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Policies to stimulate the output and employment effects of bioenergy resources in Poland and Ukraine

Abstract: The paper aims to consider the available policies for biomass output as a feedstock for further bioenergy production in post-war Ukraine in order to draw conclusions and learn lessons for the further deployment of bioenergy in Ukraine, and to define the number of jobs that bioenergy has enabled and could contribute in both Poland and Ukraine in the future. Poland has significant biomass potential, the lion's share of which is agricultural crop waste, corn, and dedicated energy crops. Ukraine has a significant potential for the production and use of biogas and biomethane due to available feedstock and a developed gas supply system. The employment factor method was used to estimate the number of jobs in bioenergy in Poland and Ukraine. Assessments, which are the main result of the work, indicate that the number of jobs in agriculture for feedstock production for energy purposes may reach thirty-three thousand by 2030 in Poland and thirteen thousand in Ukraine. Agribiomass crop production for energy purposes in Poland is supported by the Common Agriculture Policy of the EU. Energy producers from biomass have priority access to the grid and qualify for feed-in tariffs, premiums and auctions, and special financial programs. In Ukraine, biomass energy producers may have a feed-in tariff for biomass and biogas and a 10% lower tariff for heat from biomass than the tariff for heat from natural gas. Despite the benefits of biomass, the installed capacities for its utilization remain insufficient due to the existing barriers in both countries.

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In the future, Ukraine will need to develop its agricultural biomass sector more actively than before in order to substitute natural gas and other energy carriers.

Keywords: bioenergy, employment, energy policy of Poland, energy policy of Ukraine

Introduction

Renewable energy is one of the means of decarbonization of a country's energy balance. The European Union is becoming a clear leader in decarbonization globally, claiming to be carbon neutral by 2050. The European Green Deal (EGD) was announced in order to reach this objective. The provisions of the EGD are embodied in the 2021 European Climate Law, which came into force in July 2021. The law sets a legally binding target of net zero greenhouse gas emissions by 2050. The Climate Act also sets out the steps needed to complete the 2050 target: a new 2030 target to reduce net greenhouse gas emissions by at least 55% compared to 1990 levels. This is a very ambitious goal, as the individual climate plans of the Member States at the time of adoption provided for a 40% reduction in emissions. Emissions will be reduced mainly through the energy sector, including using energy from renewable sources and ceasing coal use (EC 2019a).

Given that EGD relies, to some extent, on technologies that are not yet commercially proven (fuel cells, hydrogen, new technologies in marine transport and aviation, etc.), the existing and commercially viable technologies of renewable energy generation have even higher value (EC 2019a).

Although Poland is a member of the EU and Ukraine is only a candidate country, Poland and Ukraine have many similarities – the population, relatively similar climatic conditions (which, in the context of this paper, is essential for biomass growth), a high dependency on imported energy resources, a significant reliance on coal. In Poland in 2019, the dependency on energy imports was 46% compared to 58% of the average EU-28 (GUS 2021a).

There is a wide array of biomass-based renewable energy technologies. Using biomass, one may obtain heat, electricity, biogas and biomethane, biofuels and bioliquids. Biomass is a carbon-neutral energy source, meaning that during the plant's lifetime and growth, it absorbs nearly as much carbon dioxide as is released during its combustion. Rural areas, which are an essential source of renewable energy, including biomass, may play their role in distributed energy generation and decarbonization (Roszkowska and Szubska-Włodarczyk 2022).

Different policies are to be put into place to ensure proper and sustainable biomass supply. This paper aims to consider the available policies for biomass output as a feedstock for further bioenergy production in Poland and Ukraine in order to draw conclusions and learn lessons for further bioenergy deployment in post-war Ukraine, and to define the number of jobs that bioenergy could enable and contribute in both Poland and Ukraine in the future. In this paper, we focus

on agricultural resources in biomass, or agribiomass, which includes dedicated energy crops, feedstock for biogas, biomethane and liquid biofuels, which is more narrow than the definition of biomass in the RED II Directive: "biomass means the biodegradable fraction of products, waste, and residues from biological origin from agriculture, including vegetal and animal substances, from forestry and related industries, including fisheries and aquaculture, as well as the biodegradable fraction of waste, including industrial and municipal waste of biological origin" and "agricultural biomass means biomass produced from agriculture" (EC 2018).

This paper aims to review the existing policies for agricultural biomass output, consider the policies available for energy producers from agricultural biomass in both Poland and Ukraine and assess the role of agricultural biomass for energy purposes in employment.

The paper is structured as follows: after the literature review in Section 1, Section 2 contains information on biomass in energy mixes of Poland and Ukraine, biomass support policies in Poland and Ukraine, and describes the method of employment assessment. The main quantitative result of the work is presented in Section 3. Finally, Section 4 concludes with policy recommendations for both countries.

1. Literature review

Agribiomass attracts the attention of many scholars in Poland, Ukraine and globally. Olsztyńska (2019) reviews the role of biomass in the energy mix of Poland up until 2018 to conclude the availability of a high share of fossil fuels, especially coal, in the energy mix. The author indicates that biomass resources for energy are abundant, while the number of heating plants is still insufficient. It is interesting to note that biomass for energy purposes in Poland was supplied by large energy groups (PGE, EDF, the Tauron Group, Energa, Enea), the majority of which are fossil-fuel companies, as biomass was burnt together with coal at CHPs. However, in 2016, most of these companies decided to burn coal only. The issues of increased support for lignocellulosic biofuels in the EU are also considered for achieving the EU's bioenergy targets; Gérard and Jayet (2023) state that supporting lignocellulosic prices in the EU would not substantially increase the lignocellulosic potential but could have collateral effects on the environment in terms of increased fertilizer use and nitrous oxide emissions. However, a growing import dependency on imported bioenergy in Europe can be tackled by untapped ancillary bioenergy (Wu and Pfenninger 2023) to meet the European-wide bioenergy targets and to ensure the job-creation potential bioenergy may provide.

Bioenergy can generally be a source of jobs in agriculture, chemistry, trade, transport and services, indirectly benefiting rural areas by promoting entrepreneurship and creative thinking (Roszkowska and Szubska-Włodarczyk 2022). An example of this is that in France, a 400 ha field of Miscanthus led to the creation of 70% of indirect jobs (related to the supply of goods and services) and the total number of full-time jobs reached ninety-one (De la Rúa and Lechón

2016). Bioenergy companies are required to pay taxes, thus filling local and central budgets (depending on the given country's tax legislation).

Agricultural biomass is a source of jobs, especially for feedstock planting. Even though these jobs are technically classified as those belonging to agriculture, there is still a considerable potential for employment growth.

From a broader perspective, the processing of agricultural biomass may be a source of jobs in engineering (to produce equipment). One such example is that in pre-war times, Ukraine produced small-capacity boilers for biomass combustion. Most boilers were exported abroad from Ukraine because of low internal demand. If the internal demand for biomass boilers was to grow, it would spur the local employment market because more people would be needed to produce the equipment and maintain it regularly.

Understanding the impact of agricultural biomass on employment is gaining weight, especially in light of the European Green Deal and the necessity of a just transition. This topic is particularly relevant for Poland and Ukraine as these countries still rely on coal to a great extent. NECP indicates that coal-mining regions are to be transformed, and the process of transformation requires careful employment planning and the creation of new jobs. There are several methods to assess the impact of renewable energy on employment:

- Surveys and analysis of administrative data. Researchers conduct surveys to collect data directly from energy companies or municipal authorities. These surveys may include questions about the number of employees, job categories, qualification requirements and wages. Summarizing the answers to the survey, the researchers estimate the level of employment. This method is time and labor-consuming and is therefore not the method of choice for country-scale assessments.
- Input-output analysis. This method involves analyzing the relationships between different sectors of the economy. Input-output tables and economic models estimate the direct and indirect effects of energy investments or policy changes on employment. This method cannot be applied in the early stage of industry development, as the respective modifications may not be reflected in the output results.
- Labor market modeling. Researchers develop models that simulate labor market dynamics and the interaction between labor supply and demand. These models incorporate variables such as wage rates, labor force demographics, and policy scenarios to estimate employment changes resulting from renewable energy policies. The employment factors method used in this paper belongs to this group of methods.

Heinbach et al. (2014) analyzed the employment and value-chain creation in Germany's so-called model municipality caused by onshore wind energy. The authors estimate that one model municipality with wind energy in Germany benefited with EUR 9.3 million and 166 jobs in 2011.

U.S. Energy and Employment Report (DOE 2016) focuses on the employment effects of different technologies of conventional energy, as well as renewable energy. This indicates that "conventional" employment data collected by the Bureau of Labor Statistics doesn't distinguish energy technologies across business segments, resulting in data inconsistency and the necessity to use different approaches to make data comparable.

Gradziuk (2022) made a comprehensive study of the impact of renewable energy in Poland on employment based on the statistical observations of Eurostat, EurObserv'ER, and other organizations. The study showed that liquid biofuels are associated with the highest number of jobs compared to other types of biomass use. The method used doesn't distinguish the types of jobs (managerial, auxiliary, etc.).

International Renewable Energy Agency (IRENA) and International Labor Organization (ILO) provide an annual outlook of worldwide employment in renewable energy based on a meta-study of the available information. IRENA's study distinguishes jobs based on various technologies (wind, solar, etc.); this is the most comprehensive and detailed source of information about the contribution of RES to the labor market and considers the respective policy framework (IRENA 2022).

GGGI (2020) indicates that despite the availability of studies about the employment effects of renewable energy on a global level, there is a pressing demand and need for employment studies in the context of renewables at the national level to ensure more complete policy sets and considerations in the countries' ambitions to reach their nationally determined contribution targets. Therefore, the study presented below contributes to the existing literature as it assesses policies related to bioenergy in Poland and Ukraine and the jobs that bioenergy provides in these two countries.

2. Material and methods

2.1. Biomass in energy mixes of Poland and Ukraine

Biomass has started to play a role in the energy mixes of Poland (Fig.1a) and Ukraine (Fig. 1b).

In the structure of renewables in Poland, the share of different types of biomass was over 84%, with the dominant share of solid biofuels being 73.4% (GUS 2021b). The contribution of biomass in the Polish energy balance amongst the renewables significantly exceeds that in the EU average – 84% compared to 53.8% in the EU-28 in 2019 (GUS 2021b). The share of renewable energy in total final energy consumption in 2019 in Poland was 11.6% (GUS 2021b) compared to 8.1% (SAEE 2021) in Ukraine. In Poland and Ukraine, the vast majority of biomass is primarily used for heat production. In Poland, the contribution of biomass to electricity output is 24.6% for solid biomass and 4.3% for other biomass. In Poland, heat generation from renewables grew significantly from 2017–2020 (from 13,000 to 21,000 TJ). Solid biofuels are a clear leader in the structure of energy carriers from renewables for heat production, taking 97.98% in 2020 (GUS 2021b). In Poland and Ukraine, agriculture is responsible for 12% of greenhouse gas emissions, including approximately half of non-CO_2 emissions, primarily from animal husbandry and fertilizers (NECP 2019).

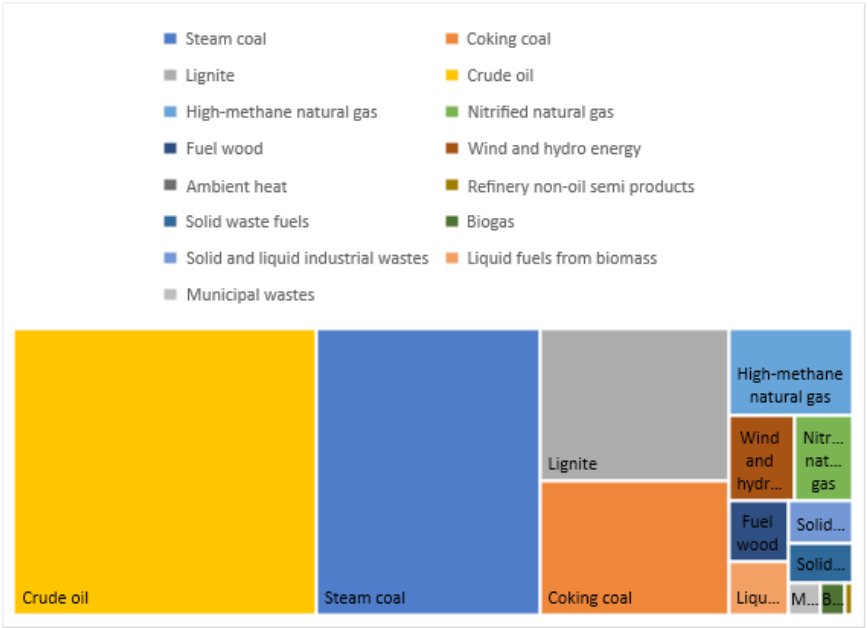

Fig. 1a. Energy mix of Poland in 2020 [%] (GUS 2022)

Rys. 1a. Miks energetyczny Polski w 2020 roku [%]

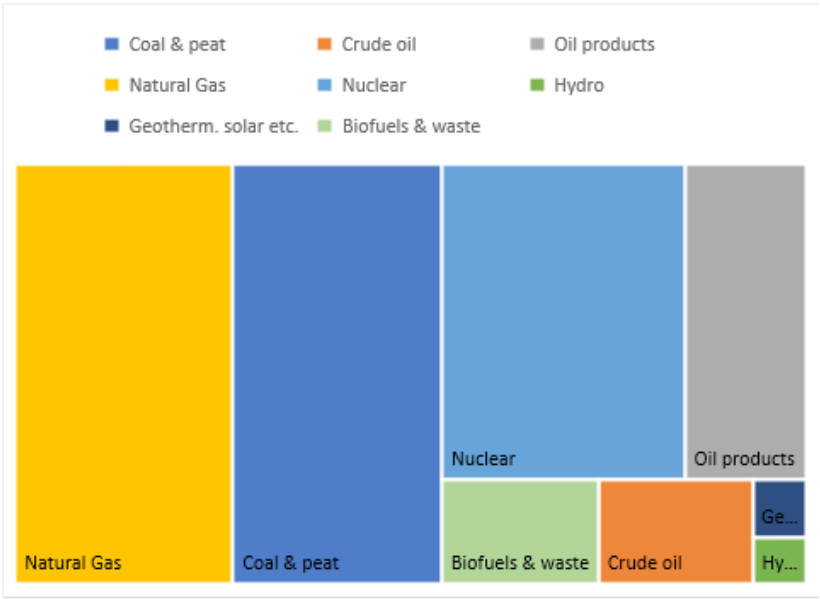

Fig. 1b. Energy mix of Ukraine in 2020 [%] (SSSU 2022)

Rys. 1b. Miks energetyczny Ukrainy w 2020 roku [%]

In Poland, about 3 million ha of land could be used to plant dedicated energy crops (Zyadin et al. 2018), of which 2 million ha is considered marginal land (Helis et al. 2021). This is mainly degraded or abandoned land. Zięnty et al. (2022) indicate the high cost of planting and maintaining dedicated energy crops coupled with uncertain policies in Poland as a significant obstacle to its widespread use in Poland, which resulted in the spread of RDF (reduced derived fuel) technology rather than biomass projects in Poland. In 2010, the surface area of energy crops in Poland was 154 ha (Helis et al. 2021). In 2021, the size of dedicated energy crops in Poland reached 13 thousand ha (Pryshliak 2021). As the result of surveys conducted, Roszkowska & Szubska-Włodarczyk (2022) indicate a lack of knowledge of farmers in Poland about the possibility of using agricultural waste for energy, which is especially the case for straw, slurry, manure, cut grass, fruit and vegetable pomace. The vast majority of respondents indicated that they use biomass only for their own needs and are not interested in the establishment of dedicated energy crop plantations (due to unprofitability of production or sales and uncertainty about the long-term demand for their products etc.).

The energy potential of biomass in Poland is estimated at 465.1 PJ, of which agriculture would provide 42% of energy contents (being the largest biomass supplier), 34% could be attributed to forestry, orchards and wood industry wastes would provide the remainder in equal proportions (Olsztyńska 2019). This is rather a good estimation because it was in the context of the EU Green Deal that the question about the practicality of biomass use for energy purposes arose became relevant, especially whether it is appropriate to remove biomass from forests or whether it could be more beneficial for the absorption of greenhouse gases. In the EU, views on the feasibility of using biomass (and, more broadly, the bioeconomy) are pretty different and polar. The issue of forest biomass use raises numerous questions (such as the primary role of forests as carbon sinks or the timespan needed for forests to grow). By contrast, the importance and usability of agricultural biomass raise much fewer questions. Despite numerous research efforts, the amount of biomass that can be safely used for energy purposes in the EU remains unknown (Andersen et al. 2021). Furthermore, in the EU, ecosystems from which biomass is collected continue to decline, but this is not the case with agricultural biomass (Andersen et al. 2021). To deploy the economically feasible bioenergy potential, the respective support policies must be carefully tailored (Özcan and Arentsen 2014).

Poland's biogas plants are located near large farms and biogas is produced from manure and slurry. Organic feedstock (waste) is a primary feedstock for biogas production, whereas targeted crops are used second (Piechota and Iglinski 2021). It is interesting to note that corn silage comprises half of the weight of distillery wastes or fruit and vegetable residues. Animal and poultry manure has the highest economically feasible potential, while agri-food waste, maize silage grown on agricultural lands, and maize silage grown on abandoned lands follow (Fig. 2).

The first biomethane installation was to be constructed and put into operation in Poland in 2021, whereas in Ukraine, this happened in 2023. This indicates an approximately similar level of technology spread. As in the case of solid biomass use by large energy companies, biomethane is claimed to be used by oil refineries and oil product retailers (PKN Orlen and PGNiG) (Piechota and Iglinski 2021).

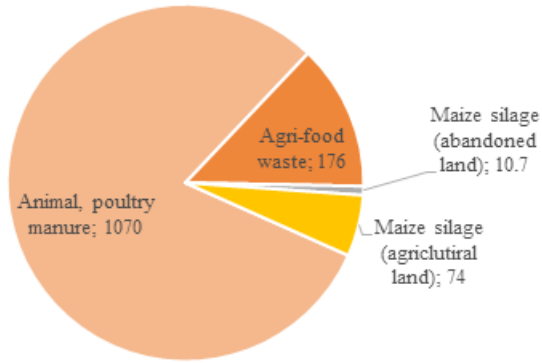

Fig. 2. Economically feasible potential for biogas output in Poland in 2021 [million m^3] (Piechota and Iglinski 2021)

Rys. 2. Ekonomicznie uzasadniony potencjał produkcji biogazu w Polsce w 2021 r. [mln m^3]

Ukraine has significant biomass potential, the lion's share of which is agricultural crop waste, corn (grown for energy purposes), and dedicated energy crops. Ukraine has relatively low forest coverage (16%), and the potential of forest biomass and sunflower husk is already 90% utilized, so there is no room for further expansion. In the structure of biomass use, woody biomass accounts for around 81%, agribiomass accounts for 17% (straw, dung, sunflower husk), and the remaining 2% is solid landfills (UABio 2022a). As of 2022, the area of dedicated energy crops in Ukraine is 6.4 thousand ha (Pryshliak 2021) (which is twice smaller than that in Poland), of which 3 thousand ha are sown with willow and 2 thousand ha are sown with Miscanthus. Energy crops are planted mainly in Western and Central Ukraine (Volyn, Lviv, Ivano-Frankivsk, and Kyiv regions). There is about 8 million ha of unproductive (marginal) land in Ukraine. Of these, about 3.5 million ha have been removed from crop rotations due to low fertility, susceptibility to erosion, or excessive moisture (Pryshliak 2021).

Biomass in Ukraine is mainly used to produce heat and electricity. Using biomass, 148,408 GWh of electricity and 388,003 TJ of heat were produced in 2020. In 2050, biomass consumption is projected to reach 23 million toe, and biomass will be able to substitute up to 14 billion m^3 of natural gas per year. Half of it will be used to produce heat, and another half is used to substitute coal for electricity production.

In 2020, in Ukraine, in the structure of renewable energy production, the largest share of renewable energy belonged to biomass (75.4%). The production of biofuels and waste increased by 17% and amounted to 4,438 thousand toe in 2020 (compared to 3,786 thousand tons in 2019) (SAEE 2021). Ukraine had a 2020 National Action Plan for the development of renewables, which set the targets for RES energy in heating and cooling, electricity output and the transport sector. The overall share of RES energy in heating and cooling (where biomass is the primary feedstock) in 2019 reached 9% compared to the 11% planned. Similarly, in the transport sector (where biofuels could be of use), the share of RES energy reached 2.5%, while it had to be 9% in 2019.

The potential of biomass is very far from being deployed. According to IRENA assessments, in 2015, the biomass potential deployment in Ukraine reached only 5%, which is especially the case for cereal straw (only 3% of potential is used), agri wastes biogas (5% of potential), and landfill gas (4% of potential). By contrast, the husks of sunflower seeds are being fully used (100%). In 2021, bioenergy potential utilization reached about 11% (UABio 2022). According to UABio, in 2019, biomass use was 3.22 Mtoe and expected to gain as much as 22.85 Mtoe in 2050 (Fig. 3). The annual average biomass market growth rate in pre-war Ukraine was 11%.

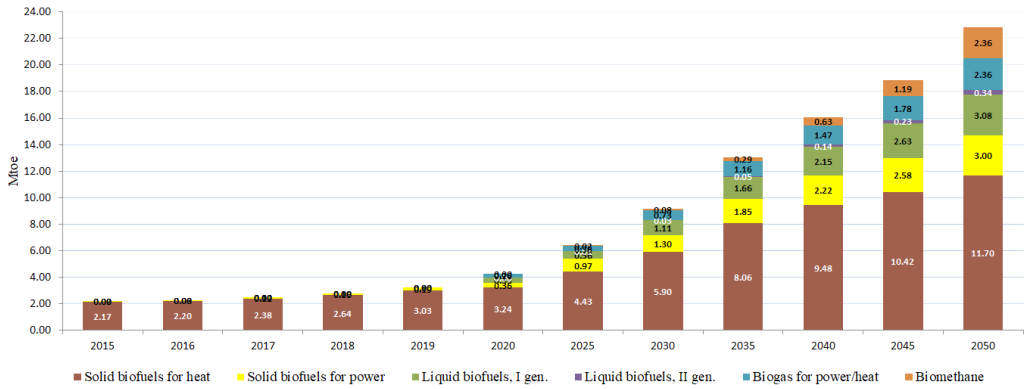

Fig. 3. The projected use of biomass in Ukraine until 2050 [Mtoe] (UABio 2020)

Rys. 3. Prognozowane wykorzystanie biomasy na Ukrainie do 2050 roku [Mtoe]

From the entire biomass indicated in Figure 3, for further calculations, we will use the data on agricultural biomass only (which includes husk, stems, and dedicated energy crops and doesn't include woody biomass, as the amounts of its use needs to decrease).

In 2020, in Ukraine, biomass substituted about 5.2 billion m^3 of natural gas (UABio 2021) (compared to 4 billion m^3 in 2019 (Tomliak 2020)). Exports of biomass reached 424 thousand toe in 2020 (compared to 442 thousand toe in 2019). In the structure of electricity production from RES in 2020, the share of biomass was 4.3% (compared to 3.1% in 2019).

The current total installed capacity of biomass-fired heat-producing facilities in Ukraine is about 5.3 thousand MW. The installed capacity of electricity-generating equipment is 170 MW, including biogas. The subsidization of natural gas can explain the slow growth of electricity-generating facilities during all the preceding years. The installed capacity of biogas plants in Ukraine is 66 MWel. The average capacity per plant is 2.37 MWel (Trypolska et al. 2022), whereas the most significant companies have 10 and 12 MW plants. Organic fertilizers, being the by-product of biogas output, could substantially improve the fertility of soils and be of use for organic agriculture, as the application of organic fertilizers in Ukraine decreased from 6.2 t/ha in 1990 to 0.27 t/ha in 2019, and the area of fertilizer application decreased sevenfold (SSSU 2022). There are plenty of solid waste landfills in Ukraine. The main impetus for biogas plants is the feed-tariff, which will remain the case for landfills in the upcoming years, as refuse sorting and

processing is not yet widespread in Ukraine. Additionally, one of the largest biogas producers (MHP) is launching the first private battery energy storage project in Ukraine with a projected capacity of 25 MW.

According to EBRD assessments, in 2019 in Ukraine, biomass enabled the saving of 8 million tons of CO_2 emissions (Tomliak 2020). The majority (about 2500 units) of biomass-fired municipal boiler houses use woody biomass. Over 150 boiler houses use straw or sunflower husk feedstock (LandLord 2017). Industry has slowly started to utilize the potential of biomass. It has good prospects for green hydrogen output. With regard to municipal heat output, the share of households in some towns reaches 90%, so both the municipal sector and the households are the two main sectors that have to increase the use of biomass.

In Poland, the areas of dedicated energy crops in 2010 reached 10.2 thousand ha (0.06% of the total arable land of the country), with a significant dominance of shrub willow and, to a lesser extent, giant Miscanthus. The interest of farmers in dedicated energy crops remains low due to the lack of financial support for starting the plantation, the high upfront costs, the high cost of harvesting machines, and the long payback period (Olsztyńska 2019).

Polish legislation introduces the minimal threshold values for agricultural biomass content for energy purposes – 85% for multi-fuel combustion plants with a capacity of 5 MWel and above, and 10% for biomass-burning installations with a capacity of 20 MW and above (Olsztyńska 2019).

In Poland, until the end of 2018, the only way to subsidize the use of biomass for heat production was the use of biomass for co-generation purposes (Olsztyńska 2019). By contrast, in Ukraine in 2015, a Law was adopted inducing the tariff from renewables at 90% of the tariff for heat produced from natural gas.

2.2. Methods

To assess jobs, the employment factors method was used. It is widely used by the International Labor Organization (ILO). To know the available and projected installed capacities, we use data from the National Renewable Energy Action Plan draft until 2030 for Ukraine (dNREAP 2030)[1] and the data from NECP 2021–2030 for Poland. To simplify the process, we consider only the electricity and heat output from agricultural biomass; in other words, the assessment doesn't include biofuels. In Poland in 2019, in the structure of energy by carriers, the share of energy from solid biomass and biogas reached 75.8% compared to 8% from liquid biofuels (GUS 2021b). The assessment is based on a study by Rutovitz et al. (2015) that uses the following formula:

[1] The draft of NREAP2030 had a high chance of being adopted in early 2022, but the Russia-Ukraine war hindered the process.

The total employment in RES can be assessed as the sum of jobs in equipment manufacturing, construction and installation, operation and maintenance, as fuel supply (which is the case of biomass). It can be denominated in Formula 1:

$$EMPL = EqMan + C\,\&\,I + O\,\&\,M + FS \tag{1}$$

To assess jobs in equipment manufacturing, we use Formula 2:

$$EqMan = Inst\left(year\right) \cdot ManEF \cdot RJM\left(year\right) \tag{2}$$

To assess jobs in construction and installation, we use Formula 3:

$$C\,\&\,I = Inst\left(year\right) \cdot C\,\&\,IEF \cdot RJM\left(year\right) \tag{3}$$

To assess jobs in operation and maintenance, we use Formula 4:

$$O\,\&\,M = CumCap \cdot O\,\&\,MEF \cdot RJM\left(year\right) \tag{4}$$

To assess jobs in fuel supply, we use Formula 5:

$$FS = PED \cdot EFfuel \cdot RJM\left(year\right) \cdot Dom \tag{5},$$

where:

- *EqMan* – equipment manufacturing,
- *C&I* – construction and installation,
- *O&M* – operation and maintenance,
- *FS* – fuel supply,
- *Inst*(*year*) – capacity installed in the bioenergy source each year [MW],
- *ManEF* – manufacturing employment factor,
- *RJM* (*year*) – regional job multiplier per year,
- *C&IEF* – construction and installation employment factor,
- *CumCap* – cumulative installed capacities,
- *O&MEF* – operation and maintenance employment factor,
- *PED* – primary energy demand,
- *EFfuel* – employment factor for fuel,
- *Dom* – share of domestic production.

The actual and projected capacities for agricultural biomass and biogas use in Ukraine are shown in Figure 4. They differ from those indicated in Figure 3 because for the following calculations, we only use data for agricultural biomass, as well as because, in Ukraine, there are no exact statistics on the installed capacities of small biomass-fired facilities.

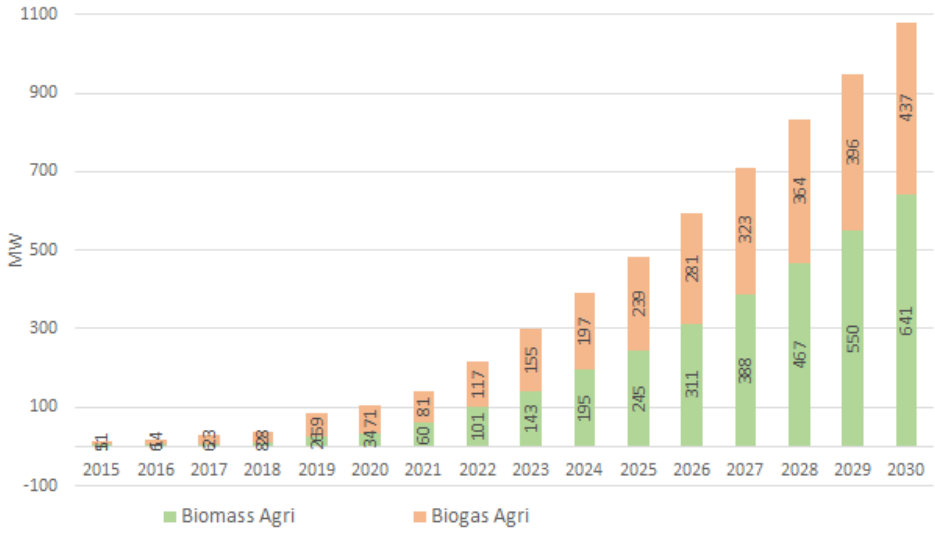

Fig. 4. Actual and projected installed capacities for agricultural biomass and biogas installations in Ukraine in 2015–2030 [MW]. Own elaboration based on (UABio 2020)

Rys. 4. Rzeczywiste i prognozowane moce zainstalowane w instalacjach biomasy rolniczej i biogazu na Ukrainie w latach 2015–2030 [MW]

The actual and projected installed capacities for bioenergy in Poland are shown in Figure 5.

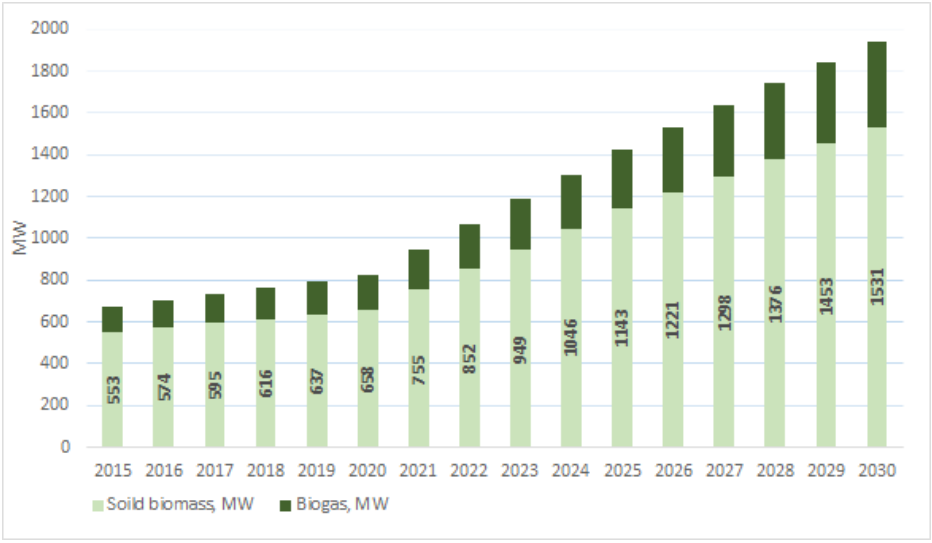

Fig. 5. Actual and projected installed capacities for agricultural biogas and biomass installations in Poland in 2015–2030 [MW]. Own elaboration based on (NECP 2019)

Rys. 5. Rzeczywiste i prognozowane moce zainstalowane w instalacjach biogazu rolniczego i biomasy w Polsce w latach 2015–2030 [MW]

It is essential to remember that the statistics in Poland don't distinguish the types of solid biomass for energy purposes; therefore, it is difficult to estimate the share of agricultural biomass. The percentage of "other" biogas (i.e., agricultural biogas) in the overall biogas in the energy balance in Poland in 2016–2020 is shown in Table 1.

Table 1. Heat and electricity output from biogas in the years 2016–2020 in Poland

Tabela 1. Produkcja ciepła i energii elektrycznej z biogazu w latach 2016–2020 w Polsce

	2016	2017	2018	2019	2020
Agricultural biogas for heat	26%	79%	85%	86%	84%
Agricultural biogas for electricity	43%	51%	55%	53%	55%

For further calculation, we assume that the production of electricity and heat from agricultural biogas in Poland will remain at 85% for heat and 55% for electricity out of the entire biogas. As for biomass, the statistics in Poland don't distinguish between the types of solid biomass.

To conduct the assessment for Poland, we assumed that the installed capacities every five years (e.g., 2020–2025, 2025–2030) grow by equal installations annually. In reality, this is not the case for many reasons (presence/lack of support policies, macroeconomic situation, etc.). Regional employment multipliers for both Poland and Ukraine are shown in Table 2. We consider them the same due to the location of countries in the same geographic region and the use of the same labor productivity.

Table 2. Regional multipliers for Poland and Ukraine

Tabela 2. Regionalne mnożniki dla Polski i Ukrainy

	2015	2020	2025	2030
Regional multipliers	1.05	1.08	1.10	1.13
Share of local manufacturing [%]	90	90	90	90

Source: (Ram et al. 2020).

The manufacturing (*Mfc*), construction and installation (*C&I*), operation and maintenance (*O&M*), and fuel supply factors for Poland and Ukraine are shown in Table 3. We consider them the same due to the use of the same technologies.

Table 3. Major factors for biomass and biogas installations

Tabela 3. Główne czynniki dla instalacji na biomasę i biogaz

	Mfc. [job-yrs /MW]	*C&I* [job-yrs /MW]	*O&M* [jobs/MW]	Fuel [jobs/PJ]
Biomass	2.9	14	1.5	29.90
Biogas	2.9	14	2.25	29.90

Source: (Ram et al. 2020).

The amount of biomass resources used and needed as fuel (i.e., biomass feedstock) in Ukraine is presented in Figure 6. The draft of NREAP2030 doesn't distinguish between the types of biogas plants (i.e., biogas, landfill gas, or another type); therefore, we assume that the share of installed capacities for agribiogas in 2019 and later is 69% (as it was in 2019).

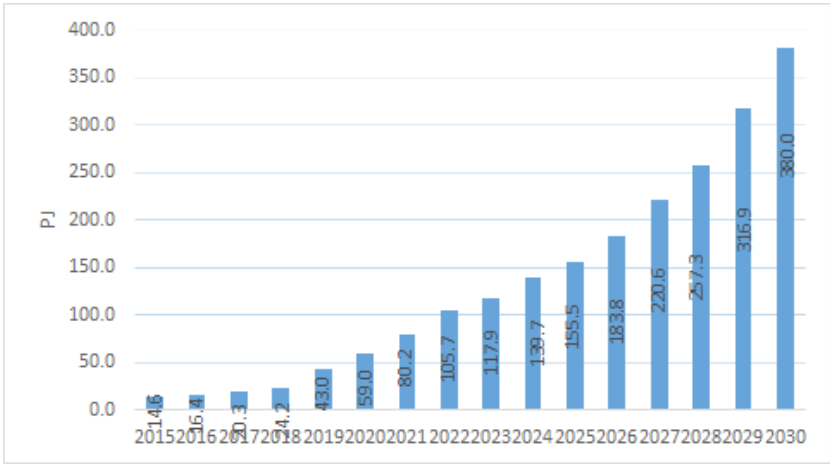

Fig. 6. Agricultural biomass and biogas feedstock in Ukraine in 2015–2030 [PJ]
Own elaboration based on (UABio 2020)

Rys. 6. Biomasa rolnicza i surowce do produkcji biogazu na Ukrainie w latach 2015–2030 [PJ]

3. Results and discussion

3.1. Agricultural biomass support policies in Poland

Overall, there are several directions of support policies in Poland. These are as follows:

- support within energy policies of the EU (and respective local policies);
- support within the Common Agricultural Policy (CAP).

Poland's National Climate and Energy Plan for 2021–2030 (NECP 2019) defines the trajectories of demand for bioenergy by sectors (heating and cooling, electricity, biofuels) and by carbon emissions sinks. NECP specifies that about 13% of the biomass (i.e. 900 PJ/year) can be used for energy purposes without compromising the food supply security or obeying the environmental requirements envisaged by CAP. Straw (i.e. agricultural biomass) is the most abundant type of biomass; its surplus reached 2–4.5 million tons per year (depending on crop yields). The energy potential of the dedicated energy crops reaches approximately 120–130 thousand dry tons, whereas orchards can yield 88.7 thousand tons annually. The energy potential of agricultural biogas reaches 7.8 billion m^3 annually.

REDII Directive (EC 2018) presumed the use of so-called first-generation liquid biofuels and advanced biofuels. The latter had to reach 0.1% (on energy contents) in 2020, but this is difficult to achieve in Poland due to limited access to technologies to process lingo-cellulose and see-weed. However, the share of advanced biofuels in 2023–2030 is expected to significantly increase– up to 4% in the fuel market (based on energy contents), which is expected to be reached by means of biomethane (Piechota and Iglinski 2021).

Overall, energy generation from renewables in Poland in general and from biomass in particular is subject to a wide range of support measures, such as *priority access to the grid, feed-in tariffs and/or feed-in premiums, auctions, repayable financial assistance, guarantees of origin and aid to non-commercialised technologies.*

Priority access to the electric grid is the critical support element. It might be reviewed, but small installations (i.e., those with a capacity of not more than 400 kW, and from 2026 those with an installed capacity of less than 200 kW) will continue to have priority access (EC 2019b).

Feed-in tariffs or feed-in premiums are only used for relatively small installations to manage the energy that was not used by that installation (in other words, it indirectly presumes the net metering system).

Auctions apply to large-scale installations only and are aimed at reducing energy-produced costs. They can be designed to stimulate energy output in particular areas. The first auction took place in 2018, covering 10 TWh (Matłacz 2019), followed by another in 2019, covering 35 TWh (or 3400 MW of installations (SRP 2019)).

Repayable financial assistance mainly applies to developing particular regions.

Guarantees of origin is a tool certifying that specific batches of energy were produced from renewable energy sources. Guarantees of origin (in the form of green certificates) are to be purchased by different entities to prove that they consume energy from RES. Green certificates apply to all RES generation types, including biomass co-firing (for facilities over 5 MW) and biomass origin (for facilities over 20 MW). Failure to obtain the green certificates results in a substitution fee tied to an average price for coal-fired electricity (IEA 2022).

Aid to non-commercialized technologies includes the assistance to technologies that are not yet cost-effective but are significant for environmental or energy considerations.

There are several funding programs aimed at the increased use of renewable energy in Poland, including not only electricity but also heating:

- Energia Plus (Energy Plus Priority Programme) (2020–2021) – a program with a total budget of PLN 4 billion, aimed at decreasing the negative environmental impact of companies by various means, including the use of RES (CMRP 2020);
- Ciepłownictwo Powiatowe (District heating) (2019–2025) – a pilot program with funding of PLN 300 million, aimed at decreasing the negative environmental impact of heat output by various means, including the use of RES;
- Agroenergia – a priority program of the National Fund for Environmental Protection and Water Management of Poland with funding of PLN 200 million, aimed at decreasing the negative environmental impact of agriculture, the spread of various types of renewable energy in rural areas, and the reduction of energy poverty in rural areas. There are two forms of

funding. Under one form, PLN 80 million was reserved for subsidies for individual farmers, but one subsidy didn't exceed PLN 800 thousand. Under another arrangement, PLN 120 million is to be disbursed as loans. The loan amounts will vary from PLN 100,000 up to PLN 2 million. Grants will amount to 40%, and loans will be up to 100% of eligible costs. One of the targeted technologies of the program is biogas installations (due to the possibility of cogeneration and the ability to utilize agricultural wastes, including those of animal origin). Biogas can be stored and used for regulation or on a when-needed basis. To qualify for the program, a farmer must possess or rent 1–300 ha of arable land. The program will last until 2027. Only new facilities qualify for the program. The program anticipates fund provision in the form of reimbursement, which means that farmers are to find the initial funding on their own, whereas the upfront costs of biogas plants are relatively high. It is interesting to note that in Poland, there is no direct financial support for biomethane production, compared to that in other EU countries (e.g. special rate for biomethane as is the case in the Netherlands, France, Denmark and Italy, and there is no feed-in tariff or feed-in premium for electricity from biomethane, as is the case in Germany, France and Switzerland).

Several financial and banking institutions provide relatively large loans for renewable energy projects in Poland. They include the Environmental Protection Bank of Poland (the eco-bank), the National Fund for Environmental Protection and Water Management, and the Woiewodeship Fund for Environmental Protection and Water Management (Gramwzielone 2020).

Agriculture in Poland has the potential for a significant reduction in CO_2 emissions. The "2030 Sustainable Rural Development, Agriculture and Fisheries Strategy" (SZRWRiR 2019), being integrated with the "Strategy for Responsible Development until 2020 (with a Perspective to 2030)", sets the objective of the agri-food sector to increase competitiveness, taking into account the environmental concerns.

CAP is a Pan-European support policy for agriculture. The prerequisite for CAP is the Treaty on the Functioning of the European Union (EU 2012), which among other objectives, is aimed at the increased agricultural output using modern technologies and the rational use of labor, ensuring fair living conditions for inhabitants of rural areas, ensuring reliable food supplies at reasonable prices. The legislative package of 2020 anticipates the minimal threshold for climate -related measures of 40% of all budget expenditures of CAP. Given the relatively new European Green Deal agenda and enhanced requirements to preserve biodiversity, planting dedicated energy crops relies on CAP's goals to develop rural areas, maintain the environment and climate, and local development, including bioeconomy.

Until 2020 in Poland, the support system for dedicated energy crops was regulated by the Act on Payments in the Direct Payments Scheme of 5 February 2015. Although this didn't include any direct support, particularly for energy crops (or the production of biomass for energy purposes) for 2015–2021, the possible support was (and is) in the form of area payment, payments for greening, payments for young farmers (under the age of 40), as well as payments to areas with natural constraints (Fig. 7). The latter are established annually by the Ministry of Agriculture of Poland. Additionally, in 2007–2009, there were payments to begin an energy plantation, should the farmer meet the necessary criteria (concerning the minimal size of the plot, maintaining the

biodiversity, etc.). The payments were 50% of the flat-rate cost, the latter for willow was about EUR 1892/ha, and the national budgets covered the funds. This policy measure resulted in an increment of the plantation areas. Since 2010, there has been no specific program to support the establishment of the plantations in Poland. By contrast, Zięnty et al. (2022) and Ben Fradj et al. (2020) indicate that establishing at least willow plantations can benefit farmers in Poland.

Fig. 7. Payments for dedicated energy crops in Poland in 2015–2022 [EUR/ha]
(Ziety et al. 2022; MRRW 2021a; MRRW 2021b; MRRW 2021c; MRRW 2021d)

Rys. 7. Dopłaty do dedykowanych upraw energetycznych w Polsce w latach 2015–2022 [EUR/ha]

Having that said, further stimulation measures are needed to establish dedicated energy crop plantations in Poland, as the available stimulation measures are insufficient to create a viable alternative to other types of biomass production (Ziety et al. 2022), and the available stimulation policy (e.g. certificates) benefits companies using biomass, and not farmers producing it. Additional studies are needed to see if dedicated energy crops or increased forestry growth could be established in the coal regions (similar to a pilot Leśne Gospodarstwa Węglowe), etc.

The obstacles that hinder wider biomass deployment for energy purposes in Poland include, but are not limited to:

- the lower price of coal compared to that of biomass (in energy units);
- the availability of infrastructure for coal;
- the absence of any need to collect paperwork for coal, while biomass needs certificates of origin, the value of which dropped in 2017 due to oversupply (Olsztyńska 2019).

3.2. Agricultural biomass support policies in Ukraine

While considering agricultural biomass support policies in Ukraine, one should remember that Ukraine is not a member of the EU and thus doesn't qualify for CAP support for feedstock production. The particular support programs available in 2022 included budget subsidy for keeping cows, the reimbursement of costs for obtaining advisory services and a budget subsidy to newly established farms (FinSee 2022). This means that there are some support mechanisms, but they are relatively scarce. This could be the case due to war. Nonetheless, in the post-war period, agricultural support programs are to be extended, particularly for the creation of soft loans (or the reimbursement of interest rates of the commercial banks to purchase the equipment or to start the plantation of dedicated energy crops).

The development of the renewables heat market in Ukraine occurs not due to subsidies or other forms of state support but rather due to the rapid rise in heat prices, which became the main driver of the market for heat from renewable sources.

Agricultural biomass is the most efficient for heat production and cogeneration. The market remains underdeveloped due to discrepancies in regulations, imperfect tariff formation in housing and communal services, and the subsidized cost of natural gas. As of the 2021/2022 and 2022/2023 heating seasons, there are three types of natural gas prices:

1) for industry (the highest, the price level not established);
2) for the budget sphere (about EUR 525/1000 m^3);
3) for households (the lowest – about EUR 260/1000 m^3).

Industry eagerly substitutes natural gas with biomass. The COVID-19 pandemic, coupled with the increased use of biomass, resulted in a 24% decrease in natural gas consumption in 2021 compared to 2020 (reaching 6.3 billion m^3 of natural gas in 2021) (UABio 2022). Due to the rapidly growing demand for biomass, the prices of the latter almost reached the price of natural gas (in terms of its energy value). The tariffs for natural gas for households are established manually, so in most households, the tariffs for heat are high but bearable. For the domestic needs of households, natural gas of domestic extraction is used. In the budget sphere, the local municipalities find it difficult to bear the cost of natural gas. Large-scale gas subsidization harms the biomass-based heat supply market, making agricultural biomass less competitive.

The budget sphere is the one that is the most targeted by the regulatory policy on the spread of renewable energy. To this end, the Law of Ukraine "On Amendments to the Law of Ukraine" On Heat Supply "to Stimulate the Production of Heat from Alternative Energy Sources" № 1959-VIII, which provides for the formation of heat tariffs for the households and the budget using RES, at the level of 90% of the tariff for heat obtained using natural gas (SCU 2017).

Ukraine is a member of the Energy Community; therefore, the country has obligations regarding the consumption of renewable energy. As of 2023, a feed-in tariff was available in Ukraine, enacted in 2009. In the case of agricultural biomass, the feed-in tariff was applicable for BioCHPs and biogas plants. Additionally, an auction system to distribute the support quotas had to be introduced as early as 2019, but no auctions have taken place until now. Before the outbreak of the Russia-Ukraine war, the final variant of quotas for auctions was not approved. Accor-

ding to STC "Biomass" information, the support quotas for biomass and biogas cannot exceed 50 MW. In the field of bioenergy, several projects ready to be commissioned with a capacity of about 50 MW (Khmelnytsky BioTPP (46 MW), Kernel (60 MW), vertically integrated holding MHP (24 MW)) (Expro 2019).

Ukraine has a significant potential for the production and use of biogas and biomethane due to the available feedstock and the developed gas supply system, and the fact that about 70% of households have access to the natural gas supply, so there is a technical possibility to connect biomethane producers to gas distribution networks of low pressure for local biomethane supply as a substitute for natural gas. In Ukraine, the feed-in tariff (EUR 0.1239/kWh) is the only economic impetus for developing biogas projects. The leading investors in biogas projects in Ukraine are large agricultural holdings, implementing projects with a capacity of at least 2.5 MW. By contrast, the available agricultural potential allows the construction of smaller stations. Biogas projects require investments higher than investments in wind or solar energy projects.

According to the Law of Ukraine "On Amendments to Certain Laws of Ukraine on Improving Conditions for Support of Electricity Production from Alternative Energy Sources" № 810-IX of 21.07.2020 (Law introducing auctions), a feed-in tariff will be provided only to facilities put into operation before 2023. This means that from 2023 onwards, all biogas plants, including small plants, will have to participate in auctions to receive state support. According to the Law of Ukraine №810-IX, the auction price for non-wind and non-solar projects may not exceed EUR 0.012/kWh, including for small producers. This makes biogas projects unattractive to investors, especially farmers (Trypolska et al. 2022). Furthermore, before the war, leading financial institutions were not inclined to provide loans for projects that involved the sale of electricity against the feed-in tariff.

The Law of Ukraine "On Amendments to Certain Laws of Ukraine on the Development of Biomethane Production" № 1820-IX of 21.10.2021 aims to form a market for biomethane in Ukraine. Immediately before the war, there were fifty-three biogas plants in Ukraine with a total capacity of 103.4 MW operating against a feed-in tariff. The verification of biomethane is required to ensure acceptable quality for the supply of gas transmission and gas distribution networks. Thus far, the mechanism of the verification procedure has not been agreed upon. It is also necessary to provide guarantees of the origin of biomethane, which is expected to be achieved with the adoption of this law. In the EU, biogas purification to the level of biomethane is subsidized (similar to feed-in premiums) due to the process being costly. In Ukraine, such subsidies are not yet provided, so enabling biomethane production requires additional incentive tools.

With regard to the liquid biofuel market, there is no blending mandate requirement in Ukraine. This explains the lack of growth or even development of this market. However, during 2017–2019, Ukraine had a program defining "The procedure for using the funds provided in the state budget for partial compensation of the cost of agricultural machinery and equipment, special wagons for grain transportation, equipment for the production of bioethanol and electricity from biomass, purchased from domestic producers" (CMU 2017; CMU 2019). Around UAH 900 million has been allocated in 2019 to finance this program. Along with equipment for bioethanol production, grain production is also subsidized. An example of this is that in 2018, the

subsidy for grain production amounted to UAH 960 million, and in 2019, there were no funds left to reimburse the cost of equipment for bioethanol production. Overall, from 2013–2017, the following actual allocations to support the biofuels market were made (BRDO 2019):

- transactions for the supply of machinery, equipment, and facilities in the amount of UAH 33.3 million were exempted from VAT;
- a zero excise tax applied in 2016 for 195.7 thousand dal of bioethanol worth UAH 207 million;
- the provision of a tax rebate for 829 people of a total of UAH 1.7 million for the re-equipment of a vehicle for the use of biofuels and gas.

In April 2022, the Supreme Council of Ukraine adopted as a basis bill №7233, which provides for a reduction in VAT on alternative fuels from 20% to 7% and waives the excise tax on bioethanol used by companies to produce motor gasoline containing bioethanol, ethyl tert-butyl ether and other additives based on bioethanol.

As of 2023, several problems (apart from war) are hindering the development of the biomass market. The war exacerbates them, but these issues will need to be addressed after the war ends. They include, but are not limited to, the following:

- In Ukraine, biomass is not considered a CO_2-neutral fuel from the point of view of legislation. CO_2 tax exemption for biomass plants will partially improve the financial performance of biomass energy projects. A register of biomass combustion plants needs to be formed to administer this tax.
- Dedicated energy crops require state support. These energy crops can be grown on 4 million ha of low-yielding land, allowing the substitution of up to 20 million m^3 of natural gas per year in the district heating system. To address the problem, the respective draft law was developed. The draft law provides for the definition of "energy crops", the establishment of rent for land to an amount not exceeding 5% of the normative monetary value of land, and the establishment of a minimum lease for land for energy crops for at least 20 years. Additionally, the draft law does not address the issue of VAT exemption for seedlings and shoots of dedicated energy crops that are not marketable products (as dedicated energy crops can be used as energy feedstock after reaching the age of seven on average). Furthermore, additional state support is needed to start the plantation and purchase special agricultural machinery to harvest the crops.

Overall, biomass growing and supply support policies are not sufficient in Ukraine. Therefore, state financial assistance should be provided to farmers involved in biomass planting, including dedicated energy crops, by expanding the state program to support farmers purchasing certain types of machinery and equipment (UABio 2019). Furthermore, special subsidies are needed to establish dedicated energy crop plantations.

Ukraine is the Energy Community Contracting Party, so RED II provisions became mandatory for Ukraine regarding the share of RES in the transport sector. This requires the contribution of advanced biofuels of at least 0.2% in 2022, at least 1% in 2025, and at least 3.5% in 2030. Additionally, Ukraine as the contracting party is to set an obligation of the final energy consumption in the transport sector to be at least 14% by 2030. It is noteworthy that even the current insufficient amount of biofuels consumed in Ukraine are first-generation biofuels

that do not meet the requirements for GHG emissions reduction; thus, the biofuels Ukraine uses are so-called non-compliant biofuels (Altmann at al. 2020). In light of the war and the cessation of the supply of petrol and diesel from Belarus and the resulting fuel crisis in May 2022, one may witness a growing interest in biofuels, at least in the mass media. This may potentially result in the adoption of legislation, for instance, regarding the biofuels blending mandate requirement.

3.3. The impact of agricultural biomass resources on employment in Ukraine and Poland

Using Formulae 1–5 and coefficients from Tables 3 and 4, we assessed jobs in Ukraine's agricultural biomass and biogas industries (Fig. 8).

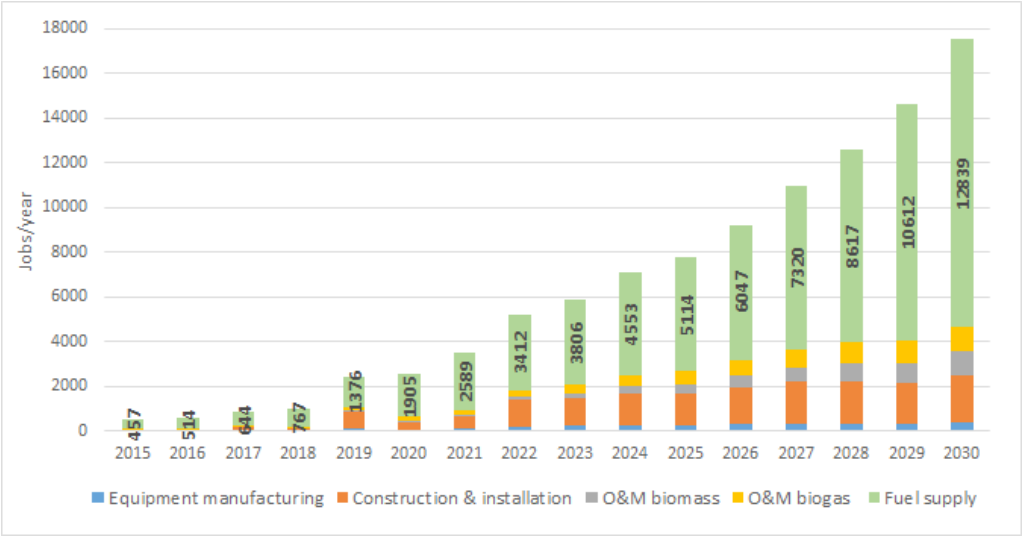

Fig. 8. The past and projected employment at biomass and biogas installations in Ukraine in 2015–2030 [jobs/year]. Own assessment

Rys. 8. Dotychczasowe i prognozowane zatrudnienie w instalacjach biomasy i biogazu na Ukrainie w latach 2015–2030 [miejsca pracy/rok]

Figure 8 indicates that the number of jobs to produce heat and electricity based on agricultural biomass will reach more than 18 thousand in Ukraine in 2030. Figure 8 also vividly shows that the lion's share of jobs related to energy production from biomass refers to fuel supply, which is classified as jobs in agriculture, and they technically took place mainly in rural areas, for example, the share of employment in agriculture in 2015 for bioenergy purposes in Ukraine

reached 84% to decline to 73% in 2030, which reflects the mechanization of processes and the economy of scale.

Figure 8 indicates that the most significant source of jobs for energy production from agri-biomass lies in the field of fuel supply, particularly planting energy crops and collecting slurry and manure.

Using the same approach, we assess the jobs for bioenergy in Poland. The amount of agricultural feedstock used for energy production in Poland is shown in Figure 9.

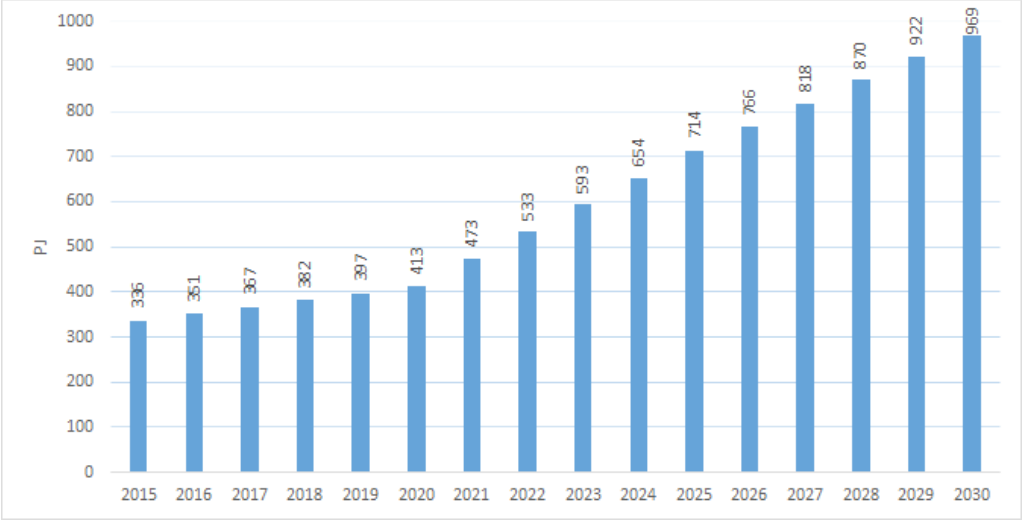

Fig. 9. Agricultural biomass and biogas feedstock in Poland in 2015–2030 [PJ]. Own assessment

Rys. 9. Biomasa rolnicza i surowce do produkcji biogazu w Polsce w latach 2015–2030 [PJ]

Using Formulae 1–5 and coefficients from Tables 3 and 4, we assess jobs in Poland's agricultural biomass and biogas industries. The results of jobs assessment are provided in Figure 10.

Figure 10 indicates that the number of jobs in agriculture in Poland for feedstock production may reach 33 thousand by 2030 compared to 10.5 thousand in 2015. The sharp growth of the installed capacities starting in 2021 indicates the development of the installed capacities and the high need for construction and installation services. The results presented for Poland are commensurable with those presented by Gradziuk (2022); however, the latter include liquid biofuels, which the current paper lacks.

To summarize, Poland is much more advanced in implementing biomass potential. There might be numerous reasons, including a more favorable environment for investments and more comprehensive support for farmers in Poland. Poland is projected to remain more advanced until 2030 (at least in terms of jobs created in bioenergy) (Fig. 11). Judging only from bioenergy development projections, Ukraine is significantly lagging behind, and the Russia-Ukraine war doesn't contribute to overcoming this backlog.

Fig. 10. The past and projected employment at biomass and biogas installations in Poland in 2015-2030 [jobs/year]. Own assessment

Rys. 10. Dotychczasowe i prognozowane zatrudnienie w instalacjach biomasy i biogazu w Polsce w latach 2015–2030

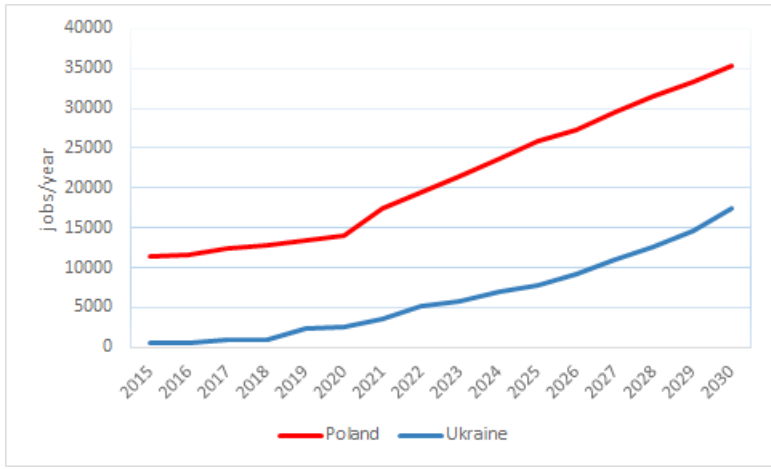

Fig. 11. The past and projected employment in bioenergy in Poland and Ukraine in 2015-2030 [jobs/year] Own assessment

Rys. 11. Dotychczasowe i prognozowane zatrudnienie w sektorze bioenergii w Polsce i na Ukrainie w latach 2015–2030 [miejsca pracy/rok]

Agricultural bioenergy is an essential source of jobs, especially in rural areas in both Poland and Ukraine.

Conclusions and policy recommendations

Biomass is an essential fuel in the course of the European Green Deal. It already plays a vital role amongst other renewables in the energy mixes of Poland and Ukraine. Biomass may play an important role in cities and rural areas regarding energy supply decentralization and job creation (to plant or collect the feedstock for biomass energy technologies). Despite the benefits of biomass, the installed capacities for its utilization remain insufficient due to the existing barriers, such as inadequate profitability of projects, high upfront costs, incomplete knowledge of farmers about modern technologies, and a lack of established business connections between the farmers and energy producers.

Comparing policies in the wider use of agribiomass, one may state that Poland has support policies within the energy policies of the EU and the CAP of the EU: the National Climate and Energy Plan for 2021–2030, which sets targets for the utilization of biomass (whereas in Ukraine, this plan is yet to be adopted); in Poland, priority access to the electric grid is given to small installations; feed-in tariffs and/or feed-in premiums are used for small installations, whereas large-scale installations would qualify for auctions; repayable financial assistance is provided for developing specific regions; guarantees of origin are used to certify energy produced from renewable sources; several funding programs exist. Ukraine is not a member of the EU and does not qualify for CAP support; rising heat prices rather than subsidies drive the development of the renewables heat market in Ukraine; agricultural biomass is underdeveloped due to regulatory discrepancies and subsidized natural gas prices; a feed-in tariff is available for agricultural biomass, but no auctions have taken place yet. In summary, Poland has more comprehensive support policies for agricultural biomass, including various support measures, funding programs, and targets. By contrast, Ukraine has limited support programs and relies on rising heat prices to drive the renewables heat market. Ukraine has a feed-in tariff for agricultural biomass.

In Ukraine, the number of jobs related to producing heat and electricity from agricultural biomass in Ukraine is projected to exceed 18,000 by 2030. Most jobs in the biomass industry in Ukraine are in fuel supply. In 2015, the employment share in agriculture for bioenergy purposes was 84%, but it is expected to decline to 73% by 2030 due to mechanization and economies of scale. The primary sources of employment in Ukraine's bioenergy sector are related to planting energy crops and collecting slurry and manure. In Poland, the number of jobs in agriculture for feedstock production is projected to reach 33,000 by 2030, compared to 10,500 in 2015. The rapid growth of installed capacities starting in 2021 suggests a high demand for construction and installation services in Poland's biomass and biogas industries. Poland is considered more advanced in implementing biomass potential than Ukraine, especially regarding job creation in the bioenergy sector.

For the further uptake of bioenergy development in Poland, the following measures are suggested:

- Introduce the definition of biomethane into the Polish legislation (Wysokienapiecie 2020) and define the quality standards for it to be similar to the quality standards for natural gas (such as the norm # PN-C-04750), which would enable to feed biomethane into the grid.

- Develop provisions and support policies to feed the biomethane into the existing natural gas grid.
- Expand the feed-in tariff and feed-in premium systems for electricity generated using biomethane.
- Qualify biomethane to obtain its guarantees of origin in Poland.
- Consider the long-term price decline for biomethane and expand the gas network in small towns and villages, particularly for the use of biomethane in the latter, which would help to decrease the dependence on imported natural gas.
- Given the fact that the overall process to develop a biomethane plant in Poland takes about three years, of which about year 1.5 is to be spent on obtaining a grant/loan (Piechota and Iglinski 2021), develop a state program aimed at the reasonably fast provision of soft loans to potential biomethane developers.
- Introduce direct subsidies for dedicated energy crops, i.e. for energy crops plantations in the form of 50% flat-rate cost reimbursement of the costs to establish a new plantation, as well as to establish an obligation for the power industry to buy all the electricity produced using the dedicated energy crops.
- Reduce legal barriers to starting plantations and simplify the process of obtaining environmental assessments or the certification of leading production.
- Spread knowledge on biomass as an energy resource both amongst farmers and ordinary people to overcome the "not in my backyard" mentality.
- Promote energy companies to organize the logistics of delivering biomass in different forms for energy purposes and widely communicate the long-term intention to purchase biomass.

Despite the current war and uncertainties about its duration, Ukraine will need to develop its agricultural biomass sector more actively than before to substitute natural gas and other energy carriers. Therefore, numerous measures to stimulate agricultural biomass sector development are to be implemented in post-war Ukraine:

- Adopt the draft law on dedicated energy crops to put this type of agricultural activity in a regulatory framework; waive income tax for the first five years of a plantation's activity, as 5-year-old bioenergy crops are not yet a final or semi-final product; waive the land rent for bioenergy crops plantations for five years.
- Implement the electronic trade of solid biomass (electronic burse).
- Stimulate the use of straw, stems, sunflower husks, agricultural residues, dedicated energy crops, liquid biofuels, and solid waste for energy production.
- Find a sustainable long-term source of funds to pay the feed-in tariff for biomass and biogas companies (and cover the existing debts).
- Adopt the draft law exempting biomass as fuel from CO_2 tax, as it directly affects the profitability of biomass-fired installations and CHPs.
- Establish a single price for natural gas for industry, the budget sphere and households, subsidizing the vulnerable families and budget sphere.
- Establish nurseries of energy crops in all regions of Ukraine (as different areas have their different climatic conditions).

- Create a soft loans program for farmers willing to establish dedicated energy crop plantations (so that the state budget would cover the difference between the market loan rates and soft loan rates).
- Support and maintain research and development in the field of feedstock planting and agro energy processing.

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Galyna Trypolska

Polityki stymulujące efekty produkcji i zatrudnienia oparte na bioenergii w Polsce i na Ukrainie

Streszczenie

Artykuł ma na celu rozważenie dostępnych polityk dotyczących produkcji biomasy jako surowca do dalszej produkcji bioenergii w powojennej Ukrainie w celu wyciągnięcia wniosków dla dalszego wdrażania bioenergii na Ukrainie oraz określenia liczby miejsc pracy, które bioenergia umożliwiła i mogłaby zapewnić kolejne w przyszłości zarówno w Polsce, jak i na Ukrainie. Polska posiada znaczny potencjał biomasy, którego lwią część stanowią odpady rolnicze, kukurydza i dedykowane uprawy energetyczne. Ukraina ma znaczący potencjał do produkcji i wykorzystania biogazu i biometanu ze względu na dostępne surowce i rozwinięty system dostaw gazu. Do oszacowania liczby miejsc pracy w sektorze bioenergii w Polsce i na

Ukrainie wykorzystano metodę współczynnika zatrudnienia. Oszacowania, które są głównym wynikiem pracy, wskazują, że liczba miejsc pracy w rolnictwie przy produkcji surowców na cele energetyczne może wynieść trzydzieści trzy tysiące do 2030 roku w Polsce i trzynaście tysięcy na Ukrainie. Produkcja biomasy na cele energetyczne w Polsce jest wspierana przez Wspólną Politykę Rolną UE. Producenci energii z biomasy mają pierwszeństwo w dostępie do sieci i kwalifikują się do taryf gwarantowanych, premii i aukcji oraz specjalnych programów finansowych. Na Ukrainie producenci energii z biomasy mogą korzystać z taryfy gwarantowanej na biomasę i biogaz oraz 10% niższej taryfy na ciepło z biomasy niż taryfa na ciepło z gazu ziemnego. Pomimo korzyści płynących z biomasy, zainstalowane moce do jej wykorzystania pozostają niewystarczające ze względu na istniejące bariery w obu krajach. W przyszłości Ukraina będzie musiała aktywniej niż dotychczas rozwijać swój sektor biomasy rolniczej w celu zastąpienia gazu ziemnego i innych nośników energii.

Słowa kluczowe: bioenergia, zatrudnienie, polityka energetyczna Polski, polityka energetyczna Ukrainy