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ALTERNATIVE SOURCES OF ENERGY IN THE LUBELSKIE PROVINCE
(a rewiev)

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Abstract. The production of renewable energy from biomass, including seeds and their products (oil), is of high importance. The basis of that production may be the cultivation of plants "typical" for a certain region. Lower importance is put on marginal plants, such as willow, topinambur etc. These plants cannot rival plants like rapeseed, potato, corn, cereal, in spite of the fact that they produce a lot of green mass. In many countries of the EU, including Poland, the highest importance is put on the production of biodiesel used as biofuel in self-ignition combustion engines. The availability of locally produced biofuels would cause greater independence from external factors.

Keywords: biomass, energy, renewable energy

INTRODUCTION

The amount of natural resources in Poland and in the whole world is unceasingly decreasing and the contamination of environment is continuously increasing. The burning of coal, natural gas and oil as well as the production of cement causes the emission of big amounts of CO_2 into the atmosphere which are the equivalent to 6.3 billion tons of carbon per year. Additionally, the destruction of forests causes further annual release of about 1.6 billion tones of carbon in the form of CO_2 (Scharmer 2001). It is clearly stated in the UN Report on climate change that if it was impossible to limit the amount of contamination that is emitted into the atmosphere by 70% per year, then the humankind would experience ecological changes in extent that had not been seen before (floods, snowstorms, natural disasters, climate changes).

In January 2001 the European Union adopted the "Strategy of Environmental Protection to 2010" which established the decrease of contamination by at least 20-40% until the tear 2020, which would require a completely new strategy and changes in the energy politics of the European Union member states. The Renewable Energy Law – EEG adopted in January 25th 2000 can be helpful in accom-

plishing that aim. This law recommends using the energy derived from wind, sun, water and from biomass. That will contribute to limitation of the usage of fossil fuels: coal, oil products and gas. In order to be able to fulfil the premises formulated in the "White Book of UE" (which presumes an increase of renewable energy up to 12% of the whole amount of produced energy until the year 2010), greater attention is needed to these sources that already exist and because of economical and political matters are not being used sufficiently.

According to the Proposal for Directive of the European Parliament and the Council of Europe on the promotion of the use of energy from renewable sources (23.01.2008), the contribution of renewable sources in total energy consumption will be increased. In Poland the use of renewable sources will be increased by 15% till 2020 (Tab. 2), (Wiśniewski and Kupczyk, 2007).

Table 1. Percentage share of renewable sources in the total energy consumption in EU member states in 2005 and 2020

Country	Years	
	2005	2020
Belgium	2.2	13.0
Bulgaria	9.4	16.0
Denmark	17.0	30.0
Germany	5.8	18.0
Ireland	3.1	16.0
Greece	6.9	18.0
Spain	8.7	20.0
France	10.3	23.0
Italy	5.2	17.0
Latvia	34.9	42.0
Lithuania	15.0	23.0
Luxembourg	0.9	11.0
Hungary	4.3	13.0
Malta	0.0	10.0
Netherlands	2.4	14.0
Austria	23.3	34.0
POLAND	**7.2**	**15.0**
Romania	17.8	24.0
Slovenia	16.0	25.0
Slovakia	6.7	14.0
Finland	28.5	38.0
Sweden	39.8	49.0
Great Britain	1.3	15.0

RENEWABLE ENERGY IN LUBELSKIE PROVINCE

Renewable energy sources are in general local resources. That is why the principles of economics advise that every region should promote those resources, which are the cheapest and this should influence the energy policies and the local development plans (Lewandowski 2002).

Geothermal energy is an energy that uses the warmth of the Earth's interior. Majority of our thermal waters have a low or medium temperature (20-60°C) and are strongly salted. They are usually characterised by a lack of self-flows and the water-bearing levels are situated at big depths. The acquisition of thermal energy from the Earth's interior still poses many technical and economic problems. However, progress in that field is very fast. But the Lubleskie province is relatively poor in this kind of waters (Bujakowski 2000, Sokołowski 2000).

Water energy. The hydroenergy resources of Poland are not rich and most of them are related with the Wisla, Odra, and the rivers of Pomerania. On the rest of the terrotiry the water energy can be quite significant. In the Lubelskie province the water energy has a marginal character (Trojanowska 1998).

Wind energy. In order to use wind energy for energy generation purposes, the wind must have velocity of 5-25 m s^{-1} and an adequate permanence. In the Lubelskie province the winds blow with an average yearly velocity of 4 m s^{-1}. The usage of this form of renewable energy is, moreover, very expensive and significant differences in wind velocity make it impossible to foresee the power that should be delivered (sold) to the power plants (Department of Environmental 2002, Lorenc 2004).

Solar energy. The yearly density of solar radiation onto the horizontal plane in Poland amounts to 950-1250 kWh m^{-2}. The insolation time amounts to approximately 1600 hours per year. Meteorological conditions are characterised by very uneven distribution of solar radiation in the year-long cycle. About 80% of the whole amount of insolation occurs in the 6 spring-summer season months (from the beginning of April until the end of September). Additionally, the time of insolation in summer lengthens to 16 h day^{-1} and in winter shortens to 8 h day^{-1} (Chochowski and Czekalski 1999).

The east part of Poland, including the Lubelskie province, has very big solar energy usage potential. Solar energy can be used in order to produce electrical energy (photovoltaic cells) and warm water (thermal solar collectors). Thermal collectors are usually used for house heating, warming the utility water and in pools. In the scale of a year they can provide approximately 60% of energy needed for warming a house, photovoltaic cells producing electric voltage while exposed to the light. In Poland

that kind of energy is much more expensive than that obtained form conventional power plants and it does not have the potential needed to eliminate other sources of energy. However, it can play a great by-role. Especially when the photovoltaic market is expanding all the time (Nowicki 2004).

Biomass energy is plant or animal-origin substances which are biodegraded. The energy from biomass can be obtained by combustion, pyrolysis and methane or alcohol fermentation. Biomass contains energy which is the least capital- demanding source of renewable energy. While combusting biomass, CO_2 emission equals the amount of that compound which has been taken in by a plant during its growth. 2 t dry mass are the equivalent (in the energy sense) of 1 ton of hard coal (Kryłowicz *et al*. 2004, Nowakowski 1999).

The most important arguments for the energy production usage of biomass are:

- assurance of profit which is difficult to obtain with food overproduction
- stable and reliable deliveries of domestic energy source
- creation of new work places, which is very important for rural areas endangered by unemployment
- limitation of CO_2 emission from non-renewable fuels
- high costs of desulphurisation of fumes from fossil fuels
- stimulation of economy, industry and trade within local rural communities
- decentralisation of energy production, which is connected with higher energy security (widening of energy producers' offer)

Biomass is currently one of the most promising, accessible and cheapest renewable energy sources. This applies to the whole country and to the Lubelskie province. At the moment, energy obtained from renewable sources amounts to 3% of the whole primary energy consumption in the country. 98% of that amount falls to biomass (WPR for lubleskie province). At the current stage of scientific and technical development, the usage of renewable resources on a bigger scale is not yet possible. The barriers are technological limitations and negative economic effects connected with them.

The main biomass producers are:

- forestry – wood waste in the wood industry and wood wrappings waste,
- agriculture – cereal straw from oil or leguminous plants, hay and liquid biodiesel from the seeds of oil plants and from cereal, beetroots, etc (biodiesel, bioethanol),
- municipal administration – biogas from dungstead, sewage sludge and dumping ground (Tys *et al*. 2003).

POSSIBILITIES OF BIOMASS PRODUCTION IN POLAND IN COMPARISON WITH OTHER EU MEMBER COUNTRIES

In Poland, yearly usable energy producing potential of biomass amounts to over 20 billion tons of straw waste, about 4 billion tons of wood waste (brushwood, sawdust, bark), about 5 billion tons of sewage sludge and dumping ground. That gives in total about 30 billion tons of biomass every year, which is energy equivalent of 15-20 billion tons of coal.

The potential for heat and power plants combusting biomass and using biogas is significant, but in reality barely used. Lack of concepts of the local boiler houses basing on boilers combusting biomass leads to high investments costs. Traditional combustion in boilers has many opponents and is not the only possible way of energy usage of biomass (sewage sludge, organic industrial sludge, dungstead). One of them is methane fermentation.

Biogas can be a product of oxygen-free bacterial fermentation, and methanol, ethanol and other compounds can be products of oxygen fermentation. Obtained gas or liquid fuel can be burnt in internal combustion engines or boilers and processed into other forms of energy. Energy contained in 1 m^3 of biogas is the equivalent of energy contained in 0.93 m^3 of natural gas, 1 dm^3 of diesel oil, 1.25 kg of coal and is an equivalent of 9.4 kWh of electrical energy. This kind of energy is renewable, environment-friendly, easy accessible and, after mastering the technology, can become cheap energy (Solarski 2007).

Biomass can be combusted not only directly, but it can also be a source of liquid fuels. Economic, strategic and ecological aspects speak for paying more attention to biofuels. Especially when we are threatened with overproduction of food and farmers have problems with selling potatoes, sugar-beets and cereals. However, recently the situation has changed. Cultivation of energy plants with increasing of food prices can fast lead to significant changes in laws applicable to that field (Kupczyk 2008, Uzdowski 1999).

The production of renewable energy from biomass, including seeds and their products (oil), is of high importance. The basis of that production may be the cultivation of plants "typical" for a certain region. Lower importance is put on marginal plants, such as willow, topinambur etc. These plants cannot rival plants like rapeseed, potato, corn, cereals, in spite of the fact that they produce a lot of green mass. In many countries of EU, including Poland, the highest importance is put on the production of biodiesel used as biofuel in self-ignition combustion engines. Local production of biofuel would cause greater independence from external factors. In the US, savings resulting from biofuel import in the last 15 years equalled

45.5 bld USD. They resulted from an increase in biofuel usage, which equalled from 0.8 to 5.0% of the general fuel consumption (Pawlak 2000).

In the estimation of relevance of energy sources of plant origin it is needed to take into account not only the direct effects but also the economic, social and ecological effects. Moreover, extremely important is the search for, verification in practical conditions and implementation of solutions that can improve the effectiveness of biofuels, because it is the only way to assure their competitiveness in comparison with traditional fuels (Kupczyk 2008, Pawlak 2000).

Lately, for quite a long time, it can be observed that farmers are interested in agro-refineries which should be treated as ecological investments. Proper economic estimation of agro-refineries is crucial for starting up factories or network of factories that would produce biofuels from rapeseed. This branch of agrarian techniques in Poland is characterised by notable backwardness in the field of production technology in comparison with other EU member states (in particular with Austria, Germany, France, Italy). In order to overcome this situation, it would be needed to optimise the system of biofuel production from rapeseed, taking into account the environment protection and the rules of agrarian process engineering (Mikucki and Jerzak 1992).

The significant problems regarding the production of biofuel result from the lack of its production components. Nowadays it is a complex issue which affects both Poland and the rest of EU countries. On the basis of German data (Scharmer 2001, Schneider and Ritte 1989) the productive capability of rapeseed may be estimated. The acreage of agricultural fields in Germany equals to about 12 mln ha. Application of rules of crop rotation and cultivation allows for rapeseed cultivation on 20% of the acreage, which makes 2.4 mln ha. At rapeseed yields of 3.2 t ha^{-1} and oil content of seed of 40%, 3 mln t of oil rapeseed may be produced. Out of this total, 2 mln t of oil may be used for production of biofuel and 1 mln for edible oil. The mineral oil usage in the Germany equals to 27 mln t $year^{-1}$ (data from 1999), so about 7.4% of its demand may be covered by biodiesel. At present, its share equals to 1.3%. This shows that this kind of fuel will never replace fossil fuels. That is why biodiesel should be used only in areas such as forests, parks and in vehicles unfavourably influencing the local environment (i.e. local transportation etc.). In recent years, however, a rapid growth of biofuels production in the world's scale can be observed (Fig. 1) and it is expected that in the year 2020 the percentage share of biofuels in the total fuel mass in EU member states will reach as much as 20% (Tab. 2). Also, biodiesel production capacities in the EU member states constantly increases as it is shown in Table 3.

Table 2. Percentage share of biofuels in the total fuels mass in EU member states

Year	2005	2006	2007	2008	2009	2010	2020
%	2.00	2.75	3.50	4.25	5.10	5.75	20.00

Table 3. Size of the biodiesel production capacity in EU member states (billions of tons)

Country	2002	2003	2004	2005	2006
Germany	0.94	1.06	1.20	2.00	2.30
France	0.45	0.50	0.50	0.50	0.65
Italy	0.34	0.42	0.60	0.60	0.65
Rest	0.27	0.31	0.53	0.70	0.90
UE-25	1.90	2.29	2.83	3.75	4.50

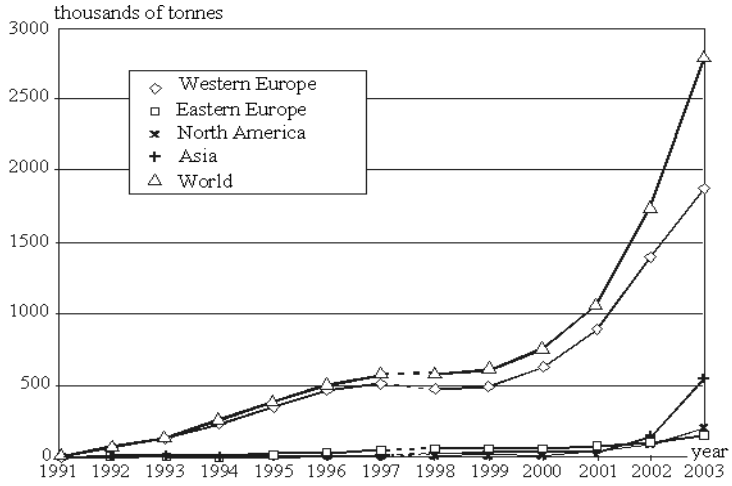

Fig. 1. World's biodiesel production (Körbitz 2003)

Rapeseed – essential source of biofuel

Production of fuel from rapeseed creates also a possibility of better usage of World's natural resources and contributes to the creation new jobs and to the development of rural areas, which along with other biodiesel's ecological features should be promoted as particularly important (Gruenberg 2003).

The success of this undertaking depends from the possibility of dissemination of rapeseed (which is the main oil plant in our climate) cultivation among farmers.

It must be emphasized, however, that rapeseed is a plant whose cultivation is particularly difficult and the variability of its yield levels can equal even 20-25%. Costs of rapeseed cultivation are high because of the great amount of fertilisers used (nitrogen and phosphorus amounts twice, and calcium amounts five times as large as for wheat). As a result, costs of cultivation of 1 ha of rapeseed are higher by 20-25% than costs of winter wheat cultivation. The fact is proved by research conducted by the Institute of Agricultural Economics and Food Economy. Whereas, the profits from rapeseed are approximately 35% lower than those in the case of wheat (Pawlak 2000).

The estimation of energy potential calculated on the basis of rapeseed production in Poland shows that 1.4 mln ha of rapeseed can be obtained in a situation in which only 10% of arable land will be cultivated. The arable acreage of rapeseed increased from 392 ths ha in 2003 to 797 ths ha in 2007 (750 ths ha in 2008 is predicted). It is estimated that an increase in rapeseed cultivation will cause a decrease in the cultivation of other plants. A part of rapeseed cultivation will take place on soils intended to fallow, like in EU countries (it will not be the worst soils). Such a significant increase in rapeseed cultivation would result in cultivation of about 13% of very good and good soils and, after taking into account the average soils, rapeseed would take about 10% of very good, good and average soils. It is possible, provided that profitability and competitiveness against other crop plants will be ensured (Kuś 2002, Kuś 2006, Wałkowski and Bartkowiak-Broda 2003).

The average yield of rapeseed in the last decade equalled about 2.3 t ha^{-1} and it was about 40% lower than the yield obtained in EU countries. That difference is caused mainly by weather conditions that are particularly critical in rapeseed vegetation. The water deficit in Poland was greater than in other EU countries. An increase in yield of rapeseed may be obtained by improvement of production technology and limitation of factors which reduce the yield (Kuś 2002).

The application of new varieties of rapeseed hybrids in agriculture, which can provide 20-30% higher yield (thanks to the process of heterodozy) is another way of increasing the yield of rapeseed. The yield of 2.5 t ha^{-1} (from 1.7 t ha^{-1} in 2003 to 2.4 t ha^{-1} in 2004) may be obtained if the methods of production optimisation are applied. Assuming threefold increase in cultivation acreage of rapeseed – to 1.4 mln ha, we can obtain about 3.5 mln t of seeds.

The component demand for food industry equals 1.5-1.8 mln t, while the national demand for components for biodiesel production predicted for 2008 equals about 800 ths t of rapeseed. According to EU directive, the content of biofuel in diesel should equal 3.45% and it should increase to 6.1% in 2011. It will require an increase of rapeseed production to about 3 mln t (Rosiak 2008). Considering the state of agro-refinery industry and component base organization, it can be supposed that their actual development is insufficient for meeting that challenge.

While calculating the expansion chances of rapeseed cultivation area in Poland, it is needed to assume that in the initial stage its participation growth in sowing structure will occur in current production areas. After analysis of the soil quality, atmospheric conditions and bigger number of large farms, it can be concluded that the most beneficial conditions occur in the area of Kujawy and Wielkopolska. In those parts of Poland the percentage participation of rapeseed cultivation amounts even to 30%. There exists a limited possibility of cultivation area growth and an increase in supply of rapeseed can take place only by the increase of yield. Less attractive are the southern parts of the Lubelskie province and north-eastern parts of the Podkarpackie province. In those parts of Poland farms are more scattered and most of them are smaller than 10 ha and, despite good soil and climate conditions, the possibilities of expanding the area of rapeseed cultivation are very limited. It is mainly caused by the lower work efficiency and increasing effect of pests activity on plantations smaller than 2 ha. These kind of regions in Poland are mainly the provinces of Małopolskie, Świętokrzyskie and the remaining part of Podkarpackie (Kuś 2002). In these areas rapeseed concentration is insufficient – both for the sake of crop rotation and of soil quality.

Poland's rapeseed cultivation area amounts to 3% of the total cultivation areas, whereas in EU member states this plant is being cultivated on aproximately 7-10% of cultivation areas, so in amount 3-4 times greater than in our state. Some Polish regions (provinces: Opolskie, Wielkopolskie, Zachodniopomorskie, Dolnośląskie) match up to western countries' standards (Fig. 2). Lubelskie province is significantly worse than these best provinces. Rapeseed cultivation amounts only to 1-1.5% of total cultivation area. There are also districts like Łukowski, Janowski, Lubartowski, Opolski where rapeseed is not cultivated at all. It should be remembered that rapeseed is very important in the crop rotation, because it is structure-forming and it enables even distribution of works at the farm and, what is extremely important, for its cultivation the same machines as for cereals are used (Piotrowski 2003).

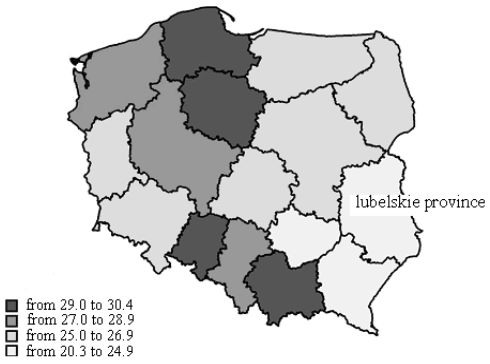

Fig. 2. Yield of rapeseed (dt ha^{-1}) in 2007 (CSO, 2008)

Aversion to the cultivation of rapeseed is caused mainly by the fact that in our region the yields do not exceed 2.2 t ha^{-1} (because of various reasons), whereas in provinces where big amounts of rapeseed are being cultivated (provinces Opol-

skie, Kujawsko-Pomorskie, Wielkopolskie) the yields are at the level of about 2.7 t ha^{-1} (in Germany – approximately – 3.5 t ha^{-1}). Figure 2 represents the total yield of rapeseed in Polish provinces in 2007. The Lubelskie province is a part of Eastern Poland where the total yield was the smallest.

Production abilities of Lubelskie province

The main factor which determines high yields of rapeseed is the share of good and very good soils. Taking this into consideration, the Lubelskie province is at the leading position in the state, because it has over 60% of such soils (the average for Poland is 50%). This means that the potential area of rapeseed cultivation can reach 80 thousands of ha (currently 15 thousands of ha) and then its share in the sowing structure would reach 7% (Polish Electroenergy, 2001). Obtaining these effects is possible under the following conditions:

- implementation of proper regional policy
- active participation of local government
- stimulation of scientific environment in the scope of research and education for the sake of rural areas and agriculture
- gaining funds that would allow to implement the system solutions.

The latest possibilities of biodiesel production on the basis of rapeseed oil create a new demand for this precious raw material and give big opportunities to the Lubelskie province.

The potential of the Lubelskie province which derives from the application of the latest cultivation technology and harvest of rapeseed destined for energy purposes:

Current state:

- current acreage of rapeseed cultivation amounts to 15 000 ha,
- rapeseed prices in the year 2008 – 1450 PLN t^{-1},
- wheat prices in the year 2008 – 830 PLN t^{-1},
- current rapeseed yield in the region (on average) – 2.3 t ha^{-1},
- current wheat yields in the region (on average) – 3.5 t ha^{-1},
- profit in the scope of province – rapeseed – 50 025 000 PLN,
- profit in the scope of province – wheat – 43 575 000 PLN,
- difference: rapeseed – wheat = 6 450 000 PLN.

Assumptions

Enlargement of the rapeseed cultivation surface to 50 000 ha and application of modern rapeseed harvest technology.

Average crop increase: to 2.6 t h^{-1}

Profit in the scope of province:

From cultivation of 50 000 ha of rapeseed – 188 500 000 PLN,

From cultivation of 50 000 ha of wheat – 145 250 000 PLN,

Difference – 43 250 000 PLN.

The profit resulting from the replacement of wheat cultivation by rapeseed cultivation in the scope of the whole province can amount to 43 250 000 PLN. It is a minimal amount and it is an effect of implementation of the basic rules of rapeseed cultivation which bases on new rapeseed harvest technology. Supplementation of the whole rapeseed production technology by elements crucial for the cultivation would bring an additional profit of further 0.3 t h^{-1}. It would make it possible to gain 2.9 t h^{-1}– i.e. twice as much as the state average. In this case the profit from 50 000 ha would amount to 64 000 000 PLN.

It is absolutely possible to realize this kind of scenario. It should be also taken into consideration that there applies an extra-payment in the amount of 45 E ha^{-1} for plants cultivated for energy purposes, which would bring further profits for the Lubelskie province.

SUMMARY

The model of equable fuel-energy balance optimal for the Lubleskie province in the span of the next several years would be one with the following structure: coal – gas – biomass. In the future this model will be displaced by the solar- hydrogen energy-producing system. Agriculture, as it is being seen as the producer of food, can also become a producer of energy resources.

Constant increase of energy demands brings a big dilemma, namely – how to balance the economic, social and ecological aspects. Development of the biofuel sector in the Lubelskie province is an ideal example of the possibilities of balancing these difficult-to-solve problems. Moreover, enlargement of rapeseed (which is a resource used in esters production) cultivation acreage would be a kind of "driving wheel" for the regional economic development.

The Lubelskie province is a rural region and the nearest future and development possibilities should be bound with this field of production. The development of the resource base that can be used for biodiesel production additionally enables the modernization, reformation and increasing of competitiveness in relation to other Polish regions and to other EU member states agriculture sectors.

Actions which increase the general agricultural knowledge of the producers will cause an increase of all agricultural cultivations, economic profitability, and will also cause the development of other sectors connected with agriculture. It concerns particularly the development of transport, plant protection, fertilisers and fodder production sectors. These kinds of actions would counteract unemployment and would cause positive structural changes in rural areas of the Lubelskie region

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ALTERNATYWNE ŹRÓDŁA ENERGII W WOJEWÓDZTWIE LUBELSKIM (artykuł przeglądowy)

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Streszczenie. Produkcja energii odnawialnej na bazie biomasy w tym również nasion i produktów z nich wytworzonych (oleju) ma w tej chwili znaczenie największe. Podstawą może być uprawa roślin „typowych" dla danego rejonu. Znacznie mniejsze znaczenie można przypisać roślinom „marginalnym" typu ślazowiec, wierzba, topinambur itp. Rośliny te, pomimo iż wytwarzają dużo zielonej masy, nie mogą konkurować (w polskich realiach) z takimi roślinami, jak rzepak, buraki, zboża, ziemniaki, kukurydza. W wielu krajach UE, w tym również w Polsce, największą uwagę poświęca się produkcji biodiesla stosowanego jako biopaliwo w silnikach z zapłonem samoczynnym. Dysponowanie zasobem paliw własnej produkcji dawałoby większą niezależność od czynników zewnętrznych.

Słowa kluczowe: biomasa, energia, odnawialne źródła energii