The biogas sector in Poland as compared to other European countries

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Abstract: Biogas can be an important fuel for the European economy. It is a green energy source that will help achieve climate neutrality by 2050. It is very likely that there will be an increase in biogas production in Europe, especially in countries with great potential, such as Poland. This paper will present the current status of biogas in Poland. It also shows the characteristics of this sector and a comparison with other European countries.
The analysis shows that other countries are successfully using biogas. They have similar agricultural conditions to Poland, such as Germany. Therefore there is a real chance for the development of these installations also in Poland.
Key words: Biogas, Poland, Biogas plants, Europe, Renewable energy sources

Introduction

Biogas production has been known for many years, but the need to reduce greenhouse gas emissions may accelerate its development. Climate change and human impact on the environment are the subject of global discussions and international agreements. Some countries, including Poland, need to make a major energy transition to reduce the negative impact on our planet. The problem is the current energy structure of these countries, which are dependent on fossil fuels. To reduce the consumption of harmful conventional fuels, low- and zero-carbon technologies need to be developed and used. Biogas can be one of such green sources. Additionally, it can help in waste management, such as from agriculture or the food industry.

Biogas is a product of anaerobic digestion of organic matter. This organic matter can be domestic, agricultural or industrial waste, as well as, for example, targeted energy crops. The biggest advantage of biogas plants is the reduction of greenhouse gas emissions and the possibility to produce green energy.

Biogas plants are part of a circular economy. They also develop the local energy economy and diversify energy sources. Biogas has many advantages and is an alternative to domestic energy.

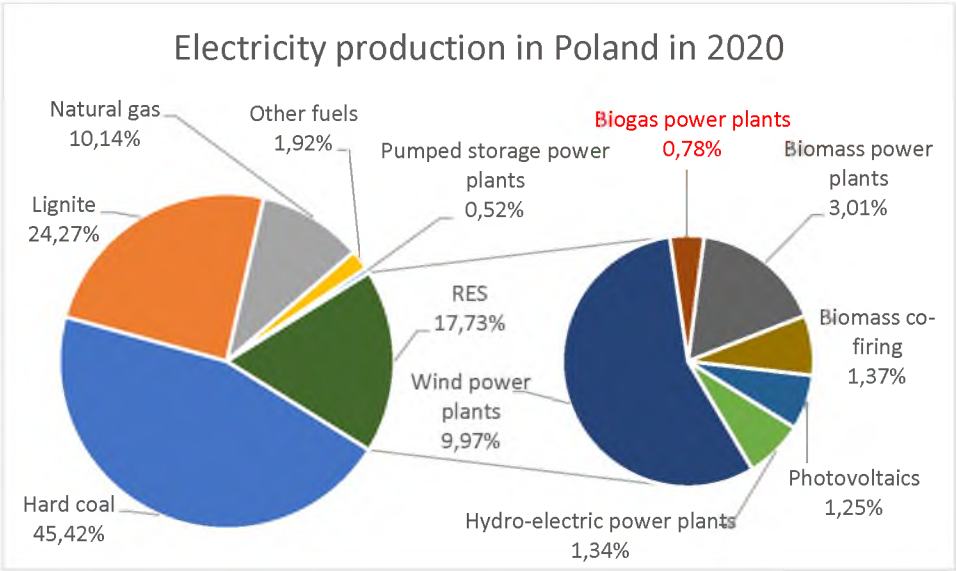
This paper provides an overview of the biogas sector in Poland and compares it with the situation in other countries. It presents the characteristics of Polish biogas plants, their number and share in the national energy structure. The study is a theoretical research paper based on analysis and comparison. The research question is: how developed is the biogas sector in Poland compared to other European countries.

Energy structure in Poland

The national energy mix in Poland is based mostly on solid fuels: hard coal and lignite, which account for 70% of electricity production. Natural gas is responsible for 10%, and renewable energy sources (RES) account for nearly 18% of production. There are also other fuels (about 2%) and pumped storage power plants (0.52%). (ARE, 2020)

More than half of the renewable energy sources are onshore wind power plants. Power plants that use biogas represent 4% of renewable energy sources and 0.78% of total electricity production. Other green sources are: solar energy from photovoltaic installations, hydroelectric energy from hydropower plants, biomass in biomass power plants and biomass co-firing (ARE, 2020).

Figure 1. Electricity production in Poland in 2020 - share of energy sources



Source: Own study based on Statistical Information on Electricity No. 12 (324) - December 2020 (ARE, 2020) (access: 28.06.2021 r.).

According to this data, Poland produced 157747.6 GWh of electricity in 2020. Biogas plants were the second lowest source of electricity production in Poland in 2020 after pumped storage plants. The amount of electricity produced from biogas was 1231.39 GWh. The reason for the low production is the small installed capacity in biogas power plants. In December 2020 it was 248 MW (0,48 % of the total installed capacity which was 51861MW). This was the smallest share of all installations (ARE, 2020).

Table 1. Electricity capacity installed at the end of December 2020 in Poland

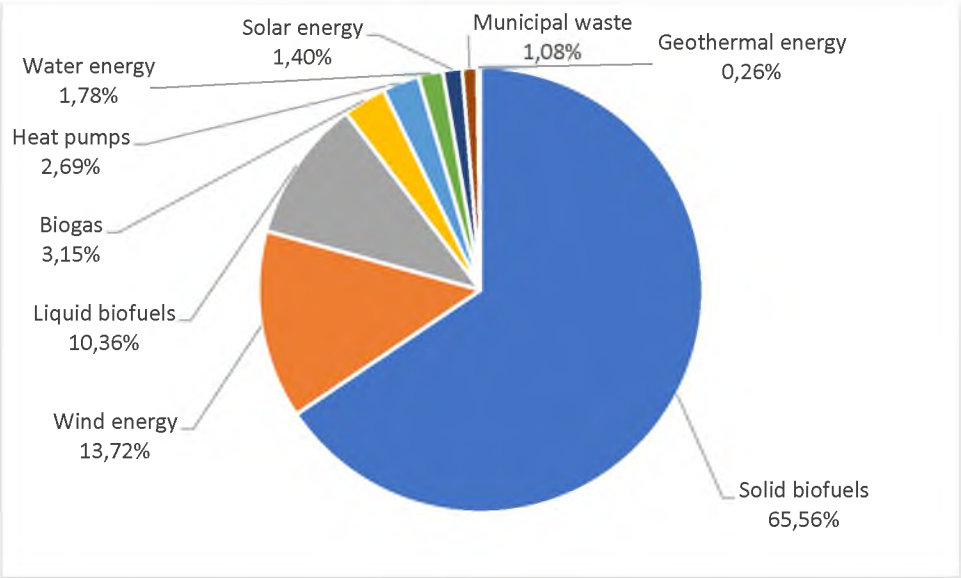
Sources of installed power	Installed capacity [MW]	Percentage share [%]
Hard coal	24 883	47,98%
Lignite	9 292	17,92%
Natural gas	3 203	6,18%

Other fuels	579	1,12%
Pumped storage power plants	1 413	2,72%
Hydro-electric power plants	974	1,88%
Wind power plants	6 402	12,34%
Biogas power plants	248	0,48%
Biomass power plants	907	1,75%
Photovoltaics	3 960	7,64%

Source: Statistical Information on Electricity No. 12 (324) - December 2020 (ARE, 2020) (access: 28.06.2021r.).

From the data presented, the percentage contribution of biogas to electricity production (0,78%) is higher than that of installed capacity (0,48%). It is quite different for photovoltaics. Although it has 16 times more installed capacity than biogas it produces only 0,47 percentage points more electricity. The reason is the changeable weather conditions and the inability of PV panels to produce energy at night. This makes biogas plants a more stable source of energy and resistant to changes in the time of day or weather conditions, which is their great advantage.

Figure 2. Structure of renewable energy generation in Poland by carrier in 2019.



Source: Own study based on Statistics Poland (GUS) - Energy from renewable sources in 2019 (https://stat.gov.pl/obszary-tematyczne/srodowisko-energia/energia/energia-ze-zrodel-odnawialnych-w-2019-roku,10,3.html) (access: 28.09.2021 r.).

Comparing the energy sources of all renewable energy sources, solid biofuels have the largest share (65,56%). Biogas is fourth (3,15%). There is a significant difference between biogas and liquid biofuels (10,36%), which are in third place. (GUS, 2020)

European and national climate goals require decarbonization of the presented energy mix. An additional problem is the high cost of CO2 emissions, which currently amounts to over 52 euro per tonne (on 19.07.2021). (PSE, 2021) Assuming an upward price trend, this will remove the most emitting sources. In the case of immediate removal of coal from the Polish structure, the National Power System would not be able to meet the needs for electricity in the

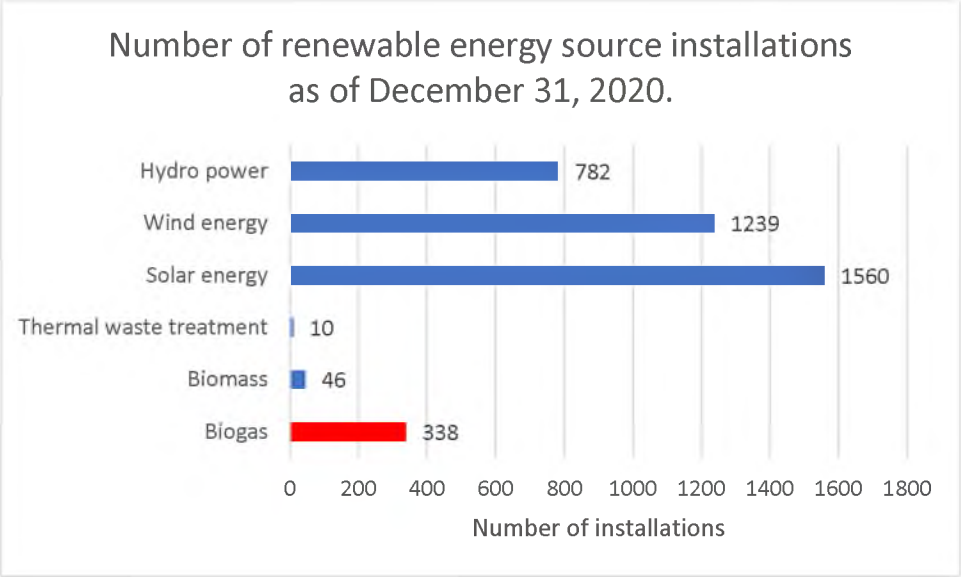
country. It is difficult to base power generation solely on renewable energy sources such as wind and solar. They are characterized by unstable operation depending on weather conditions. Energy storage technologies are a solution, but they are not so common at the moment, and they are still in development. It is necessary to choose a strategy for the future energy mix, taking into account environmental and economic aspects.

The most realistic scenario is the removal of coal, using natural gas as a transition fuel. This fuel has significantly lower greenhouse gas emissions into the atmosphere and can effectively replace coal-fired units in the short term. The popularity of natural gas is demonstrated by such national investments as the LNG Terminal in Świnoujście, the Baltic Pipe gas pipeline (under construction) or the Floating Storage Regasification Unit (FSRU) in the Gulf of Gdańsk (planned). In Europe, the confirmation of a greater demand for natural gas is the TurkStream pipeline or the construction of Nord Stream II from Russia to Germany. Gas will remain, at least for some time, in the European economy. This is important because biogas is an environmentally friendly alternative or supplement to natural gas. It could also use the existing gas infrastructure or be used in other ways.

Biogas plants in Poland

The current state of biogas plants in Poland is not large. Compared to some European countries, there are few biogas installations in Poland. This topic has been under discussion for a long time. Just over 10 years ago there were plans to have at least one biogas plant in each commune by 2020 that would produce electricity and heat. Unfortunately, so far the government programs and assumptions have not been a success and the biogas sector has grown slowly. Currently, according to the Energy Regulatory Office, Poland has 338 biogas installations with a total installed capacity of 255.7 MW (data as of 31.12.2020). (URE, 2020) The number of biogas plants is small compared to wind, hydro or solar installations. Especially that Poland has a large potential for agricultural biogas.

Figure 3. Number of RES installations in Poland



Source: Own study based on Renewable energy installations - as of December 31, 2020 (URE, 2020) (access: 28.06.2021 r.).

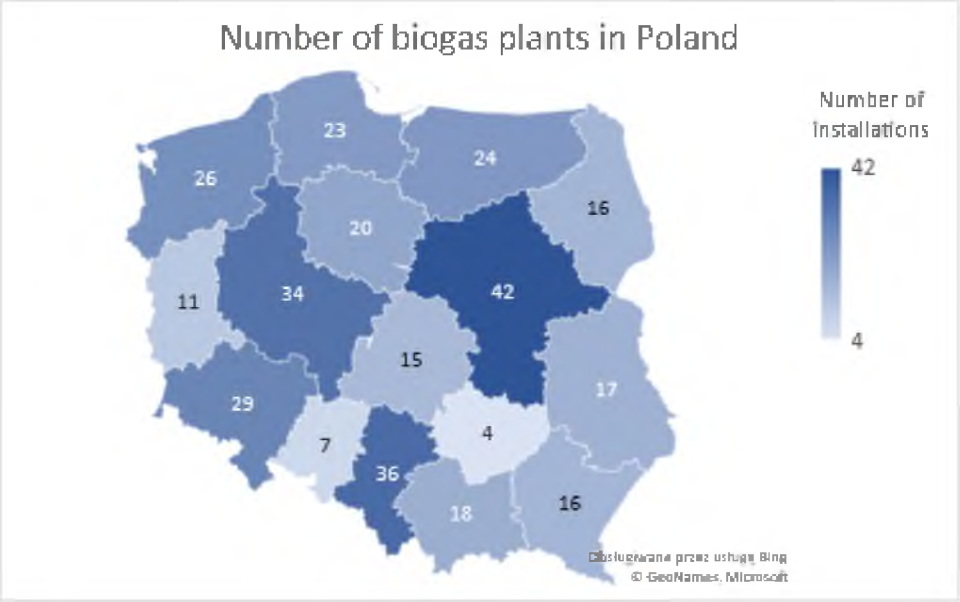
According to this data (URE, 2020), the total installed capacity from all RES at the end of December 2020 was 9979.176 MW in Poland. The installed capacity in biogas (255.7 MW) accounted for 2.56% of the RES share. The others: wind energy (6347.1 MW) 63.6%, solar energy (887.43 MW) 8.89%, biomass (1343.06 MW) 13.46%, hydro energy (976.05 MW) 9.78% and thermal waste conversion (169.83 MW) 1.7%. It can be seen that biogas played a marginal role in this comparison. It is worth noting, however, that 46 biomass plants had a bigger share of installed capacity than the 338 biogas plants. This shows that biogas installations have a smaller capacity than, for example, thermal waste or biomass installations. The average installed capacity of one biogas plant in Poland is 0,76 MW. Only photovoltaic installations are smaller (0,57 MW). The average power of other installations: biomass (29,2 MW), thermal waste treatment (16,98 MW), wind energy (5,12 MW), water energy (1,25 MW).

The installed capacity of biogas plants has been growing since 2005. An exception to this trend is the years 2016 - 2018 when there was an investment slump due to legislative and legal problems and low green certificate prices. In 2017 they reached their lowest level of about 24 PLN/MWh. (Magazyn Biomasa, 2020) This resulted in high uncertainty for investors, as well as financial collapse of some installations. In the last 10 years there has been an increase in biogas capacity of more than 65%. However, this is not much compared to other installations. Since 2010, wind and biomass installations have experienced the highest growth. Photovoltaics has also seen dynamic growth in the last two years.

Characteristics of biogas sector in Poland

Most of the 338 biogas plants in Poland are located in the Mazovian (42 installations), Silesian (36 installations) and Greater Poland (34 installations) Voivodships. The least biogas plants are located in the Świętokrzyskie (4 installations), Opolskie (7 installations) and Lubuskie (11 installations) Voivodships. The smallest average installed capacity per installation is in Podkarpackie voivodship (average 0.47 MW) and the largest installations are in Pomorskie voivodship (average 1.13 MW). The largest installed capacity of biogas plants is in the Wielkopolskie (28,67 MW), Mazowieckie (28,55 MW) and Pomorskie (26,09 MW). The provinces with the smallest installed capacity are Świętokrzyskie (3,82 MW), Opolskie (3,95 MW) and Lubuskie (5,53 MW). Counting per one installation, the lowest average installed capacity is in Podkarpackie (average 0.47 MW) and the highest in Pomorskie (average 1.13 MW). (URE, 2020)

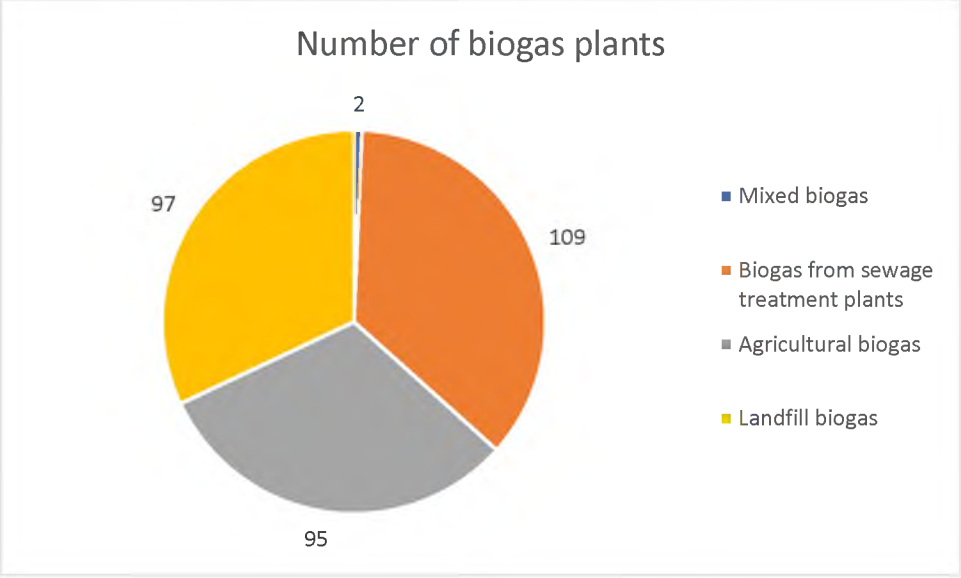
Figure 4. Number of biogas installations in Poland by province as of December 31, 2020.



Source: Own study based on Renewable energy installations - as of December 31, 2020 (URE, 2020) (access: 28.06.2021 r.).

There are three main types of plants: agricultural biogas plants, landfill biogas plants, and plants from sewage treatment plants. The ERO data, which also specifies what type of biogas plant a biogas plant is, is from 2018. The most recent data does not separate this division.

Figure 5. Number of biogas installations in Poland as of December 31, 2018, by type



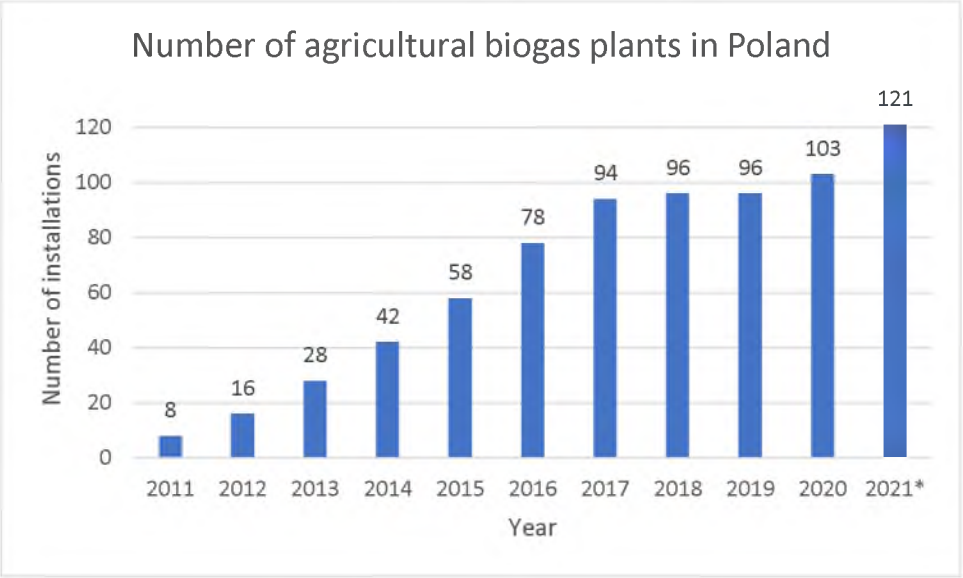
Source: Own study based on Renewable energy installations - as of December 31, 2020 (URE, 2019) (access: 28.06.2021 r.).

Currently, agricultural biogas plants are more important. This is proven by the data determining the production of heat and electricity in Poland made available by the Central Statistical Office (GUS, 2020). Heat production from biogas was 1004, 2 TJ in 2019. 3.5% of this

value came from biogas from landfills, 10.5% from sewage treatment plants, 86% was agricultural and other biogas. On the other hand, the total share of biogas in electricity generation was 1162 GWh in 2019. Of this, 15.3% was biogas from landfills, 30.2% was biogas from wastewater treatment plants, and 54.5% was agricultural and other biogas.

The great importance of agricultural biogas plants is also confirmed by the large increase in installations over the last year. Based on data from the National Agricultural Support Centre (KOWR, 2020), there were 116 agricultural biogas plants at the end of 2020. According to the latest information, as of 5 July 2021, the number was already 121 installations, which belong to 104 business operators. (magazynbiomasa.pl, 2021) Most of the agricultural biogas plants are located in northern and central Poland. The production of agricultural biogas in 2020 amounted to 325,395 million m^3. (KOWR, 2020) This amount is increasing every year, just like the installed capacity of biogas installations in Poland. Everything indicates that this growth dynamics will be increasing.

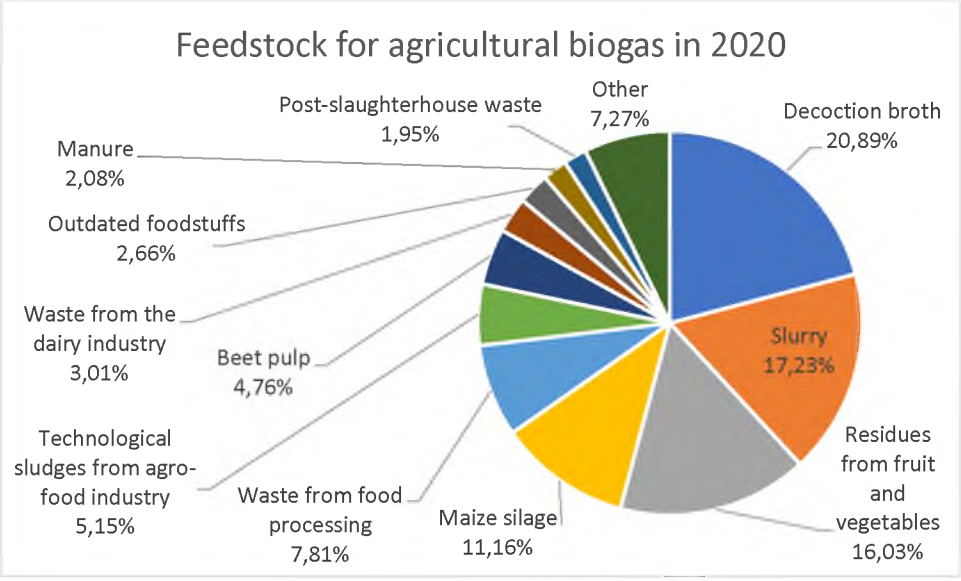
Figure 6. Number of installations in the register of agricultural biogas producers in Poland



Source: Own study based Data on the activity of agricultural biogas producers from 2011 to 2020 (KOWR, 2020) (access: 03.07.2021 r.) and * (magazynbiomasa.pl, 2021) (access: 18.07.2021 r.)

There are many raw materials from which agricultural biogas is produced in Poland. In 2020, 4,409,054.9 tons of substrates were used for this purpose. The largest part of the feedstock was decoction broth (920,995 tonnes), slurry (759,774 tonnes) and fruit and vegetable residues (706,945 tonnes). The rest of the raw materials were maize silage (491,869 tons), food processing waste (344,329 tons), process sludge from the agri-food industry (227,148 tons), beet pulp (209,816 tons), dairy industry waste (132,910 tons), outdated foodstuffs (117,184 tons), manure (91,681 tons), and slaughterhouse waste (85,777 tons). The rest of the raw materials are included in the "Other" category (320,625 tons).

Figure 7. Types and quantities of raw materials used for the production of agricultural biogas in Poland in 2020



Source: Own study based Data on the activity of agricultural biogas producers from 2011 to 2020 (KOWR, 2020) (access: 03.07.2021 r.).

Barriers to biogas development in Poland

The biogas market in Poland had barriers that effectively slowed down its development. Between 2014 and 2017 there was an intense drop in green certificate prices which led to a crisis in the biogas market and financial problems for many investors. The sector became unstable and uncertain, even after legal changes and the introduction of new support systems. This is particularly shown in Figure 6. From 2017 to 2019 there was stagnation in the biogas market in Poland. No new installations were built during this period. This was related to investors' fears and high risks. The barriers also include high investment costs or legal regulations related to the biomethane market. Currently, there is a large increase in the number of new installations (18 new installations this year), which confirms a better time for biogas and stabilisation of the market.

Biogas in Europe

Renewable gases, including biogas, are supported in Europe through the European Green Deal (EGD). The use of biogas helps achieve the EGD's goal of climate neutrality by 2050. Biogas reduces greenhouse gas emissions from agriculture and waste management. This is confirmed, for example, by a document - the EU strategy for reducing methane emissions, which was published in October 2020. (European Commission, 2020)

There are large differences in the level of development of the biogas sector in Poland compared to other European countries (e.g. Germany). The document Bioenergy Europe Statistical Report Biogas 2019 says that gross biogas energy consumption has expanded 25 times since 1990. The report also says that despite the increasing trend, biogas represented only 1% of total gross domestic energy consumption in the EU-28 member states in 2017, with 12% of bioenergy used across the European Union coming from biogas. In the EU-28, Switzerland, Norway and Serbia, there were a total of 17,783 biogas plants in 2017. The largest number was

located in Germany and Italy. The fewest were in Bulgaria and Romania. The only country that did not have such an installation in the EU was Malta (Bioenergy Europe, 2019).

Table 2. Number of biogas plants in EU-28 countries in 2017. (number of installations)

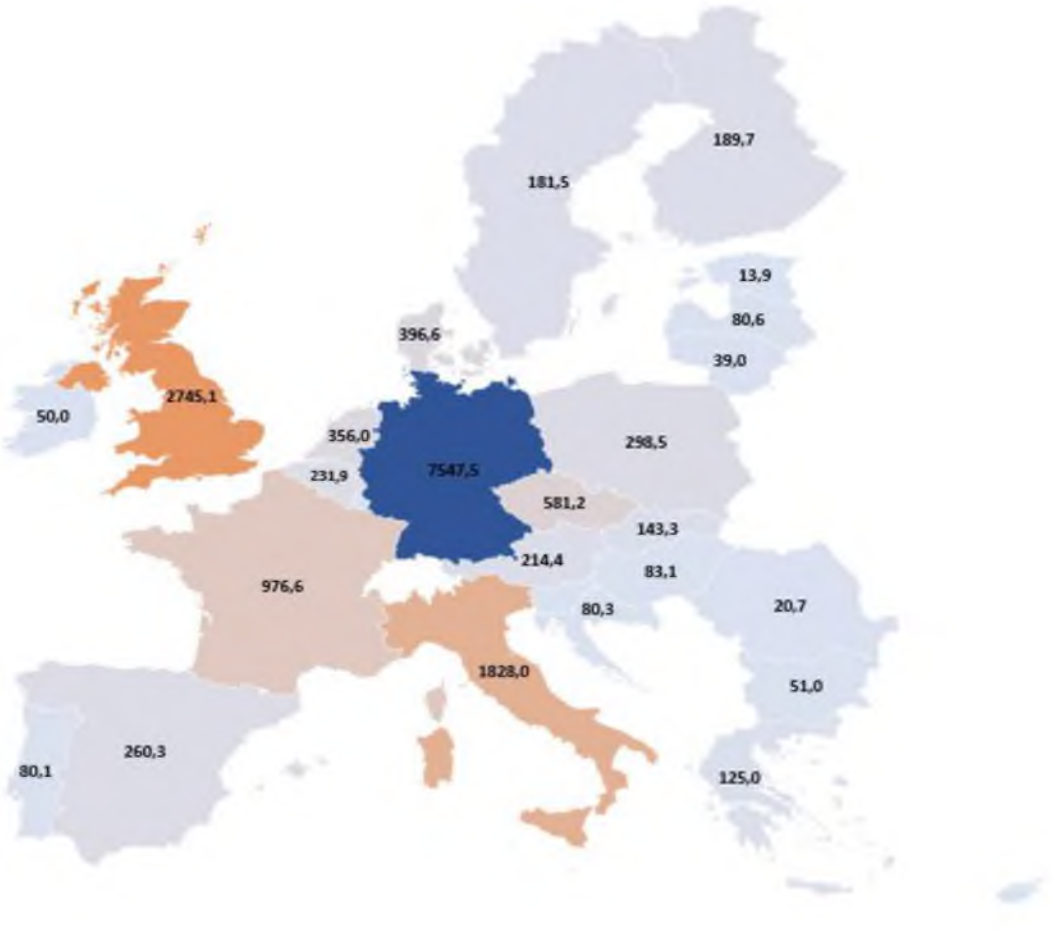
Country	**Number of biogas plants**	**Percentage share in EU**
Germany	10971	64,54%
Italy	1655	9,74%
France	742	4,36%
United Kingdom	613	3,61%
Czech Republic	574	3,38%
Austria	423	2,49%
Poland	308	1,81%
Netherlands	268	1,58%
Spain	204	1,20%
Sweden	198	1,16%
Belgium	186	1,09%
Slovakia	179	1,05%
Denmark	144	0,85%
Finland	96	0,56%
Hungary	81	0,48%
Portugal	64	0,38%
Latvia	56	0,33%
Greece	37	0,22%
Lithuania	36	0,21%
Luxembourg	30	0,18%
Ireland	29	0,17%
Croatia	26	0,15%
Slovenia	26	0,15%
Estonia	18	0,11%
Cyprus	13	0,08%
Bulgaria	11	0,06%
Romania	11	0,06%
Total	**16999**	

Source: Own study based Statistical Report 2019 Biogas (Bioenergy Europe, 2019) (access: 09.07.2021 r.).

Among the EU-28, Switzerland, Norway and Serbia had the highest number of biogas plants based on agricultural feedstocks in 2017 with 12721 installations. Biogas plants from wastewater treatment plants were 2854 installations, while biogas plants from landfills were 1374 installations. In each country, the use of feedstock for biogas production is different. In Sweden, Spain and the UK, most biogas comes from wastewater from treatment plants. Countries like Austria, Latvia, Cyprus and Germany use a lot of energy crops. In the case of Finland, bio-waste and municipal waste account for the largest share. In Belgium, biogas production is based on industry (food and beverages). In Italy, Denmark, Poland and France agricultural residues have the biggest share. In Hungary and Germany they are also of great value. (Bioenergy Europe, 2019)

The leader in biogas production in Europe is Germany (7547.5 ktoe). Less are produced by: United Kingdom (2727.1 ktoe), Italy (1828.0 ktoe) and France (976.6 ktoe) but even the combined total of biogas production at the end of 2019 of these three countries is less than the production in Germany. It is worth highlighting the large production in the Czech Republic (581.2 ktoe), which is a relatively small country. Biogas production there is almost twice as large as in Poland. (EurObserv'ER, 2020)

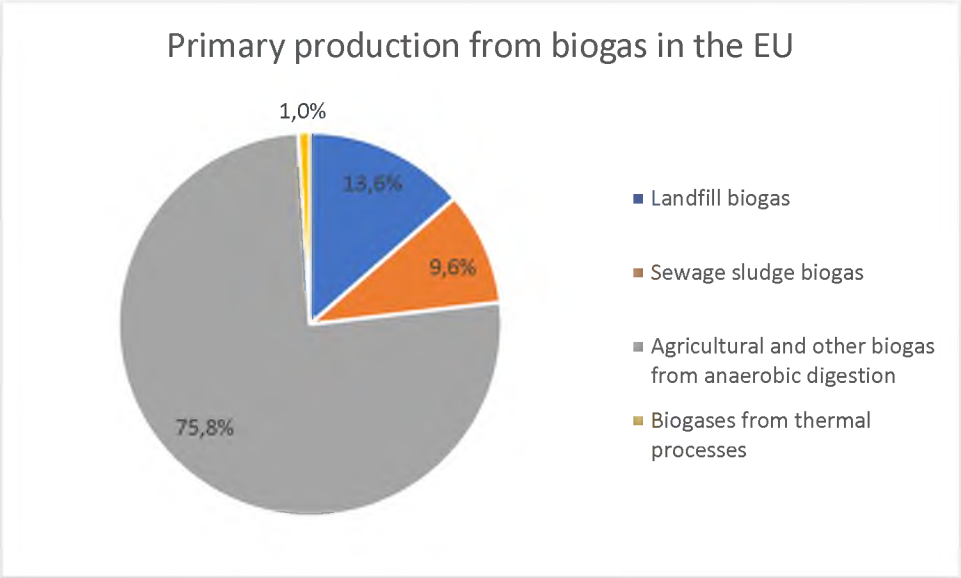
Figure 8. Biogas production in European Union countries at the end of 2019* [ktoe].**



Source: Own study based Biogas barometer (EurObserv'ER, 2020) (access: 17.07.2021 r.).
*Estimated production. When information was not available, data were estimated by EurObserv'ER for 2019 using the 2018 distribution.
** 1 toe = 11,63 MWh

In 2019, total biogas production in the EU-28 was 16,629.8 ktoe. More than 75% of this was agricultural biogas (12612 ktoe), 13.6% was landfill biogas (2259.5 ktoe) and 9.6% was sewage sludge biogas (1593.5 ktoe). Biogases from thermal processes accounted for 1% of the share (164.7 ktoe).

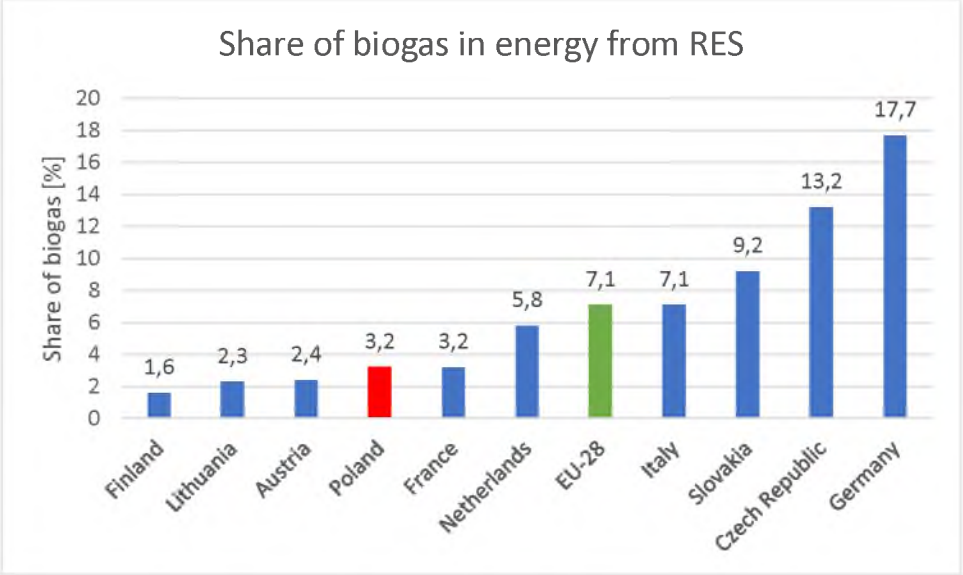
Figure 9. Primary production from biogas in the European Union in 2019* by biogas type



Source: Own study based Biogas barometer (EurObserv'ER, 2020) (access: 17.07.2021 r.).
*Estimated production. When information was not available, data were estimated by EurObserv'ER for 2019 using the 2018 distribution.

Taking into account the share of biogas energy in the generation of energy from renewable sources, according to the Central Statistical Office (GUS, 2020), in 2018 Poland was below the European Union average (7.1%). The highest percentage share was held by Germany (17.7%) and the already mentioned, Czech Republic (13.2%). Slovakia also had a share above the average (9.2%).

Figure 10. Share of biogas energy in renewable energy generation in 2018 in selected countries



Source: Own study based Energy from renewable sources in 2019 (GUS, 2020) (access: 21.07.2021 r.).

Summary

The biogas sector in Poland is in a development phase. The current state is below the European Union average. Other countries such as Germany have been consistently developing this sector for many years. At the same time in Poland the growth dynamics was moderate. In 2017-2019 there was a crisis on the renewable energy market in Poland which resulted in a lack of investment in new biogas plants (Figure 6). The support system for these installations needed improvement. Only from 2020 we can see an increase in the number of investments.

The energy sector in Poland requires large investments in zero- and low-emission energy sources. The reason for this is the decarbonization of the energy mix and new climate goals. Therefore there is a big interest in renewable energy sources, including biogas. It is one of the elements of Poland's Energy Policy until 2040. There has been a big increase in agricultural biogas plants in Poland recently. This is the direction in which this sector will develop, just like in other European countries. Poland has a very big potential in biogas. Especially in agricultural biogas due to a developed agricultural economy. This is confirmed by Eurostat data, which show a significant share of Polish farms in comparison to other European countries. Poland is one of the biggest producers of vegetables and fruits as well as the biggest poultry meat producer in the EU. A large potential is also a developed food and beverage industry (Eurostat, 2020). Data of the Poznań University of Life Sciences say that the potential of biogas in Poland is 13-15 billion m3/year. This is very high compared to the current production. Poland can become an important part of biogas production in Europe if it provides support and good conditions for investment. The Czech Republic, for example, which has more biogas plants than Poland, confirms the possibilities for development of this sector. A lot of countries use agricultural waste for production which also has a big potential in Poland. Additionally biogas can be used to produce biomethane. It is a popular direction, also among European countries.

There are positive aspects to the development of Polish biogas and promising forecasts for the future. This is confirmed by the letter of intent for the development of the biogas and

biomethane sector in Poland signed in October 2020. It also includes plans to create a sectoral agreement. Thanks to the cooperation it will be possible to develop the biogas market in Poland faster. It is also worth noting the support programs in the form of subsidies such as "Agroenergia" (National Fund for Environmental Protection and Water Management) or the FIT/FIP support system. They are aimed at encouraging investors to build new biogas plants. The use of biogas will help achieve both economic and environmental goals. The biogas sector in Poland has great potential and may, like in other European countries, have a large share in obtaining energy from renewable sources.

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