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POSSIBILITIES FOR THE USE OF BIOFUELS IN EUROPE AND IN SERBIA

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RESEARCH ARTICLE

ABSTRACT: Biomass is one of the major potentials of renewable energy sources in Serbia. Due to the lack of legal acts, regulations, and incentive systems by the state, this potential has not been sufficiently utilized. According to some estimates, the theoretical potential of biomass in Serbia amounts to about 3.2 million equivalent tonnes of oil. This paper gives an overview of the existing situation in Serbia, including a set of measures necessary to stimulate the production of biofuels, primarily for the purpose of more intensive development of agriculture, reduction of pollution of the environment, reduction of the import of crude oil and for the creation of new jobs. The aim of this paper is to present the possibilities, conditions, and obstacles in the production and use of biodiesel in Serbia, as well as the comparison of the use of biodiesel in the countries of the European Union. Special attention is paid to the economics of production and the ecological motive for the production of biodiesel, as well as the ability to reduce CO2 emissions and the environmental impact of transportation vehicles.

KEY WORDS: biofuel, renewable energy sources, transportation vehicles, environmental impact

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MOGUĆNOST KORIŠĆENJA BIOGORIVA U EVROPI I SRBIJI

REZIME: Biomasa je jedan od glavnih potencijala obnovljivih izvora energije u Srbiji. Zbog nedostataka pravnih akata, propisa i sistema podsticaja od strane države, ovaj potencijal nije dovoljno iskorišćen. Prema nekim procenama, teoretski potencijal biomase u Srbiji iznosi oko 3.2 miliona ekvivalenstnih tona nafte. Ovaj rad daje pregled postojeće situacije u Srbiji, uključujući niz mera neophodnih za stimulisanje proivodnje biogoriva, prvenstveno u cilju intezivnog razvoja poljoprivrede, smanjenja zagađenja životne sredine, smanjenja uvoza sirove nafte i stvaranje novih radnih mesta. Cilji ovog rada je da predstavi mogućnosti, uslove i prepreke u proizvodnji i upotrebi biodizela u Srbiji, kao i poređenje upotrebe biodizela u zemljama Evropske unije. Posebna pažnja je posvećena ekonomiji proizvodnje i ekološkom motivu za proizvodnju biodizela, kao i mogućnost smanjenja emisije CO_2 i uticaja transportnih vozila na životnu sredinu.

KLJUČNE REČI: biogorivo, obnovljivi izvori energije, transportna vozila, uticaj na životnu sredinu

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1. INTRODUCTION

The total global oil consumption is almost 4 billion tonnes a year, whereas its reserves are estimated at around 120-160 billion tonnes, which represents one of the major problems in the field of energy. On the other hand, the natural and technical potential of renewable energy sources on a daily basis is about 20,000 times greater than the daily consumption of nuclear fuels and fossil fuels, together. Fossil fuels are largely the cause of global warming, generating the greenhouse effect through combustion. Spending on crude oil reserves and environmental problems related to its processing and utilization are the two main reasons why we should turn to bio-sources that convert into biodiesel and bioethanol.

Biofuels in the narrower sense include fuels derived from biomass and used for transportation purposes. This category of fuel includes methane, gas produced by the gasification process, alcohols, esters and other chemicals derived from cellulosic biomass. The basic raw materials for the production of biofuels are plant and tree plantations, sugar and oil crops, agricultural and forestry residues, as well as individual fractions of municipal and industrial waste. Oil reserves are steadily decreasing, so developed countries have been intensively engaged in biomass production processes over the past decade. In Europe, rape oil (82.8%) and sunflower oil (12.5%) are used as the dominant raw material for the production of biodiesel, whereas soybeans are used in the USA for the production of biodiesel [14]. Biodiesel is a non-toxic and biodegradable motor fuel derived from rapeseed oil or other vegetable oils (sunflower, palm, soybean oil) through esterification with methanol as well as from animal fats and recycled oils (Fig 1) [2, 14].

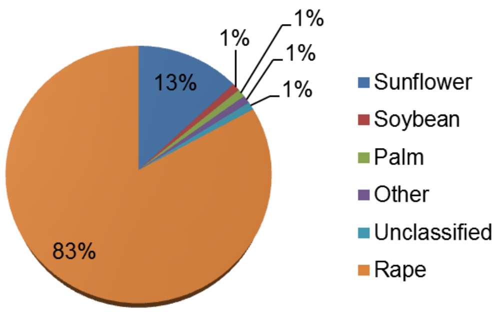

Figure 1. Graph of the most important raw materials for the production of biodiesel

In developed countries, already used oils and animal fats can be further utilised in the production of biodiesel. Such an environmentally friendly and renewable energy source is used as a substitute for mineral diesel. The use of pure biodiesel reduces the emission of harmful gases (NOx, CO2, SO2) and solid particles, does not contain sulfur, lead, nitrogen, toxic aromatic compounds, and is biodegradable so that its use reduces environmental pollution. Biodiesel is commonly used as a mineral oil additive to reduce emissions of solid particles, carbon dioxide, aromatic hydrocarbons, and other air pollutants resulting from the combustion in conventional diesel engines. Mixtures of a maximum of 20% biodiesel with mineral diesel can be used without the requirement to modify the engine in almost all conventional diesel engines. By-products in biodiesel production (such as glycerine, lecithin, and fatty acids) can be used in the pharmaceutical and cosmetic industry, whereas by-products from bioethanol production can be used as protein-rich foods [17].

One of the goals of the European Commission Directive 2009/28/EC [7], is to have 10% of energy demand in the transportation sector covered by the renewable energy sources (RES) by 2020. In other words, 50 billion litres of fossil fuels in the European Union (EU) will be replaced by biofuels [3]. In the United States, the Energy Act [4] (passed in 2005) and the 2007 Energy Security and Safety Act [5] both promote RES, including biomass primarily through liquid biofuels, and set the target of producing 136 billion litres of biofuel for the transportation sector in 2022. According to some forecasts, it is expected that more than 5% of the fuel in the road sector and 1% in air transportation in the world will be replaced by biofuels by 2030 [6]. Considering the great importance the biofuels have in the transportation sector, as well as the forecasts for their higher demand, the aim of this paper is to review currently available conventional liquid biofuels including advanced liquid biofuels and compare their properties with fossil gasoline and diesel, indicating the appropriate raw materials and the paths of their conversion. The work additionally contributes to the definition and differentiation in terminology of the basic concepts related to biomass and the classification of biofuels.

2. BIOFUELS AND THEIR DIVISION

According to the European Directive 2009/28/EC [7] and the National Action Plan for the Use of Renewable Energy Sources of the Republic of Serbia [13], based on the Directive, biofuels represent liquid or gaseous fuels produced from biomass and used in transportation. There are different approaches to the classification of biofuels considering the large variety of raw materials and the diversity of the involved conversion processes, which are evolving towards sustainability and the required fuel quality standards. The most commonly used biofuel classification in the literature [8, 14, 15], includes the following generations:

- 1st generation biofuels: bioethanol, biodiesel, vegetable oils (SVOs or "Pure Plant Oil" - PPO) and biogas / landfill gas
- 2nd generation biofuels (2G): bio alcohols (cellulose ethanol, bio methanol), BtL fuels (synthetic liquid fuels produced by thermo-chemical conversion of biomass, for example FT diesel and FT kerosene), biodiesel from waste materials, HTU diesel (bio DMF), hydro treated vegetable oils (renewable diesel), bio-dimethyl ether (bio DME), bio-synthetic gas (bio SNG) and bio-hydrogen
- 3rd generation biofuels (3G): algae biofuels (for example, algae bio alcohols, biodiesel and BtL fuels)
- 4th generation biofuels (4G): biofuels produced using genetically modified organisms, such as photosynthetic microalgae with a higher proportion of lipids and the ability to use larger amounts of carbon dioxide than those commonly used for photosynthesis processes, this way participating in carbon sequestration processes (removing carbon dioxide from the atmosphere) and consequent reduction of the greenhouse effect [8, 12, 18].

Figure 2 shows the classification of energy sources and their share in total global energy consumption [9].

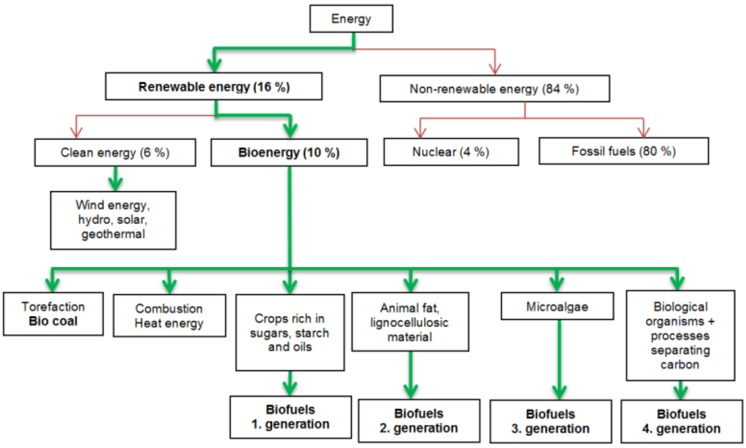

Figure 2. Classification of energy sources with the contribution to the global energy consumption [9]

Depending on the soil quality and climatic and economic conditions, different raw materials can be used to obtain biodiesel (see Table 1). In order to reduce the costs of biodiesel production, alternative raw materials are considered, such as inert vegetable oils and used oils and fat [9, 14].

Table 1. Row materials for biodiesel production [9]

Raw material for biodiesel production	Country
Soybean oil	USA, Brazil
Rape oil (80%) and sunflower oil (20%)	Europe
Palm oil	Indonesia, Malaysia
Flax and olive oil	Spain
Vegetable oils / animal fats	Canada
Animal fats, beef cattle and rapeseed	Australia

2.1 World total biofuel production and consumption

World total biodiesel production for the year 2017 in different countries is shown in Figure 3. With a production volume of around 3.3 billion litres, Argentina was ranked fourth that year. The United States and Brazil were among the largest biodiesel producers in the world, totalling some 6 and 4.3 billion litres, respectively. The United States are projected to reach production levels of over 1 billion gallons[1] of biodiesel by 2025. After the implementation of the Energy Policy Act of 2005 [4], which provided tax incentives for certain types of

[1] 1 gallon=3.79 l

energy, biodiesel production in the USA began to increase. The Volumetric Ethanol Excise Tax Credit is currently one of the main sources of financial support for biofuels in the USA. In 2010, the USA exported about 85 million gallons of their biodiesel products. Comparatively, Argentina accounted for over half of the world's total exports. The United States have one of the highest bioenergy capacities in the world, totalling 13,151 megawatts in 2017. Today, biofuels provide around 3% of total road transportation fuel consumption globally on an energy usage basis. Consumption of these fuels in some countries is considerably higher. According to International Energy Agency (IEA), Brazil met about 23% of the road transportation fuel demand with biofuels in 2009. IEA analysis shows that biofuels may have to play an important role if the world is to make meaningful reductions in carbon dioxide emissions and reduce reliance on crude oil at costs similar to those of gasoline and diesel in the medium-term. Global biofuels production and consumption are on the rise. According to the US Energy Information Administration (USEIA), there is no record found on biodiesel production and consumption before 2000. Most of the countries started using biofuel in the last decade. Many more countries are in the early stages of using biofuel and they are trying to develop the infrastructure and production technologies to follow the suite. Leading countries based on the biofuel production in 2017 (in 1,000 metric tonnes of oil equivalent) are presented in Figure 4, which indicates that the USA produced around 80% of the total biofuel in the world. Europe, Asia and Oceania are increasing their biofuel production. The remaining countries are in their initial stages of production.

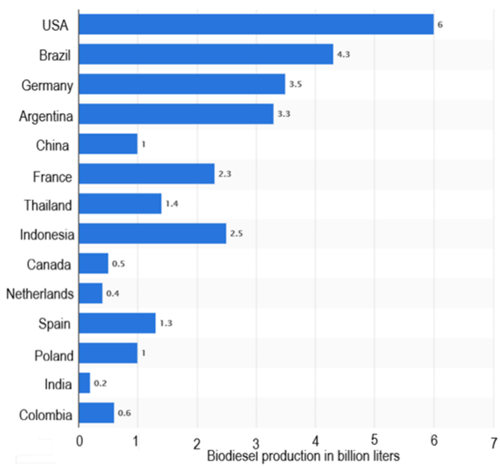

Figure 3. World total biofuel production in 2017 [24]

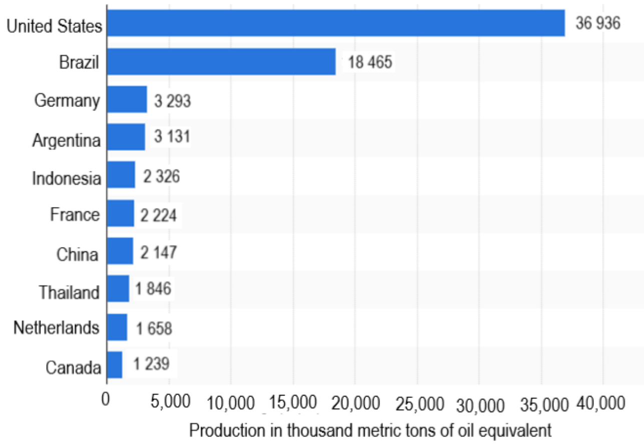

Figure 4. The leading countries based on biofuel production in 2017 (in 1,000 metric tonnes of oil equivalent) [24]

This statistic represents the leading countries in biofuel production in 2017. In Germany, production reached around 3.3 million metric tonnes of oil equivalent that year. That means, Germany is among the global top three countries in biofuel production.

2.2 Biofuel production in the Americas

Biofuels are characterized by fuels that obtain their energy through the process of biological carbon fixation. These hydrocarbons are made by or from living organisms in a relatively short period of time - in comparison to the formation of fossil fuels which requires millions of years. The United States were by far one of the largest producers of biofuel in the world in 2016, accounting for 43.5 percent of global biofuel production (Table 2, Figure 5) The country produced 35 million metric tons of oil equivalents that year, while Brazil produced 18.2 million metric tons of oil equivalents. Global biofuel production has gradually increased from 9.2 million metric tons of oil equivalents in 2000 to 84.12 million metric tons of oil equivalents in 2017.

Biofuels are commonly used as part of mixtures with fossil fuel sources or as additives. One of the largest consumers of biofuels in the USA is the national army. Many vehicles can be fueled using blends containing up to 10 percent of ethanol. In the beginning of the 20th century, many Ford T models were fueled with ethanol. Biofuels can also be generated through the consumption or conversion of biomass material. This conversion can occur thermally, chemically, or biochemically. Biomass consumption in the United States totaled 4,696 trillion British thermal units[2] in 2015.

[2] 1Btu=1.054 kJ

Table 2. Biofuels production [22]

Thousand tonnes oil equivalent	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Growth rate per annum			
											2016	2016	2005-15	Share 2016
US	10,670	14,709	20,934	23,761	28,044	31,184	29,808	31,057	32,890	33,849	35,779	5.4%	15.2%	43.5%
Canada	174	503	546	786	809	950	1,017	1,056	1,188	1,142	1,160	1.2%	22.8%	1.4%
Mexico	-	5	5	5	14	13	15	58	58	58	58	-	-	0.1%
Total North America	10,844	15,216	21,485	24,552	28,866	32,147	30,840	32,171	34,137	35,049	36,997	5.3%	15.4%	45%
Argentina	30	173	635	1,055	1,670	2,234	2,295	2,014	2,644	2,038	2,828	38.4%	71.7%	3.4%
Brazil	9,590	12,427	15,486	15,277	16,866	14,403	14,739	17,114	18,005	19,332	18,552	-4.3%	8.4%	22.5%
Colombia	144	155	158	320	455	572	627	650	676	693	626	-10%	46.2%	0.8%
Other S.& Cent. America	513	596	806	634	229	310	300	354	378	379	373	-1.9%	6.5%	0.5%
Total S. Cent. America	10,278	13,351	17,085	17,285	19,220	17,519	17,961	20,131	21,703	22,442	22,378	-0.6%	9.8%	27.2%
Total Europe & Eurasia	5,269	7,021	8,482	10,646	11,604	10,876	11,734	12,503	14,445	14,012	13,777	-1.9%	15.5%	16.7%
Total Africa	9	6	11	18	8	8	23	32	40	40	40	-	20.5%	0.05%
Total Asia Pacific	1,446	1,876	3,074	3,435	4,306	5,280	6,300	7,450	9,374	8,476	9,110	7.2%	25%	11.1%
Total World	27,848	37,471	50,138	55,936	64,008	65,834	66,863	72,293	79,703	80,024	82,306	2.6%	14.1%	100%

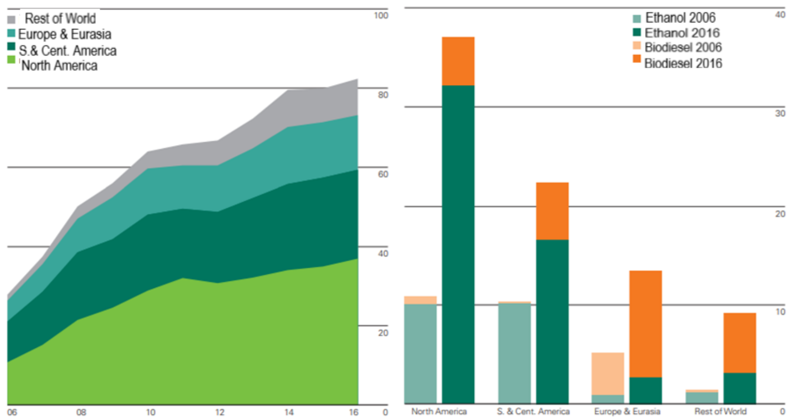

Figure 5. World biofuels production (million tonnes oil equivalent) [22]

Global biofuels production rose by 2.6 % in 2016, well below the 10-year average of 14.1 %, but faster than in 2015 (0.4%). The USA provided the largest increment (1,930 thousand tons of oil equivalent, or ktoe). Global ethanol production increased by only 0.7 % partly due to falling production in Brazil. Biodiesel production rose by 6.5 % with Indonesia providing more than half of the increment (1,149 ktoe).

World biofuels production increased by 3.5 % in 2017, well below the 10-year average of 11.4 %, but the fastest for three years. The US provided the largest increment (950 thousand tons of oil equivalent, or ktoe). By fuel type, global ethanol production grew by 3.3 %, contributing over 60 % to total biofuels growth. Biodiesel production rose by 4 % driven mainly by growth in Argentina, Brazil and Spain [22].

Global biofuel market is dominated by the USA in North America and Brazil in Central and South America. They have been producing huge amount of biofuels annually and trying to meet their major part of transportation fuel demand with biofuel. Currently, Brazil produces 27 billion liters bioethanol annually which is supported by the development of new sugarcane varieties and agricultural technologies. The USA widely used bioethanol from corn and grain, and biodiesel from soybean as an alternative fuel. They also aimed to replace 30% of fossil fuel with biofuel while Europe is aiming for 5.75% [1].

2.3 Production of biodiesel in the EU

The USA is the world's largest biodiesel producer. Biodiesel is also the most important biofuel in the EU and, on an energy basis, represents about eighty percent of the total transport biofuels market. Biodiesel was the first biofuel developed and used in the EU in the transportation sector in the 1990s. At the time, rapid expansion was driven by increasing crude oil prices, the Blair House Agreement and resulting provisions on the production of oilseeds under Common Agricultural Policy set-aside programs, and generous tax incentives, mainly in Germany and France. EU biofuels goals set out in Directive 2003/30/EC (indicative goals) and in the RED 2009/28/EC (mandatory goals) further pushed the use of biodiesel.

In 2017, EU FAME[3] and HVO[4] production did benefit from higher domestic consumption, as elevated imports only commenced in September that year. FAME production increased by 5 percent, mainly due to expansion in Spain, Italy, Portugal, Belgium, and Poland. HVO production increased by 5 percent, driven by elevated production in the Netherlands and Spain, and a new co-processing unit coming into production in Portugal (Tables 3 and 4).

Table 3. EU FAME Main Producers (Million Litres) [23]

	2011^r	2012^r	2013^r	2014^r	2015^r	2016^r	2017^e	2018^f
Germany	3,408	3,106	3,307	3,911	3,555	3,592	3,522	2,610
France	2,090	2,175	2,170	2,386	2,442	2,215	2,181	1,700
Spain	787	538	659	1,017	1,103	1,319	1,680	1,200
Netherlands	558	974	790	1,056	795	638	568	570
Poland	414	673	736	786	861	985	1,029	1,030
United Kingdom	261	352	640	554	572	496	503	510
Italy	704	326	521	452	625	398	599	560
Belgium/Luxemburg	536	568	568	568	535	521	568	570
Austria	352	301	247	332	386	349	352	365
Portugal	419	356	329	349	386	333	388	400
Other	1,667	1,214	604	203	811	977	1,007	1,375
Total	11,197	10,582	10,570	11,614	12,072	11,823	10,397	10,890

Ranked by production in 2018 r = revised / e = estimate / f = forecast.

Source: FAS EU Posts based on information in MT and converted to litres using a conversion rate of 1 MT = 1,136 litres

Table 4. EU HVO Production (Million Litres) [23]

	2009^r	2010^r	2011^r	2012^r	2013^r	2014^r	2015^r	2016^r	2017^e	2018^f
Netherlands	-	-	-	410	872	1,013	1,192	1,154	1,218	1,220
Finland	281	365	250	317	392	438	536	545	545	545
Spain	-	-	28	73	179	377	262	418	465	470
Italy	-	-	-	-	-	323	323	323	323	445
Portugal	-	-	-	-	-	-	-	-	32	32
France	-	-	-	-	-	-	-	-	-	128
Total	281	365	278	800	1,444	2,151	2,313	2,440	2,583	2,840

Ranked by production in 2018 r = revised / e = estimate / f = forecast.

Source: FAS EU Posts based on information in MT and converted to litres (conversion rate of 1 MT = 1,282 litres).

The structure of the EU biodiesel sector is very diverse and plant sizes range from an annual capacity of 2.3 million litres owned by a group of farmers to 680 million litres owned by a

[3] traditional first generation biodiesel
[4] hydrogenated vegetable oil

large multi-national company. Biodiesel (FAME) production facilities exist in every EU member state with the exception of Finland, Luxemburg, and Malta. In contrast, HVO production is concentrated in only six countries (Table 4). The majority of HVO capacity consists of dedicated HVO plants, while in Spain HVO is co-processed with conventional fuel in oil refineries. EU FAME production capacity is expected to decrease by 5 percent in 2018 to 20.3 billion litres, as plants are closed for good as a result of strong competition. In addition, numerous plants run below capacity or are temporarily shut down. For example, in Germany three plants announced to either temporarily (at least until the end of June) or until further notice run at half of their capacity. In France, Saipol announced that it would cut its production by between 400,000 and 600,000 MT in 2018. EU HVO production capacity is forecast to increase to 5.3 million litres in 2018, when two new facilities will start production in Italy and France [23].

3. PRODUCTION AND USE OF BIODIESEL IN SERBIA

The use of available energy sources is very high on the list of energy strategy priorities, primarily to meet energy needs, as well as to improve the conditions for energy production. By ratifying the Energy Community Treaty, the Republic of Serbia has accepted the obligation to adopt and implement a plan for the implementation of Directive 2003/30/EC on the promotion of the use of biofuels and other fuels from renewable energy sources in the transportation sector [21].

In Europe, biodiesel is defined in the standard EN 14214 in 2003, and in Serbia in the standard SRPS EN 14214 (standard for fuels for motor vehicles - fatty acid methyl esters for diesel engines) in 2006 [11]. EU Directive 2003/30/EC define biofuels and imposes on states the obligation to put 5.75% of biofuels on the market by the end of 2012 (of the total amount of fuel used in transport). Unfortunately, our country has not met the mentioned target for biofuels, and in the meantime a new EU directive 2009/28/EC has entered into force, which stipulates that by 2020, the target of 10% of biofuels will reach the market [7]. The proposal for the growth dynamics of RES share in the period from 2009 to 2020 in the transport sector is presented in Table 5.

In Serbia, over 600,000 hectares are available for the production of oil plants, which indicates that Serbia has the potential to produce biodiesel at the level of over 200,000 ton per year.

Tabela 5. Dynamics of growth of share Renewable energy source (%) in the sector of energy consumption [7]

2009 base year for the development of NAPOIE in accordance with the RES Directive 2009/28 / EC									
	2009	2013	2014	2015	2016	2017	2018	2019	2020
RNE – traffic (%)	0	0	0	2	3	5	7	8	10
NAPOIE – National Action Plan for Renewable Energy Sources									

In the European Union, one hectare of rapeseed provides enough grain to produce 1,090 litres of biodiesel fuel [10]. However, in Vojvodina, rapeseed, sunflower and soybean produce significantly lower yields than the European average (Fig.6). With an average seed yield of 1.69 t/ha, and oil seed content of 36%, 1 ha of rapeseed in Serbia provides 608 kg of oil or about 690 l of biodiesel fuel. The average yield of sunflower seed in Serbia is 1.79

t/ha, so with oil content 40% yield of sunflower biodiesel is 716 kg/ha or 816 l/ha. The average yield of soybean in Serbia is 2.25 t/ha, so the content of grain oil is 18%, yield of biodiesel 405 kg ha, ie 460 l/ha [19].

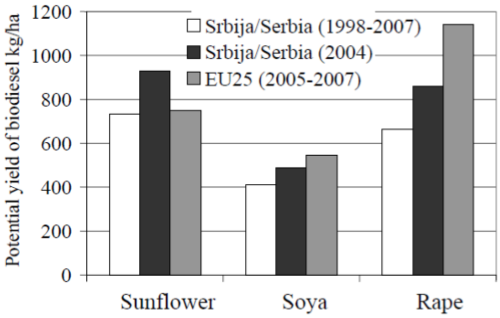

Figure 6. Potential yield of biodiesel per 1 ha of oilseed crops in Serbia and EU depending on the yield of oilseed crops [19]

The potential area in Serbia for cultivation of oilseeds for processing into biodiesel is estimated at approximately 350,000 ha (668,800[5] - (271,722[6] + 54,000[7])) (Table 6).

Theoretically, domestic biodiesel could be substituted by 13 to 16% of domestic fuel consumption (calculated on an energy basis). In fact, these figures are significantly smaller because of the impossibility of organizing economic production on crushed and intermittent agricultural holdings in Central Serbia.

For the organized production of large quantities of biodiesel, it is necessary consider the conditions and resources of raw materials for its production. The most important oilseeds produced in Serbia are: sunflower, soy and rapeseed rape. In Serbia, the sunflower is mostly cultivated over around 220,000 hectares on an annual basis, whereas the production of rapeseed is around 22,000 tonnes annually. In Serbia, there are sufficient cultivable areas meeting all the agro-technical conditions for growing rapeseed as a basic culture for the production of biodiesel. From the aspect of resources, this would provide the necessary conditions for Serbia to become an important European biodiesel producer. However, for the development of the biodiesel industry, it is necessary first of all to take measures at the state level to support investment in this sector of energy [19].

[5] Potential area for cultivation of oilseeds, 20% of the orange area
[6] for raw food oil
[7] from seeds and animal husbandry, from which 212,800 to 250,600 t of biodiesel could be provided

Table 6 Potential production of biodiesel on the area of 350,000 ha in relation to the sowing structure of oilseed crops [19]

Variants	Sowing structure	Potential production of biodiesel (t)	Potential substitution of fossil diesel with biodiesel	
			All sectors (%)	In agriculture (%)
I	100 % Oilseed Rape	212,800	13.49	46.67
II	70% Oilseed Rape 30 % Sunflower	224,140	14.21	49.16
III	50 % Oilseed Rape 50 % Sunflower	231,700	14.69	50.81
IV	70 % Sunflower 30 % Oilseed Rape	239,260	15.16	52.47
V	100 % Sunflower	250,600	15.88	54.96

3.1 Production economics and ecological motives for the production of biodiesel

One additional advantage of using biodiesel is that the consumer receives reliable and high-quality fuel at a lower price. For example, at petrol stations in the EU the difference between diesel and biodiesel is about 10 Eurocents per litre. The price growth trend in crude oil is much higher than in edible oil, which leads to the expectation that in the future biodiesel will be even more competitive. The production of renewable fuels leads to a reduction in imports of fossil fuels, which simultaneously affects exports. In order for biodiesel to be profitable, it is estimated that it must have the price that is about 8% lower than the price of fossil fuel.

Research in developed countries has shown that the environment is mainly polluted by motor vehicles (over 50%), then by thermal power plants and industrial plants. Fuel combustion emits many pollutants in the air, such as lead, inorganic chlorine and bromine compounds, hydrocarbons, nitrogen oxides, and sulfur oxides. For these reasons, the international community is increasingly compliant with the regulations that determine the quality of liquid petroleum fuels, (acceptable for the environment and human health), and increasingly stimulates the use of the fuel of plant origin (that have considerably reduce harmful emissions).

For the purpose of protecting the environment, a request is made that mineral fuel must contain as little sulfur as possible. Biodiesel does not damage the diesel engine. On the contrary, its increased lubricity compared to mineral diesel reduces the wear of vital parts of the engine. A mixture of biodiesel and mineral diesel reduces emissions of harmful gases, and maximum lubricity is achieved at 10% mixture [19].

Considering that in Serbia biodiesel is not yet widely used, the results of pollution testing using biofuels in Germany can be listed. The German Environmental Protection Association presented data of comparative testing conducted on 54 different diesel engines:

- CO2 emissions from biodiesel engines are 10% to 12% smaller than those from diesel engines
- Hydrocarbon emissions in biodiesel engines are 10% to 35% smaller
- Emission of solid particles in engines with biodiesel is less than 24% to 36%
- The soot emission for engines with biodiesel is 50% to 52% smaller.

All of the above results show that biodiesel is much more environmental friendly compared to conventional mineral fuel, either as a pure fuel or as a mixture with mineral diesel [20].

The ecological effect of using biodiesel is more favourable than when classical diesel is used, so that its effect on the environmental pollution is significantly smaller, as can be seen in Table 7 [16].

The reduction of fossil CO2 emissions is one of the main motivations behind policies and targets promoting a transition towards biofuels in the transportation sector. Unsurprisingly, an increasing biofuel share entails a higher emission reduction potential. This is more significant in scenarios where ethanol plants dominate, than in scenarios where methanol plants do. The reason is the high conversion efficiency to electricity and heat in ethanol plants, in combination with the in general significantly higher CO2 emission factors of displaced electricity and heat compared to displaced fossil transport fuels.

Table 7. Emission of harmful gases in biodiesel, and diesel combustion

Measuring parameters	100 %	
	Biodiesel	**Diesel**
CO [ppm]	92	179
NO [ppm]	113	129
NO_2 [ppm]	26.5	23.4
NO_x [ppm]	139	153
SO_2 [ppm]	5	102
H_2 [ppm]	11	19
O_2 [vol%]	17.7	17.5
CO_2 [vol%]	2,7	2.84
Particles of the soot [mgm^{-3}]	31.2	98.3
Benzene [mgm^{-3}]	<10	825
Toluene [mgm^{-3}]	<10	398
Xylene [mgm^{-3}]	<10	40

4. CONCLUSIONS

Our country needs to take appropriate measures to encourage the production of this ecological and renewable fuel. Such measures would ensure a more intensive development of agriculture, improve environmental protection, reduce crude oil imports, and create new jobs. Moreover, such measures are becoming an obligation, since all EU members, in proportion to the estimated resources, are obliged to increase the production of biofuels. Given that our country has significant potential for growing plant cultures for the production of biodiesel, it is expected that the domestic biodiesel industry will intensify in the forthcoming period.

The advantage of conventional biofuels, especially biodiesel, is that they can be produced in decentralized and smaller plants, representing an advantage for the development of rural environments. Contrary to that, the production of advanced biofuels is mainly related to large plants in order to achieve better economic performance. At the same time, large investments are needed that can only be provided by large companies. Therefore, such companies will dominate the market of advanced biofuels and control the raw materials prices to a great extent, thereby limiting the benefits of the production of biofuel for the rural environment.

In 2010, production and use of biodiesel was not recorded in Serbia, although our country has significant land potential for the production of raw materials for processing into biodiesel. From such a surface it is possible to provide raw materials for production of over 200,000 tonnes of biodiesel per year.

State policy and production costs of biofuels, as well as requirements for competitiveness, can significantly influence the prices of biofuels and agricultural raw materials. Our country has accepted international obligations and has the available potential of biomass, so it is necessary to take all incentive measures as soon as possible in order to reach the binding target of 10% share of biofuels in transportation sector by 2020 (EU Directive 2009/28/EC).

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