

ENERGY AGRICULTURE AS AN EXAMPLE OF MULTIFUNCTIONAL DEVELOPMENT OF AGRICULTURE AND RURAL AREAS IN POLAND

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Abstract

The paper aims at analyzing agricultural production for energy generation purposes, including the production of agricultural biogas, as an opportunity for functional diversification of agriculture and for multifunctional rural development in Poland. There have been many changes observed in Polish agriculture. New directions of crop production and of the use of agricultural products have emerged. One of the changes is the increasing significance of the production of agricultural biogas and energy from biogas. There have been built both small-scale and large-scale biogas plants. Most of the agricultural biogas plants are located in northern, western and south-western Poland, i.e. in the areas where there are relatively large farms which can provide a supply of substrates necessary for the production of agricultural biogas. The formation of biogas plants and the use of agricultural production for generating energy, are an eagerly anticipated trend contributing to the dissemination of renewable energy sources, the functional diversification of agriculture, the development of additional economic activities in rural areas, and the increase in the energy security of particular regions and the entire country.

Key words: Poland, diversification of agriculture, multifunctional rural development, agricultural biogas plants.

Introduction

Rural areas and agriculture are integrally connected. Agricultural activity is visible in social, economic, and cultural rural space. The relation between agriculture and rural areas is bidirectional: changes within one cause transformations within the other. Hence, a stable and multifunctional development of rural areas mainly requires the diversification of agriculture and its multifunctional development.

The diversification of agriculture approaches the state in which, except for food production, agriculture plays additional functions, i.e. economic, ecological, social, and cultural (van Ploeg et al., 2000; Adamowicz, 2005; Czarnecki, 2005; van Huylenbroeck et al., 2007; Halamska and Śpiewak, 2008; Kłodziński, 2008; Wilkin, 2008; Fleskens et al., 2009). In order to achieve this goal, it is necessary to extend agricultural activities and diversify the use of farm resources. New economic activities based on agricultural production, including those testifying to the small scale of rural industrialisation (cf. Kłodziński, 2010), contribute to the creation of new jobs and new sources of additional income not only for farmers, but also for all inhabitants of rural areas. T. Marsden and R. Sonnino (2009) argue that multifunctionality in agriculture aims at: (i) increasing revenues, (ii) constructing new agriculture that meets the requirements of the entire population, (iii) using viable rural resources (human, natural, technical, and organizational) in farms or elsewhere. Local governments have an important role to play in such projects because the prerequisite for success, besides initiatives from below, is institutional support. It is really very important in the context of the implementation of economic projects which give an

impulse to the creation of new functions. Such actions require the flow of information, access to knowledge and skills to use the knowledge in practice. The latter are mainly determined by appropriate institutions acting on behalf of local governments (Floriańczyk et al., 2012).

An example of non-consumptive use of crop production is its use in the process of energy generation and the formation of energy agriculture. These changes concern not only the agricultural sector, but rural areas in general. The use of agricultural production to generate energy implies successive economic projects connected with both the production and the distribution of achieved energy products such as centers purchasing energy stock and producing briquettes from agricultural waste. Considering the fact that in Poland the most important and most prospective renewable energy sources are wind energy, biomass and biogas, including agricultural, whose use is closely related to agriculture and rural areas (Chodkowska-Miszczuk, 2014), it should be stated that the development of renewable energy is a chance for functional diversification and multifunctional development of rural areas in Poland. A good example here is the use of agricultural production such as organic substrates or crop production for energy purposes, i.e. for the production of biogas in agricultural biogas plants: large ones with installed capacity above 200 kW (average app. 1 MW) and small-scale ones with installed capacity below 200 kW. The formation of agricultural biogas plants is the effect not only of the search for non-consumptive use of agricultural products but also of the diversification of energy sources and the shift towards renewable,

locally available energy sources. The use of agricultural stocks and substrates for the production of agricultural biogas and energy also brings plenty of benefits for the environment (Dyrektywa 2009/28/WE).

The paper aims at analyzing agricultural production for purposes of generating energy, including the production of agricultural biogas, as a chance for a functional diversification of agriculture and for a multifunctional rural development in Poland. The issue has been discussed in the context of changes observed in the energy sector, in agriculture and in rural areas. It should be emphasized that projects realized at the interface of agriculture and power industry create opportunities for the implementation of multifunctional agriculture and non-agricultural functions in rural areas.

Materials and Methods

The following research has been conducted on the basis of data derived from the Agricultural Market Agency (in Polish: *Agencja Rynku Rolnego*, ARR), The Agency for Restructuring and Modernization of Agriculture (in Polish: *Agencja Restrukturyzacji i Modernizacji Rolnictwa*, ARiMR), Energy Regulatory Office (in Polish: *Urząd Regulacji Energetyki*, URE), The Local Data Bank from the Central Statistical Office in Poland (in Polish: *Bank Danych Lokalnych Głównego Urzędu Statystycznego*, BDL GUS) and The European Funds Portal (PFE).

We have considered the years 2005–2013 and 2005–2014. We have employed methods of data aggregation and modification, including mathematical-statistical analyses (regression and correlation), and methods of data presentation (maps, maps with diagrams, charts).

All analyses have been made in relation to the first level of administrative division in Poland – i.e. the level of regions (we have considered 16 voivodships) and to the third level of administrative division in Poland, i.e. in all gminas (57) where agricultural biogas plants were registered as of the end of 2014.

Results and Discussion

Renewable energy sources in electricity generation

In Poland, the role of renewable energy sources in energy production, including electric, is becoming more and more important. In 2012, the share of electricity generated from renewable sources amounted to 4%, in 2013, it increased to 6% (URE, 2015). This trend is more evident when we consider the installed capacity of power plants using renewable energy sources. In the years 2005–2014, there was an over five-fold growth in the total capacity installed in power plants using renewable energy sources. Analyzing the structure of renewable energy sources, it should be emphasized that in the years 2005–2014,

the largest (almost 45-fold) growth of installed capacity was noticed in wind plants. At the end of 2014, total installed capacity in wind plants amounted to 63.6% of total installed capacity in all technologies of renewable energy sources in Poland. Moreover, in the analyzed period, a five-fold increase in installed capacity was also observed in biomass plants. The latter, with total installed capacity of over 1 GW, are the second, after wind energy (3.8 GW), power among all renewable energy sources in Poland.

Presently, biogas, including agricultural biogas, is becoming more and more important. In the years 2005–2014, the total installed capacity in biogas plants in Poland increased approximately six times. The growing number of agricultural biogas plants and their growing installed capacity play a crucial role here. In the year 2011, the total installed capacity in agricultural biogas plants accounted for 24%, in 2012 – for more than 26%, at the end of 2014 – for 35% of total installed capacity in all biogas plants in Poland (URE, 2015; ARR, 2014).

Changes in crop production and the development of energy agriculture

Analyzing the changes in Polish agriculture related to the evolution of energy agriculture, it is worth noting that the directions of crop productions have been modified. It is apparent, for example, in the increase of the production of oilseed rape used for energy purposes, which is mainly used for the production of biocomponents and biofuels. In 2006, 66% of the production of oilseed rape was allocated for consumption. In 2009, it was only 40%. As E. Rosiak (2006) notes, this trend has been strengthening.

In 2013, compared to the state as of 2005, the area of oilseed rape and turnip rape in private farms doubled (according to the Regulation of the European Parliament and Council No. 1166/2008 of 19 November 2008, together with data on the cultivation of oilseed rape, the data on the cultivation of turnip rape is announced – as one variable describing land use). In 2005, half of the national crop of these plants was located in four voivodships: Dolnośląskie, Kujawsko-Pomorskie, Wielkopolskie, and Zachodniopomorskie, and in 2013, in five voivodships: the four mentioned above and in the Lubelskie voivodship (Fig. 1). The increase in energy use of oilseed/turnip rape was, among others, the result of legal regulations and of financial instruments, including direct payment for energy crops in the years 2007–2009. In 2009, the total area of the crop of oilseed/turnip rape accounted for 70% of the total area of all plants (annual and perennial plants) cultivated for energy purposes (Chodkowska-Miszczuk and Szymańska, 2011).

A significant increase has also been noted in the area of maize allocated for silage use as, among

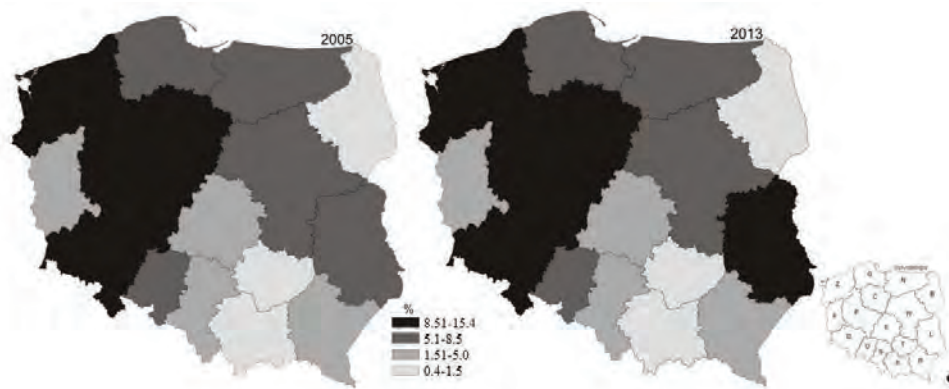


Figure 1. Share (%) of the oilseed rape and turnip rape area in private farms in voivodships in the oilseed rape and turnip rape total area in private farms in Poland in 2005 and 2013; Voivodships: B – Podlaskie; C – Kujawsko-Pomorskie; D – Dolnośląskie; E – Łódzkie; F – Lubuskie; G – Pomorskie; K – Małopolskie; L – Lubelskie; N – Warmińsko-Mazurskie; O – Opolskie; P – Wielkopolskie; R – Podkarpackie; S – Śląskie; T – Świętokrzyskie; W – Mazowieckie; Z – Zachodniopomorskie.

Source: developed by the authors based on the data from BDL GUS.

others, substrate for the production of agricultural biogas. In the years 2005–2013, the area of maize in private farms grew by more than half and, as the results of regression show, this trend will continue (Fig. 2). The increasing importance of this crop is also

reflected in the higher number of voivodships which are the main regions producing maize in Poland. In 2005, more than half of national crops was produced by three voivodships: Mazowieckie, Podlaskie and Wielkopolskie. In 2013, a significant share of maize

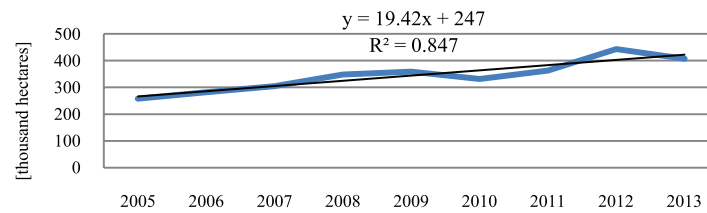


Figure 2. Changes from year to year in the area of maize (for silage) in private farms in Poland with a trend line and a regression equation.

Source: developed by the authors based on the data collected from BDL GUS.

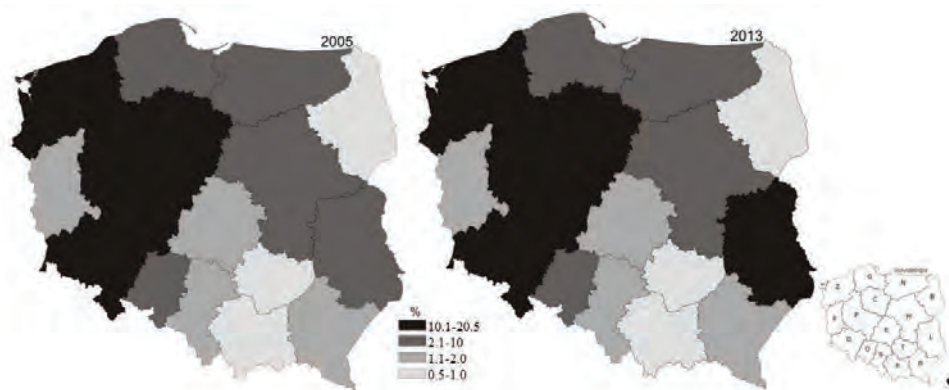


Figure 3. Share (%) of the maize silage area in private farms in voivodships in the maize silage total area in private farms in Poland in 2005 and 2013; Voivodships: B – Podlaskie; C – Kujawsko-Pomorskie; D – Dolnośląskie; E – Łódzkie; F – Lubuskie; G – Pomorskie; K – Małopolskie; L – Lubelskie; N – Warmińsko-Mazurskie; O – Opolskie; P – Wielkopolskie; R – Podkarpackie; S – Śląskie; T – Świętokrzyskie; W – Mazowieckie; Z – Zachodniopomorskie.

Source: developed by the authors based on the data collected from BDL GUS.

area in its total area in Poland was registered in these three above-mentioned voivodships and in the Kujawsko-Pomorskie voivodship (Fig. 3).

The increasing importance of energy crops is not only the result of available financial incentives. It is also the result of low investing costs connected with the production, processing and energy use of crop production as well as the opportunity to store and convert them to different types of energy substrates (Machan, 2001; Sims et al., 2006; Panoutsou, 2007). A great role is also ascribed to environmental effects, including the possibilities to use agricultural land of lower quality (Scholz and Ellerbrock 2002; Jasiulewicz, 2010).

Agricultural biogas plants

Projects implemented at the interface of agriculture and power industry, including also biogas plants, create new chances for functional diversification of agriculture and dissemination of non-agricultural functions in rural areas. On the one hand, they involve agricultural production; on the other hand, they contribute to undertaking new actions in rural areas and to creating new jobs.

The determinants affecting the market of agricultural biogas in Poland include endogenous factors concerning the agricultural sector, i.e. the directions of agricultural production, mainly crop production, and agrarian structure. Among the most

important exogenous factors are legal regulations, including (i) the Directive of the European Parliament and the Council no. 2009/28/WE, (ii) “The directions of development of agricultural biogas plants in Poland in the years 2010–2020” as well as available financial support.

Considering endogenous factors, we should emphasize that the formation of agricultural biogas plants in Poland requires an appropriate supply of substrates – intentional crops and/or wastes of agricultural production from farms. The larger the biogas plants, the larger is the amount of substrates necessary for their functioning. Only relatively large farms are able to provide the optimum amount of stock in some areas. Generally, farms with an average area of 10–15 ha determine the formation of biogas plants having larger installed capacity. Therefore, the higher the share of private farms of 10–15 ha in the total number of farms in the gmina in which the biogas plant works, the higher is the installed capacity in this biogas plant ($r=0.328$, $p<0.500$).

At the end of 2014 in Poland there were 57 large (average installed capacity above 1 MW) agricultural biogas plants. In comparison, in 2011, there were only 22 of them, and at the end of 2012 – 29. The spatial distribution of agricultural biogas plants is not even in the country. They are located mainly in northern, western and south-western Poland (Fig. 4).

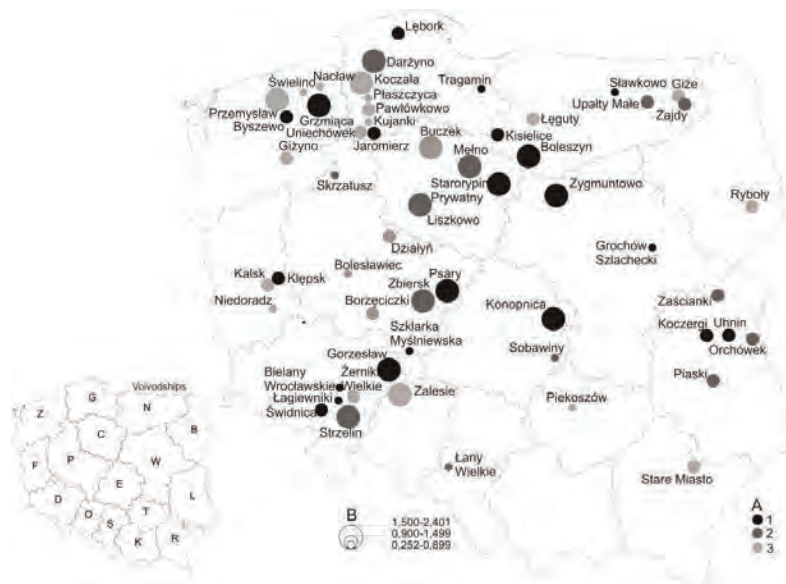


Figure 4. Agricultural biogas plants distribution in Poland, in the end of 2014

Explanation: A – basic feedstock for agricultural biogas production: 1 – liquid manure, 2 – other agricultural and food industry waste, 3 – maize silage; B – total installed electric capacity of agricultural biogas plants [MW]; Voivodships: B – Podlaskie; C – Kujawsko-Pomorskie; D – Dolnośląskie; E – Łódzkie; F – Lubuskie; G – Pomorskie; K – Małopolskie; L – Lubelskie; N – Warmińsko-Mazurskie; O – Opolskie; P – Wielkopolskie; R – Podkarpackie; S – Śląskie; T – Świętokrzyskie; W – Mazowieckie; Z – Zachodniopomorskie.

Source: developed by the authors based on the data collected from the ARR, 2014.

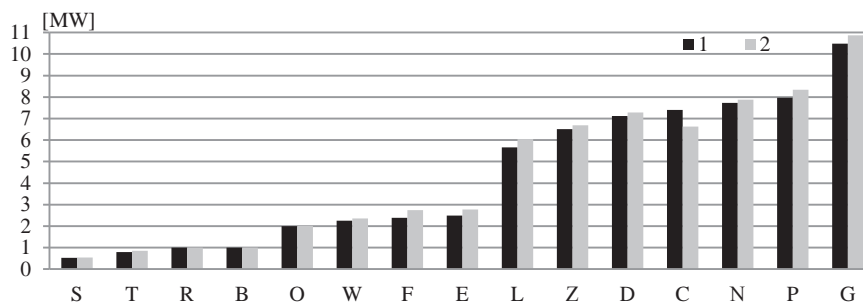


Figure 5. Total installed capacity of agricultural biogas plants in Poland, in September 2014

Explanation: 1 – installed electric capacity, 2 – installed thermal capacity; Voivodships: B – Podlaskie; C – Kujawsko-Pomorskie; D – Dolnośląskie; E – Łódzkie; F – Lubuskie; G – Pomorskie; K – Małopolskie; L – Lubelskie; N – Warmińsko-Mazurskie; O – Opolskie; P – Wielkopolskie; R – Podkarpackie; S – Śląskie; T – Świętokrzyskie; W – Mazowieckie; Z – Zachodniopomorskie.

Source: developed by the authors based on the data collected from the ARR, 2014.

In Poland, total electric capacity installed in agricultural biogas plants amounts to above 65 MW, almost the same value is reached by thermal capacity (above 67 MW). The largest agricultural biogas plants are noticed in Pomorskie, Wielkopolskie, Warmińsko-Mazurskie, Kujawsko-Pomorskie, and Wielkopolskie voivodships. The total power installed in biogas plants in the above-mentioned voivodships accounts for 60% of the total power installed in all agricultural biogas plants in Poland (Fig. 5).

Considering biogas plants from the point of view of substrates for the production of biogas acquired from agricultural production, we can note the division of all installations into three groups. In the first group, there are biogas plants using liquid manure (basic organic waste for the production of agricultural biogas). In the second group, there are biogas plants based on other than liquid manure waste of agri-food production. In the third group, there are biogas plants whose work depends on intentional crops, mainly silage from maize. Biogas plants using organic waste from agri-food production (liquid manure and others) are mainly located in such voivodships as Zachodniopomorskie, Pomorskie and Wielkopolskie. These voivodships are characterized by outstanding animal husbandry in all agricultural production against the background of the entire country. In central and eastern Poland, there is a domination of biogas plants whose functioning is connected with the supply of maize.

Due to a relatively short history of the production of agricultural biogas in Poland, high investment costs and long and complicated documentation stage, most of the agricultural biogas plants have been built with the participation of external investors (outside the place where the biogas plant is constructed). Among the projects of biogas plants co-financed from EU funds in the programming period 2007–2013 note the dominance of, external firms investing in large (average capacity installed 1 MW) biogas installations

in, among others Zachodniopomorskie, Pomorskie, Warmińsko-Mazurskie, and Podlaskie voivodships (PFE, 2015). Agricultural biogas plants often appear next to existing manufacturing facilities specializing in, for example, pig husbandry or food processing, in order to use production waste. In this way in Poland most of the biogas plants in which the production of agricultural biogas is based on organic waste were built.

Small-scale and micro-scale agricultural biogas plants

In Poland, there are investments in small-scale biogas plants with installed capacity up to 200 kW and micro-scale biogas plants with capacity up to 40 kW. The formation of small-scale biogas plants and solar energy follow one of two ways (besides small hydropower) of the development of small-scale renewable energy sources installations in Poland (Chodkowska-Miszczuk, 2014a). The development of the installations, including small-scale agricultural biogas plants, cannot be properly conducted without effective system solutions (Barry and Chapman, 2009). Hence, the formation of small plants, including biogas plants, was included and accepted in the regulation called “The Energy Three Pack” in July 2013. According to the regulation, one of the most crucial legislative instruments was the support for micro-installations (up to 40 kW). Moreover, the owners of micro-installations do not have to have business. The legislature enables the owners to acquire preferential conditions to join the national grid system and to sell the electricity generated in micro-installations (Act on 26 July 2013). It is supposed that further support for prosumer power generation will be reflected in the Act on renewable energy sources which is being created by the Polish Parliament at this moment (<http://www.mg.gov.pl/>).

The building of a small plant using renewable energy sources, including a biogas plant, is connected with relatively high investment costs, especially from the point of view of individual investors, e.g. farmers. Therefore, it is crucial to obtain external funds. An example of subsidizing small-scale renewable energy sources investments is the system of co-financing agricultural biogas plants from Rural Development, EU Program 2007–2013. The financial support acquired from Rural Development is allocated for building small-scale agricultural biogas plants. Due to an arduous investment process, the projects of biogas plants co-financed from these financial means are currently in the phase of implementation. In Poland, 176 farmers applied for financial support for building micro-scale biogas plants (data from ARiMR, state as of 18.11.2011). Most applications prepared by farmers were from the Wielkopolskie voivodship (every third application). A higher than average number of applications was made also by farmers from Kujawsko-Pomorskie, Lubelskie, and Mazowieckie voivodships.

It seems that the existing financial and legislative instruments supporting the diversification of agriculture and energy use of agricultural production available in the previous EU programming period (2007–2013), as well as those provided in the current programming period (2014–2020) have intensified the development of the market of agricultural biogas in Poland, especially with regard to the formation of small-scale biogas plants. Taking into account the much smaller scale of such a project, with regard to both the financial and substrate requirements, small-scale and mainly micro-scale agricultural biogas plants (with installed capacity up to 40 kW) have a chance to be built in the areas with fragmented agrarian structure, where there is a dominance of small farms of on average 5 ha in eastern and south-eastern Poland, e.g. in Lubelskie, Podkarpackie, Świętokrzyskie, Malopolskie voivodships. Agriculture and rural areas in the above-mentioned voivodships especially require new, non-agricultural directions of development, additional sources of income and new jobs.

Conclusions

In Polish agriculture, there are observed many changes, including new directions of crop production and use of agricultural products. Such elements as the production of agricultural biogas and energy from biogas are becoming more and more significant. Large- and small-scale biogas plants have been built. Most of the agricultural biogas plants have been erected in northern and south-western Poland. Only there are relatively large farms of 10–15 ha which

are able to provide an optimal supply of substrates necessary to the production of agricultural biogas, mainly from maize silage, but also from organic waste. In this part of Poland there are being built large (with installed capacity app. 1 MW) agricultural biogas plants. Biogas plants based on waste from agricultural production are formed mainly as investments within existing firms from agri-food industry, as for example biogas plants in Pomorskie, Zachodniopomorskie and Wielkopolskie voivodships.

Due to the fact that a great number of biogas plants, including those with the largest capacity installed, use intentional crops, the significance of crop production for energetic purposes (i.e. of maize or of oilseed rape) is becoming more and more important. These crops play a crucial role in such voivodships as Zachodniopomorskie, Wielkopolskie, Kujawsko-Pomorskie, Dolnośląskie, and Lubelskie in terms of oilseed rape cultivation, and in Wielkopolskie, Kujawsko-Pomorskie, Mazowieckie and Podlaskie in terms of maize cultivation. It is predicted that this trend connected with increasing significance of energy crops (especially the increase in the area of maize crops) will be maintained in the following years.

The development of agricultural biogas plants is reflected in changes occurring in agriculture. New functions have appeared and energy agriculture has been more and more common. Agriculture has access to new production fields, and becomes the basis for actions directly associated with the energy security of the country. In this context, the formation of small-scale installations, especially micro-scale agricultural biogas plants, is important. They provide an opportunity for agricultural diversification and multifunctional rural development in areas where the dominance of small farms is noticed, mainly in eastern and south-eastern Poland. This trend has been eagerly anticipated and it contributes to the dissemination of renewable energy sources, the development of additional economic activities, new jobs connected with investment process, servicing of installations in rural areas, and the growth in the energy security of particular regions and the entire country. It is worth noting that the production of agricultural biogas plants and/or substrates can be significantly based on the current infrastructure and the facilities of farms. An additional advantage is also the opportunity to use the produced energy for the purposes of a farm or for sale (the development of prosumer power generation). Therefore, there is a special need to support legislatively, administratively and financially projects aiming at developing dispersed energy generation, including small-scale biogas installations in Poland.

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