THE ROLE OF AGRICULTURE IN ENSURING THE ENERGY SECURITY IN POLAND

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Abstract
The purpose of this article has been to present a range of products which can be obtained from agricultural production and used for energy purposes. The domestic demand for plant material to be converted to biocomponents was assessed, including the demand for oilseed rape seeds and other grain used to make bioethanol in Poland. One of the ways to limit the adverse effect of fossil fuels on the environment is by using renewable resources. Agriculture is the producer of biomass used to make biocomponents for liquid fuels and raw materials for substitution of solid fuels. The EU, wishing to stimulate production of biomass for energy purposes, has brought to life several legal acts which force the use of biofuels in the European Community. Farmers who produce substrate for bio-fuel production were offered subsidies to energy crop plantations, at first paid from the state budget, and in 2007 – 2009 provided under the Common Agricultural Policy (CAP), which increased the farmers' revenues from farming. The decisions approved of while reviewing the CAP are to improve – via the market mechanism – the production and export potential of the whole EU. This is to be achieved, for example, by abolishing the subsidies to energy crops, which ceased to be paid in 2010. Such subsidies improved (artificially) the profitability of energy crop plantations, while causing a relative decrease in food production in Europe. By participating in the CAP, Poland is obliged to undertake certain measures in the domestic policy that will comply with the decisions made on the EU level.
Key words: energy policy, renewable energy sources, Common Agriculture Policy (CAP).

Introduction

Production of biofuels, which dates back to the 1970s, is most often perceived as a desirable and advantageous development, representing a link in a series of actions pursued with the aim of creating alternative, renewable sources of energy, which are frequently seen as eco-friendly (Spiess, 2013). It is commonly believed that agriculture is one of the biggest pools of RES. The degree to which the potential of agriculture for RES generation is actually utilized depends on a number of factors, e.g. market situation, economic support, costs of production of renewable and conventional energy or the technological progress. However, it seems that a special role should be played by the state's active policy, without which the growth of biofuel production could never be so dynamic. Among the most crucial arguments in favour of developing such a policy are: an increasing demand for energy due to the social and economic progress; higher energy prices and the consequent pressure to limit the export of crude oil; diversification of energy sources and achievement of energy self-reliance (energy security); environmental considerations and the pressure on using renewable energy resources; low prices of agricultural produce and surplus agricultural production in most developed countries, which in the early stage make the above policy more readily acceptable; finally, production of RES enables farmers to raise their income (Figiel and Hamulczuk, 2013).

Predictably, the above vision of agriculture will strongly affect global policies and economies in the long term. In an effort to define contemporary challenges, the European Commission put forth the strategy called Europa 2020 (2010), which is to guarantee an intelligent, sustainable and socially inclusive economic development. This document states that sustainable policy measures in the energy sector will be reaching a 20% decrease in greenhouse gas emission until 1990 (with a possible 30% reduction if relevant international agreements are concluded), a 20% decrease in energy consumption relative to the EU programmes for the year 2020, an increase of the share of RES up to 20% of the total energy consumption in the EU, with an exact percentage adjusted to individual countries relative to their fuel budgets and potential development of renewable energy production. Poland has been obliged to achieve a 15% share of RES in the total energy consumption and a 10% increase in the contribution of biofuels to the total consumption of transport fuels (Pająk and Mazurkiewicz, 2014).

One of the major aims of the Common Agricultural Policy (CAP) is an improved efficiency of farming achieved with no detriment to the natural environment (The National Centre …, 2010). Growing problems of climate change, bioenergy and water resources management will have a considerable influence on of the CAP (Preparing for the "Health Check" of the CAP reform, 2007), leading to the transformation of the overriding aim of agricultural production, such as food making. The CAP's second pillar includes multi-year funds dedicated to the development of rural areas in order to enhance their competitiveness, to manage natural resources in a sustainable way and to support the development of farms.

The EU countries are observed to be experiencing a change among consumers and residents regarding their expectations towards agriculture. Having a broader knowledge on multi-faceted agriculture, including production of feedstock for energy

generation, the society more readily supports farming as the type of economic activity which supplies not only basic marketable products but also other types of goods, including public ones. It can be expected that the paradigm of multi-functional agriculture will be fundamental to the CAP as well as to the practical solutions it will propose.

Agriculture has an important role to perform in economy, society and environment. It will be impossible to engage agriculture in the system of sustainable development of rural areas unless its multi-functional character is taken into consideration. Thus, the policy of rural development is based on two concepts: multi-functionality and sustainable development.

The European Union is a leader in the promotion and implementation of renewable energy sources. In quantities, the dominant renewable energy carrier is and will continue to be biomass. The most important sources of biomass include timber from forests and orchards, short rotation plantations of woody plants (e.g. willow-*Salix*) and wood processing byproducts; energy crops, for example seeds from oil plants processed into esterified oils, which are then used as fuel, potato tubers – *Solanum tuberosum*, beetroots - *Beta vulgaris*, cereal grains processed into ethyl alcohol added to petrol, organic residue and waste – straw and other plant remains generated during agricultural production as waste, waste generated by the food processing industry, organic municipal waste, organic industrial waste (from paper and cellulose manufacturing) (Janowicz, 2006). Biomass can be used for energy purposes, for example by combustion of solid bio-fuels or co-combustion with coal in furnaces (esters of oilseed rape oil, ethanol, methanol) or gases (agricultural biogas, biogas from wastewater treatment plants, biogas from landfills). The actual way in which biomass is converted into energy carriers depends on its chemical composition. Biomass conversion to energy carriers can be achieved by physical, chemical and biochemical methods (Bielski, 2012).

Climate change as a challenge has found its reflection in the CAP, and the evolution of agriculture towards the non-food use of agricultural products has become an important element of many research projects in Poland and in the whole EU. Production of biofuels will have a considerable impact on agriculture. However, a conflict arises between the food production security and undesirable climate changes, with the latter possibly limited by the replacement of fossil fuels with biofuels.

Materials and Methods

The purpose of this article is to discuss agricultural products which could be used for generation of energy. Another objective has been to show the increasingly important role of renewable energy sources (RES) originating from agriculture in the Polish energy balance. The discussion is set in the context of financial subsidies available under the Common Agricultural Policy (CAP) and dedicated to production of energy feedstock in agriculture. The analysis has relied on some relevant references, legal regulations, statistical data and our own calculations. The data supplied by the main Statistical Office (GUS) and the National Index Target set for the years 2014-2020 enabled the authors to assess the demand for biocomponents, the raw material need to produce them and the land area needed for growing the required amounts of biomass. The data are presented in tables and descriptions.

Results and Discussion

According to the Polish law, and more specifically Article 1 (2) of the Energy Law (1997), the principal aims of the Polish energy policy are as follows: to create conditions for the country's sustainable development, ensure the energy security of Poland, promote economical and rational use of fuels and energy, stimulate competition, counteract negative consequences of monopolies, respond to the requirements imposed by the natural environment conservation and protection, and finally to protect interests of energy consumers and minimize costs. One of the main priorities defined in the document titled "The Polish Energy Policy until 2030" is to promote renewable energy sources and to increase their consumption.

Maintaining energy balance in a country involves the sustainable adjustment, both current and long-term, of the supply of energy and fuels. Economic and ecological aspects should be considered as well as the potential management of energy demand, without restricting the needs of consumers to be provided with usable energy. Definitions of energy security emphasize the aspect of environmental protection. This is one of the reasons why the role of RES is taken into account when ensuring the state's energy security. In the near future, development of renewable energy sources will be one of the priorities (Borgosz-Koczwara and Herlender, 2008). This is also an important problem for other countries, regions, Europe and the world. Forecasts suggest that energy consumption will increase by 60% until 2020. The increased global demand for energy (especially in China, India or Brazil) should be satisfied not just by supplying more coal, oil or natural gas, but also by developing RES (solar, wind power, or tidal power, as well as geothermal power and energy accumulated in biomass) (Bielski, 2011a).

The dynamic increase in biofuel production stimulated by the policy supporting the development

of this branch of energy generation has contributed to some increase in the prices of agricultural products and foods; it has also added to higher fluctuations in these prices. Farmers whose revenues have increased are beneficiaries of the discussed policy. The positive effect of such a policy is notable mainly in developed countries. In less developed ones, however, some negative results can be seen, e.g. a threat to the food security. The gain and loss balance is therefore less than obvious. The uncertainty and price risk have risen and food consumers everywhere, also in more affluent countries, can feel the negative consequences of higher and more volatile prices of agricultural products. For that reason, relaxation of the strict EU policy with respect to the minimum share of biocomponents in fuels is worth considering. Another noteworthy aspect is that the energy potential of biomass is rather limited. Some analyses seem to indicate that if the whole biomass produced by agriculture worldwide was used for energy generation, it would satisfy 10% of the global energy demand (Figiel and Hamulczuk, 2013).

The regulation of the European Commission Council of 2003 laid the legal foundation for special subsidies given to agricultural producers who grow energy crops. The rate of payments was 45 EUR·ha^{-1}, but there was the budget threshold consisting of the maximum guaranteed acreage of 1.5 million ha. Any excess of this limit was to cause a proportional decrease in subsidies. In late September 2006, the European Commission proposed to cover the new member states, who had not profited from such subsidies, with the same support scheme for growing energy crops. The aim was to raise their interest in energy crops and to include permanent plantations into the system of direct payments. Farmers were eligible to receive payments for crops grown for energy purposes, according to Art. 2 Item 1 of the European Commission (2004) if the declared acreage was at least 0.3 ha. Yields representative for particular energy crops were announced annually in a regulation issued by the Ministry for Agriculture and Rural Development, having considered average yields of individual energy plant species per hectare. Plants whose cultivation entitles the farmer to apply for energy crop payments were specified. Payments to the area of farmland under energy crops were granted on condition that the yields had been contracted and plants had been processed into energy products (European Parliament, Council of the European Union, 2009).

The Rural Areas and Agriculture Development Strategy 2007 – 2013 (2005), where within the frameworks of the "Support to sustainable development of rural areas" the plants that can be cultivated for energy generation purposes is also important for development of energetic plants production development (Bielski, 2011b).

In 2007, there was so much interest in growing energy crops among farmers that the maximum limit of farmland under energy crop plantations was exceeded and it was necessary to reduce the acreage which entitled plantation owners to payments. The reduction rate was 0.70337. In the European Union, the implementation of the payment scheme began in 2004, when the total acreage of energy crop plantations was 0.31 million ha. Afterwards, it grew to 0.57 million ha in 2005 and 1.23 million ha in 2006, reaching 2.84 million ha in 2007. In Poland, energy crop plantations covered 3507 ha in 2005 and 6113 ha in 2006, growing to 175381 ha, including 6816 ha of permanent plantations, in 2007, 62904 ha in 2008 and 10198 ha in 2009. In 2010, subsidies to energy crop plantations were stopped, having reached the aim, such as the total acreage of 2 m ha. However, energy crop producers could take advantage of direct payments, which they are entitled to also when growing non-food plants. Despite being lower than in other EU countries, direct payments in Poland are the most significant contributor to Polish farmers' revenues. The Common Agricultural Policy claims that one of the purposes of direct payments is to raise farmers' income above what they would be able to earn from selling their own non-food products (Marks-Bielska, 2010). The highest sums resulting from complimentary national area payments were cashed in Poland in 2007 – 12.4 million PLN, in 2008 – 6.8; in 2009 – 8.4 million PLN. In 2005 (0.8) and in 2006 (1.7 million PLN) payments to plantations of willow or thorn-free rose grown for energy use were funded from the state budget.

Under the CAP, the generation of renewable energy derived from agriculture was supported by direct payments in the first pillar; moreover, it is possible to take advantage of the five measures in the Rural Development Programme (the RDP) for 2007-2013 (the CAP's second pillar, i.e. measures for the sake of development of rural areas). In order to stimulate the production of feedstock for renewable energy generation, the European Commission suggested that the member states be allowed to offer national support, up to 50% of starting a permanent plantation of energy plants, available on these parcels of farmland for which farmers submitted applications for support eligible to energy crop plantations (Bielski, 2012).

In November 2009, the decisions finalizing a review of the Common Agricultural Policy (so-called Health Check) were approved. The review was a continuation of the CAP reform, initiated in Luxembourg in 2003. It led to the publication of the European Council (EC) Regulation 72/2009, of 19 January 2009, which replaced Regulation 1782/2003,

Table 1

Forecast demand for primary and renewable energy in Poland

Specification	Units	Years			
		2015	2020	2025	2030
Primary energy	Mtoe	95.8	101.7	111	118.5
Renewable energy	Mtoe	8.4	12.2	13.8	14.7
The share of renewable energy in total primary energy consumption	%	8.8	12.0	12.4	12.4

Source: Marks-Bielska and Bielski, 2013.

previously regulating questions of awarding direct payments. The solutions which then entered into force contain several modifications which will necessitate changes in the regulations governing the scheme of direct payments in Poland (European Union, 2009). The decisions sanctioned as a result of the CAP review were intended to raise, via the market mechanism, the production and export potential of the whole EU. This in particular was to be achieved by abolishing subsidies to energy crops starting from 2010. These subsidies improved (artificially) the profitability of energy crop plantations, causing a relative reduction of food production in the EU.

An increase in the share of RES in the fuel and energy balance contributes to the improved efficiency at which fossil fuels are used and saved. It also adds to a better quality of the natural environment owing to a lower emission of pollutants and less waste (Goldemberg, 2007; Borgosz-Koczwara and Herlender, 2008).

The predicted increase in the demand for primary energy until 2030 in Poland equals about 27% versus the year 2010. The share of renewable energy in the total primary energy consumption will rise from about 8.8% in 2015 to 12% in 2020 and 12.4% in 2030 (tab. 1).

Agricultural biomass (one of the major renewable energy sources) is considered to be the source of the highest energy potential. With respect to the degree of its processing, biomass can be divided into primary (annual and perennial energy crops, surplus biomass from permanent pastures unused by animal production) and secondary (waste and byproducts from agricultural production and food processing: liquid and solid animal waste, organic residue from the food production industry, e.g. glycerin, distillers grain, slaughter offal, dairy wastewater, etc.). The importance of the agricultural biomass energy potential is unquestionable, but there are rather big differences between its estimates (Gajewski, 2011).

Biomass is a typical local fuel and should be used locally by individual consumers, as the main fuel in distributed energy and heat co-generation plants. Using biomass resources for energy purposes depends on a number of factors, including economic incentives (Bielski, 2012), or technological progress. Until recently, Poland has lacked mechanisms connecting the agricultural biomass demand with the possible productive output of agriculture. At present, the question of agricultural biomass is included in the document titled Strategy for sustainable development of the countryside, agriculture and fisheries for 2012-2020. An exhaustive description of this issue can be found in the Specific Measure 5. protection of the environment and adaptation to climate change in rural areas, in priority 5.3. Adaptation of agriculture and fisheries to climate change and their contribution to counteracting such change (mitigation), and in Priority 5.5. Increasing the use of renewable energy sources in rural areas.

The acreage covered by plants suitable for production of bioethanol (starch and sugar feedstocks: cereal grain, potato-*Solanum tuberosum*, maize-*Zea mays*, sugar beet-*Beta vulgaris*) depends on factors related to the natural conditions and the organization of production because the cultivation of such plants must comply with the criteria of sustainable development (The European Parliament Directive 2009). However, the main limiting factors belong to the realm of economics, with energy crops grown mostly on poorer soils, which produce lower yields and consequently the costs of bioethanol production are higher. A major constraint on bioethanol production is the availability of biomass feedstock (Balat, 2011). The situation is very much the same in respect to methyl esters of fatty acids (biodiesel). Data on the forecast growth in the demand for higher fatty acid esters and bioethanol, and consequently the acreage needed to satisfy this future demand, are contained in table 2, indicating that over 1.5 million ha of farmland should be secured in Poland in 2014 for the purpose of ester production.

The assessment of the domestic demand for oilseed rape seeds must include an area needed to satisfy the demand of the food industry (about 450 thousand ha). Our analysis of the data suggest that in 2014 almost 2.0 million tons of grain should be processed to bioethanol in Poland. It is difficult to predict precisely how much farmland will be needed to produce such an amount of grain because various species of cereals could be grown and some bioethanol could be imported.

Table 2

Forecast demand for energy oilseed and grain for bioethanol in Poland

Years	Biocomponent demand (ths. m^3)	Feedstock demand (ths. Mg)	Demand for cropped area (ths. ha)
oilseeds			
2014	1 224	3 549	1 470
2020	1 593	4 621	1 913
grains			
2014	589	1 944	486
2020	780	2 574	644

Source: the authors, based on the national Index target for 2014 – 2020, including the diesel consumption on the level of 15 018 thousand m^3 and petrol of 5 166 thousand m^3 (the average consumption of fuels in 2011 – 2012), providing that the energy consumption in the consecutive years would remain at the unchanged level.

The European Union takes a stand on the reduction of CO_2 emission, claiming that it can be achieved by developing second generation biofuels (obtained by processing lignin cellulose raw products). The essence of second generation biofuels is the use of waste products, useless in food production. Straw is an example of agricultural produce which may be used for energy generation. Kuś and Faber (2009) calculated that the surplus of straw produced by the Polish agriculture is about 9 million tons, of which at least 30 – 40% can be used for alternative purposes, including energy generation. Realistically speaking, about 3 to 4 million tons of straw can be used to produce energy.

However, in order to meet the increasing demand for biomass, it will be necessary to harvest it from dedicated plantations of perennial plant species. Biomass for energy purposes can be obtained from several plant species, but in practice their choice will depend on habitat conditions, costs of purchasing seedlings or plantings, the equipment available on a given farm, and the way in which biomass is to be utilized. The most important species are: miscanthus-*Miscanthus*, short rotation willow-*Salix*, Pennsylvania fanpetals-*Sida hermaphrodit*, reed canarygrass-*Phalaris arundinacea*, giant knotweed-*Reynoutria sachalinensis* and Jerusalem artichoke-*Helianthus tuberosus*. Due to the shortage of biomass from dedicated energy crop plantations on the market, a further increase in the energy use of straw is expected. In the short term, the development of agriculture dedicated to production of energy crops will force to cover from 1.5 to 2 million ha of farmland for production of energy biomass (Kuś and Faber, 2009).

Another aspect of ensuring the country's energy security is the promotion of distributed, low-power energy sources, generating energy locally and supplying it directly to farmsteads and households. These criteria are best met by renewable energy installations: biomass furnaces, micro-biogas plants, small water turbines and solar batteries. Installing such technologies in agriculture, that is generation of energy by a farmer for their own use, enables lowering the amount and cost of energy bought from external sources, which translates into measurable financial gains. It can also help to control the noxious aspects of agricultural production, for example when plant or animal production waste, such as liquid manure, is converted to energy. The rational employment of such local energy sources creates benefits for a single farm as well as for whole agriculture. When a farm uses energy from renewable resources, it can replace with it increasingly less available to farmers and more expensive non-renewable fuels, such as coal or oil coke for generating electric energy or heating buildings and water, as well as liquid fuels (natural gas, liquid gas, diesel oil, heating oil) used to power engines or for heating buildings. Price relations between the above conventional energy carriers to RES, compounded by problems in ensuring the energy security of all individual energy consumers by conventional, large-scale energy companies, create opportunities for the development of numerous renewable energy installations, which are currently more profitable (Oniszczak-Popławska et al., 2011).

One of the most prospective directions in the energy use of biomass resources is thought to be agricultural biogas production. A biogas plant is an installation designed specifically to produce biogas from plant biomass, animal waste or organic waste (e.g. from the food industry). Unfortunately, this direction in the energy conversion of biomass has not developed to a satisfactory degree. The low share of agricultural biogas in the total energy production is due to a small number of working agricultural biogas plants (according to the Register of energy enterprises producing agricultural biogas of 17 March 2014, there were 39 such installations). The reasons could be certain formal barriers to building biogas plants (including the economic, legal and technological obstacles) as well as the low availability of feedstock (Fugol and Szlachta, 2010).

Biogas plants could supplement the national energy production capacity, especially when the theoretical potential has been estimated at the level of 5 billion m^3 of biogas annually, while the actual potential, based on waste products generated by agriculture and the food industry is assessed at 1.7 billion m^3 of biogas annually. Such quantities of biogas could cover about 10% of the domestic demand for gas or, in other words, could completely satisfy the energy needs of the rural population in Poland (Ministry of Economy, 2010).

It is possible to install thousands of small wind power generators directly on farms in the rural areas in Poland. This would translate into a significant support to the national plans to fulfill Poland's international obligations in terms of reduced CO_2 emission and decreased combustion of fossil fuels for commercial energy generation. The solution might also bring about several social benefits, for example, by creating conditions for industrial production of construction components necessary to build small wind power plants, stimulating the general interest in renewable energy sources in the countryside, encouraging the research and development in the scope of building small wind power plants, etc. Turowski and Nowowiejski (2010) claim that it would be feasible to achieve a 50% decrease in electric energy purchase by a farm equipped with its own energy source. In addition, the farmer could earn an additional income by selling surplus energy to an energy distributor.

By participating in the Common Agricultural Policy, Poland is obliged to undertake certain measures which comply with the decisions taken on the level of the European Union. The main goal of the development of RES in Poland is to fulfill, by the year 2020, the criterion regarding the share of RES in the final energy consumption, and to further improve its contribution in the following years. In 2006 – 2012, the use of RES in Poland kept increasing by an average 7.8% annually. At the end of that time period, nearly three-fold more energy was generated from renewable resources than in 2005, and the amount of RES produced in 2008 – 2009 was 10% higher than predicted. The dynamic growth was attainable mainly owing to the mechanism of green certificates. On the other hand, since 2005 consumption of electricity has been growing faster than predicted, which makes it more difficult to achieve the assumed growth rate parameters for RES. This tendency can continue until 2020, when the share of RES in the electric energy production could be 1.25% higher than expected. In the above circumstances, it will not be possible to attain the aims of the national energy policy unless available renewable energy sources are developed more dynamically. In Poland, the highest potential among RES can be attributed to biomass resources and wind power, but other sources such as photovoltaic energy or energy generated from municipal waste should not be overlooked. All these actions in Poland will call for the enlargement of the current system of renewable energy generation support by introduction of the guaranteed prices mechanism. Acceleration of the RES development in Poland will also need mechanisms to encourage private capital and to gain approval of local communities towards renewable energy installations. In the Polish conditions, the best solution might be the introduction of the so-called local property (inclusion of local communities in the financing of investments into RES installations in return for the possibility to buy less expensive energy or to participate in profits) (Pająk and Mazurkiewicz, 2014).

Conclusions

As presumed, the authors have suggested what types of feedstock for energy generation can be obtained from agricultural production. The rapidly increasing role and importance of renewable energy sources (RES) from farming in Poland's energy balance have been discussed. The arguments were set in the context of the financial support available under the Common Agricultural Policy (the CAP) and dedicated to energy crops. The analysis of statistical data and legal regulations has led to the following conclusions:

1. The most popular energy types of feedstock, which can be produced by the Polish agriculture, are cereal grains, oilseed rape seeds (basic raw products for production of liquid biofuels) and maize silage (production of agricultural biogas).
2. The current tendencies show that the most dynamically developing branch on rural areas will be the renewable energy generation. Agriculture will play a new role in the future. As well as producing food, it will supply biomass used for energy generation.
3. In agreement with the global tendencies, agriculture in Poland will perform a significant function in attaining goals connected to renewable energy sources. Apart from supplying feedstock, rural areas will develop their own installations for converting it into energy, so that biomass will be used locally, where it is produced.
4. Because of their distributed character and use of local resources, renewable energy sources can become an element which to some extent will contribute to ensuring energy security; they will also help to lower energy costs.
5. The growing acreage cropped with energy plants in Poland so far has been stimulated by economic decisions, e.g. an effort to raise income by gaining support to energy crop plantations in the first

years after Poland's access to the EU, when Polish farmers became eligible to apply for the CAP instruments, first provided by the state budget and then from the EU funds (especially after 2007, when the list of eligible farmers was extended by adding subsidies to annual plantations, including cereals and oilseed rape).

6. As well as incentive such as subsidies and payments for producers of energy crops, the EU has also created many obligatory legal regulations, which force the member states to implement the Community's decisions.

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