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AGRICULTURAL BIOGAS PRODUCTION AND THE DEVELOPMENT OF PROSUMER ENERGY IN POLAND*

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Abstract. The first part of the article presents basic information affecting the development of renewable energy sources (RES) and the theoretical basis for state activities resulting from the concept of external effects and public goods. In the second part data from the Agency for Restructuring and Modernisation of Agriculture (ARMA) were used to estimate the possibility of establishing agricultural biogas plants on Polish territory as well as their current number and installed capacity. It has been found that the potential for production of agricultural biogas is used to a small degree and by very large installations, which is not conducive to the development of prosumer energy. Two reasons have been identified for the aforementioned situation: the high start-up costs of such operations and inconsistent state policy aimed at supporting RES. The situation is further worsened by a lack of RES legislation and the directions of proposed changes, which are shifting to support for large energy producers at the expense of prosumers.

Key words: agricultural biogas, renewable energy, prosumer

JEL code: Q5

Introduction

According to the latest results of observations conducted by the World Meteorological Organization (WMO), the year 2014 has been the warmest year in the history of official measurements (WMO, 2014) and even since the year 1500. This is confirmed by data from the Polish Institute of Meteorology and Water Management (IMWM). What is more, the ten warmest years in the history of observations have occurred since 2000 (National Climatic Data Center). Therefore, an increasingly large part of society is taking notice of the changes in climate and the need to take actions aimed at halting them. Despite significant problems of a

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political and economic nature, the UE implemented such actions. During a summit of the EU leaders held in October 2014, they reached an agreement on climate protection. According to it, firstly, the EU shall, as a whole, reduce CO2 emissions by 2030 by at least 40% when compared to the year 1990. Secondly, the share of renewable energy sources in total electrical energy used is to reach a minimum share of 27% by 2030. It remains an open question whether these goals are not overly ambitious, taking into account the delays and resistance of other countries to bearing the costs of climate protection (Golasa, P., Lenort, R., Wysokinski, M., Baran, J., Bienkowska-Gołasa., 2014). However, the development of renewable energy sources forced by this agreement has become a chance for the development of said sources, especially in rural areas.

The aim of this article is to determine the possibilities for agricultural biogas production in Poland and the opportunities for development of prosumer energy. To achieve the aim, the following research tasks were set:

- to analyse agricultural biogas production opportunities in particular regions in Poland;
- to identify existing biogas plants and to characterise their average power.

The first part of the article presents the theoretical basis of environmental economics, while the second part uses data from the Agency for Restructuring and Modernisation of Agriculture on farms, and from the Energy Regulatory Office (ERO) on the number and capacity of biogas plants, in order to execute the study objectives.

Research results and discussion

Theoretical economic basis for RES support

With current technical capabilities, production of renewable energy production is significantly more expensive than conventional energy. In order for it to develop, countries must establish special conditions and support systems. Thus the question arises regarding the theoretical basis for such an intervention, its sources and methods. This issue is the subject of environmental economics. The problem can be approached from the perspective of two imperfections in the market of external effects and public goods (Stiglitz I. E., 2004)

The first one occurs when the actions of one entity impact the state of other individuals. This effect can generate costs for them, which is when negative external effects occur, or give benefits (positive external effects). This results in sub-optimal allocation of resources, as per the Pareto principle, as one of the optimum conditions, on the equality of marginal transformations and substitutions, is broken (Acocella N., 2002). In the case of negative external effects, entities behind them fail to bear the full costs of their actions, which leads to the scale of their operations becoming excessively large. If the issue is examined from the

perspective of the environment being as a public good, there is a problem of no disclosure of preferences in terms of both demand and supply of these goods. Public goods are used by everybody, regardless of whether they bear the costs of their maintenance or not. Accordingly, the phenomena of external effects and public goods are mutually aligned, since in both cases discrepancies occur in terms of private and social costs (Fiedor B., 2002).

The question arises whether the state should intervene in such a situation. According to Coase, it should not because each party, the one injured and the one benefiting, can conduct negotiations on the removal of the effects in questions, so as to obtain the socially desired effect (Coase R. H., 1960). In the current economic situation, negative external effects resulting from the impact of businesses on the environment, have the most significance. As negotiations between the parties polluting the environment and the rest of society are difficult for organisational and technical reasons, it seems that Coase's approach is not really fitting and the existence of these effects is the justification for state intervention. Society as a whole is interested in increasing the scale of activities generating positive external effects and reducing the negative effects, so the role of the state is to provide an appropriate framework for this type of actions (Wysokinski M., Baran J., Gołasa P., Lenort R., 2014) . Meanwhile, the answer to the question of whether these actions are to be performed by means of administrative instruments - standards, or economic instruments (e.g. based on the Pigou tax) remains up to the authorities of the particular state.

Biogas production

Biogas is a mixture of gases, consisting mainly of methane and carbon dioxide, produced by microorganisms in the process of decomposition of organic substances under anaerobic conditions. It includes - depending on the raw materials, conditions and technology - methane (CH4) - 50% to 75%, carbon dioxide (CO2) - 25% to 45%, hydrogen sulphide (H2S) 20-20000 ppm, hydrogen <1% , carbon monoxide (CO) - 0.1%, nitrogen <2%, oxygen <2%. The larger the share of methane in the biogas, the higher its calorific value. With a methane content of 65%, a calorific value of 23 MJ/m^3 is assumed. In practice, there are several types of biogas plants, mainly differing by the substrate used for the creation of biogas. There are biogas plants for agricultural materials, landfills, sewage treatment plants and mixed sources.

Currently, a major substrate for the production of agricultural biogas is animal excrement, slurry in particular (Wysokinski, M. Dziwulski, M., 2013). The problem lies in its low dry matter content and hence - low biogas production potential. For this reason substrates used in a biogas plant are supplemented with energy crops. Corn is the prevalent choice. This is supported by its extremely high energy yield per hectare, with German studies showing 45 Mg of fresh weight per hectare. In addition, the plant is quite easy to grow, it does not require specialised equipment and storage is not a major problem. It can be placed in a silo, covered with foil and subjected to an ensiling process. Although production of agricultural biogas from corn itself is possible, for process technology reasons: stability of the process as well as an

increase in the production of methane, it is desirable to use slurry as a second substrate. (Institut fur Energetik und Umweltg, 2005).

Photo 1: Corn storage facility for a biogas plant

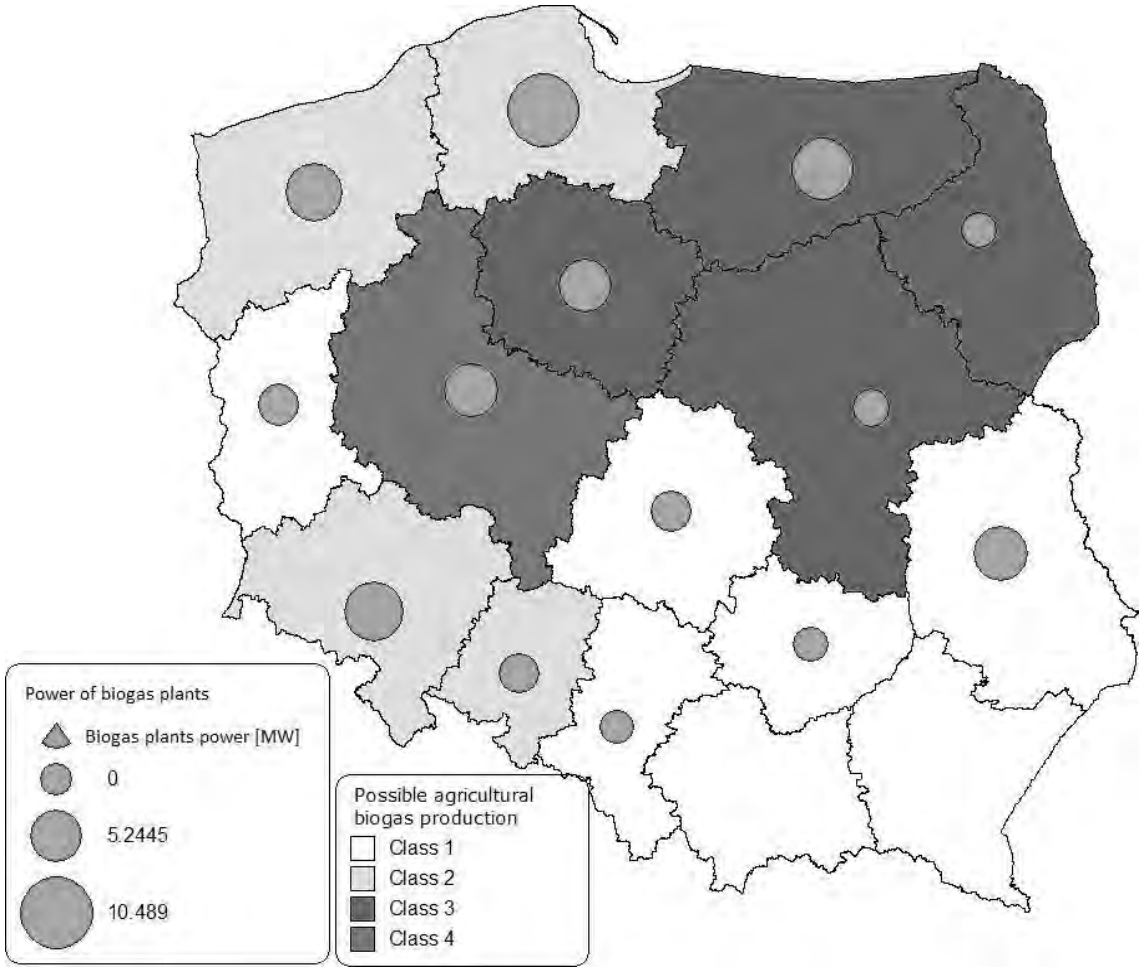
Photo 2: Co-generation engine

Source: author's photos

The final product from a biogas plant is biogas (with parameters similar to natural gas), electricity, or electricity together with generated heat. The last of these products is the most widespread for practical and economic reasons (high efficiency of cogenerative devices and the possibility of selling both electricity and heat).

Production capacity in Poland

Agricultural biogas plants currently operating in Poland are focused on the following substrate: corn, slurry, urine, solid manure. Consequently, the research has focused on these substrates. It has also been taken into account that for technological reasons biogas plants require substrates of vegetable and animal origins. Knowing the requirements for substrates for a biogas plant with a capacity of 0.1-1 MWel (megawatt of electricity) and the number of farms producing such materials from the Agency for Restructuring and Modernisation of Agriculture (ARMA), estimated the possibilities for biogas plant development in Poland.



Source: author's construction based on data from ARMA

Fig. 1. **Possible agricultural biogas production in individual regions and its use**

The best opportunities for agricultural biogas production were observed in the Wielkopolskie region. There are nearly 4000 farms in whose case the scale of production would allow for the operation of at least a small agricultural biogas plant. The possibilities for the Mazowieckie, Kujawso-Pomorskie, Warmińsko-Mazurskie and Podlaskie regions are at a slightly lower, albeit also high level, whereas in the case of regions in the South-East of Poland, the capacity is at its lowest. In the document Directions for Development of Agricultural Biogas Plants in Poland in the years 2010-2020, the Ministry of Economy has drawn up a plan to build one agricultural biogas plant on average per commune. Theoretically, this should mean that almost 2000 such installations should be built in Poland. The current state is much less optimistic.

Table 1

Agricultural biogas plants in Poland in 2014

	Region	Number of biogas plants	Power [MW]	Average power [MW]
1	Dolnośląskie	*6*	*7,123*	1,19
2	Kujawsko-Pomorskie	*4*	*7,401*	1,85
3	Lubelskie	*5*	*5,661*	1,13
4	Lubuskie	*3*	*2,391*	0,80
5	Łódzkie	*2*	*2,498*	1,25
6	Małopolskie	*0*	*0*	
7	Mazowieckie	*2*	*2,26*	1,13
8	Opolskie	*1*	*2*	2,00
9	Podkarpackie	*0*	*0*	
10	Podlaskie	*1*	*1*	1,00
11	Pomorskie	*9*	*10,489*	
12	Śląskie	*1*	*0,526*	0,53
13	Świętokrzyskie	*1*	*0,8*	0,80
14	Warmińsko-Mazurskie	*7*	*7,726*	1,10
15	Wielkopolskie	*7*	*7,482*	1,07
16	Zachodniopomorskie	*6*	*6,678*	1,11
	Total	55	64,035	1,16

Source: author`s calculations based on data from Energy Regulatory Office (ERO)

Currently, 55 such facilities are operating in Poland, most of them in the Pomorskie (where the highest capacity of such installations exists), Warmińsko-Mazurskie and Wielkopolskie regions. In Poland, at a country level, large or very large installations with a capacity starting at 600 kWel and up to even 2 MWel dominate. There are practically no small facilities up to 100 kWel. This is contrary to the idea of prosumer energy.

Prosumer energy

The concept of prosumer energy appeared in Jeremy Rifkin's works along with the concept of the third industrial revolution based on the following pillars: transition to renewable energy, equipping all buildings with micro-installations generating renewable energy on-site, use of the Internet to build and manage an energy exchange network, so that excess energy can be sold to other users (Rifkin I. R., 2012). Although the overall concept is utopian at this point in time, this prosumer approach to energy production is absolutely practical. It is based on a micro-generation of power, which entails producing energy primarily for one's own use in systems based on renewable energy sources. Entities undertaking such activities are prosumers - playing the roles of both producer and consumer of energy, with sales limited to excess energy. Such a solution has many advantages, ranging from eliminating losses associated with excess energy through to mitigating the risks of power station or transmission network failures. Moreover, such prosumer energy systems generate additional jobs, especially important in the case of rural areas (Bienkowska W., 2013).

The assumptions of this model for biogas development were presented in the aforementioned government document. The creation of a so-called distributed energy infrastructure was planned, which would contribute to an increase in its safety. It would allow a significant portion of the gas, electricity and heat supply to be based on many local biogas production plants (Ministry of Economy, 2010). Unfortunately, given the previously presented data on the number and size of agricultural biogas plants in operation at the beginning of 2015, it can be said that these plans are impossible to achieve. The main causes can be attributed to two issues:

- high start-up costs. For a typical prosumer installation with an installed capacity of 40 kWel they amount to about PLN 1.5 million[*]. These are extremely high costs and only farms with the most robust income are able to meet this challenge;

- uncertainty regarding the support system for renewable energy produced in biogas plants. Late stage work on a new act on renewable energy sources is currently underway in Poland. Unfortunately for the smallest installations, one can increasingly observe a departure from the prosumer ideals to the benefit of large power generators. On 16 December 2014, the Parliamentary Extraordinary Commission working on the RES act draft rejected an amendment covering the introduction of guaranteed tariffs for the smallest producers of energy from renewable sources - microprosumers. (IEO, 2014). This results in reduced support for small energy producers, which translates directly into an increased operational risk.

Conclusions, proposals and recommendations

1. The project of developing agricultural biogas plants in rural areas based on the idea of prosumer energy is a very interesting concept. Poland, as a country with a large number of farms and regions of high agricultural biogas substrate production capabilities, is a place where this could be implemented in practice, as in Germany.
2. Currently, with 55 agricultural biogas plants operating, this potential is virtually unrealised.
3. Taking into account the theoretical premises of environmental economics and commitments undertaken in the international arena, state activities in this area are essential. The deciding factor will be the act on renewable energy sources planned for 2015.
4. Act on renewable energy sources will determine the direction for the development of renewable energy sources in Poland in the coming decades - large power plants based on co-generation or distributed power generation (prosumer-based) using more

[*] At a rate of 4.3 PLN/EUR = 348837 euro

expensive, but environmentally friendly, technologies. It is strongly advised to give a chance to prosumer energy development.

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