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TECHNICAL AND ECONOMICAL ASPECTS OF BIOGAS PRODUCTION FROM AGRICULTURAL SOURCES INCLUDING POLISH CONDITIONS

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ABSTRACT

The paper aimed at investigating the influence of technical and economical aspects of biogas production from agricultural sources including the Polish conditions, which affacted implementation of the Directive 2009/28/EC of the European Parliament and the Council on the promotion of the use of energy from renewable sources. The investigations included the analysis of biochemical and technical problems of biogas production and the development of renewable energy resources in Poland. Operational tests (conducted 2011-2012) of a small biogas plant, with the total capacity of two reactors of 411 cubic meters, have enabled determination of the electricity production cost amounting to 113.76 PLN·MWh^{-1} and the heat production costs amounting to 206.06 PLN·MWh^{-1}. The construction cost of the biogas plant was 1100 PLN per cubic meter. The exploitation costs of biogas plant were – 42 450 PLN·year^{-1} as the cumulative costs of: the annual cost of installation maintenance 27 000 PLN·year^{-1} and the cost of use of the biogas plant – 5 450 PLN·year^{-1}. The calculated profit from the sale of the produced electricity was 100 622 PLN·year^{-1}. The calculation has been prepared in accordance with the prices in Poland in 2011-2012.

Introduction

Agricultural biogas – fuel gas produced by anaerobic digestion of agricultural raw materials, agricultural products, liquid or solid livestock manure, by-products or residues from the processing of agricultural products or forest biomass, with exception of gas from sewage treatment plants and waste landfills (according to the Journal of Laws, 1997 No. 54, item. 348). Implementation of the Directive 2009/28/EC of the European Parliament and the Council (23rd April 2009) on the promotion of the use of energy from renewable sources has contributed to the increased interest in the development of renewable energy sources, including obtaining biogas from agricultural sources. On 13th July 2010 the Council of Ministers approved a document entitled “Guidelines for biogas development in Poland in 2010-2020”, which assumes construction of biogas plants in each Polish community.

Publications of various research institutes and technical centers, including the Institute of Technology and Life Science, Branch in Warsaw and Poznan has become the answer to the growing demand for expertise in the area of biogas (Romaniuk et al., 2011; Romaniuk et al., 2012 a,b; Głaszczka et al., 2010; Myczko et al., 2011).

Objective of the studies and methodology

The aim of the study was to present technical and economical aspects of biogas production from agricultural sources including Polish conditions, having an impact on implementation of the Directive 2009/28/EC of the European Parliament and the Council on the promotion of the use of energy from renewable sources.

The scope of work included: the analysis of biochemical and technical problems of biogas production; the development of renewable energy resources in Poland (in particular the study on the increase of the number of biogas stations); the economic balance of biogas station.

Investigations of agricultural biogas plant located at a private farm in Studzionka village (Lubusz voivodeship) were done according to the methodology of the Institute of Technology and Life Sciences presented by Romaniuk et al. (2011, 2012b).

The total exploitation costs *(C_e)* were specified according to the formula No. (1) – (Romaniuk et al., 2011, 2012b):

$$C_e = C_{main} + C_{use} \quad (\mathrm{PLN \cdot year^{-1}}) \tag{1}$$

where:

C_{main} – the annual cost of installation maintenance, (PLN·year^{-1})

C_{use} – cost of use of the biogas plant, (PLN·year^{-1})

Unit exploitation cost c_{ej} is:

$$C_{ej} = \frac{C_{main} + C_{use}}{V} \quad (\mathrm{PLN \cdot m^{-3}}) \tag{2}$$

where:

V – amount of produced biogas in normal conditions, (m^3·year^{-3}).

Biogas station research has been carried out in the period of 2011-2012. Costs and profits were provided according to 2011-2012 prices.

Biochemical and technological problems

The following factors are the main reasons of disturbances in the biogas production process of both a biochemical and technological nature (according to Schattauer and Weiland, 2006):

– Fermentation temperature can quickly drop by a few degrees. Temperature drop inhibits the activity of methane bacteria, because they can survive only in a strictly limited temperature range. Hydrolyzing bacteria and acetic acids are not as sensitive to temperature fluctuations and can survive at lower temperatures. For this reason, in the fermenter, acid accumulates (pH decline) especially when the substrate supply is not stopped. Therefore, to ensure the effective use of installation, fermentation temperatures must be regularly monitored. This phenomenon contributes to the inhibition of the process, if the temperature goes up at the same time. This problem particularly relates to the systems operating within thermophilic fermentation. Another factor influencing the formation of ammonia is primarily a dosage substrates containing significant amounts of protein into the fermentor. As a result significant quantities of ammonia nitrogen are released.

- Hydrogen sulphide – the concentration of H_2S released in the reactor increases with the decrease of pH value, and increases with the temperature growth.
- Faults in the substrate dosing - biogas plants inoculation is done in most cases, with cattle liquid manure, because this substrate has a suitable bacteria concentration. During the start-up phase of biogas plants, it is important that the substrate serves as a constant component as possible allowing bacteria to develop constantly. It is also important that the amount of substrate is provided in small doses of methane bacteria to give sufficient time for growth.
- If loading of substrate to the digester is provided too fast, the process of methane bacteria development will be slowed down. As a result of the acidification process, which can take the entire volume of the digester, like intermediates formed in earlier stages of fermentation, cannot be further decomposed. Immediately after the start-up phase a normal use of the system begins.
- Hydraulic retention time (HRT) – residence time of the substrate in the system until replaced by a new material and is a direct measure of load fermented organic material. If short time activity occurs very quickly gas production will break down. In this case more bacteria can multiply at the same time by frequent exchanges of the substrate. In practice, you can not get the maximum production, so rather you should seek a compromise between the stability of the fermentation process and gas production.
- Influence of the substrate quality on the fermentation process – the use of residual feed or substrates at an advanced stage of decomposition can lead to a significant reduction in gas production and foam secretion.
- Pre-treatment of the substrate – better availability of organic matter to conduct biodegradation, and as a result – higher gas yield. It is necessary to remove not wanted matter, such as stones, wood, etc. Initial treatment by fragmentation in particular requires a substrate such as hay or crop residues.
- PH – if the fermenter gets more substrate with lower pH, it can lead to the inhibition of the methane fermentation process. In this case, before feeding the medium to the fermentor, it will be necessary to adjust the pH by adding alkali. Clear differences in pH between the content of the fermenter and the feed substrate also lead to strong foaming, as if CO_2 is released from the liquid.

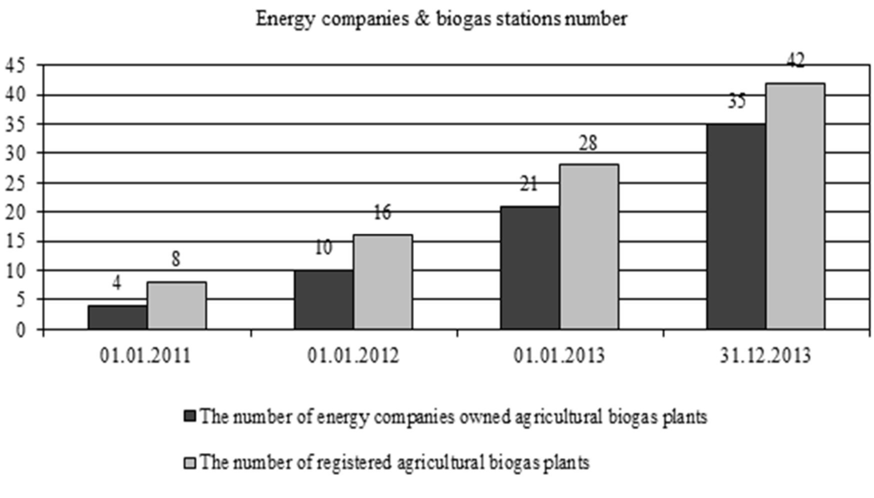
Development of renewable energy resources in Poland

The aim of the development of renewable energy sources, including obtaining biogas, is the need to protect the environment, to diversify the local energy supply, support innovative technology solutions, create opportunities for regional development and new jobs. The so-called "climate package" implemented for Poland as an obligation to obtain a 15% share of RES in the structure of energy consumption by 2020. However, due to a high cost of investment in the process of investigation to increase the share of renewables in energy balance, it was necessary to take specific actions at the government level, to coordinate, develope support systems, which can guarantee their systematic development.

The Agricultural Market Agency gathers information about the activities of energy companies involved in the production of agricultural biogas. Registered entities are obliged to submit quarterly reports containing the following information:

– the type and amount of substrates used in the production of agricultural biogas,
– the amount of agricultural biogas produced, the amount of biogas introduced into the gas distribution network,
– the amount of heat and electricity generated from agricultural biogas cogeneration system.

The graph below shows the change in the number of entities included in the Polish register of agricultural biogas plants and the number of installations in the period of 2011-2013.



Source: author's own calculation based on data of Agricultural Market Agency (ARR)

Figure 1. The number of energy companies and registered agricultural biogas plants in Poland

The produced agricultural biogas, after the necessary cleaning of unfavorable compounds, was used to produce electricity and heat. Table 1 below presents data on the level of production of agricultural biogas, electricity and heat from agricultural biogas in the above mentioned period.

Table 1
Amount of agricultural biogas, electricity and heat production in Poland in 2011-2013

Year	Agricultural biogas production (10^6 m^3)	The amount of electricity produced from agricultural biogas (GWh)	The amount of heat produced from agricultural biogas (GWh)
2011	36.65	73.43	82.63
2012	73.15	141.80	160.13
2013	112.38	227.88	249.06

Source: author's own calculation based on data of Agricultural Market Agency, www.arr.gov.pl

Energy production from biogas in Poland and the European Union

The following tables 2 and 3 give the level of production of biogas divided into categories in the European Union and the volume of electricity production.

Table 2
Energy production from biogas in the EU in years 2010-2011(ktoe)

Country	Years							
	2010				2011			
	Landfill gas	Gas from sewage treatment plants	Biogas remaining from agriculture	Total	Landfill gas	Gas from sewage treatment plants	Biogas remaining from agriculture	Total
Germany	232.50	402.6	6034.5	6669.6	149.0	504.2	4414.2	5067.6
UK	1492.6	256.0	0.0	1750.6	1482.4	282.4	0.0	1764.8
Italy	349.6	8.1	149.8	507.5	755.6	16.2	323.9	1095.7
France	236.7	44.1	53.2	334.0	249.7	41.9	58.0	349.6
NL	36.7	50.2	206.5	293.4	31.5	51.5	208.3	291.3
CZ	29.5	35.9	111.3	176.7	31.8	38.8	179.9	249.6
Spain	119.6	12.4	66.7	198.7	148.1	15.3	82.6	246.0
Austria	5.1	22.3	144.2	171.6	4.3	164	138.8	159.5
Poland	43.3	63.3	8.0	114.6	47.5	67.8	20.1	135.4
Belgium	41.9	14.6	70.9	127.4	41.9	14.6	70.9	127.4
Sweden	35.7	60.7	14.8	111.2	12.4	68.9	37.9	119.3
Denmark	8.1	20.1	74.0	102.2	5.2	19.6	73.2	98.1
Greece	51.7	15.0	1.0	67.7	55.4	16.1	1.4	72.8
Ireland	44.2	9.6	4.6	58.4	43.8	8.2	5.6	57.6
Slovakia	0.8	9.5	1.8	12.2	3.0	13.6	29.3	45.8
Portugal	28.2	1.7	0.8	30.7	42.3	1.8	0.9	45.0
Finland	22.7	13.2	4.5	40.4	23.9	13.4	4.8	42.1
Slovenia	7.7	2.8	19.9	30.4	7.1	2.7	26.2	36.0
Hungary	2.6	12.3	19.3	34.2	7.3	6.4	15.5	29.1
Latvia	7.9	3.3	2.2	13.3	7.8	2.4	11.8	22.0
Luxemb.	0.1	1.2	11.7	13.0	0.1	1.4	11.3	12.8
Lithuania	2.0	3.0	5.0	10.0	5.9	3.1	2.1	11.1
Estonia	2.7	1.1	0.0	3.7	2.2	1.1	0.0	3.3
Romania	0.0	0.0	3.0	3.0	0.0	0.0	3.0	3.0
Cyprus	0.0	0.0	1.0	1.0	0.0	0.0	1.0	1.0
Total	2801.7	1065.0	7008.8	10875.4	3157.9	1298.0	5719.3	10085.8

Source: EurObservER, 2012

Table 3
Production of electricity from biogas in the EU in years 2010-2011 (GWh)

Year	2010			2011		
Country	Plants producing only electricity	Electric energy from cogeneration (CHP)	Total	Plants producing only electricity	Electric energy from cogeneration (CHP)	Total
Germany	14847.0	1358.0	16205.0	10935.0	8491.0	19426.0
UK	5137.0	575.0	5712.0	5098.0	637.0	5735.0
Italy	1451.2	602.9	2054.1	1868.5	1536.2	3404.7
France	756.0	297.0	1053.0	780.0	337.0	1117.0
Netherlands	82.0	946.0	1028.0	69.0	958.0	1027.0
Spain	536.0	117.0	653.0	709.0	166.0	875.0
Czech Rep.	361.0	275.0	636.0	535.0	394.0	929.0
Austria	603.0	45.0	648.0	555.0	70.0	625.0
Belgium	149.0	417.0	566.0	158.0	442.0	600.0
Poland	0.0	398.4	398.4	0.0	430.0	430.0
Denmark	1.0	352.0	353.0	10	342.0	343.0
Ireland	184.0	22.0	206.0	181.0	22.0	203.0
Greece	190.5	31.4	221.9	37.6	161.7	199.3
Hungary	75.0	21.0	96.0	128.0	55.0	183.0
Portugal	90.0	11.0	101.0	149.0	11.0	160.0
Slovenia	7.2	90.2	97.4	5.7	121.0	126.7
Slovakia	1.0	21.0	22.0	39.0	74.0	113.0
Latvia	5.9	50.8	56.7	0.0	105.3	105.3
Finland	51.5	37.8	89.2	53.6	39.4	93.0
Luxemburg	0.0	55.9	55.9	0.0	55.3	55.3
Lithuania	0.0	31.0	31.0	0.0	37.0	37.0
Sweden	0.0	36.4	36.4	0.0	33.0	33.0
Romania	0.0	1.0	1.0	0.0	19.1	19.1
Estonia	0.0	10.2	10.2	0.0	17.0	17.0
Total	24528.2	5803.0	30331.2	21302,4	14554.1	35856.4

Source: EurObservER, 2012

Legal acts on renewable energy sources including biogas

Lack of coherence in the Polish legislation on renewable energy sources, in particular the absence of law on renewable energy sources, lower prices of certificates, are the main reasons of inhibition of biogas plants development in Poland. A biogas market leader – Germany – applied legal solutions that have become a model copied by other countries. The basis for payment of wages for RES entrepreneurs is the law for promoting renewable energy sources – "Gesetz für den Vorrang Erneuerbarer Energien" (Erneuerbare-Energien-Gesetz – EEG). The following Table 4 shows rates of 1 kWh of electricity from different sources.

Table 4
The financial support rate depending on biogas plant power

Type of source	Nominal biogas plant power	The rates for the acquired electricity from RES (1/100 € per 1 kWh)	German law reference
Landfill gas	up to 500 kW (inclusive)	8.60	§24 EEG
	from 500 kW to 5 MW (incl)	5.89	
Gas from sewage treatment plants	up to 500 kW (incl)	6.79	§25 EEG
	from 500kW to 5 MW (incl)	5.89	
Biogas remaining, eg. from agriculture	up to 1 MW (incl)	6.84	§26 EEG
	from 1MW to 5 MW (incl)	4.93	
	above 5 MW	3.98	
Biomass	up to 150 kW (incl)	14.3	§27 EEG
	from 150 kW to 500 kW (incl)	12.3	
	from 0.5 MW to 5 MW (incl)	11.0	
	up to 20 MW (incl)	6.0	
Biogas generated from manure	max 75 kW*	25.0	§27b EEG

* Additional conditions:

- biomethane conversion into electricity is conducted on-site biogas production,
- installed power of biogas plant (total),
- manure is at least 80 % by mass.

Source: author's own calculation based on data of Erneuerbare-Energien-Gesetz, 2012

In countries that are leaders in the production of biogas, generally limited to 60% of the input of grain and corn, in the case of the sale price mechanism the FiT tariff is introduced (Feed-In Tariffs). Introduction of the feed-in tariffs system in Poland is provided by a government bill on renewable energy sources, which in accordance with the rules of the European Union (Directive of the European Parliament and the Council 2009/28 / EC of 23 April 2009 on the promotion of the use of energy from renewable sources) was enacted by the end of 2010, and was not implemented by Poland before the European Court of Justice.

The Polish government action may indicate the intention to promote micro and small biogas plants established on small farms to avoid biogas market monopolization by large companies. The advantage of the installation up to 0.5 MW is the fact that it is easier to transport substrates for the biogas plant. However, the greater the power of biogas, they can also use a lot of extra equipment, safety procedures concerning environmental protection and health, and use many types of wastes. They can also achieve the best financial results with the installed capacity in the range of 1-2 MW. The downside may be a need to transport substrates from a distance, and it should be stressed that the transport operation may be inconvenient for the local community.

Method of calculation of energy produced from biogas

The method of calculation of the amount of energy generated from biogas was provided by the Ministry of Economy on 18 October 2012 on the specific scope of obligations to obtain and submit for cancellation certificates of origin, the substitute fee, purchase of electricity and heat from renewable energy sources and the obligation to confirm the data on the amount of electricity generated from renewable energy sources (Journal of Laws, item 1229).

The manufacturing unit, which burns biomass or biogas together with other fuels and the energy produced from renewable energy sources are classified as a part of the electricity or heat corresponding to the share of the chemical energy in biomass or biogas fuel chemical energy consumed in the production of energy, calculated on the basis of the calorific value of the fuel, according to the formula (3):

$$EOZE = \frac{\sum_{i=1}^{n} MBiWBi}{\sum_{i=1}^{n} MBiWBi + \sum_{j=1}^{m} MKjWKj} E \tag{3}$$

where:

- E_{OZE} – the amount of electricity or heat from renewable energy sources, (MWh, GJ)
- E – the amount of electricity or heat produced in a generating unit, which combusts biomass or biogas together with other fuels, (MWh, GJ)
- M_{Bi} – amount of biomass or biogas, burned in the generating unit, (Mg)
- M_{Kj} – amount of fuel other than biomass or biogas combusted in the generating unit, (Mg)
- W_{Bi} – calorific value of biomass or biogas burned in a generating unit, ($MJ \cdot Mg^{-1}$)
- W_{Kj} – calorific value of fuel other than biomass or biogas combusted in the generating unit, ($MJ \cdot Mg^{-1}$)
- n – the number of types of biomass or biogas burned in a generating unit,
- m – the number of types of fuels other than biomass or biogas, burned in the generating unit.

Biogas quality parameters

The quality of biogas in Poland is standardized by the Regulation of the Ministry of Economy of 24th August 2011. On the detailed scope of the obligation to confirm the data on agricultural biogas produced introduced into the gas distribution network (Journal of Laws of 2011, no. 187, item 1117). In addition, the following quality parameters of agricultural biogas introduced into the gas distribution network have been established (Table 5 and 6).

Table 5
The quality parameters of agricultural biogas introduced into the gas distribution network

No.	Indicator	The limit value
1.	Hydrogen sulphide content	$7.0\ mg \cdot m^{-3}$
2.	Mercaptan sulphur content	$16.0\ mg \cdot m^{-3}$
3.	Total sulphur content	$40.0\ mg \cdot m^{-3}$
4.	The content of mercury vapor	$30.0\ \mu g \cdot m^{-3}$

No.	Indicator	The limit value
5.	The dew point temperature of water at the pressure of 5.5 mpa A) from 1 April to 30th September B) from 1 October to 31st March	 no more than +3.7 ˚C no more than – 5.0 ˚C
6.	Calorific value of agricultural biogas introduced into the natural gas transport network:	
	a) With a high content of methane group E of the Wobbe index in the range of 45.0 MJ·m^{-3} (incl) up to 54.0 MJ·m^{-3}	34.0 MJ·m^{-3}
	b) Nitrogen-rich, subgroup Lw, Wobbe index in the range of 37.5 MJ per cubic meter (incl) up to 45.0 MJ·m^{-3}	30.0 MJ·m^{-3}
	c) Nitrogen-rich, subgroup Ls, Wobbe index in the range of 32.5 MJ·m^{-3} (incl) up to 37.5 MJ·m^{-3}	26.0 MJ·m^{-3}
	d) Nitrogen-rich, subgroup Ln, Wobbe index in the range of 27.0 MJ·m^{-3} (incl) up to 32.5 MJ·m^{-3}	22.0 MJ·m^{-3}
	e) Nitrogen-rich, subgroup Lm, Wobbe index in the range of 23.0 MJ·m^{-3} (incl) up to 27.0 MJ·m^{-3}	18,0 MJ·m^{-3}

Source: author's own elaboration based on data of Polish Law 2011, no. 187, item 1117

Table 6
Terms of references for biogas production

Terms of reference for biogas	Parameter	
	Pressure	Temperature
Combustion process	101.325 kPa	298.15 K (25˚C)
Volume measurement	101.325 kPa	273.15 K (0˚C)

Source: author's own study based on data of Polish Law 2011, no. 187, item 1117

The amount of agricultural biogas production shall be recalculated into the equivalent amount of electricity generated in renewable energy sources, according to the equation (4):

$$E_{OZE\,ekw} = \eta \sum_{i=m}^{n} (M_{bri} \times r_i) \tag{4}$$

where:

$E_{OZE\ ekw}$ – the amount of electricity possible to be generated using renewable energy sources as an equivalent of biogas introduced into the gas distribution network, (MJ)

n – the number of batches of agricultural biogas introduced into the gas distribution network,

m – indication of next batch of agricultural biogas introduced into the gas distribution network,

M_{bri} – number of agricultural biogas introduced into the gas distribution network in different parts of (m^3), with a specific calorific value measured using the measuring devices settlement,

r_i – the real calorific value of a particular amount of agricultural biogas introduced into the gas distribution network, (MJ·m^{-3})

η – reference efficiency value for separate electricity production unit consuming agricultural biogas, (η= 52.5%)

Results of investigations of biogas plant

Investigations of the agricultural biogas plant were carried out according to the methodology of the Institute of Technology and Life Sciences presented in the work: "The method of assessment of agricultural biogas plants" (Romaniuk et al., 2011). Biogas station research has been carried out in period 2011-2012 and is presented below (Table 7). Costs and profits were given according to 2011-2012 prices.

Table 7
Results obtained during the study of biogas plants in Studzionka village (Lubusz Voivodeship)

Parameters and results	Units	Values
Number of fermentation chambers	(-)	2
Total capacity of fermentation chambers of biogas plant	(m^3)	410
Investment cost of the whole installation	(PLN)	450 000
The cost of building - 1 m^3 of biogas plant	(PLN)	1 100
The amount of biogas produced per year	(m^3)	112 000
Calorific value of biogas	($MJ \cdot m^{-3}$)	20.75
The amount of electric energy produced from biogas	($MWh \cdot year^{-1}$)	212
The amount of heat produced from biogas	($MWh \cdot year^{-1}$)	246
The potential profit from the sale of produced electricity	($PLN \cdot year^{-1}$)	100 622
The market price of energy sold to the grid	($PLN \cdot MWh^{-1}$)	197.72
The market price of green certificates of origin	($PLN \cdot MWh^{-1}$)	273.73
The annual cost of maintaining installation C_{main}	($PLN \cdot year^{-1}$)	27 000
Cost of use of the biogas plant C_{use}	($PLN \cdot year^{-1}$)	15 450
The exploitation costs of biogas plant C_e	($PLN \cdot year^{-1}$)	42 450
The cost of electricity production in the installation	($PLN \cdot MWh^{-1}$)	86.2
The cost of heat production in the installation (In the calculation does not take into account 30% of the heat that is used to the biogas plant heating)	($PLN \cdot MWh^{-1}$)	156.13
Annual use of slurry and poultry manure for biogas production	(t)	1058.5
The cost of raw material	($PLN \cdot t^{-1}$)	10
Annual cost of raw material	(PLN)	10 585
The cost of electricity production	($PLN \cdot MWh^{-1}$)	113.76
The cost of heat production	($PLN \cdot MWh^{-1}$)	206.06

Conclusions

Based on the literature review and the research which was carried out, the following conclusions have been presented:

1. Biogas plants are the objects of stable energy, which when properly used with the technological regime, have a constant electrical performance and can be built to meet the demand for electricity. Biogas production is still a major part of the objectives of the National Action Plan for energy from renewable sources by 2020.
2. In Poland, it is warranted to build both agricultural biogas plants below 100 kW, as well as much larger installations. The final investment decision should result from a comprehensive account of the opportunities and needs.
3. Usage of agricultural biogas depends on many factors specific to location of each installation (distance from the grid, general and local demand for a particular source of energy).
4. Only the investor, not local administration representatives decide how to use the produced biogas (purification and delivery to the network, or conversion to electricity and / or heat).
5. National policies have the greatest influence on the development of renewable energy production in different countries of the European Union.
6. The lack of consistent rules, and especially delayed publication of the Renewable Energy Sources Law constitute an impediment for the development of agricultural biogas plants in Poland.
7. Operational tests of a small biogas plant with total capacity of the two reactors of 411 m^3 conducted in 2011-2012, have enabled determination of the actual electricity production cost - 113.76 $PLN \cdot MWh^{-1}$ and heat production costs - 206.06 $PLN \cdot MWh^{-1}$. The cost of building of 1 m^3 of biogas plant in the economic way was PLN 1100. The exploitation costs of the biogas plant was 42 450 $PLN \cdot year^{-1}$ as the cumulative costs: the annual cost of installation maintenance 27 000 $PLN \cdot year^{-1}$ and the cost of use of the biogas plant was 5 450 $PLN \cdot year^{-1}$.
8. The calculated profit from the sale of the produced electricity was 100 622 $PLN \cdot year^{-1}$.

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TECHNICZNE I EKONOMICZNE ASPEKTY PRODUKCJI BIOGAZU ZE ŹRÓDEŁ ROLNICZYCH Z UWZGLĘDNIENIEM POLSKICH WARUNKÓW

Streszczenie. Celem pracy były badania wpływu aspektów technicznych i ekonomicznych produkcji biogazu ze źródeł rolniczych z uwzględnieniem polskich warunków, mających wpływ na wdrożenie Dyrektywy 2009/28/EC Parlamentu Europejskiego i Rady na promocję użytkowania energii ze źródeł odnawialnych. Badania zawierały analizę problemów biochemicznych i technicznych oraz rozwój OZE w Polsce. Ponadto przedstawiono metodę kalkulacji ilości energii pozyskanej z biogazu oraz parametry jakościowe biogazu. Badania mikrobiogazowni rolniczej o łącznej pojemności komór fermentacyjnych 411 m^3 przeprowadzone w latach 2011-2012 w miejscowości Studzionka, woj. lubuskie, pozwoliły na uzyskanie następujących wyników: koszt produkcji energii elektrycznej 113,76 $PLN \cdot MWh^{-1}$ oraz produkcji ciepła 206.06 $PLN \cdot MWh^{-1}$. Jednostkowy koszt wybudowania instalacji wynosił 1100 $PLN \cdot m^{-3}$. Koszty eksploatacyjne kształtowały się na poziomie 42 450 $PLN \cdot rok^{-1}$ stanowiąc sumę kosztów: utrzymania 27000 $PLN \cdot rok^{-1}$ oraz kosztów użytkowania, które wynosiły 5450 $PLN \cdot rok^{-1}$. Dochód z tytułu sprzedaży energii oszacowano na poziomie 100622 $PLN \cdot rok^{-1}$. Rachunek ekonomiczny został sporządzony wg poziomu cen z lat 2011-2012**.**

Słowa kluczowe: odnawialne źródło energii, biogaz, elektryczność, ciepło, kogeneracja