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EFFECTS OF SMALL BIOGAS PLANTS IN POLAND

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ABSTRACT: The paper describes current situation in Poland regarding biogas plants development. The lack of new act on renewable energy sources for a long time, not contributes to the development of biomass energy. The situation seems to have changed after the entry into force of the new law. Nevertheless, the low support of state and auction system does not guarantee the profitability for biogas particularly in agriculture. We applied questionnaire survey to Polish local communities regarding biogas plants. The practical recommendations for decision makers regarding better renewable energy policy were formulated.

KEY WORDS: agriculture, bioenergy, biogas plants, cost, renewable energy

Introduction

The development of the renewable energy sector can be supported by the state. The investments without regulations and support systems in the field of their financing are unprofitable. The reasons are high investment costs, business risks and unit costs of energy generating. The bioeconomy, including renewable energy, like biogas plants are attractive investments in undeveloped rural areas. This renewable energy source is popular in the Germany and Czech Republic, where the number of biogas plants is growing. Currently, 80% of the largest biogas plants are located in Germany, with the capacity of 20 MW each, however, the German market is experiencing some difficulties. In Poland, their number is yet insufficient, and investors implementing biogas projects encounter community protests and significant bureaucracy. The small development of energy based on biogas is disappointing for two reasons. First of all, Poland imports almost $\frac{2}{3}$ of natural gas, mostly from Russia, and the only option to change this situation is based on a very expensive (several-dozen million PLN) expansion of infrastructure for importing this fuel from other countries. Unfortunately biogas is not indicated as an alternative for growing imports and the deteriorating Polish trade balance. The second reason is the high risk of non-fulfillment of Poland's target regarding the share of "green" energy in the final energy consumption in 2020.

For a long time, it was not possible to adopt the act on renewable energy sources, and thus create a new support system in Poland. Uncertainty has appeared on the market. The situation seems to have changed after the entry into force of the new law. The support system came from January 1, 2016. Further, the level of support, the reference point, whether the auction system is appropriate is discussed. In some opinion, more than 1 megawatts of installed biogas power will not be competitive and will not win these auctions.

One can find 24 operators of agricultural biogas plants (2013). Among them, the leader is Poldanor company, which operates 8 agricultural biogas plants in Poland located in: Koczała, Pawłówek, Płaszczycza, Uniechówek, Kuyanki (Pomorskie Province), Naclaw, Świelin, and Giżyn (West Pomeranian Voivodeship) (Poldanor. Information center about the energy market CIRE, 2012). Biogas plant location in Poland is shown in the table 1.

Table 1. Number of biogas plants of different type in Polish provinces

| Province | Biogas plants creating energy from | | | | Altogether |
|---------------------|------------------------------------|-------------|-----------|-------|------------|
| | Wastewater treatment Plants | agriculture | landfills | mixed | |
| Mazowieckie | 13 | 5 | 20 | 0 | 38 |
| Slaskie | 17 | 2 | 15 | 1 | 35 |
| Wielkopolskie | 7 | 8 | 10 | 0 | 25 |
| Dolnoslaskie | 10 | 9 | 9 | 1 | 29 |
| Pomorskie | 4 | 9 | 6 | 0 | 19 |
| Zachodniopomorskie | 4 | 13 | 8 | 1 | 26 |
| Malopolskie | 10 | 2 | 5 | 0 | 17 |
| Kujawsko Pomorskie | 5 | 6 | 7 | 0 | 18 |
| Warminsko-Mazurskie | 6 | 10 | 3 | 0 | 19 |
| Lodzkie | 3 | 4 | 4 | 0 | 11 |
| Lubelskie | 5 | 7 | 2 | 1 | 15 |
| Podlaskie | 5 | 9 | 1 | 0 | 15 |
| Podkarpackie | 10 | 3 | 4 | 0 | 17 |
| Lubuskie | 2 | 4 | 2 | 0 | 8 |
| Opolskie | 3 | 1 | 3 | 0 | 7 |
| Swietokrzyskie | 2 | 1 | 1 | 0 | 4 |
| Total | 103 | 93 | 100 | 4 | 303 |

Source: Woźniak, 2017, <https://www.cire.pl/item,141910,2,1,2,0,305667,0,stan-biogazowni-w-polsce.html#komentarz> [03-10-2018].

The total nominal power of agro-biogas plants can increase significantly in the future. The Institute for Renewable Energy (IEO) reports that several hundred biogas projects are implemented in Poland (IEO, 2016). Nevertheless, the implementation of biogas investments is delayed. Current support for biogas plant market in Poland is not sufficient (it was PLN 286/MWh in 2012). There are advantages in applying “Biogas”, it is cheap in production and a reliable source of energy with endless uses. It is also a good way to get rid of unwanted liquid waste materials. The energy it produces is powerful and clean, and it does not pollute groundwater supplies neither cause air pollution and can be used as a fuel to power electrical generators. As well as being used to power appliances it can be used to fuel gas turbines to generate electricity. Biogas is also quite safe to use and combustion. Additionally, once

the anaerobic decomposition has stopped producing biogas, that what is left behind is generally a high quality composting material which can be recycled for use as an excellent soil amendment. Anaerobic compost also enhances moisture retention, thereby reducing the need for water, another precious resource. However, the disadvantage of biogas if compared to fossil fuel natural gas it is that it has only about one-half the BTU heating value of natural gas. Also there is not much biogas infrastructure available, such as gas recovery and handling systems, piping, meters, gas pump or blower, etc, so the use of biogas is very limited.

An overview of literature

In the case of micro and small biogas plants, there is a deficiency of data on the costs of such investments in Poland. The solution would be to use the available data referring to German biogas plants, but this data do not have much in common with the conditions prevailing on the Polish market due to the different and expanded market in Germany. Costs and productivity improvements in the case of agricultural biogas technologies in Poland and insufficient support system for biogas plants in Poland were indicated. The first agricultural plant in Poland was opened in 2005 in Pawłówek. The biggest agricultural plant in Poland was opened in 2009 in Liszkowo (Igliński, 2009).

The general objective adopted for the whole European Community is 20% share of RES in the "EU energy balance", the Directive also sets national targets for individual Member States. The scope of the directive extends to three sectors of the economy: electricity production, heating and transport. The goal set for Poland was to achieve in 2020 "15% of energy from renewable sources in the entire domestic consumption." Progress in the Polish economy in fulfilling commitments, despite numerous assurances and positive forecasts, has not been satisfactory. On January 31, 2011, the European Commission issued a report on the progress in implementing RES targets by 2020 (based on the objectives contained in directives relating to green electricity and biofuels, respectively Directive 2001/77/EC and 2003/30/EC). The data from the Central Statistical Office published at the end of December 2016 show that the share of energy from renewable sources in final consumption in 2015 amounted to 11.77% in Poland, compared to 11.90% planned by the government. The Central Statistical Office also verified data from previous years, slightly raising the values in this data. Until recently, the environmental performance of biogas production was not assessed in a detailed manner,

but to highlight concerns about emissions of greenhouse gases at various stages of the biogas production chain some studies have started.

The situation in Germany is completely different. Biogas production in Germany has increased over the last 20 years. The main reason is the legally frameworks. Government support in renewable energy with the Electricity Feed-in Act (*StrEG*), guaranteed the producers of green energy the feed into the public power grid, thus the power companies were forced to take all energy produced by independent private producers of green energy (Germany, *Stromeinspeisungsgesetz (StrEG, 1990)*). In 2000 the Electricity Feed-in Act was replaced by the Renewable Energy Sources Act (*EEG, 2016*). This law even guaranteed a fixed compensation for the produced electric power over 20 years. The amount of around 8 ¢/kWh gave farmers the opportunity to become energy suppliers and gain a further source of income (Wieland, 2003). The German agricultural biogas production was given a push in 2004 by implementing the so-called *NawaRo-Bonus* as a payment given for the use of renewable energy crops. In 2007 the German government stressed its intention to invest in further effort and support to improve the renewable energy supply and provide an answer concerning growing climate challenges and increasing oil prices by the 'Integrated Climate and Energy Programme' (Biogas, no date).

Both biomass and biogas have a large potential for use in the production of "green energy" in Poland. The term biomass is referred to waste wood from forestry and wood industry, energy crops as well as to waste and residues from the food and agricultural industry (Pawlik, 2010). The biogas plants' potential in Poland in 2015 was 88.14 MW, of which 25% were agricultural type biogas plants, landfill biogas and waste water treatment plants. In 2011, agricultural biogas plants in Poland produced 26.7 million m³ of biogas, of which 53 GWh of electricity and 60 GWh of heat were generated. According to the Energy Regulatory Office, there were 303 biogas plants in Poland (as of September 30, 2016). In comparison with 2015, their number increased only by 36. The largest increase was recorded in the case of agricultural biogas plants, as 26 installations of this type were created. The total number of agricultural biogas plants in 2017 was 95, which is 31% of all biogas plants in Poland. In 2017 year, there were 95 such facilities in the register of agricultural biogas plants (Wieczerek-Krusińska, 2016). Their total electric power output was 101.09 MW. Last year, the list expanded only by 3 new biogas plants with a total capacity of 1.88 MW. As part of this year's auction (2018), on which the new system for supporting green energy production is to be based, the Ministry of Energy will order 3.8 TWh of electricity from existing small installations for agricultural biogas (up to 1 MW) and 4.15 TWh of energy from larger sources for this fuel (above 1 MW). In both cases,

entrepreneurs cannot submit a bid higher than PLN 550 per MWh. At this level, the ministry proposed the so-called reference price for this technology. And although it is the highest among the reference prices proposed in the draft regulation for other RES technologies, it is still below the break-even point.

Research methods

The literature review was conducted. The data on renewable energy from statistical office and other sources were gathered and analyzed. The results obtained from as much as 17 filled out questionnaires "Renewable energy sources – current state, barriers and development perspectives for the Polish Municipalities" circulated by the author in municipalities in the north of Poland were used to resolve the research problem.

As a result of the survey conducted by the author in Polish communes, it turned out that the greatest impact on the location of biogas plants has an access to substrates (energy crops), the possibility of connecting to the energy grid and the management of heat from energy production. The research also shows that entrepreneurs sell the electricity to the national grid, while the heat is used for their own needs. The majority of biogas producers generate both thermal and electric powers. This amounted to few MW of electric energy and few GJ of heat per year. The benefits of biogas plants presented in this case were related to economic effects in the form of savings, avoiding the costs associated with the purchase of carbon dioxide emission permits for the production of energy from fossil fuels, as well as reducing waste disposal costs and energy costs.

Results of the research

The results show that in biogas plants being built in communes will use substrates of agricultural origin, such as, for example, slurry and waste from the processing of agricultural products, such as green forage, silage. The substrates will be obtained from the following sources: maize and grass silage, potato pulp and decoction as well as Ferma-Pol farm. One of the municipalities reported that it will be 70920 Mg/year substrate weight, and biogas plants will have a capacity of 1-2 MW, so traditionally, they will be too large. The energy production will be, according to one of the communes, 9 987 718 kWh/year.

One of the municipalities that has biogas plant is the commune of Giżycko. An agricultural biogas plant with a capacity of 1 MW was created in Upały. An investor of an agricultural biogas plant company with Upały-Rol,

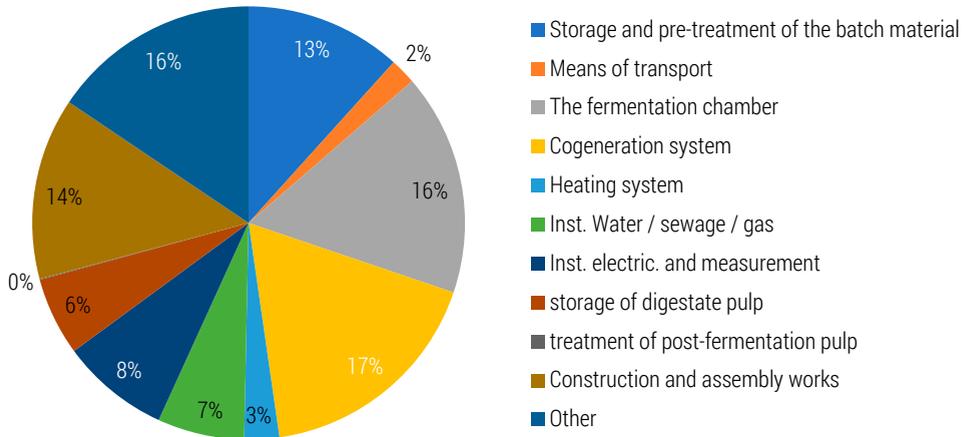
Ltd – in 2011 applied for permission for the construction of a biogas power plant. The grant agreement for the biogas plant in Upały provided the investor with a co-financing of 40% of the project costs from the Environment fund WFOŚiGW in Olsztyn (PLN 4 million). The construction of a biogas plant total cost was PLN 10 million. The biogas plant in Upały was established on a farm with an area of 1 thousand ha. The substrate needed for energy production – mainly slurry and maize are obtained only from this area. It is primarily liquid manure and maize, as well as other agricultural production waste, especially those of animal origin. The operation of the biogas plant in Upały-Roll. Ltd. will cause that the surrounding fields will be fertilized with harmless, fermented raw materials, and not with the unprocessed slurry and liquid manure as previously. Thanks to this, nutrients will become more easily absorbed by plants. In addition, there will be no unpleasant odours. What's more, the applied technical and technological solutions, i.e. full encapsulation of the process, tight arrangement of geomembranes and control wells under tanks, and optimal setting of the fuel combustion process in cogeneration engines and rainwater treatment will cause that the investment will not have a negative impact on the natural environment. The utilization of plant and animal waste will in turn result in a lower odour nuisance of the plant

The important issue is the cost of the substrates. For example, the cost is about 100 PLN/t for maize silage, and up to PLN 50/t for slurry. A separate issue is the cost of substrates transport from the waste generation/biogas plant site. If the biogas plant operator pays for the transport of substrates (transport costs can also be covered by the supplier), the costs of fuel as well as the purchase and servicing of the car should be added. In German conditions, repair and maintenance services amounted to approx. 10% of annual operating costs for 90% of biogas plants. Financing structure is: own funds – 20%, bank loan – 80%, interest rate per year – 8.5%, loan period – 12 years. Figure 3 presents the structure of investment outlays for previously given project assumptions. The total expenditure will amount to PLN 15.5 million, which gives a result ratio of PLN 18.6 million/MW_{el}. The cogeneration system (17%) and the fermentation chamber (16%) have the largest percentage share in the expenditure structure.

In the structure of operating costs without depreciation (PLN 3.9 million) the largest share has the cost of purchase and storage of substrates. Liquid manure will be obtained cost-free maize silage at a price of 100 PLN/t. In addition, it was assumed that these media will be stored in the sleeve (+20% for the price of silage). Another significant item is the cost of transporting the digested pulp to meadows.

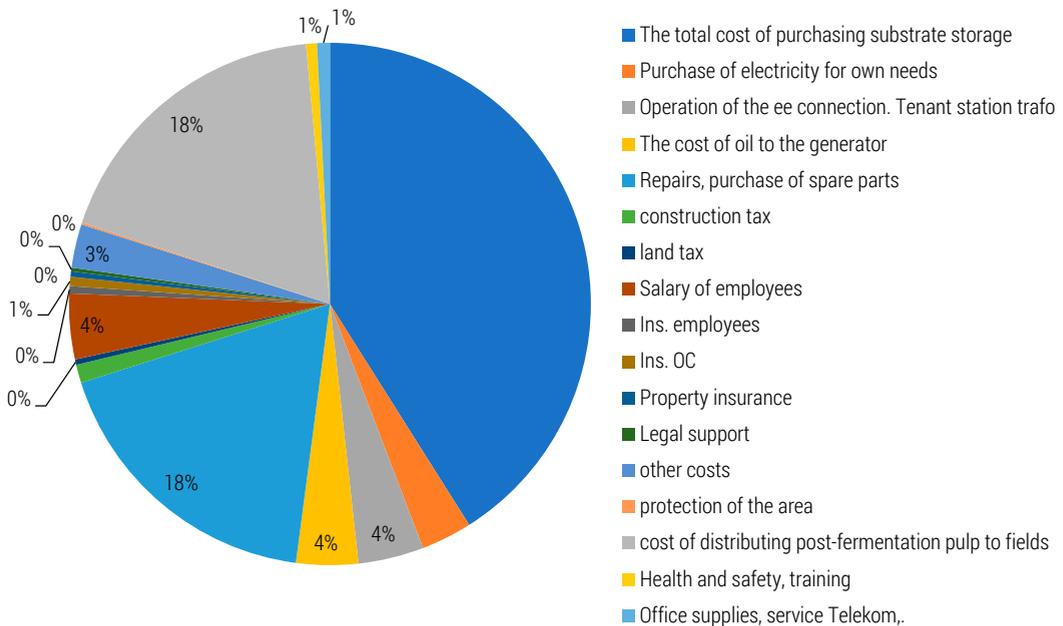
Figure 1. The structure of capital expenditures for a 0.86 MW biogas plant

Investments outlays 15,5mln



Source: author's own work based on http://www.ieo.pl/dokumenty/biogazinwest/przyklady_obliczeniowe_Biogaz_Inwest_gnojowica_kiszonka.pdf[15-06-2018].

Figure 2. The structure of annual operating costs for a 0.86 MWel biogas plant – (PLN 3.9 million)



Source: author's own work based on Guide for investors, 2011.

Conclusions

Research implications are important from the practical point of view. The biogas is renewable energy source, it contributes to the environmental aspects, and to agriculture by utilisation of wastes. Biogas plant create new jobs, also it transforms wastes into less harmful substance. The biogas plant also has shortcomings that cannot be omitted. The continuous lack of funds, clearly makes its mark on it. Such investments in analysed municipalities are expensive, which is why there are not common in Poland. They would help in the activation of agricultural areas. During winter, access to substrates is quite limited which may generate losses in the biogas generation process. The losses resulting from the uncertainty of investment should be also taken into account. Polish law renders also difficulties in the construction of biogas plants. Before an investor can see a legal case, all its enthusiasm will be lost and the money will be invested in something different. The large-scale introduction of biogas could create chaos on the energy market, as the prices of raw materials and other energy products would change sharply. And there is an impact from a completely different side, namely the unpleasant odour that accompanies the work of a biogas plant. It cannot be avoided, although it is limited to the nearest installation neighbourhood.

It can be seen that biogas plants can be a solution contributing to the greater empowerment of local communities. Smaller installations can be built there, and their investors can be usually local farmers, local entrepreneurs or local energy cooperatives. In Poland the market has developed in a completely different direction than in Germany. The support system – green and yellow certificates and investment subsidies – was constructed in such a way that it was more profitable to build large biogas plants, oversized, 2 MW of capacity, in the open field, using substrates whose sources are far distant by up to 30 km, without cogeneration. The basic factor conducive to the construction of a biogas plant is the appropriate legal regulations.

Acknowledgements

This research has been supported by Collegium of Business Administration Warsaw School of Economics.

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