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ROLE OF BIOMETHANE IN THE IMPROVEMENT OF ENERGY SAFETY IN POLAND***

1. INTRODUCTION

Energy from renewable sources has recently gained in importance as a consequence of the increasing energy prices and climate changes of anthropogenic origin. Therefore many countries put much emphasis on the use of renewable energy sources, i.e. water, sun, wind and biomass which cover more and more of the energy demand. One of the methods of energy production from biomass is biogas production in specially designed biogas plants. For the sake of creating conditions for the development of this branch it was necessary to undertake support and promotion actions on the central and regional level.

The novelized act on renewable energy in Germany caused a boom in the biogas energy sector. In 1999 850 agricultural biogas plants were operational in Germany, 1700 in 2003, and 2800 in 2005. In Poland 64 biogas power plants were reported to exist by the year 2005. This number covers agricultural biogas plants and mainly landfill gas installations and sewage treatment biogas.

2. SHORT CHARACTERISTIC OF GAS MARKET IN POLAND

Poland abounds in hard coal, therefore the dependence on import from other countries is very small. On the other hand, natural gas consumption in Poland increases and the perspective of dependence on gas import by the year 2030 shows to the increasing need of import. In Table 1 we have the import demand for energy products by the year 2030.

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Table 1

Predicted demand for imported energy minerals vs. their consumption in Poland [14]

Year	Mineral			Total [%]
	oil [%]	natural gas [%]	coal [%]	
2010	91.8	66.6	−20.7	24.1
2020	90.1	71.5	−18.0	31.1
2030	91.2	75.8	−7.2	38.8

The analysis of the data in table 1 reveals that the dependence on natural gas import will increase by 75.8% by the year 2030 as compared to predicted gas consumption. The structure of natural gas deliveries to Poland in the years 2005 to 2012 is shown in Table 2.

Table 2

Structure of natural gas deliveries to Poland in the years 2005 to 2012 [11]

Year	Polish production [mln Nm^3]	Participation of production [%]	Import [mln Nm^3]	Participation of import [%]	Natural gas consumption [mln Nm^3]
2005	4518.2	31.25	9940.5	68.75	14458.7
2006	4458.9	30.02	10393.4	69.98	14852.3
2007	4498.7	31.83	9635.7	68.17	14134.4
2008	4291.0	28.72	10649.0	71.28	14940.0
2009	4277.0	31.08	9486.0	68.92	13763.0
2010	4277.0	29.21	10365.0	70.79	14642.0
2011	4300.0	26.73	11787.0	73.27	16087.0
2012	4300.0	28.10	11000.0	72.90	15300.0

The analysis of Table 2 reveals that the national production of natural gas is more or less stable and covers about 30% of gas demand in Poland. The remaining part is imported from various sources. Practically all gas import comes from the east [12] where 95% of gas deliveries come from Russia. Judging from the data in Table 2, natural gas consumption in Poland in the years 2005 to 2012 only slightly increased. This also refers to Table 1, where the energy mineral import trends are presented.

The natural gas demand stems from, e.g.:

- increasingly high requirements regarding CO_2 reduction by EU countries,
- lowering hard coal participation in energy balance,
- directing the financing of EU projects to subjects connected with lower carbon dioxide emissions by energy companies.

3. SHORT CHARACTERISTIC OF BIOGAS PRODUCTION IN EUROPE

The analysis of the European Green Gas Grid report 2014 reveals that biomethane production in Western Europe countries is increasing in popularity. It turned out that most of the natural gas import to Europe comes from the east and many EU countries cover as much as 100% of their demand from the imports of natural gas. In this situation the lowering of the reliance of these countries on gas import on behalf of biomethane production becomes of top importance. The number of biogas plants engaged in biogas production is presented in Table 3.

Table 3

Number of biogas plants producing biomethane in countries involved in the biogas production [3]

Country	Number of existing biogas plants
Germany	151
Sweden	51
Holland	23
Austria	10
Finland	6
Luxembourg	3
Great Britain	4
France	3
Italy	2
Denmark	1
Hungary	1
Croatia	1

Biomethane produced in these plants supplies natural gas distribution networks, simultaneously lowering its import. According to the DENA indicator of the biomethane sector in Germany in 2014 there existed 151 biogas plants producing biomethane, which in 2013 was introduced to the gas supply network in a quantity of 520 mln Nm^3. In Statistics Netherlands [17] we can read that the biomethane production increased by 70.3% as compared to the year 2012, providing also 11.8% of national primary energy production. These examples reveal the great significance of biomethane in countries which do not have their natural gas resources.

It should be observed that about 14 billion Nm^3 of biogas is produced in Europe now (calculated for natural gas) out of which about 3.1 billion Nm^3 constitutes biomethane introduced to the gas supply network. The biomethane production is planned to be doubled by the year 2020 [3]. In the coming years this sector will develop most dynamically (in 2030 a production of about 20 billion Nm^3 of biogas is planned). The predicted biogas quantity introduced to the gas supply network is plotted in Figure 1.

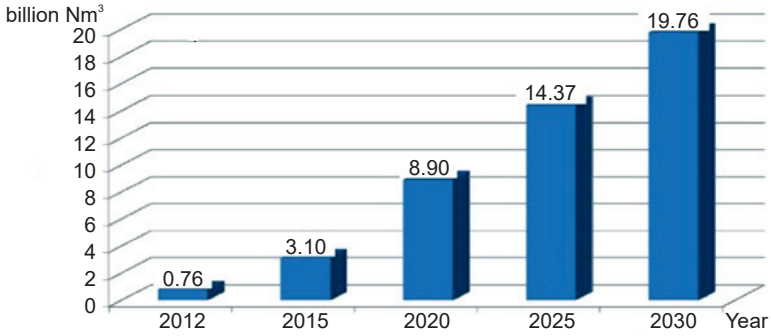

Fig. 1. Perspective of biomethane introduction to the gas supply network in Europe [5]

The building of new biogas plants is the most rapidly developing RES sector, especially in Germany, where as much as 6 billion Nm^3 of gas yearly is planned to be produced and introduced to network by the year 2020 [2, 4]. This may involve switching some of the biogas plants producing electricity to high-methane gas production, which can be introduced to the supply network. Presently biogas production in Germany for electrical generation totals to 5–6 billion Nm^3 annually, recalculated for methane.

As already mentioned, in the beginning of 2014 about 250 high-methane biogas plants were operational in Europe, in that number prevail new objects which are used for the production of network gas rather than electricity. There is no biogas plant oriented to the production of biomethane to be introduced to the network. Recently at least two permits for such objects have been issues in Lublin Province.

4. ELEMENTS OF ENERGY POLICY IN POLAND – BIOGAS PLANTS

For the sake of improving the development of agricultural biogas plants in Poland there was issued a governmental document necessitating the promotion and supporting of biogas production for agricultural purposes. The assumption of „Directions of development of agricultural biogas plants in Poland in the years 2010 to 2020" is creating optimum conditions for the development of installations producing biogas for agricultural purposes, thanks to which by the year 2020 on average one biogas plant is built in each county which can make use of biomass and the provided conditions for such a plant have been met [5].

Biogas plants should be localized in sites where the natural conditions for biomethane production exist, i.e. large arable lands, large pastures, etc. The document *Directions of development of agricultural biogas plants in Poland in the years 2010 to 2020* does not suggest any definite ways of agricultural biogas utilization.

The biogas use should depend on such factors as, e.g.:

– distance from the supply network,
– general and local demand for electricity or heat etc.

The document was approved by the Cabinet on 10 November 2009 *Energy policy of Poland by the year 2030* sets the participation of renewable energy sources in the final energy

consumption on a minimum level of 15%. The further development of biogas in Poland will be stimulated by the improving support conditions for this technology. The present form of the support system is based on market-salable certificates and accessible investment grants [10].

The data of the Institute for Renewable Energy show that mainly biogas cogeneration plants of capacity 1–2 MW are built; besides the number of realized investments (0.5–1.0 MW) constantly increases. Investors are more interested in this solution, political acceptance of biogas investments in agricultural areas keeps growing, especially little biogas plants of capacity tens of kW and small biogas plants of capacity up to hundreds of kilowatts [7]. The quantity of produced biogas and the number of plants in Polish provinces are presented in Table 4.

Table 4

Biogas production in provinces [1]

Province	Biogas production [Nm^3/year]	Number of biogas plants
Lower Silesia Province	26,151,204	6
Kujawy-Pomerania Province	21,281,090	3
Lublin Province	20,050,000	5
Lubuskie Province	8,971,270	3
Łódź Province	11,237,069	2
Mazovia Province	9,933,840	2
Opole Province	8,000,000	1
Podkarpacie Province	6,075,000	2
Podlasie Province	8,935,000	2
Pomerania Province	42,556,655	9
Silesia Province	2,470,915	1
Świętokrzyskie Province	2,464,000	1
Warmia-Masuria Province	30,919,918	7
Wielkopolska Province	29,314,883	8
West Pomerania Province	31,248,200	7
Małopolska Province	0	0
Total	259,609,044	59

Judging from the data in Table 4, the highest agricultural biogas production was observed in the Pomerania totaling to about 42.5 mln Nm^3 per year. On the second place we have West Pomerania Province with about 31 mln Nm^3 of biogas; interestingly, in Great Poland we have more plants but the amount of produced biogas is slightly lower. The distribution of biogas plants in Poland is presented in Figure 2.

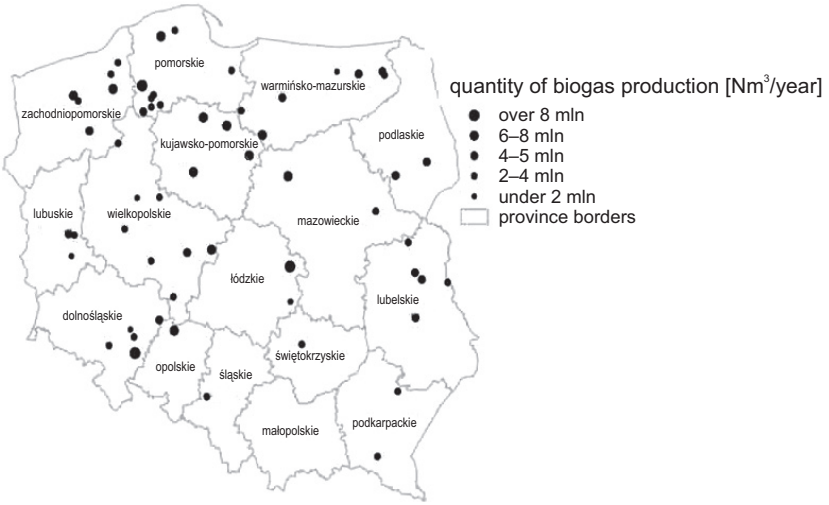

Fig. 2. Map of existing agricultural biogas plants and biogas production [9]

5. NETWORK GAS SUPPLY POTENTIAL BASED ON POLISH BIOGAS PLANTS' PRODUCTION

One of many ways in which biogas can be used is its treatment and introduction to the gas supply network. The new legal act – *Energy Law* [12] obliges distribution companies to connect the interested RES production to gas supply networks. In this case the investor having at his disposal RES for biogas production applies to a power institution for attaching it to the gas distribution network [8].

Among the conditions on the basis of which the access is granted are:

- place of attachment of biogas installation and its technical parameters,
- scope of necessary modifications relating to the attachment of the biogas installation to the gas distribution network,
- technical parameters of the connection to the gas distribution network,
- minimum and maximum biogas supply pressure,
- requirements relating to the measurement/counter systems and place they are installed,
- connection entry capacity,
- characteristic of agricultural biogas supplies, in that: minimum and maximum hourly, daily and yearly quantities of biogas deliveries and reception [6],
- asset division between distribution company and biogas producer,
- requirements regarding equipment of the gas station, measurement/counter systems and its type, and also telemetry and technical conditions of anti-corrosion protection [17].

Analogous to conventional energy sources, also in this case the application can be rejected because of the technical or economic reasons [13].

The main purpose of the biogas plant is the production of agricultural biogas which will be used for various purposes, e.g.

- injection to the processed biogas to the gas supply network,
- production of electricity and heat,
- storing in local natural gas storages,
- used as a chemical mineral.

6. IMPORTANCE OF PROGRAM "BIOGAS PLANT IN EACH COUNTY" FOR ENERGY SECTOR

According to the CSO office, 1,571 rural counties in Poland are inhabited by 11 mln persons. The consumption of various types of energy in a statistical rural county is presented in Table 5.

Table 5

Annual energy consumption in households in a statistical county [8]

Type of energy	Consumption [MW]	Participation [%]
Electricity	7,200	57
Network gas	5,100	40
Network heat	400	3
Total	12,700	100

The analysis of the table reveals that electricity has the highest and heat has the lowest participation in energy consumption. It was calculated that the average production of one biogas plant in Poland equals to 4.40 mln Nm^3 of agricultural gas per year, i.e. about 25 564 MW. General data typical of a representative county are presented in Table 6.

Table 6

General data from a representative county [16]

No.	Parameter	Value
1	Population [in thousand]	12
2	Surface [km^2]	120
3	Number of houses	3,000
4	Number of cars	3,500
5	Number of entrepreneurs	1,000
6	Participation of usable arable land in total surface [%]	55
7	Total number of farms	1,800
8	Participation of forests in total surface [%]	30

The analysis of Table 6 reveals that the average surface of arable land in a representative county is about. 6,000 ha. The demand for silage and the relating minimum grassland area is presented in Table 7.

Table 7

Demand for silage and minimum culture area as a function of installed capacity of electrical power generator [7]

Installed capacity	Biogas demand	Silage constitutes 100% of substrate				Minimum area for grasslands
		Minimum demand for silage				
	[m^3]	[t/year]	[t/month]	[t/week]	[t/day]	[ha]
1 MW	3,650,000	21,000	1,750	420	60	440
500 kWe	1,825,000	10,500	875	210	30	220
300 kWe	1,095,000	6,300	525	126	18	132
200 kWe	730,000	4,200	350	84	12	88
100 kWe	365,000	2,100	175	42	6	44
50 kWe	182,500	1,050	87.5	21	3	22
30 kWe	110,606	636	53.0	12.73	1.82	13.3

The analysis of Table 4 reveals that a moderate biogas plant in Poland brings about 4.4 mln Nm^3 of agricultural biogas. It follows from Table 6 that 440 ha of grassland are needed for the production of 3.65 mln Nm^3 of biogas. Hence, about 353 ha grassland is needed for an average biogas plant to produce 4.4 mln Nm^3 of agricultural gas. Having assumed that the activity of a biogas plant is based on one of the most popular substrates, i.e. corn silage, a biogas plant could be built in each representative county and about 10% of agricultural lands would have to be used for this purpose.

Simple calculations were performed to show how the gas import to Poland could be reduced in two situations. In the first case assumption was made that biogas plants will be used for the production of network gas. In the second case, it was assumed that one biogas plant producing network gas will exist.

Case no. 1

According to Table 3 59 biogas plants exist in Poland and they produce about 259.6 mln Nm^3 of agricultural gas. If we assume that agricultural gas contains about 55% of methane [10], this brings about 148.7 mln Nm^3 of biomethane which then has been treated and brought to the network parameters [18]. Thus we can assume that gas import can be reduced by about 0.15 billion Nm^3 of gas.

Case no. 2

As already mentioned, 1,571 counties exist in Poland. One gas plant in each county means 1,571 biogas plants. Each biogas plant produces on average 4.4 mln Nm^3 of gas totaling to 6,912 mln Nm^3 of biogas [15]. After treating methane we have 3,801 mln Nm^3 of

network gas. When we add our own gas production on a level of ca. 4.5 billion Nm^3 we get about 8.3 billion Nm^3 of own network gas. If the LNG terminal built in Świnoujście produces about 5 billion Nm^3 we will get about 13.3 billion Nm^3 of gas to cover Polish demand for gas. In this case gas import would be on a level of 2–3 billion Nm^3 to cover the total energy demand.

The biogas plants would give employment for about 15,000 people in rural areas. When the national production of biogas plant equipment would develop, the number of places of work in the industry would at least double.

7. FINAL CONCLUSIONS

The building of agricultural biogas plants should favorably influence the Energy Policy of Poland by:

- considerable reduction of dependence of the national economy on imported energy in the form of natural gas from only one direction,
- creating a source of cheap energy as compared with Polish fossil fuels, mainly coal, which should lower the tension between mining and RES energy industry,
- lack of noxiousness for operators (a dispersed energy industry),
- creating additional places of work in Poland at the operation of the installation and at the production of the equipment (all elements of the installation can be manufactured in Poland),
- possibility of managing cellulose biomass and lowering social tensions relating to the reduced use of biomass in the co-combustion processes; manageability of developed base of biomass suppliers,
- stimulation of scientific studies of biogas treatment, storage and utilization by-products,
- production of large quantities of energy from installed capacity and rational use of EU investment grants.

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