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PRODUCTION AND USE OF BIOFUELS

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ABSTRACT. The aim of this paper is to show the state and prospects of development of biofuels production in chosen countries. Legal and financial regulations on biofuels production as well as opportunities of putting to use raw materials in order to this are also discussed. The paper indicates that the most significant producers of ethanol have been Brazil and the USA, while the biggest producers of biodiesel have been Germany, France and Italy.

Key words: biocomponents, biofuels, biodiesel, bioethanol, production

Introduction

In many countries constant growth in crops have resulted in overproduction and directed both farming and industry on efficiency and environmental protection. Favourable conditions have been formed for industrial usage of many plants. A direct impulse for industrial usage of many plants was the oil crisis of the 1970's and following decades. This crisis pointed to plants as a renewable and environmental source of fuels for combustion engines. Common Agricultural Policy reform has also contributed to rapid development of vegetable fuel production. This reform allowed cultivation for non-food using, including rapeseed for biofuel, on compulsory unworked land. Calling biofuel we take into account such biocomponents as:

– bioethanol – this is dehydrated ethyl alcohol, produced from raw materials or by-products and waste, which is added to gas,

– ester – this is fatty acid methyl/ethyl ester made in rapeseed or by-products and waste processing.

Biocomponents may be mixed with liquid fuels or used as self-contained engine fuel.

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Legal regulations

According to "Directive 2003/30/EC of the European Parliament and the Council on 8th May 2003 on the promotion of the use of biofuels..." (**Directive...** 2003) member states should abide to put minimum amount of biofuels on their markets. This directive aims to raise biodiesel's market share to 2% by 2005 and 5.75% by 2010. Biofuels can be put on the market:

– as clean biofuels or high concentrated in mineral oils derivatives according to appropriate quality standards in transport,

– as biofuels in mineral oils derivatives mixture in accordance with European standards for shipping fuels,

– as liquid biofuels derivatives such ETBE (Ethyl Tetra-Butyl Ester) in which percent of biofuel correspond with the specified one in article 2(2) of this directive.

Fuels contained more than 5% both FAME (Fatty Acid Methyl Ester) and bioethanol will be specially marked in outlets and results of using these biofuels will be monitored by member states. Each year member states will give reports to the Commission. Fuels and biofuels sales volume and information about promotion of biofuels will be included in these reports. In first report, after coming into force of this directive, member states will indicate the level of national indicator aims for first stage. In 2006 report, member states will present indicator aims for second stage.

Until 31st December 2006 at the latest and then every two years, the Commission will prepare auditing report for European Parliament and the Council concerning growth in using biofuels and other renewable fuels in member states. In all member states, legal and administrative regulations in order to adjust to mentioned directive will be come into force until 31st December 2004 at the latest. Usage of plant origin components in fuels is not obligatory in the European Union. Particular member states can decide about the way of biofuels promotion themselves. Community law does not oblige member states to produce and put on the market liquid fuels only with biocomponents.

Law on 2nd October 2003 on biocomponents using in liquid both fuels and biofuels is the most important legal act regulation this sector in Poland. Among others, biocomponents producing, storing and sales rules, rules of raw materials using in biocomponents production, quality requirements for biocomponents and rules of biocomponents market monitoring are under control. According to the annual regulation of the Cabinet minimum amount of biocomponents, which must be put on the market in liquid both fuels and biofuels, is specified. The regulation of the Cabinet on 10th January 2004 specified minimum ester share in diesel oil in 2004 at the 0.11% level and minimum bioethanol share in gas at the 1.6% (from 1st January 2004 to 31st September 2004) and 2.4% (from 1st October 2004 to 31st December 2004) level. Actually agric-refining industry is in stage of planning and taking preliminary investment decisions. For that reason such low indicator for esters was specified. Although this regulation was rejected by Constitutional Tribunal in April this year, it can be assumed that new law will act on similar terms.

Liquid biofuels, after leving an excise tax on them, are more expensive than fuel oil. Profitability of using biofuels results from lower excise tax rates in order to aid farmers income, environmental protection, form new places of work and fuel safety. The regulation of Minister of Finance on 23rd December 2003 on excise tax was given to encourage to produce and mix biocomponents for fuels. This regulation exempt from excise tax:

– sales of biocomponents,

– sales of liquid fuels containing from 4.5% to 5% of biocomponents in the amount of 1.5 zl per each liter of biocomponents added to these fuels,

– sales of liquid fuels containg more than 5% to 10% of biocomponents in the amount of 1.8 zl per each liter of biocomponents added to these fuels,

– sales of liquid fuels containing more than 10% of biocomponents in the amount of 2.20 zl per each liter of biocomponents added to these fuels.

However, tax exemption can not be higher than excise tax amount due by way of sales of these fuels.

Biodiesel production in chosen countries

Various trade names are used in different countries, that is to say Biodiesel, Raps-Diesel (Germany), Ekodiesel and Biodiesel (Austria), Diestr (France), Bionafta, Ekonafta, Ekoester (the Czech Republic and Slovakia). All these names means, chemically speaking, fatty acid methyl/ethyl ester made as a result of transesterfication:

rapeseed oil + methanol (ethanol) = ester + glycerin

Rapeseed oil was the first type of oil used for transesterfication to produce biodiesel and still is the main source of quality biodiesel (Fig. 1). The advantage of biodiesel produced from rapeseed oil is its high stability caused by significant share of mono-unsaturated oleic fatty acids (60%) and insignificant share of saturated fatty acids (6%).

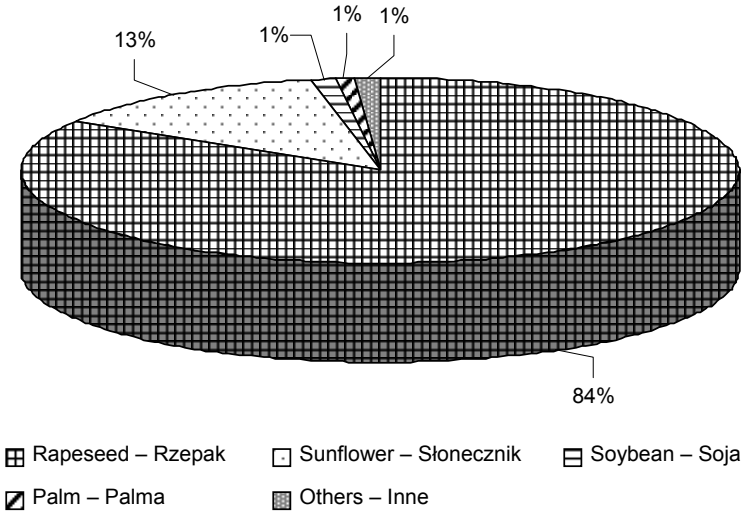

Fig. 1. Raw materials for biodiesel (on the basis of **Körbitz** 2003)
Ryc. 1. Źródła oleju wykorzystywane w produkcji biodiesla
(na podstawie **Körbitza** 2003)

In Europe starting research and production of biodiesel has been a political decision fortified with economic and social analyses, informations from elementary, technical and exploitative research and strengthen by legal acts. Biodiesel became more and more popular because of its environmental characteristics and good results of important exploitative research. Austria was the first European country, which initiated rapeseed research programme with four aims: to provide a secure supply of liquid transport fuels, to create an environmental friendly fuel for diesel engines, to reduce health and safety risks and to provide customers with a reliable fuel at a reasonable ratio of costs to benefits. Biodiesel production and sales began in Austria in 1988. At this time the product was of questionable quality, but tremendous progress has been made since then. Development include improving process technology, developing sophisticated standards for assuring fuel quality, establishing biodiesel production in many countries all over the world, intelligent product positioning in defined fuel market segments, obtaining biodiesel warranties from diesel engine manufactures and implementing supportive legal measures and voluntary regulations (**Körbitz** 2003). In consequence, European production of biodiesel has increased rapidly during the last several years and is now concentrated primarily in three countries: Germany, France and Italy (Table 1). In 2004, according to the European Biodiesel Board in Brussels, these countries produced adequately 715 000 t, 375 000 t and 273 000 t of biodiesel. European Union (EU-15) production of biodiesel amounted to 1 434 000 t. Estimated biodiesel production capacity reached 2 246 000 t in 2004.

Table 1

Biodiesel production in some European Union countries in 2002-2004 (thous. t)
(EU: biodiesel... 2003)
Produkcja biodiesla w niektórych krajach Unii Europejskiej w latach 2002-2004 (tys. t)
(EU: biodiesel... 2003)

Country Kraj	2002	2003	2004*
Germany – Niemcy	450	715	1 088
France – Francja	366	357	502
Italy – Włochy	210	273	419
Austria	25	32	100
Denmark – Dania	10	41	44
Great Britain – Wielka Brytania	3	9	15
Sweden – Szwecja	1	1	8
Spain – Hiszpania	0	6	70
Total – Razem	1 065	1 434	2 246

*Biodiesel production capacity.
*Zdolności produkcyjne.

France

In France, biodiesel is called DIESTER (i.e. diesel – ester). Diester has been generally used by petrochemical industry since 1993. Natural characteristics of biodiesel let diesel oil, containg low level of sulphur, restore lubricating qualities. Two levels of incorporation are actually used: maximum 5% admixture in diesel oil freely available on the gas stations, and 30% admixture in diesel oil used in city transport etc. Almost half of diesel oil sold on the French market contains 2-3-4% addition of ester. Regulations do not impose a special marking this fuel, so average Frenchman do not know about biocomponents using in diesel oil. Diester production sold on the French market without excise tax is restricted (2003 – 317 500 t, 2004 – 385 500 t). Fuel quantity limits exempted from excise tax (in the amount of 0.33 EUR/l) are assigned to all factories. Diester is produced by four factories: DICO in Grand Couronne near Rouen (Seine Maritine), ROBBE in Venette near Compiegne (Oise), SIDOBRE SINNOVA in Boussens near Tuluza (Haute – Garonne) and NOVAOL in Verdun.(**Agricultural...** 2003).

Germany

Not so long ago, biodiesel was put on the German market only as 100% RME (raps methyl ester). First of all, this was caused by excise tax reductions. In Germany in 1997 production capacity amounted to 100 000 t, while in 2003 – 1 M. t of biodiesel a year. Today, more than 1600 German gas stations sell biodiesel (**EU: biodiesel...** 2003).

Italy

Italian system is based on limiting quantity of biodiesel exempted from excise tax. In 2001, 125 500 t of ester were entirely exempted from excise tax. In Italy, as well as in France, fuel quantity limits exempted from excise tax are assigned to all factories and two levels of incorporation (5% and 30%) are also used. The Italians more often then the others use ester to heat buildings (**EU: biodiesel...** 2003).

Poland

In Poland, biodiesel production based on rapeseed oil was acting as experiments. Biodiesel was produced by the following factories: Nitrogenous Works „Kędzierzyn", agro-rafinery „Mochełek", Chemical Works „Rokita" in Brzeg Dolny. In 1998, little amount of biodiesel was also produced by Innovative-Implementing Ltd Company SOPUR in Bydgoszcz. The main user of biodiesel was CPN Regional Management in Wrocław. Each year, a few dozen of biofuel were produced. After CPN had ineffectively applied for tax reductions on diesel oil containing biodoesel, in March 1998 CPN suspended its production. Nowadays, chemical industry have production capacity, e.g. above mentioned Zakłady Azotowe „Kędzierzyn". Table 2 presents minimum biofuels share in total use of liquid fuels (according to **Directive...** 2003).

Table 2
Minimum biofuels share in total use of liquid fuels in 2005-2010 according to Directive 2003/30/EC (%) (Directive... 2003, Żmuda 2003)
Minimalny udział biopaliw w ogólnym zużyciu paliw ciekłych w latach 2005-2010 zgodnie z ustaleniami Dyrektywy 2003/30/EC (%) (Directive... 2003, Żmuda 2003)

Specification Wyszczególnienie	2005	2006	2007	2008	2009	2010	According to Według wartości
Biocomponents share Udział biokomponentów	2.00	2.75	3.50	4.25	5.00	5.75	energy value energetycznej
Bioethanol Bioetanol	3.20	4.41	5.61	6.81	8.01	9.21	cubical value objętościowej
ETBE (bioethanol equivalent) EETB (w przeliczeniu na bioetanol)	6.82	9.37	11.93	14.49	17.04	19.60	cubical value objętościowej
Ester	2.12	2.92	3.71	4.51	5.30	6.10	cubical value objętościowej

Introducing of ester addition in diesel oil will result in demand growth for rapeseed and other raw materials used for ethyl alcohol production. Table 3 presents rapeseed consumption in Poland in years 2005-2010. On the basis IERiGŻ estimates, in 2010 rapeseed food consumption will amount to 1.3 M. t. This year rapeseed production in Poland should rise by 913 000 t to meet Directive requirements. Taking into account crop yield in the amount of 2.4 t, harvested area should be 920 000 ha.

Bioethanol

In 2001, ethanol world production amounted to 31 M. m^3. This year the most significant producers of ethanol were Brazil (about 12 M. m^3), and the USA (8 M. m^3). Asian production was about 6 M. m^3, almost haft of that was produced in China and 1.7 M. m^3 – in India. European Union (EU-15) production reached 2 M. m^3 and one third was produced in France. Ethanol is generally used in oil sector (66% of total production), technical and chemical sector (21%) and for food (13%) (**Schmitz** 2003). Bioethanol can be directly blended with gasoline or chemically combined to produce ETBE (Ethyl Tertio-Butyl Ester) and blend it with gasoline. Sizes and states of ethanol blended with gasolines are different for particular countries. Table 4 shows use of ethanol in the oil industry in chosen countries. The largest amounts of ethanol for fuel are used in Brazil (12 M. m^3) and in the USA (6 M. m^3) while in Europe – in France and Spain. The most available raw materials rich in sugar are used to produce ethanol (e.g. cereals, sugar beets, sugarcane).

Table 3

Rapeseed consumption in Poland in 2005-2010 (Rosiak 2004)
Zapotrzebowanie na rzepak w Polsce w latach 2005-2010 (Rosiak 2004)

Specification Wyszczególnienie	2005	2006	2007	2008	2009	2010
Food processing (M. t) Przerób na cele spożywcze (mln t)	1.0	1.1	1.1	1.2	1.2	1.3
Crop yield (t/ha) Plon (t/ha)	2.2	2.2	2.3	2.3	2.3	2.4
Harvested area under rapeseed for processing (thous. ha) Areał przeznaczony pod uprawę rzepaku dla przetwórstwa (tys. t)	450	450	480	520	520	540
Ester share in ON (%) Udział estrów w ON (%)	2.12	2.92	3.71	4.51	5.3	6.1
Ester consumption (thous. t) Zapotrzebowanie na estry (tys. t)	127	175	222	270	317	365
Rapeseed consumption (thous. t) Zapotrzebowanie na rzepak (tys. t)	317	438	555	675	793	913
Harvested area under rapeseed for consumption (thous. ha) Areał przeznaczony pod uprawę rzepaku konsumpcyjnego (tys. ha)	140	200	240	290	350	380
Total rapeseed consumption (M. t) Łączne zapotrzebowanie na rzepak (mln t)	1.3	1.4	1.6	1.9	2.0	2.2
Necessary harvested area (thous. ha) Niezbędny areał uprawy (tys. ha)	590	650	720	810	870	920

In Poland, considerable amounts of ethanol are blended with gasolines, too. In Poland bioethanol is produced in two stages: production of raw spirit in distilleries and then dehydration. The second process was considerably improved in the last several years. Ethanol purchase price for the oil industry was decreased. In last period, it oscillated between 1.8-1.9 zl/l. Usage of ethanol in fuels below 5%, according to cubical value, made new standard on gas fuels come into force and excise tax rate for fuels producers reduce. First time, reducing excise tax rates on these fuels was applied in fourth quarter in 1993. In Poland, the main raw materials used to produce raw spirit are rye, potatoes and molasses. Raw materials costs are the most significant part of ethanol production costs (60-70%), therefore raw materials used in raw spirit production structure change depending on price relations. Table 5 shows that today and in the future alike, national raw materials delivery capacity are not barrier for bioethanol production. The problem can arise in using substantial quantity of by-products. Difficult economic situation and limited demand cause registered distilleries not to continue production. In 2002/03 season 776 distilleries were ready to run a production, from that only 340 started producing.

Table 4

Use of ethanol in the oil industry in chosen countries (Schmitz 2003)
Wykorzystanie etanolu przez przemysł paliwowy w wybranych krajach (Schmitz 2003)

Ethanol Etanol	France Francja	Spain Hiszpania	Sweden Szwecja	USA	Brazil Brazylia
Production volume (m^3) Produkcja (m^3)	115 thous. in 2001 115 tys. w 2001	100 thous. in 2001, 225 thous. in 2002 100 tys. w 2001, 225 tys. w 2002	50 thous. in 2001 50 tys. w 2001	6 M. in 2001 6 mln w 2001	12 M. in 2001 12 mln w 2001
State Postać, w jakiej jest wykorzystywany	15% addition of ETBE 15% dodatku EETB	ETBE EETB	5% addition of bioethanol 5% dodatku bioetanolu	10% addition of bioethanol 10% dodatku bioetanolu	22%, 100% and ETBE 22%, 100% i EETB
Raw materials used in production Surowce wykorzystane do produkcji	about 75% of sugar beets and 25% of wheat ok. 75% buraków cukrowych i ok. 25% pszenicy	100% of barley and wheat 100% jęczmienia i pszenicy	100% of wheat 100% pszenicy	almost 100% of maize prawie w 100% kukurydza	100% of sugar cane 100% trzciny cukrowej
Price Cena	about 400-450 EUR/m^3 około 400-450 UER/m^3	about 400-450 EUR/m^3 około 400-450 EUR/m^3	about 550--650 EUR/m^3 około 550--650 EUR/m^3	260-320 USD/m^3 260-320 USD/m^3	200-250 EUR/m^3 200-250 EUR/m^3

Table 5

Production of raw spirit and dehydrated spirit and main raw materials used to produce spirit in Poland (Żmuda 2003)
Produkcja spirytusu surowego i odwodnionego oraz podstawowe surowce wykorzystywane w Polsce do produkcji spirytusu (Żmuda 2003)

Year Rok	Raw spirit Spirytus surowy (M. t)	Dehydrated spirit Spirytus odwodniony (M. t)	Raw material quantity (thous. t) Ilość surowca (tys. t)			Share in annual crops Udział roczny w zbiorach (%)	
			rye żyto	potatoes ziemniaki	molasses melasa	rye żyto	potatoes ziemniaki
1994	210.0	27.0	*	*	*	*	*
1995	245.0	63.0	664.8	649.0	0.0	10.6	2.6
1996	278.0	100.9	680.0	640.0	31.0	12.0	2.4
1997	240.6	110.6	630.5	370.6	50.0	11.9	1.8
1998	208.0	99.8	522.0	216.0	76.0	9.2	0.8
1999	167.2	88.5	378.0	112.0	107.0	7.3	0.6
2000	173.3	51.5	176.5	118.7	38.8	4.4	0.5
2001	181.0	69.4	*	*	*	*	*
2002	210.0	82.8	*	*	*	*	*

*Data not available.
*Brak danych.

Conclusions

1. The most significant producers of ethanol have been Brazil and the USA, while the biggest producers of biodiesel have been Germany, France and Italy.

2. Financial support, especially tax reductions, is often applied in biofuels production.

3. In Poland, there are actually no raw material and technological difficulties with bioethanol production, while biodiesel market generally does not exist.

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PRODUKCJA I WYKORZYSTANIE BIOPALIW

S t r e s z c z e n i e

Świadomość wyczerpywania się zasobów konwencjonalnych źródeł energii oraz nadprodukcja żywności spowodowały skupienie wysiłków na energetycznym wykorzystaniu surowców rolniczych. Wykorzystanie surowców rolniczych na cele paliwowe przyczyni się do zagospodarowania nadmiaru produktów rolniczych. Produkcja biopaliw jest droższa niż produkcja paliw mineralnych, dlatego stosuje się różne regulacje w celu zachęcenia do produkcji biopaliw. W ostatnich czasach mocno rozwija się produkcja biopaliw ciekłych: biodiesla, bioetanolu. Na świecie (Brazylia, USA) dominuje produkcja bioetanolu, natomiast w Europie – produkcja biodiesla.