective biomass potential.

Biomass in the EU: present and future

About 17 percent of energy consumption in 2016 in the EU was from renewable sources and bioenergy accounted for almost 60 percent of this renewable energy (**Figure 1a**). Since heating and cooling accounts for 47 percent of energy consumption in the EU, while transport and electricity account for 31 and 22 percent respectively (**Figure 2**), the high bioenergy share is mainly due to the fact that the heating sector is responsible for the majority of our energy consumption share, and biomass plays a major role among other renewable sources. The

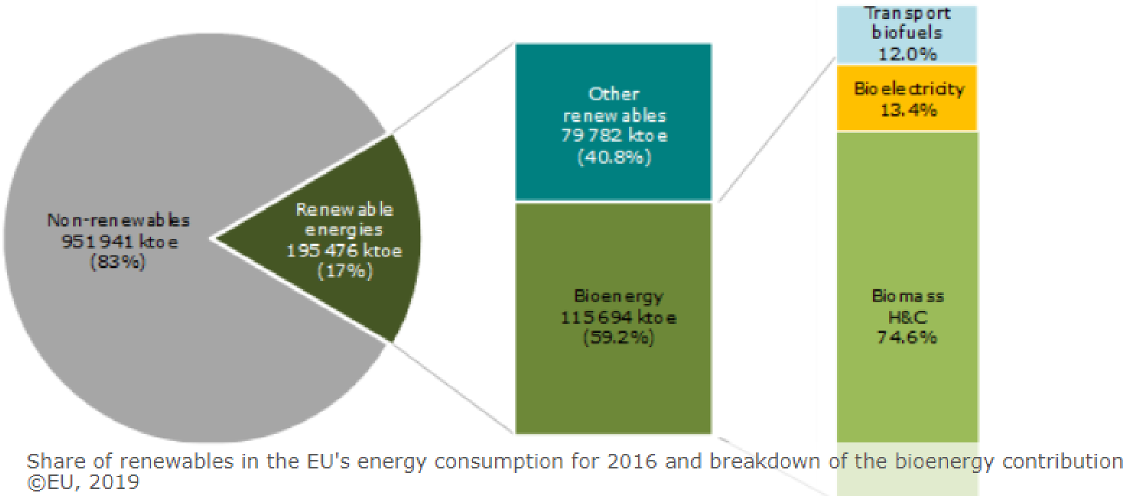

Figure 1a: ***Share of renewables in the EU's energy consumption for 2016 and breakdown of the bioenergy contribution*. Source: EU, 2019**

renewable energy cards in the European Union have so far been dealt 59 percent to biomass energy, and around 15 percent each to hydro and wind energy (**Figure 1b**).

Bioenergy thus leads the renewable energy sector mainly due to its role in the heating sector, and it also plays an important role in transport, where the greater development of other renewables is still awaited (**Figure 1a**).

Biomass is thus the most important domestic source of renewable energy. Although the share of other sources is more likely to grow at the expense of biomass, biomass energy forms the backbone of the energy transition away from fossil sources, at least in the next few decades before sustainability criteria become too stringent for biomass combustion.

Experts at Bioenergy Europe calculate that the sector represents an annual turnover of around €60.6 billion and around 703,200 jobs in the EU-28 (Bioenergy Europe), which has a great impact in terms of impact on the society and wealth distribution.

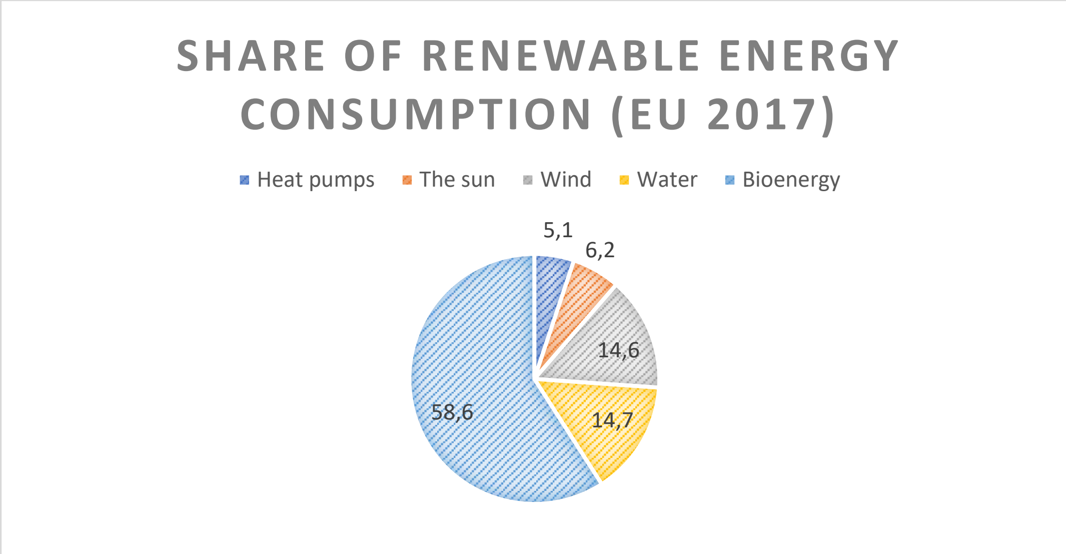

Figure 1b: Renewable energy consumption, EU 2017

Biomass is mostly a domestic European resource. EU imports do not exceed 5% of European consumption, while 78 percent of our fossil fuel consumption is imported. This also contributes to lower greenhouse gas emissions. According to Bioenergy Europe, the bioenergy sector has saved around 7 percent of the EU-28's greenhouse gas emissions (303 million tons of CO2), roughly equivalent to Spain's annual CO2 emissions.

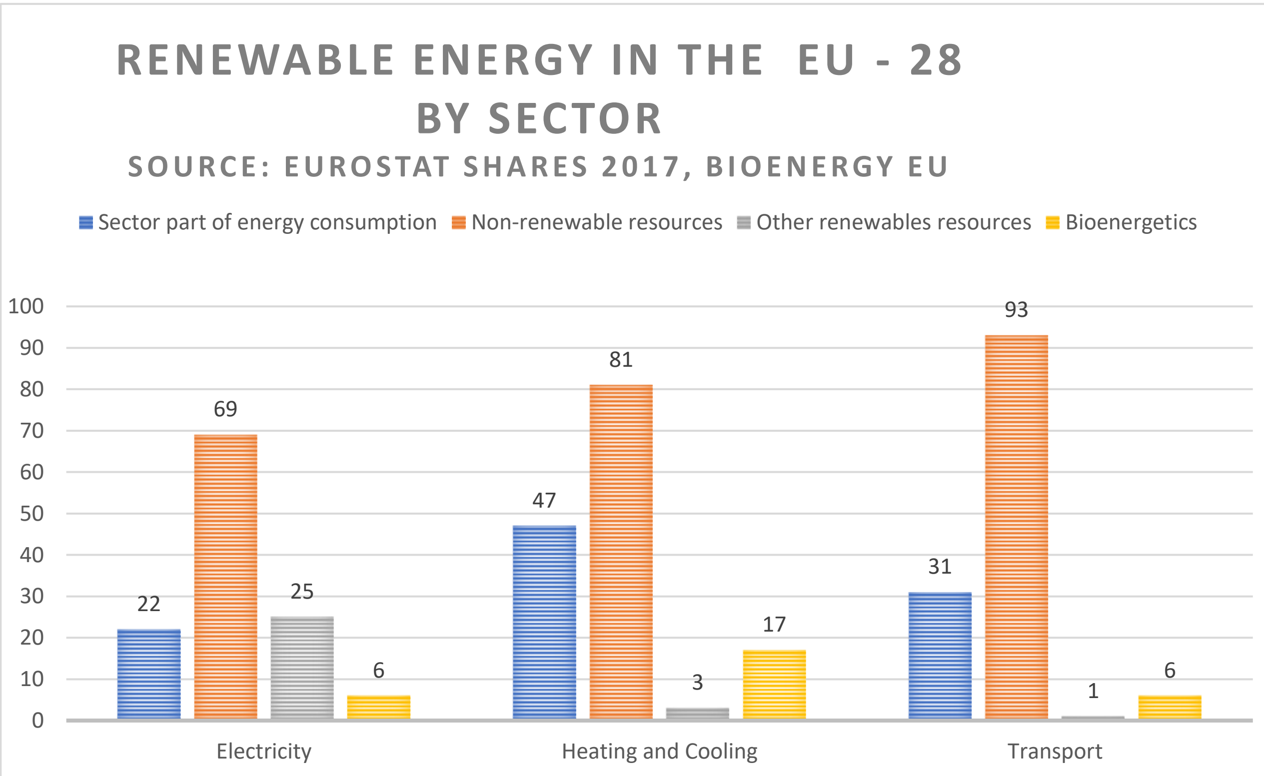

Figure 2: Renewable energy by sector, EU-28

Role of biomass in the future

Biomass energy as a substitute for fossil fuel combustion is one of the key measures for climate change mitigation, provided it is produced sustainably and efficiently (IPCC,Bioenergy). According to available estimates, bioenergy could account for between one tenth and one third of global energy consumption in 2050. A major advantage of biomass energy is its diversity. It provides electricity and heating, fuels transport and can use both purpose-grown biomass and waste and by-products from agriculture and industry or households. Biomass energy offers many opportunities to reduce greenhouse gas emissions on the one hand and to contribute to rural development, agriculture and sustainable management of the landscape and natural resources on the other.

Today, bioenergy production amounts to 5.7 EJ (trillion joules) (2017 data for the EU-28). Studies estimate the bioenergy potential in Europe between 7 and 31 EJ in 2050 (Faaij2018). For comparison, today's energy consumption in the EU is around 68.1 EJ. The potential mentioned above would thus tentatively represent 10 to 46 percent of our energy consumption today. The research included the potential of purpose-grown agricultural biomass, agricultural residues, forest biomass and biodegradable waste, as shown in **Figure 3**.

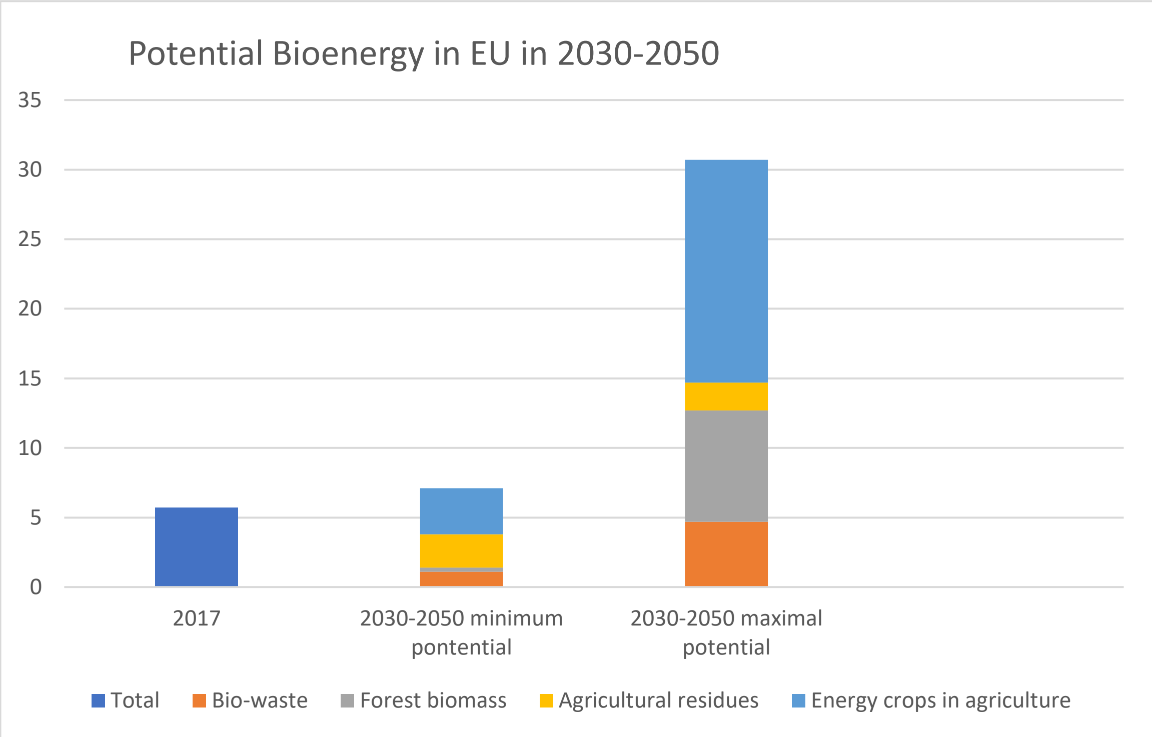

Figure 3: Potential bioenergy in EU 2030-2050

From this range it is clear that estimating the potential of bioenergy is not an easy task. It encompasses many types of biomass and ways to use it for energy production. It is difficult to predict the market and policy environment in which the sector will develop and how sustainable management of biomass resources will be ensured. The potential of bioenergy will also be affected by continuing climate change, with associated changes in precipitation, rising temperatures, extreme weather events and therefore hazards and changes in crop yields.

Globally, this may not be a major impact, but in certain areas it will be, and we have limited ability to predict these impacts so far (IPCC. AR5, WG3).

Developments in sectors such as food, feed, building materials and paper will also be key. The risks associated with small advances in efficiency and the dramatic increase in demand for biomass in the chemical, construction or food production industries need to be taken seriously. This may, in the absence of appropriate instruments, contribute to the growth of greenhouse gas emissions associated with pressure on the use of natural resources and ecosystems storing significant amounts of carbon (IPCC,Bioenergy).

Situation in Czech Republic

The key strategic document that contains policies and measures in the field of energy and thus across all five dimensions of the Energy Union is the State Energy Concept (SEC). In addition, territorial energy concepts are also developed and must be in line with the State Energy Concept. These conceptual documents are enshrined in Act No 406/2000 Coll., on energy management, as amended (hereinafter referred to as 'Act No 406/2000 Coll.'). The State Energy Concept is adopted for a period of 25 years and is binding for the exercise of state administration in the field of energy management. It is prepared by the Ministry of Industry and Trade, which evaluates it at least once every 5 years and informs the Government of the evaluation. In addition, it submits to the Government by 31 December each year an evaluation of the implementation of the objectives and measures set out in the SEC. The current State Energy Concept of the Czech Republic was approved by the Government on 16 May 2015 and has a horizon until 2040.

The long-term vision of the Czech energy sector is a reliable, affordable, and sustainable supply of energy to households and the economy. This vision is summarized in a trio of overarching strategic objectives of the Czech energy sector, namely security, competitiveness, and sustainability.

The renewable energy dimension is also part of the decarbonization dimension. Here, the following has been agreed an EU-wide target of 32% by 2030, expressed as the share of renewables in gross final energy consumption. Revised text of Directive 2018/2001 on the promotion of the use of energy from renewable energy sources also includes requirements for sub-targets in the heating and cooling sector and the transport sector. The Czech Republic proposes a contribution to the European 2030 target of 22%, which is an increase of 9 percentage points compared to the Czech national target of 13% for 2020. The proposed average annual growth in the share of RES in the heating and cooling sector corresponds to 1%.

In the Czech Republic, the dominance of biomass is even more pronounced than the European average, in 2017, 87% against 59% of the energy portfolio (KNAPEK, 2020).This is mainly due to the tradition of burning firewood directly in households, numerous municipal heating plants and heating plants and a relatively dense network of biogas stations. In the Czech Republic, when people say 'renewable energy', they mean mainly bioenergy. Of the many ways of using biomass for energy purposes, the most important so far is its combustion, biogas production or methyl ester production. An estimated amount of 2 million of tons of dry mass per year can be used for energy purposes in the Czech Republic (SCERBA, 2008).

As shown in **Figure 4**, the national distribution of renewables from 2018 data.

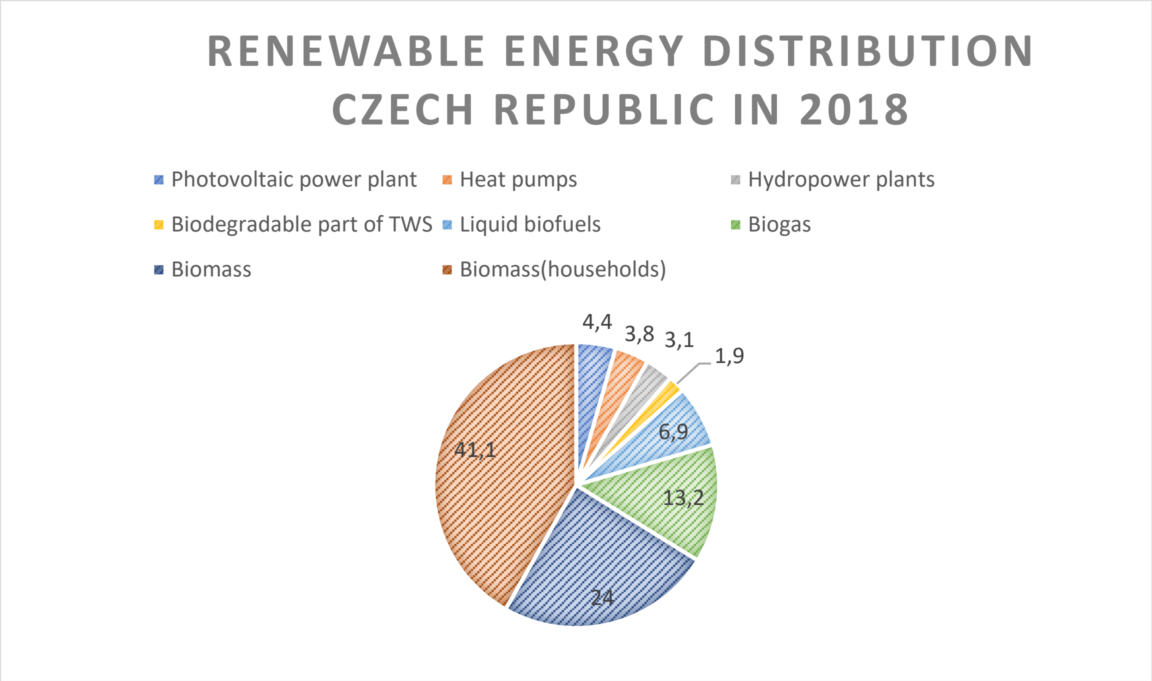

Figure 4: Renewable energy – Czech Republic 2018

Energy use in this country is beginning to expand, although with a delay compared with the Scandinavian countries. A common objection to burning is that all the straw that has grown in the fields each year must be returned to the soil as biomatter. In fact, there are very few nutrients in the straw. At present, with the use of ploughing to enrich the soil with humus, it is only of value on heavier soils, otherwise only with simultaneous application of slurry or other nitrogen fertiliser. (HAVLÍČKOVÁ et al., 2007).

The country typical climate can be described as transitional between ocean and continental, reporting not too cold and dry summers and slightly cold and wet winters. This, in addition to the extended surface of hills and highlands, is the reason for its 34 percent woodland: Czech Republic is indeed one of the most forested countries in Europe.

Situation in Austria

Efforts to shift the economy towards decarbonization and energy efficiency are done at different levels in Austria. On a higher scale, the National Energy and Climate Plan and the Climate and Energy Strategy of the Austrian Federal Government define the actions that will drive the long-term transformation of the energy system towards the 2030 targets set by the Paris Agreement. It ranges from energy efficiency, e-mobility, research on the energy systems of the future and much more, including a so-called Bio-economic Strategy that will build a platform and an action plan to lead the bio-economy cluster. On a smaller scale, the Tax Reform Act from 2020 implements additional ecological measures in the mobility area, introducing a lower taxation for petrol and diesel with a minimum content of biogenic material of 4.6 percent, and removing taxes for mineral oil fully generated from biogenic. Not only, *klimaaktiv mobil* also contributes to a green mobility supporting the deployment of clean vehicles.

Regarding Renewable Energy Supply (RES), Austria is well on track to meet its 2020 EU target of 34 percent renewables in gross final energy consumption, having reached 33.5 percent already in 2016 (Austrian Energy Agency, 2019). Next milestones are complete decarbonization of the electricity supply by 2030, together with 45 to 50 percent of RES in the gross final energy consumption, and achieving carbon neutrality by 2040.

To support this challenging transition, on Wednesday 17 March 2021 the Austrian government approved the Renewable Energy Bill, which will create a legal and financial impetus for the transition to 100 percent electricity from sun, wind, water, and biomass only. One billion euros will be invested each year in the expansion of renewable energy sources.

In terms of biomass energy, Austria is in line with the European Union average with 58 percent of the total Renewable Energy Supply in 2017. Despite the limited total capacity installed (**Figure 5**), biomass is the main source of domestic RES rated at 44 percent, followed by hydropower at 27 percent. The most important source of raw material is wood from the widespread alpine forests, which in 2016 provided 79 percent of Austria's biomass volume; the remaining part is coming from agriculture by-products and the waste sector.

If a proper development of biomass is planned, its potential could increase by a further 39 percent by 2030. This would involve mainly agricultural and the waste sectors, since their potential is not fully exploited. Furthermore, bioenergy is expected to cover about a third of the domestic energy demand if a net reduction of energy use is achieved (biomassverband.at).

In terms of geographical conformation, Austria is a mountainous country dominated by Alps and forests. The Alpine landscape describe nearly three-quarters of the country, while the wooden surface is estimated for 47.6 percent of the national one, about 4.000.000 ha: the consequent availability of timber plays a key role in the bioenergy potential. However, the full potential could not be fully exploited because of ecological and economical restrictions linked to both harvesting and transport (ENGLISCH).

Not only, thanks to the timber availability, the industry is also a source for biomass, since wood and paper industry provides byproducts like saw dust, bark, black liquor, supporting the use of wood pellets, chips and logwood.

Austria expects to raise the share of renewable energy sources while reducing energy consumption. Specifically, 22 PJ will be saved in 2040 compared to 2020, while 49% of the total energy mix is assumed to come from renewables in 2040. Regarding greenhouse gas emissions in 2030, supplementary measures will result in a 27% decrease compared to 2005.

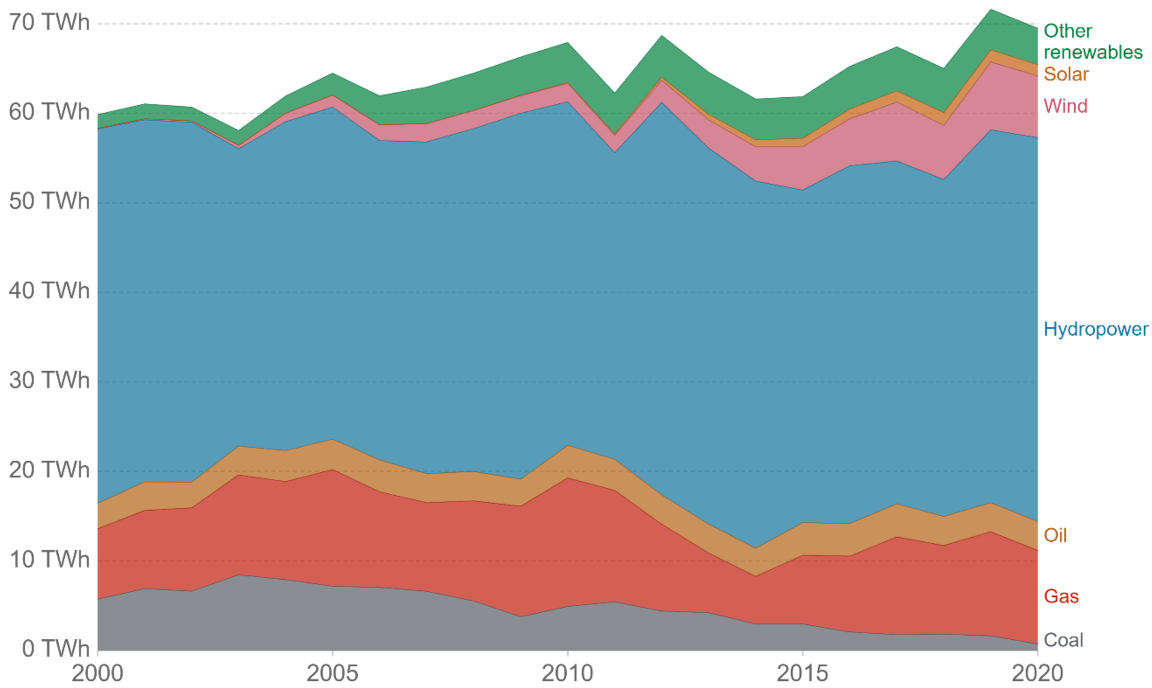

Figure 5: Electricity production by source, Austria. Source: OurWorldinData.org/energy – CC BY

4. RESULTS

Comparison between biomass and other renewable resources:

Biomass has common and exclusive advantages together with other renewable energy sources. Between the common ones, it can boost energy diversity, securing countries from a strong dependency on import of fossil fuels. This can prevent heavy, negative impacts of financial and social crisis that influence the price of fuels or directly the supply. Nonetheless, biomass shares the typical characteristic of wind, solar, hydroelectric energy of generating power in a local and regional level, reducing the impact of transport on the emissions and the price associated with the energy itself. In fact, it is shown that most of the biomass products are mainly consumed locally in the countries of production, and the international trade is limited (IEA Bioenergy).

Furthermore, it creates social security and employment, offering a huge number of job place.

As opposed to the other sources, biomass not only is carbon neutral, but can also offer many different energy services to the society, industry, and environment.

Considering that the intensive use of land for conventional agriculture degrades the quality of the plot in terms of humus level and water retention capacity, it is necessary to reintegrate its functionalities. As a common practice, the straw from the crop is left on the land after harvesting (the rest is taken as biomass by-product for direct combustion of treatment and transformation in biofuels). Despite it, with intensive use the land and lack of organic matter, soil quality cannot be recovered, and the land is not assigned for food crop anymore. Here, since ligno-cellulosic and herbal biomass does not need a great amount of nutrients to grow, the adoption of intentionally grown energy crops, can increase the nutrients content, the water retention, and the resistance to erosion by atmospheric agents, and at the same time by composting it will fertilize the plot. Furthermore, intentionally grown biomass has a great versatility, as different species have maximum yields in different land moisture and temperature conditions, allowing to provide a diversified response in the unpredictable horizons of climate change (Knápek 2020).

Known with the name of agroforestry, the practice of planting trees in the areas of food crops has a great impact on the liveability and sustainability of an agricultural system. They can either be deciduos, fruit trees or the Short Rotation Coppice (SRC) introduced above (willow, poplar, ash etc.) and can maintain soil organic matter and biological activity at levels satisfactory for soil fertility and be employed to reclaim eroded and de graded land (KARKI, 2018). The great advantage of employing SRC up to 20 % in conventional crops is combining the ecological services described above and obtaining alternative energy vectors for the independence of the farm. The practice might not be profitable or economically oriented but is able to make more resilient the land and the nearby conventional crops (WEGER, 2020).

Overall, biomass use for energy purpose boasts the adoption of the principles of circular economy, since it is mainly focusing on employing existing biological matter that has otherwise no use. In pursuit of sustainability, it necessary to start from maximizing the lifecycle value of products, included the biological ones, to avoid the over-utilization of natural resources and their impact on the environment. On the one hand, in this framework bioenergy might be considered more sustainable than other renewable sources that imply costly and emission-intensive components (solar panels, wind turbine blades) and a polluting disposal process that does not always allow full nor partial recycling. On the other hand, in large solar and wind plants, the energy gain for the same land area is several times higher than biomass, complicating the technical comparison of energy efficiency. Regarding the competitiveness, especially the economic one, the profitability of biomass energy is strictly related to the processes of collection, transportation, and conversion of the matter, as opposed to wind and solar energy who are available on the spot. On the other hand, biomass has the great advantage of being dispatchable, avoiding the need for storage, the overload of the grid and allowing for higher profits by synchronizing supply with the demand.

Comparison between Czech Republic and Austria

Czech Republic has a higher share of bioenergy within the Renewable Energy Supply, 87 percent against 58 percent of Austria. This indicates a more intensive activity, mainly linked to the traditional use of wood or coal to provide domestic households heating, that is now switching to biomass pellets.

On the other hand, Austria possesses a huge forestry surface distributed almost uniformly throughout the country, about a half against one third of the Czech Republic, ensuring a long-term availability of timber. Instead, as reported in (KNÁPEK, 2020), the intensive continuos exploitment of Czech forests for energy purposes hinders the long-term availability of wood, generating a new challenge for the country regarding the exploitment of alternative biomass sources, such as agriculture by-products and energy crops.

Another remarkable parameter is the surface and the rate of change of arable land in the last decades. In fraction of total land surface, Czech Republic shows a static trend in the last few years settling at about 32 percent of arable land, corresponding to about 2500 thousands of hectares. A great loss is visible in 2013, corresponding to the digitalization of land registry, conversion of arable to grassland and urbanized building sites, fragmentation of land ownership. Austria instead shows a constant and slowly decreasing trend that, in the last 25 years, brought the arable land to be close to 16 percent of the total surface, for about 1330 thousands of hectares (**Figure 6**).

Between 1993 and 2016 Czech Republic recorded a steep -22.5 percent, while Austria a -5.3% decrease, with a European average of -12.5 percent. This reflects the difference in terms of urban sprawl and past economic and political history between the two countries, since the continuity of land ownership and availability of EU policies and subsidies distinguished modern wester agro-economies from post-soviet agro-economies (KNÁPEK, 2020).

If this factor limited the development of biomass potential in the past, is not a threat anymore thanks to the inclusive EU policies. Instead, the determining advantage is the total surface of arable land, out of which agricultural by-products and energy crops can be developed, and Czech Republic therefore shows a greater potential.

The Czech Republic registers a urbanization ratio between 73 and 74 percent in the last decade, while for the same period of time Austria has a lower value between 57 and 58.5 percent of population living in urban areas. Remarkably, no abrupt change is visible in 2013 for Czech Republic, meaning that the arable land change is exclusively due to land management (**Figure 7)**.

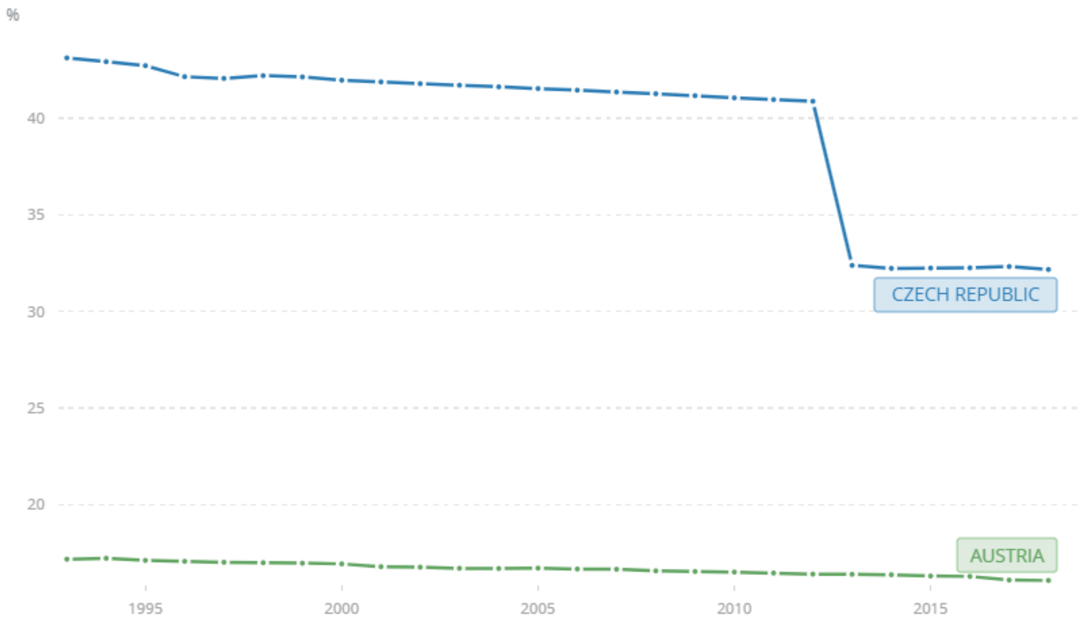

Figure 6: arable land percentage. Source: https://data.worldbank.org/ (license CC BY-4.0)

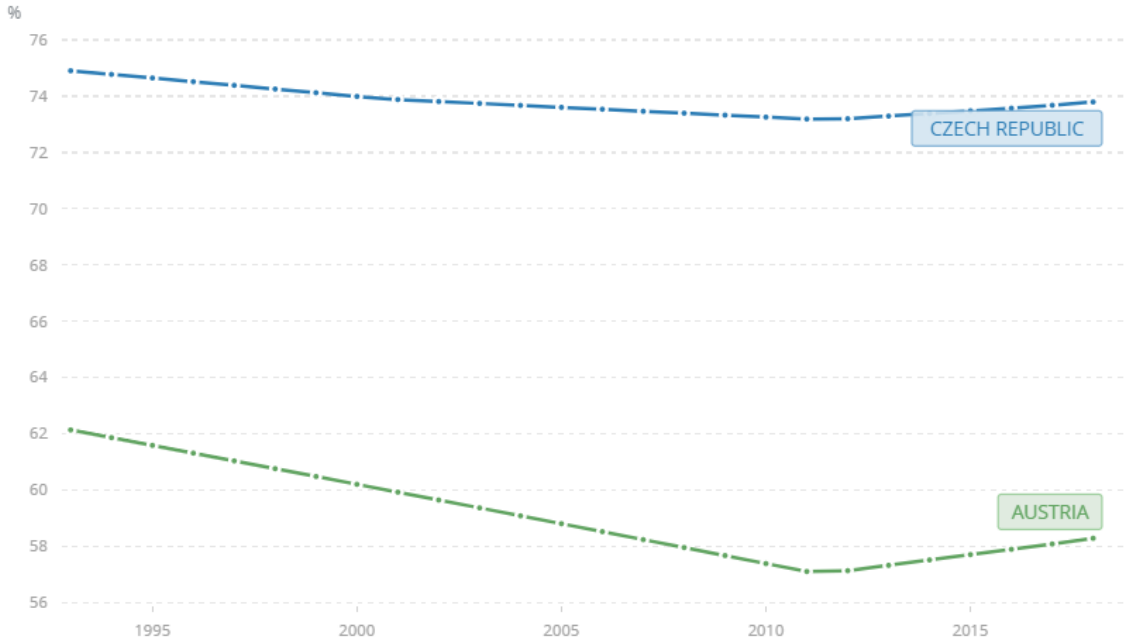

Figure 7: urban population fraction. Source: https://data.worldbank.org/ (license CC BY-4.0)

The lower urbanization rate in Austria is of course due to a stronger mountain presence which fragments urban regions and hinders the development of a transport and road network. Nonetheless, the percentage of population living in predominantly urban region is inverted, 25 percent in Czech Republic against 31 percent in Austria (**Figure 8**), showing a limited urban development in the Republic despite the higher urbanization. In this perspective, the presence of bigger urban centers might contribute to a larger extent to Research and Development centers as well as to the presence of industrial areas, encouraging potential development.

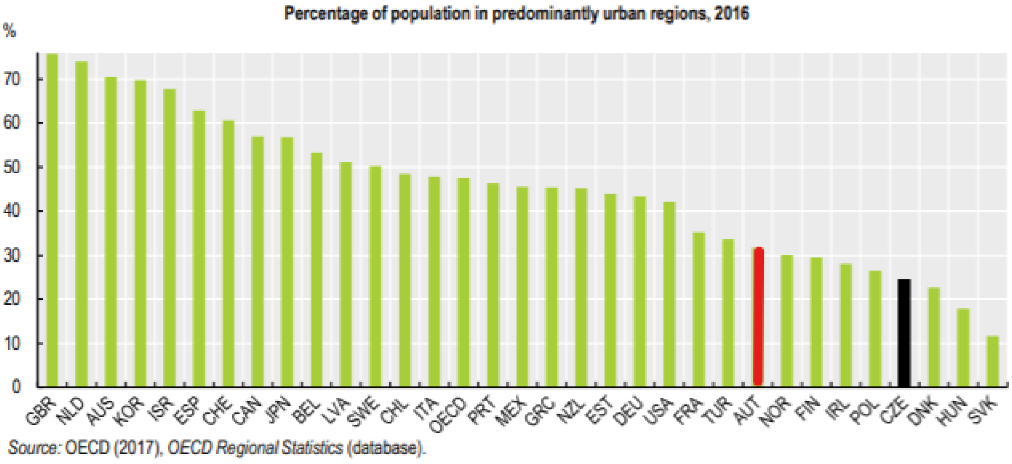

Figure 8: Percentage of population in predominantly urban regions, 2016. Source: OECD

The relation between energy and economy also play a key role in the evaluation of the potential of a renewable source of energy, and is represented in the Energy Intesity. This index, measured in kWh/$, is the ratio between the primary energy consumption and the Gross Domestic Product (GDP). In other words, it represents the energy efficiency of a country in terms of production of socio-economic welfare.

Comparing the energy intensity of Czech Republic and Austria across the last decades, it is noticeable a decreasing trend. As expected, the technological progress raise the gross overall efficiency, which is higher in Austria, namely a western country against a post-soviet one. Nonetheless, the absolute and relative improvement in term of efficiency is higher is Czech Republic, 48 percent against 39 percent, showing that the country is not lacking the ability of evolving and innovating its energy system (**Figure 9**).

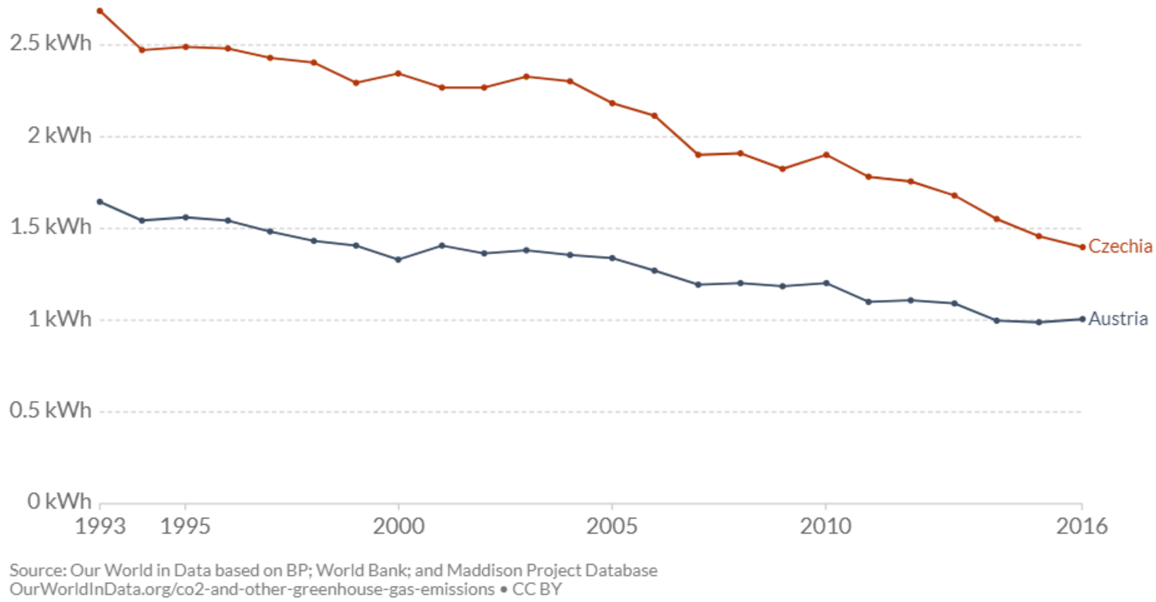

Figure 9: Energy intensity on GDP of Czech Republic and Austria, 1993-2016. Source: OurWorldinData.org

5. CONCLUSIONS

The paper presented the role of Renewable Energy Supply in general - and of biomass in particular - in the European, Czech, and Austrian energy portfolio with the ultimate goal to detect differences and similarities and the reasons for them. The factors of forest and arable land surface, urbanization trends, energy intensity have been discussed and qualitatively investigated to explore their positive or negative impact on biomass potential development.

Results show that biomass, except for transportation and treatment of the matter, wins the comparison in terms of dispatchability, circular economy, provision of ecological services and land recovery, creation of many more job places in different sectors.

Furthermore, the more mountainous geographical conformation of Austria guarantees a long-term availability of wood, but its limited arable land surface hinders the integration of agriculture by-products with respect to Czech Republic that owns less forest but more land. The ex-soviet country history hindered the development, but the ongoing urbanization process offers many opportunities, in addition to the new inclusive EU policies. Since the compared characteristics apply to the countries in question, the results are specific and not fully generalizable.

The outcomes want to show that, regardless of the country, bioenergy should be a cardinal point of the transition towards a green economy and energy system, and that its potential is wide and does not only implies zero net-emission but also ecological, economic, and social benefits. Biomass use for energy purpose is an extremely complex concept that can be applied in many ways, in the direction of both active - as intentional growth of energy crops - and passive exploitation of already existing matter, from agricultural, industrial, urban waste by-products. Biomass deployment is the backbone of the transition and should deserve as much social awareness, investments and technological development as wind and solar energy do.

In terms of future development, instead, the discussion is still open and full of different scenarios. NECPs draws future strategies and projections, being accomplished in Czechia, and quite left behind by Austria. The development has a great potential especially in the sector of secondary biomass from agriculture by-products and intentionally grown energy crops, but also barriers and rules to follow. The need of organic matter for fertilization purpose hinders its use for energy purposes, especially in Czechia, as well as harvesting, transformation and transportation processes and land degradation related to climate change. In the long run, biomass use can be positive only if built according to strict sustainability criteria, namely ensuring soil quality and natural fertilizers for food crops.

Finally, when scientific practices or tools are discussed, measured, or tested, it usually happens on a micro level that involves technological aspects and some assumptions on the real-life conditions. Technology is technical, indeed, but is applied to a much more complex world which is extremely hard to model, understand, describe. The authors believe that this approach is not general enough to catch all aspects of the real process. Therefore, the outcomes of this work serve as an attempt and an invitation to additionally investigate the basic differences on the macro level and how those affect the problem and the target of a study, in this case potential of bioenergy deployment.

6. REFERENCES

DOLEŽAL, *BIOM: časopis o energii, co roste* [online]. 2020 [cit. 2021-06-16]. Available from: https://czbiom.cz/wp-content/uploads/casopis_Biom_2020_02_web.pdf

PASTOREK, Zdeněk, Jaroslav KÁRA a Petr JEVIČ. *Biomasa: obnovitelný zdroj energie*. Praha: FCC Public, 2004. ISBN 80-865-3406-5.

CELJAK, Ivo: Biomasa je nezbytná součást lidského života. Biom.cz [online]. 2008- 12-22 [cit. 2021-06-16]. Available from: http://biom.cz/cz/odborne-clanky/biomasa-je-nezbytna-soucast-lidskeho-zivota. ISSN: 1801-2655.

KUŽEL, Stanislav, Jiří PETERKA, Ladislav KOLÁŘ. Komplexní využití biomasy: I. díl. České Budějovice, 2010. Skripta. JU v Českých Budějovicích.

HAVLÍČKOVÁ, Kamila a Jan WEGER. Metodika analýzy potenciálu biomasy jako obnovitelného zdroje energie: metodická příručka. Průhonice: Výzkumný ústav Silva Taroucy pro krajinu a okrasné zahradnictví, c2006, 132 s. ISBN 80-865-5955-6

SOUČKOVÁ, Helena a Jan MOUDRÝ. Nepotravinářské využití fytomasy. 1. vyd. České Budějovice: Jihočeská univerzita, Zemědělská fakulta, 2006. ISBN 80-704- 0857-X

HAVLÍČKOVÁ, Kamila a Jan WEGER. Zhodnocení ekonomických aspektů pěstování a využití energetických rostlin: vědecká monografie. V Českých Budějovicích: Jihočeská univerzita, Zemědělská fakulta, 2007, 92 s. ISBN 978-80- 7040-948-0

Havlíčková, K., Weger, J.: Metodika analýzy potenciálu biomasy jako obnovitelného zdroje energie. Acta Pruhoniciana 83, VÚKOZ, Průhonice, 2006, 96 s. ISBN 80-85116-48-0.

Scerba E., Skorpil J., Dvorsky E., Hejtmankova P. (2008) *Biomass as Traditional and Local Source of Energy in the Czech Republic*. In: Goswami D.Y., Zhao Y. (eds) Proceedings of ISES World Congress 2007 (Vol. I – Vol. V). Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-540-75997-3_502

IEA Bioenergy: ExCo: 2013:02

KNÁPEK, Jaroslav et al., *Dynamic biomass potential from agricultural land*, Renewable and Sustainable Energy Reviews, 2020

KARKI Amrit Singh, 2018, *Agroforestry and its benefits*,
<https://en.reset.org/knowledge/agroforestry-and-its-benefits>

WEGER, Jan and LOJKA, Bohdan and BUBENÍK, Jaroslav, 2020, *Agrolesnické systémy a rychlerostoucí dřeviny,* https://biom.cz/cz/odborne-clanky/agrolesnicke-systemy-a-rychlerostouci-dreviny

Vnitrostátní plán České republiky v oblasti energetiky a klimatu [online]. [cit. 2021-6-18]. Available from :https://ec.europa.eu/energy/topics/energy-strategy/national-energy-climate-plans_en

Svaz moderní energetiky [online]. [cit. 2021-6-18]. Available from: https://www.modernienergetika.cz/aktuality/rakouska-vlada-ma-jasny-plan-jak-do-10-let-vyrabet-svoji-elektrinu-pouze-z-obnovitelnych-zdroju-cesko-dal-v-podpore-zelene-energie-tape/

Rakousko chce do roku 2030 vyrábět elektřinu pouze z obnovitelných zdrojů. *Obchodně-ekonomický úsek velvyslanectví ČR v Rakousku* [online]. [cit. 2021-6-18]. Available from: https://www.mzv.cz/vienna/cz/obchod_a_ekonomika/akce/rakousko_chce_do_roku_2030_vyrabet.html

Hannah Ritchie and Max Roser (2020) - "Energy". *Published online at OurWorldInData.org.* Retrieved from: 'https://ourworldindata.org/energy' [Online Resource]

Bioenergy in Austria: a factor creating added value https://www.biomasseverband.at/wp-content/uploads/Bioenergy-in-Austria.pdf

IEA, *Bioenergy Austria – 2018 update,* https://www.ieabioenergy.com/wp-content/uploads/2018/10/CountryReport2018_Austria_final.pdf

ENGLISCH, Michael, *Sustainable forest biomass potentials in Austria,* available from https://www.oeaw.ac.at/forebiom/WS1lectures/SessionI_Englisch.pdf

[online]. [cit. 2021-6-18]. Available from: https://ourworldindata.org/energy/country/austria

[online]. 2018 [cit. 2021-6-22]. Dostupné z: https://ct24.ceskatelevize.cz/veda/2520385-biomasa-neni-az-tak-obnovitelny-zdroj-energie-jak-se-myslelo

KOLONIČNÝ, Jan. [online]. 2010 [cit. 2021-6-22]. Dostupné z: https://biom.cz/cz/odborne-clanky/emise-pri-spalovani-biomasy-2

Facts and figures on bioenergy in the EU [online]. [cit. 2021-6-21]. Available from: https://ec.europa.eu/jrc/en/science-update/facts-and-figures-bioenergy-eu

EU Taxonomy [online]. [cit. 2021-6-22]. Dostupné z: https://ec.europa.eu/info/business-economy-euro/banking-and-finance/sustainable-finance/eu-taxonomy-sustainable-activities_en

SMITH, Matthew, Anna KRALLI a Peter LEMOINE. *Analysis on biomass in National Energy and Climate Plans* [online]. Rotterdam: Trinomics B.V., 2021 [cit. 2021-6-26]. Dostupné z:

https://www.fern.org/fileadmin/uploads/fern/Documents/2021/Fern_-_Biomass_in_NECPs_-_Final_report.pdf