

FOOD AND BIOENERGY – EVIDENCE FROM POLAND

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Abstract. The goal of the article is to evaluate whether production of modern biofuels in Poland competes with food production. CSO and AMA data have been used in the analysis. The data in question refers to the area of arable land in Poland, yields and livestock as well as renewable energy production structure and quantity and production of biodiesel, bioethanol and agricultural biogas. Data concerning quantity of raw materials used for production of the agricultural biogas have been accessed from AMA. Data for 2005-2015 have been collected. Production of bioenergy based on agricultural raw materials has significantly increased. From 2005 to 2015, it increased from 5 to 42 TJ. Approximately 92 % of bioenergy from agricultural sources are bioethanol and biodiesel produced from the first generation of raw materials, the production of which is in direct competition with food production. The share of biogas was 8 % only. Waste constituted over 70 % in the raw materials used to produce biogas. The area of production of energy crops has reached 8 % of arable land in 2015 from 1.5 % in 2005. It means that in Poland production of bioenergy from agricultural sources competes with food and feed production and its further increase is not desirable. Actions focused on the increased use of the second generation raw materials for energy production and decreased use of food raw materials should be taken.

Key words: bioenergy, bioethanol, biodiesel, biogas, food–energy competition.

JEL code: Q16, Q20, Q42

Introduction

Increased demand for energy in the world becomes a reason to search for new energy sources. Additionally, it is expected that new energy sources will create lower emissions as well as they will be renewable sources. The energy coming from renewable sources includes energy of water, wind, sun, geothermal and bio fuels. In some applications, e.g. in transport liquid biofuels, it has become the only substitute for fossil fuels. The biofuels production opportunities have been known for many decades so far, but their production on industrial scale became cost-effective only when crude oil prices increased to very high levels and when low emission economy concept started to be followed. Production of fuels is considered one of the most important directions for development the modern concept of bioeconomics.

Bioenergy draws on a wide range of potential feedstock materials: forestry and agricultural residues and wastes of many sorts, as well as material grown specifically for energy purposes. The raw materials can be converted to heat for use in buildings and industry, to electricity, or into gaseous or liquid fuels, which can be used in transport, for example. This degree of flexibility

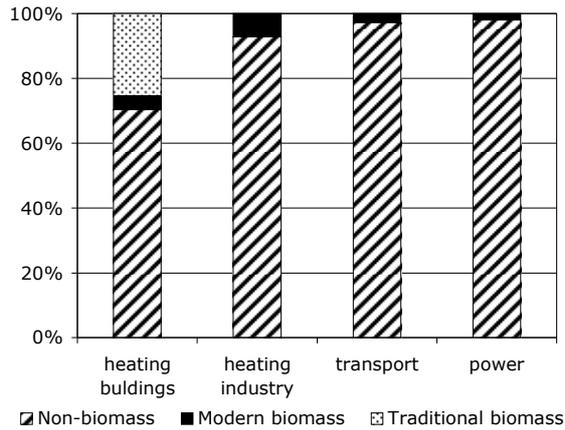
is unique amongst the different forms of renewable energy.

The most commonly used conversion methods – combustion of fuels to produce heat or electricity; anaerobic digestion to produce methane for heat or power production; and the conversion of sugary and starchy raw materials to ethanol, or of vegetable oils to biodiesel – all are well-established and commercial technologies. A further set of conversion processes – for example, the production of liquid fuels from cellulosic materials by biological or thermo chemical conversion processes, such as pyrolysis – are at earlier stages of commercialisation or still under development.

The bioenergy share in total global primary energy consumption has remained relatively steady since 2005, at around 14 %, despite a 24 % increase in overall global energy demand between 2005 and 2015 (REN21., 2016).

Solid biomass represents the largest share of biomass used for heat and electricity generation, whereas liquid biofuel represents the largest source in the transport sector (Fig. 1).

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Source: (REN21., 2016)

Figure 1. Shares of biomass in final energy consumption by end-use sector, 2014

Only 10 % of the total quantity of biomass used for energy production comes from agriculture. The highest share, ca. 40 % belongs to by-products of plant origin, 30 % belongs to waste of animal origin and energy crops (Edenhofer, Madruga, Sokona, 2012).

Two most popular biofuels globally are bioethanol and biodiesel; other biofuels include butane, fischer-tropsch diesel, syngas, and biogas. Bioethanol is made from wheat, corn, sugarcane etc., and biodiesel is made from oil seeds such as soybeans, rape seed, and palm oil. The feedstock used in the production of biofuels is also used for human and animal consumption, affecting food crop prices. Biofuels production process has been accompanied by a threat of food price increase resulting from competitive application of agricultural raw materials used for foodstuff or biofuels production.

First generation biofuels are produced using vegetable oil, animal fat, and used cooking oil. The feedstock used in producing biofuels is also used as food, and the prices of these feedstocks are directly associated with the demand from biofuels creating conflict between the food and energy sectors. This continuous issue has led to the development of second and third generation biofuels to overcome the limitations of first generation fuels. Second generation fuels are produced using non-food crops like wood (saw

dust), organic waste (corn stover) and specific biomass plants such as jatropha, camelina, and switchgrass. The third and fourth generation fuel, also called advanced biofuel, is produced using specially engineered energy crops like algae as feedstock, which provides higher yield with lower resource inputs (techNavio, 2015). Fourth generation of feed stock for biofuels production is still in laboratory stage, so we don't know yet what kind of organisms will be developed with use of genetic engineering methods. In Table 1, classification of raw materials used for biofuels production has been presented.

Table 1

Generation of biofuels

| 1 st generation | 2 nd generation | 3 rd generation | 4 th generation |
|--|---|----------------------------|---------------------------------|
| Cereals Rape Palm oil Soybean oil Corn | Organic waste Non-food crops Cellulosic waste | Micro-algae Seaweed | Genetically modified feedstocks |

Source: author's study

It is recommended to reduce production of the first generation biofuels, i.e. manufactured using the same raw materials as during food production, in connection with competitive effect that appears between biofuels production and food production (Nelson, 2010). Even so, the global production is still growing. Production of liquid biofuels reached the level of 133 billion litres in 2015 and it was 3 % higher than in 2014. More than 74 % of the global production of liquid biofuels is constituted by bioethanol, biodiesel 22 % and other advanced biofuels 4 %. The biggest global manufacturer is the USA where 46 % of the global biofuels production is manufactured, then Brazil constituting 24 % share and EU – 15 %. The USA share in the global bioethanol production is ca. 50 %, and 25 % ca. is Brazil share. The European Union (EU) takes the fourth place, following China that constitutes 6 %. As far as biodiesel production is concerned, the first place is taken by the EU with

42 % share and it is followed by the USA – 18 % and Brazil – 11 % (OECD/FAO, 2015; OECD/FAO, 2016). Biodiesel production in the EU has been developed due to support provided by the Common Agricultural Policy, but also in connection with the Directive on transportation. It is manufactured from rapeseed, so its production competes with foodstuff production. Biofuels production in the EU are not related to macro-economic indicators in the Member States. High consumption of renewable energy in the EU results from the conducted environmentally-friendly policy (European..., 2009; Rokicki, 2016).

Aim and methods

The goal of the article is to evaluate whether production of modern biofuels competes with food production. The goal has been achieved due to implementation of three scientific tasks: 1) determination of raw materials quantities of agricultural origin used for production of modern biofuels; 2) determination of the agricultural crops area where production is used to produce biofuels; 3) determination of the agricultural area share used to produce biofuels and determination of the share change ratio.

Central Statistical Office of Poland (CSO) and Agricultural Market Agency (AMA) data have been used in the analysis. Data coming from the CSO statistics referred to the agricultural areas in Poland, average yields and livestock. Data regarding quantity and energy production mix coming from renewable energy sources, including production of biodiesel, bioethanol and agricultural biogas, have also been collected. Data concerning quantity of raw materials used for production of the agricultural biogas have been accessed from AMA. Data for 2005-2015 have been collected. There is no comparable statistical data for the previous years. It has been assumed that from oilseed rape we obtain on average 40 % of oil and from 1 ton of cereal grains we obtain 340 l of ethyl alcohol. The subject of the study is the agricultural area utilized

directly for the production of raw materials for biofuel production and its share in the total agricultural area in Poland. The object of the study is therefore crop production in Poland.

Agricultural area used to produce raw materials necessary in biofuels production process has been determined considering main crops. Due to short series of data, the results have been presented in tables and in a descriptive form. There is no reason to apply statistical methods. Additionally, there is no price analysis because prices on Polish agricultural market strongly depend on situation on whole European market, so much wider analysis is necessary to explain influence of biofuels market size on food market prices.

Specific conditions for biofuel production development in case of biomass

There is a correlation between the economic growth, intensification of agricultural production and stronger impact on natural environment. Production of biofuels and bioenergy is one of public goods provided by agriculture in result of greenhouse gases reduction (GHG) and impact on natural environment (Danilowska, 2015). Many authors present mechanism of reducing the agriculture impact on natural environment in connection with biomass production development needed for energy generation. It mainly results from reduction of GHG general emission, carbon deposition from atmosphere but also from management of agriculture production waste and food production waste. It is one element of the sustainable intensification of agriculture (Dressler et al., 2012; Golebiewska and Pajewski, 2016; Jarosz and Faber, 2016; Lenerts, 2015; Pajewski, 2016; Popluga et al., 2015; Popluga and Feldmane, 2016; Rokicki, 2016). Some authors state that production of first generation biofuels contributes to net reduction of GHG emission to a very limited extent, but it could generate negative impact resulting from introduction of agricultural mono cultures

(Zoladkiewicz, 2016). As a result, more and more attention is paid and more support provided to use the second generation biofuels or other cheap energy sources, e.g. wind turbines, photovoltaic cells (Eriksson et al., 2016; Jefremov and Rubanovsakis, 2015; Popluga and Feldmane, 2016; Woon, Lo, Chiu, Yan, 2016). The agriculture biofuels production is still a kind of social innovation (Melece, 2015) because production of renewable energy from the traditional solid biomass (timber) is still better developed in many EU countries (Krievina and Melece, 2016).

Further development of the agricultural production of biofuels mostly results from the environmentally-friendly policy conducted by Member States (Jefremov and Rubanovsakis, 2015; Golebiewski, 2014; Pelse and Lescevic, 2016), including activities aimed at supporting energy micro-installations development (Chodkowska-Miszczuk, 2015) that will cause income diversification in agricultural holdings and economic risk reduction (Wicka and Wicki, 2016; Wicka et al., 2013).

The most important obstacles, as far as further development of the agricultural production of biofuels based on biomass is concerned, are the following: high cost of investment in production facilities (Golasa, 2016; Melece, 2015; Wielewska, 2016a; Wielewska, 2016b) and still high cost of energy from renewable sources (Rokicki 2016). The power production cost is lower when combined heat and power unit (CHP) is used (Dressler et al., 2012). The results confirm that renewable energy production is cost-effective when fossil fuels prices remain high (Jasiulewicz and Gostomczyk, 2016; Borawski et al., 2016).

Research results

In Poland, the agriculture bio-energy production includes three types of fuels: bioethanol, biodiesel and biogas. Biodiesel production increased in Poland in 2008 when subsidies were introduced. The agriculture biogas energy share

in total energy supply was included in statistics in 2011 for the first time and its share in total bioenergy supply is very small. The energy production is shown in Table 2.

Table 2

Production of modern bioenergy from agricultural feedstocks in Poland in years 2005-2015

| Year | Production of energy from agricultural resources in TJ | | | |
|------|--|-----------|------------|--------|
| | biogas | biodiesel | bioethanol | total |
| 2005 | - | 2 471 | 2404 | 4 875 |
| 2006 | - | 3 423 | 3542 | 6 965 |
| 2007 | - | 1 822 | 2792 | 4 614 |
| 2008 | 107 | 9 943 | 2 459 | 12 509 |
| 2009 | 188 | 14 010 | 3 838 | 18 036 |
| 2010 | 334 | 14 584 | 4 538 | 19 456 |
| 2011 | 634 | 13 974 | 4 057 | 18 665 |
| 2012 | 1 463 | 23 247 | 5 124 | 29 834 |
| 2013 | 2 084 | 24 217 | 5 098 | 31 399 |
| 2014 | 2 811 | 27 343 | 3 812 | 33 966 |
| 2015 | 3 413 | 34 479 | 4 696 | 42 588 |

Source: GUS 2009, GUS 2014, GUS 2016

Biodiesel prevails in the biofuels production mix. Since 2008, the biodiesel share in total production of energy generated from agricultural raw materials is ca. 80 %. During biogas production, the second generation raw materials can be used and its percentage in energy production increased from 1 % in 2008 to 8 % in 2015. Energy from renewable sources provides 12 % of total energy consumption in Poland and bioenergy from agricultural sources is only 1.5 % of energy consumption.

In 2011, in biogas production 0.5 mil tons of raw material was used and in 2015 eventually 2.5 mil tons of raw material was used. There is no data for the previous years. 70 % of raw material for biogas production was agricultural wastes and food industry wastes. Ca. 30 % of raw material were specific plants (mostly maize silage) (Table 3). High percentage of wastes in the mix of raw material used during biogas production means that it is very modern sector

where mostly the second generation raw materials are used. There are only 78 agricultural biogas plants in Poland, whereas in Germany there are more than 10 000 plants, in France more than 700 and 17 000 in the whole EU.

Table 3

Structure of feedstock used in agricultural biogas plant in Poland in 2011-2015

| Year | Structure of feedstock used in agricultural biogas plant in per cent | | | |
|------|--|-------------|--------------|---------|
| | agric. wastes | food-wastes | agric. crops | others* |
| 2011 | 59 | 11 | 28 | 2 |
| 2012 | 41 | 28 | 31 | 0 |
| 2013 | 31 | 43 | 26 | 0 |
| 2014 | 29 | 40 | 31 | 0 |
| 2015 | 27 | 47 | 26 | 0 |

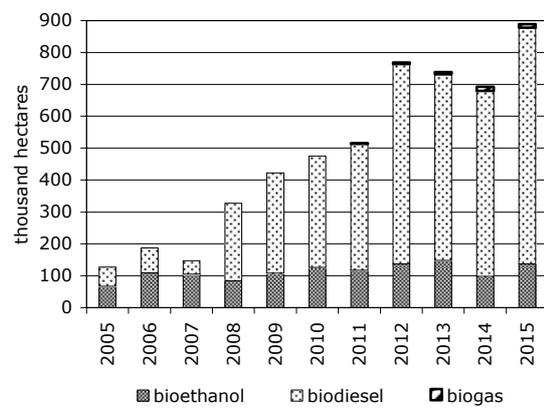
*in years 2012-2015 less than 0.5 per cent

Source: author's calculation based on data from AMA reports for years 2011-2015

Area of crops used as raw material in agricultural biogas plants is only 12 000 hectare (0.11 % of the arable land area). Use of slurry in agricultural biogas plants is equal to 0.5 % of the total production. The importance of the use of waste in agricultural biogas plants is therefore relatively low in the overall amount of waste. Similarly, biogas production does not compete with food production. Agricultural crops used for bioethanol and biodiesel production occupy much bigger area. In 2015, the total area was equal to ca. 880 000 hectares; while in 2005, the total area was equal to 130 000 hectares and 475 000 hectares in 2010 (Fig. 2). In the years 2010-2015, 50 to 70 % of rapeseed production in Poland was processed to biodiesel. In case of bioethanol production, only 2 % of production was used to bioethanol production.

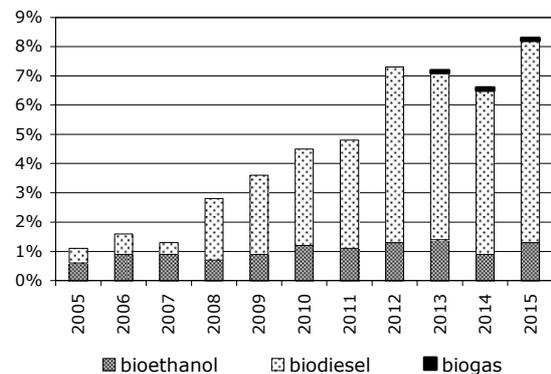
Production area of agricultural raw materials used for bioenergy production significantly increased since 2008 when subsidies for rapeseed production to be used to generate energy were introduced. Bioethanol production to be used as biofuel is not cost-effective without subsidies. Total arable land area used for production

of raw materials necessary during bioenergy production process has increased. In 2015, the area where agricultural energy raw materials were produced was equal to ca. 8 % of the total arable land area. The percentage of land used for energy crops was systematically increasing. In 2008, it was 2.8 %. The average yearly increase rate was 14.5 % in 2008-2015. Since 2012, the growth rate decrease can be also observed. This suggests that the reached level shall be maintained (Fig. 3).



Source: author's calculation

Figure 2. Area of crop for biofuels production in Poland in years 2005-2015



Source: author's calculation

Figure 3. Share of arable land allocated for energy crops in Poland in years 2005-2015

Observed high percentage of land used for production of energy crops means that bioenergy production competes with food production. In Poland, the quantity of the food produced exceeds domestic demand; nevertheless, permanently increasing area used for production of energy crops makes more difficult to increase

e.g. animal production or food export (Grontkowska and Wicki, 2015).

Conclusions

- 1) Renewable energy production grows all over the world. In the recent years, the fastest increase can be noticed in photovoltaic cells energy production. Importance of energy from bio mass is still high and equal to even 14 %.
- 2) Ca. 10 % of biomass used for energy production is delivered from agriculture, but as far as production of modern bioenergy is concerned, the agricultural raw materials constitute major part.
- 3) Production of energy from agricultural raw materials competes with food and feed production. It is then recommended to use the second generation raw materials, mostly by-products and wastes as source of biomass.
- 4) In Poland, the renewable energy constitutes ca. 12 % of energy consumption and agricultural bioenergy constitutes only 1.5 % of energy consumption.
- 5) More than 90 % of the agricultural bioenergy is produced from raw materials which can be also used for food production (cereals, rape seed). Up to 8 % (900 000 hectares) of the arable land area is used for production of energy raw materials, mostly rapeseed.
- 6) Bioenergy production in Poland competes with food production; yet, it does not limit food availability but reduces forage production capacity as well as food export capacity.
- 7) In Poland, it is recommended to support development of systems using the second generation energy raw materials and to reduce production of energy from agricultural raw materials which can be used for food production.

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