Univerzitet u Beogradu
Poljoprivredni fakultet
Institut za poljoprivrednu tehniku
Naučni časopis
POLJOPRIVREDNA TEHNIKA
Godina XLI
Broj 4, 2016.
Strane: 42 – 54

University of Belgrade
Faculty of Agriculture
Institute of Agricultural Engineering
Scientific Journal
AGRICULTURAL ENGINEERING
Year XLI
No. 4, 2016.
pp: 42 – 54

BIOMASS POTENTIAL FROM AGRICULTURE - CASE OF SLOVAKIA AND SERBIA – part 1

Zuzana Palkova[1*], Goran Topisirovic[2]

[1]Slovak University of Agriculture, Nitra, Slovakia
[2]University of Belgrade, Faculty of Agriculture, Serbia

Abstract: The natural resources (oil, coal, natural gas) are insufficient to satisfy the needs of the people for electric and heating energy because sources of fossil fuels are limited. Emission of large quantities of carbon-dioxide into the atmosphere, in the course of combustion processes of solid and liquid fuels have been disrupting the environment. The future lies in the renewable energy sources (*RES*) surrounding us.

The rapid rise of crude oil prices in the early 70-ies of 20th Century focused global attention to the need for efficient use and finding new sources of energy. In addition, energy consumption is growing dramatically in developed countries. *EIA* expects that demand for energy will grow by 56% between 2010 and 2040 (U.S. Energy Information Administration, 2016).

In order to overcome the problems caused by the constant rise in the global population, rapid exploitation of many natural resources, increase of pollution and climate change, the World and Europe must radically change their approach to the production, processing, consumption, storage, recycling and disposal of biological wastes. European 2020 strategy indicates bioeconomy as a key element for sustainable and "green" development in the region (European Commission, 2012). Bioeconomy includes sustainable production of renewable biological resources and their conversion into food, biofuels, bioenergy and bioproducts (eg. bioplastics, biopesticides, etc.). It includes agriculture, forestry, fisheries, food and paper production, as well as part of the chemical, biotechnological and energy industries.

Agriculture is a major consumer but also can become energy producer. Bearing in mind the amount of biomass produced, and the possibilities for its utilization, the negligible amount of biomass that is currently used as an energy source. An important

[*] Corresponding author. E-mail: zuzana.palkova@uniag.sk

Acknowledgement: this paper is a review of some results achieved during the research in frames of the bilateral project „Determination of Solid Biomass Potential from Agriculture in Slovakia and Serbia“ (DeSoBi), Project No. SK-SRB-2013-0039 / SRB 451-03-545/2015-09/13

feature is that biomass combustion is not an increased content of CO_2 in the atmosphere, as the ecological point of view is very important. The necessity of integrated approach to the biomass policy is given special importance. Biomass is preferred to other sources of renewable energy, due to the increase in the alternative sources of income it provides to the farmers, and the development of the regional economic structures. It is expected that throughout Europe a new "energy producing" division of agriculture is about to unfold, which, in close cooperation with the energy producing and service providing sections of the national economy, may greatly contribute to the reduction of the energy shortage, while finding new sources of income.

Usage of biomass, which is mostly the agricultural waste, would reduce demand of the country for import of fuels, would promote environment protection, and the economy would prosper, which would contribute to the sustainable development of society.

At this study the sources of biomass and its potential will be described, as well as energy from agricultural biomass, with special emphasis on the situation and potential of Slovakia and Serbia in biomass. The possibilities of the use of alternative renewable energy sources were considered, such as biodiesel, biogas and bioethanol. Also the opportunities for development and implementation of the second, third and fourth generation biofuels are listed. The study included both positive and negative impacts of the production and use of renewable energy from agricultural biomass (biofuels) compared to the fossil fuels.

***Key words**: agriculture, biomass, potential, renewable energy*

CURRENT EU POLICY FRAMEWORK

The use of renewable energies (wind power, solar and photovoltaic energy, biomass and biofuels, geothermal energy and heat-pump systems) undeniably contributes to limiting climate change. Furthermore, it plays a part in securing energy supply and creating employment in Europe, thanks to the increase in the production and consumption of local energy. Renewable energies, however, remain on the fringe of the European energy mix as they still cost more than traditional energy sources.

To increase the use of renewable energy sources, in its Renewable Energies Roadmap the EU has set itself the objective of increasing the proportion of renewable energies in its energy mix by 20 % by 2020 (European Renewable Energy Council). To achieve this, EU countries have committed to reaching their own national renewables targets ranging from 10% in Malta to 49% in Sweden. They are also each required to have at least 10% of their transport fuels come from renewable sources by 2020.

All EU countries have adopted national renewable energy action plans showing what actions they intend to take to meet their renewable targets. These plans include sectorial targets for electricity, heating and cooling, and transport; planned policy measures; the different mix of renewable technologies they expect to employ; and the planned use of cooperation mechanisms (European Commission, Renewable energy moving towards a low carbon economy, 2016).

This objective requires progress to be made in the three main sectors where renewable energies are used:

- EU based target for *GHG* emission reductions of 20% relative to emissions in

1990;
- 20% share for renewable energy sources in the energy consumed in the EU with specific target for the Member States;
- 20% savings in energy consumption compared to projections. In addition, there are specific 2020 targets for renewable energy for the transport sector (10%) and decarbonisation of transport fuels (6%). (European Commission, 2014).

In 2014, negotiations about EU energy and climate targets until 2030 EU countries have agreed on a new 2030 Framework for climate and energy, including EU-wide targets and policy objectives for the period between 2020 and 2030. EU countries have already agreed on a renewable energy following targets (European Commission, Climate Action, 2014):
- 40% cut in greenhouse gas emissions compared to 1990 levels;
- at least a 27% share of renewable energy consumption;
- at least 27% energy savings compared with the business-as-usual scenario.

THE ENERGY SAVINGS TARGET AND IMPLEMENTING MEASURES

The 2020 target of saving 20% of the EU's primary energy consumption (compared to projections made in 2007) is not legally binding for Member States, but significant progress has nevertheless been made. After years of growth, primary energy consumption peaked in 2005/2006 (around 1825 Mtoe) and has been slightly decreasing since 2007 (to reach 1730 Mtoe in 2011). This trend is partly due to the economic crisis and partly due to the effectiveness of existing policies. It is also due to reduced energy intensity of EU industry which was 149 toe per million euro in 2010, down from 174 in 2000 and 167 in 2005.

With the adoption of the Energy Efficiency Directive (*EED*) in 2012 there is now a comprehensive legislative framework at *EU* level. This needs to be fully implemented by Member States. The *EED* will help to drive progress in this area, although the Commission's preliminary analysis suggests that with current policies the 2020 target will not be met. The lack of appropriate tools for monitoring progress and measuring impacts on the Member State level is part of the problem. Another major challenge is to mobilize the funds needed to ensure continued progress.

Since 2009-2010, implementing measures have been adopted under the Ecodesign and Energy Labeling Directives on energy related products. These measures reduce the energy demand of industrial and household products leading to savings for end-users. Measures have been adopted for a number of electronic appliances, including domestic dishwashers, refrigerators, washing machines, televisions and tyres as well as industrial products such as motors, fans and pumps. The estimated impact of the adopted ecodesign and labelling measures are energy savings in the range of 90 Mtoe in 2020.

To address the energy consumed in the building stock, in particular for heating and cooling purposes, the EU adopted a revised Energy Performance of Buildings Directive (*EPBD*) in 2010. Besides the obligation for Member States to apply minimum energy performance requirements for new and existing buildings, the Directive requires them to ensure that by 2021 all new buildings are "nearly zero-energy buildings." However, delays and incomplete national measures to implement this directive risk undermining the necessary contribution of the buildings sector towards lower GHG emissions and reduced energy consumption. The cost-effective savings potential in the building sector is estimated to be 65 Mtoe by 2020. The EU has supported the development of energy efficient technologies, including through public partnerships on energy efficient buildings, green cars and sustainable manufacturing.

In the transport sector, the Regulations establishing performance standards for light duty vehicles have led to substantial reductions in GHG emissions reflected in the fleet average CO_2 emission of new cars from 172 g per kilometer in 2000 to 135,7 g per kilometer in 2011.

LEGISLATION AND POLICY RENEWABLE ENERGY

Renewable sources of energy - wind power, solar power (thermal and photovoltaic), hydro-electric power, tidal power, geothermal energy and biomass/biogas - are an essential alternative to fossil fuels. Using these sources helps not only to reduce greenhouse gas emissions from energy generation and consumption but also to reduce the European Union's (*EU*) dependence on imports of fossil fuels (in particular oil and gas).

In order to reach the ambitious target of a 20% share of energy from renewable sources in the overall energy mix, the EU plans to focus efforts on the electricity, heating and cooling sectors and on biofuels. In transport, which is almost exclusively dependent on oil, the Commission hopes that the share of biofuels in overall fuel consumption will be 10% by 2020.

Policy orientations:

- Promotion of the use of energy from renewable sources (*EC*, Legislation, 2016)
- Renewable Energy Road Map (*EC*, Energy, 2016)
- Intelligent Energy for Europe programme (2003-2006) (*EC*, Energy, 2016)
- The Global Energy Efficiency and Renewable Energy Fund (*EC*, Energy, 2016)

Electricity:

- Renewable energy: the share of renewable energy in the *EU* in 2004 Electricity (*EC*, Energy, 2016)
- Renewable energy: the promotion of electricity from renewable energy sources (*EC*, Energy, 2016)
- Support for electricity from renewable energy sources (*EC*, Energy, 2016)

Heating and cooling:

- Biomass Action Plan (*EC*, Energy, 2016)

Biofuels:

- EU strategy for biofuels (*EC*, Energy, 2016)
- Motor vehicles: use of biofuels (*EC*, Energy, 2016)

Wind energy:

- Promotion of offshore wind energy (*EC*, Energy, 2016)

LEGISLATION/STRATEGY/POLICY IN SLOVAKIA AND SERBIA

European legislation in the energy sector is mainly represented by directive of European Parliament and Council No. 2003/54/*ES* concerning common rules for the internal electricity market, the directive of European Parliament and Council No. 2003/55/EC concerning common rules for the internal market with natural gas.

The directives were into the law and order of the Slovak Republic fully transposed by Act No. 656/2004 concerning energetic and Act no. 107/2007 concerning the regulation in network industries. Based on this new energy legislation has been issued the Decree of the Ministry of Economy, Regulatory Office for Network Industries and Government Regulation No. 123/2005 were established governing the operation of gas and No. 317/2007 that were established governing the operation of the electricity market.

The RES legislation was developed as a response to the EU Renewable Energy Directive. It is a strategy that outlines how the Slovak republic can reach its 2020 target which is 14 % of energy from renewables by 2020. A major role will play a biomass heat production and promotion of the combined biomass heat and power production. Draft of the Energy Policy was approved by SR Government Resolution no. 29/2006 of 11.01.2006 (Enviroportal, 2016).

Proposal for the Slovakia Energy Security Strategy was approved by SR Government Resolution no. *732/2008 of 15.10.2008 (MH, 2016)*. The aim of Energy Security Strategy is to achieve competitive power, ensuring safe, reliable and efficient delivery of all forms of energy at affordable prices, taking into account customer, environmental protection, sustainable development, security of supply and technical safety.

Strategic and program documents in the area of using *RES*:

- 2006 Energy policy of Slovakia,
- 2007 The strategy of higher utilization of *RES*,
- 2008 Energy Security Strategy,
- 2009 *Act No 309/2009* Coll. the promotion of *RES* and highly efficient *CHP* 2009,
- Directive *2009/28/EC* on the promotion of *RES*.

From the total arable land area in Serbia of 4 867 000 ha, 40% can be utilized as a source of biomass, as well as 16% of agricultural land under fruits and vegetables can be utilized for this purpose.

The actual annual production of biomass in Serbia is around 12,5 million tons. Of this amount, 1,7 million tons of agricultural biomass, and 1,02 million tons comes from forestry.

ENERGY FROM BIOMASS AND BIOGAS - DEFINITION AND BASIC TERMS

“Biomass shall mean the biodegradable fraction of products, waste and residues from agriculture (including vegetal and animal substances), forestry and related industries, as well as the biodegradable fraction of industrial and municipal waste” (Definition according to the Directive 2001/77/*EC* of the European Parliament and of the Council of 27 September 2001 on the promotion of electricity produced from renewable energy sources in the internal electricity market).

Biomass is a plant material, which is used directly as a fuel, or is converted to other forms before the combustion.

The use of biomass as an energy source dates back to ancient times, so that in many developing countries of the world and remains a primary fuel in households.

Given that in recent years starts organized use of biomass outside the household, and that counts as a significant energy source, biomass is treated as a new renewable energy source. Energy potential of biomass is in the first place among the other renewable energy sources.

The potential for bioenergy is very large and very prevalent around the world. Today, biomass is already the main source of the world's energy needs from all available renewable energy sources, reaching 12% (50 *EJ*/yr.) of the total global needs (406 *EJ*/yr.) The use of biomass is mainly based on agricultural and forestry wastes.

BIOMASS FROM AGRICULTURE

Agricultural biomass consists of the remains of various crops: straw, corn stalks, cobs, stalks, husks, seeds. This type of biomass has a low power of firewood and a large proportion of moisture and various impurities.

Agricultural biomass can have multi-purpose use, such as producing of:

- humus (plowed),
- fodder (treated with chemicals, mixing with proteins, etc.),
- heat (combustion),
- building materials (various pressed plates),
- parts of furniture (chipboard),
- alcohol (fermentation),
- biogas (anaerobic fermentation),
- paper and packaging,
- cleaning chemicals, decorative items,
- as well as for many other purposes.

Given that use of agricultural biomass often causes problems in practice, compromise was found in use of: ¼ biomass plowed in order to improve soil fertility, ¼ used for the production of animal feed, ¼ for energy production and ¼ for other purposes (alcohol industry, furniture, packaging, paper, etc.). The production of energy from agricultural biomass would provide significant savings if this energy is used for heating in winter or for drying agricultural crops.

According to the physical state of matter, as well as influence on energy source use, biomass can be: solid, liquid and gas.

Solid biomass are the remains from crop production, the remains of orchards and wine yards pruning, forestry residues, plant mass of fast growers (known as Short Rotation Coppice - *SRC*), and above all fast growing forests, part of selected municipal waste, residues from the wood processing industry, remains of primary and secondary processing of agricultural products and more.

Liquid biomass is the liquid biofuels – plant oils, transesterificated plant oils – biodiesel and bioethanol.

Gaseous biomass represents biogas, which can be produced from animal manure and energy crops (grass and maize silage), or as a raw material may be used and other waste materials. Gaseous, even liquid, biomass, are the products of gasification and pyrolysis of solid biomass.

Given the existence of a very large number of waste materials, which to some extent includes biomass, but in addition to biomass contains harmful and dangerous substances, developed countries under the term biomass mainly define fuel that can be regarded as a clean fuel, with no harmful and dangerous substances.

Table 1. Description of the materials that are and are not included under the term „biomass“, concerning use as renewable energy source

Biomass as renewable fuel does include:	*Biomass as renewable fuel does not include:*
Plants and plant parts	*Fossil fuels*
Fuel produced from plants and plant parts, which all components and mid-products are produced from biomass, also.	*Peat*
Residues and by-products of plant and animal origin in agriculture, forestry and commercial fish production	*Mixture of municipal waste*
Organic waste, such as: Biodegradable waste from processes in food industry, biodegradable residues from the kitchen, separated biological waste from households and firms, biodegradable waste from the wood industry and waste to maintain the natural environment. It is necessary that this type of waste has a calorific value of at least 11 000 kJ·kg^{-1} (criterion of the environmental protection).	*Wood Residues containing polychlorinated biphenyls or polychlorinated terphenyls, mercury and other harmful substances that are emitted in above limits quantities during the thermal use of wood.*
Gas produced from biomass by gasification or pyrolysis and other products, as a result of these processes.	*Paper and cardboard*
	Sewage
Alcohol (as fuel) produced from biomass whose components and intermediate products are produced from the biomass, also.	*Textile*
	Animal body parts
Biogas is produced by anaerobic fermentation, which doesn't include fermentation of materials that do not fall into biomass and in which there is no more than 10% of sewage	*Gas from sewage treatment*
Waste wood from wood processing industry and processing of wood materials	*Gas from landfills*

The biomass as a renewable energy source usually involves materials made of plant material, including products, by-products, waste and residues, and plant mass, but without the harmful and hazardous substances, which can be found in painted and otherwise chemically treated wood, in the processes in the wood processing industry.

Precise definition of the meaning of biomass as a renewable energy source from German document Biomass Ordinance on Generation of Electricity from Biomass (Biomass Ordinance - Biomass V), from June 2001, is given in Tab. 1.

Biomass is part of a closed carbon cycle. Carbon from the atmosphere is stored in plants and combustion releases carbon back to the atmosphere as carbon dioxide (CO_2). As long as the principle of renewable development is followed (planting same amount of trees as cut), this form of energy has no significant impact on the environment.

When biomass is used as fuel instead of fossil fuel emits the same amount of CO_2 into the atmosphere. Carbon content in biomass, with approximately 50% of its total mass, is already part of the atmospheric carbon cycle. When fossil fuels it's different, because their combustion releases in the atmosphere additional carbon amount that was trapped in the long-term carbon reservoirs.

CHEMICAL CONTENT OF BIOMASS

Biomass consists mainly of carbon, hydrogen and oxygen. In addition, significant amounts of trace elements may be found in different types of biomass, such as straw contains very large amounts of chlorine and/or silicon, and rapeseed relatively high amounts of nitrogen. The presence of these trace elements may cause some problems when using, for example, during the combustion of chlorine can cause corrosion in the boiler, silicon can buildup of deposits, nitrogen will increase the nitrogen oxide emissions.

The energy content of certain types of biomass is usually expressed through the Low Level Heat (*LHV*). *LHV* depends on the moisture content in the biomass, and the content of hydrogen in the fuel. Actual biomass *LHV* with known moisture content can be calculated from *LHV* values of dry biomass with the following equation:

$$H_u(w) = H_u(wf)(100 - w) - \frac{2{,}44w}{100} \tag{1}$$

where:

Hu(w)	[MJ·kg^{-1}]	- *LHV* for determined moisture content in biomass,
Hu(wf)	[MJ·kg^{-1}]	- *LHV* of totally dry biomass,
w	[%]	- moisture content,
2,44	[-]	- water evaporation *const.*

ENERGY FROM BIOMASS

Biomass energy can be obtained in several ways:

- direct burning to obtain heat (wood, crop residues, waste wood)
- digestion - the processing of animal waste (manure) into biogas,
- processing of biomass into alcohol (ethanol) or the production of vegetable oil

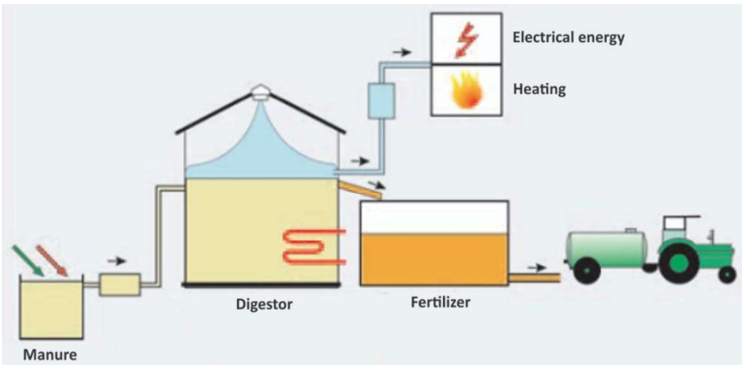

Figure 1. Process of manure treatment and production of organic fertilizer and biogas

In agriculture, there are large amounts of crop residues which can be partly used for energy purposes. It is not recommended to completely remove all plant residues from the ground, so as not to become poor soil and disturb the natural cycle of the circulation of matter in it. Often, due to ignorance about processing the plant residues, farmers burn the fields, which is very harmful.

Biomass from livestock production (livestock manure) is also an excellent energy source. The energy generated from the liquid manure in the exploitation does not emit harmful gases that are produced from combustion of conventional fossil fuels and thus contributing to greater environmental protection. For example, about 10 to 12 kg of liquid manure with 4 to 10% dry matter is needed to obtain 1 m^3 of biogas. Domestic animals whose liquid manure can be economically used for the production of biogas are: dairy cows, cattle, fattening pigs, laying hens.

The most important problem is actually investing in systems for the production of biogas. If the energy invested in the exploitation and processing of an energy source is higher than the energy yield of this resource, the exploitation is total loss. The aim is to create a self-sustainable system. Installations for the production of energy from biomass in the future will enable progress in the development of ecology, agriculture, energy and the whole economy of each region that opt for their use and operation.

BIOFUELS FROM BIOMASS

The world is focused on the development of new processes for the production of biofuels from biomass. Stock of oil sources are globally estimated at 50 years and now is seriously considered the use of biomass, especially in terms of obtaining biofuels. An increasing number of countries in the world is gradually increasing percentage of biofuel mixed with fossil fuels and thus form a new policy of supply.

Biofuels are liquid or gaseous fuels, produced from biomass. Biofuels can be produced directly from plants or indirectly from industrial, commercial, domestic and agricultural waste.

There are three basic methods of biofuel production:

1. The first is based on the burning of dry organic waste (household waste, industrial and agricultural waste, straw, wood and peat).
2. Then there is the fermentation of wet waste (animal manure) without the presence of oxygen to produce biofuel with 60% methane and the fermentation of sugar cane or corn to produce alcohol and ester.
3. Third is energy obtained from forestry, farming or fast growing trees for fuel production.

However, the best known certainly is fermentation, whose products are the two most well-known types of alcohols and esters. They would theoretically be able to replace fossil fuels, but given that it was necessary to adapt the plant, commonly used in a mixture with fossil fuels.

Biofuels have the potential aimed at reducing the production of carbon dioxide, which is primarily based on the fact that the plants from which produce biofuels absorb CO_2 during their growth, which is released during the combustion of biofuels. However, since the energy is required for the growth and cultivation of plants, their conversion into biofuels and later distribution, additionally release carbon dioxide. Emissions of carbon dioxide that is released during the production and distribution of biofuels can be calculated using a technique called "Life Cycle Analysis (*LCA*)", which is based on the monitoring and calculation of CO_2 emissions from the beginning of plant growth, or putting seeds in the ground, to release gas during engine combustion. Various studies have been made for different biofuels, whose results were also different. Most of the *LCA* studies showed how biofuels compared to fossil fuels create significantly less harmful greenhouse gases and their use, i.e. the replacement of fossil fuels would mean significant decrease of greenhouse gases. In addition to reduced CO_2 emissions and the emissions of Sulphur oxides, particulate matter and carbon monoxide emissions are reduced, as well.

There are different types of biofuels, which are divided into first and second generation, depending on the source material for production, costs of production, prices and CO_2 emissions.

The first generation of biofuels is based on the production of sugar, starch, vegetable oils or animal fats, while second generation production uses agricultural and forest waste. The raw materials used in the production of biofuels used for food production, thereby increasing prices of raw materials, and with them the cost of production. Therefore, in collaboration with researchers made the second generation of biofuels. The development of second generation biofuels is still in its early stages.

Currently, the market is dominated by: biofuels, biodiesel and bioethanol.

BIOGAS

When it comes to biogas, it usually refers to gas with a large amount of methane, produced by fermentation of organic substances like manure, sludge from waste water treatment, municipal solid waste or any other biodegradable materials in anaerobic conditions. It is often used for biogas and names such as marsh gas, landfill gas, swamp gas and the like, according to the source. Each variant has different levels of methane and carbon dioxide in it, along with a smaller proportion of other gases.

This process is becoming increasingly popular for the treatment of organic waste, because it provides a convenient way of turning waste into electricity, thereby reducing the amount of waste and the number of pathogenic substances contained in waste. Also, the use of biogas is encouraged, because in this way obtain the power, while not increasing the amount of carbon dioxide in the atmosphere. Also, the methane is burned much cleaner than coal.

Table 2. Energy obtained from gas combustion

Gas	*Obtained energy ($kWh \cdot m^{-3}$)*
Biogas	*7*
Natural gas	*10*
Propane	*26*
Methane	*10*
Hydrogen	*3*

Anaerobic bacteria break down the organic matter in the absence of oxygen and produce biogas as a product of the decomposition. The most commonly used organic matter to produce biogas is cattle manure. The primary advantages of biogas production from manure are: nutrient recycling, obtaining high-quality fertilizer for further use in agriculture and avoiding odour of manure. In addition to these primary benefits resulting biogas is a very useful product. Biogas consists of about 70% of methane (CH_4), and the rest consisting of carbon dioxide, carbon monoxide and nitrogen. The relative ratio of gases depending on treated material and treatment process.

Biogas has a significant energy value of about 7 $kWh \cdot m^{-3}$ which makes it very cost effective and universal fuel, far more cost effective than other fossil fuels and biomass.

BIODIESEL

Biodiesel is an environmental friendly energy source, which is obtained from vegetable oils with multiple benefits and advantages compared to conventional types of fuel. Their uses reduce the emission of gases and avoid creating the "greenhouse effect". The combustion of biodiesel produced carbon dioxide, which is neutral. Biodiesel does not contain a sulfur, lead or nitrogen compounds. Better is burned in the engine, and its use reduces pollution of air, water and human environment even three times, because it is biodegradable. The by-products formed during biodiesel production (glycerin, fatty acids, lecithin) can also be used, reducing the need for their imports. Glycerin is a true ecological engine coolant, and has many uses in the pharmaceutical and cosmetic industries.

Unlike the conventional fuel, biodiesel does not contain sulfur (i.e. sulfur content is very low), thereby reducing the potential for acid rain. Biodiesel contains no toxic aromatic compounds such as benzene. The high oxygen content contributes to reducing the content of unburned particulate matter (or soot) in the exhaust gas, while contributing to more complete combustion and reduced emissions of carbon monoxide. As with all fuels, burning biodiesel produces carbon dioxide, however, since plants use carbon dioxide from the atmosphere (photosynthesis) for its growth, carbon dioxide formed by combustion of the fuel balances with carbon dioxide absorbed during the growth of annual plants used as raw materials for the preparation of vegetable oils. Although the expression "diesel" enters his name, biodiesel doesn't contain no petroleum products or other fossil fuels. In bio-diesel are non-toxic, biodegradable and renewable raw materials

Production and use of biodiesel

Biodiesel is defined by European standard *EN* 14214 from 2003. In Serbia, is defined in 2006 by the state standard *SRPS* (*JUS*) *EN* 14214 "Automotive fuels". Fatty acid methyl esters for diesel engines, requirements and test methods "(which is identical to the European standard *EN* 14214). In addition, in May 2006 is adopted the "Regulation on technical and other requirements for liquid fuels" which defines technical and other requirements that fuels must fulfill.

In the *EU* one hectare of oilseed rape provides a sufficient amount of grain for the production of 1.090 liters of biodiesel fuel. However, in Vojvodina province, rapeseed, sunflower and soybean, achieve significantly lower yields than the European averages. With an average yield of 1,69 $t \cdot ha^{-1}$, and seed oil content of 36%, 1 ha of oilseed rape in Serbia provides 608 kg of oil, or about 690 liters of biodiesel. Average yield of sunflower in Serbia is 1,79 $t \cdot ha^{-1}$, and with the oil content of 40% can be produced 16 $kg \cdot ha^{-1}$ or 816 $l \cdot ha^{-1}$ of biodiesel from that sunflower. The average soybean yield in

Serbia is 2,25 t·ha^{-1}, while the oil content in grain of 18% can give biodiesel yield of 405 kg·ha^{-1} or 460 l·ha^{-1}.

Serbia has significant potential of land for production of raw materials for processing into biodiesel, which is estimated at about 10% of the total arable land. With this area it is possible to provide sufficient amount of raw materials for production of 210 to 250 thousand tons of biodiesel per year, which is enough to replace 13-16% of fossil diesel in Serbia. Currently, rapeseed appears as the only feedstock for biodiesel production. Unprofitable production, inexperience and inadequate agricultural practices are the main obstacles to increased production of rapeseed. The most important reserve for the provision of large quantities of raw materials for biodiesel is increasing the yield of oilseeds, mainly rapeseed. They are well below the European average. For several reasons, sunflower is imposed as more favorable raw material for biodiesel production in Serbia.

The competitiveness of biodiesel is determined primarily by two factors: the retail price of Euro-diesel fuel and the price of biodiesel, which largely depends on the price of feedstock, and prices of oilseeds. Analysis showed that the price of biodiesel based on sunflower and rapeseed is higher than the cost of Euro-diesel fuel, even assuming a relatively modest purchase price of these oilseeds grains.

In Serbia a decade ago were founded several companies that were involved in the manufacture of biodiesel. However, due to the high excise duties, these enterprises are extinguished or its business refocused on the production of edible oils. With the same reason in Serbia cannot be found either biodiesel imports.

BIOETHANOL

Bioethanol can be obtained by fermentation of simple sugars from various types of biomass.

Most often are used different carbohydrate raw materials of the general formula $(CH_2O)n$. Raw materials can be divided into three groups: sugar (sugar beets, sugar cane, sorghum, fruit, etc.), starch (corn, wheat, rice, potato, cassava, sweet potato, barley, etc.) and lignocellulosic (wood, agricultural surpluses, municipal waste, etc.). Lignocellulosic and starch materials are required to undergo a corresponding pre-treatment to make them suitable for the decomposition, while the sugar feedstock directly degrade the action of microorganisms. On the other hand, the use of sugar and starch raw materials affects the economy of the country and the availability of food. Therefore, more attention is paid to the use of second-generation raw materials which include lignocellulosic biomass. In recent years, the production of bioethanol used and algae, chitin and various industrial by-products.

The production of bioethanol from lignocellulosic raw material provides several benefits: lower prices of raw materials, increasing arable land for agricultural crops intended for human and animal nutrition, less use of fossil fuels.

Like alcohol, bioethanol is produced by the alcoholic fermentation of sugar by yeast, followed by a purification process. If the raw material is grains, the starch is converted to sugar by enzymes.

During this process is created a product that can be used as animal feed enriched with protein, with a protein content of 30%.

Bioethanol is used in a mixture with gasoline in various concentrations. In Brazil is even used in the undiluted state (*E100*). In Germany, the standard *DIN EN 228*, allows the use of a mixture of fuel containing up to 5% bioethanol (*E5*). Vehicle engines that are tailored and flexible for different fuels (fuel flexible vehicles - *FFV*) can use fuels containing up to 85% bioethanol (*E85*).

Mixing bioethanol fuel in the EU is allowed up to 5% (regulated by the same standard *EN228*), which requires a limit of water content in order to avoid phase of separation of ethanol and gasoline mixture. The use of bioethanol offers certain advantages that are reflected in lower toxicity and better biodegradability, and its market price does not depend on oil prices. The downside of the use of bioethanol is reflected in the poor sustainability of some sources of biomass, unfavorable energy balance, lack of efficiency of microorganisms, hygroscopic nature of the fluids and higher fuel consumption.

Another possibility is the use of bioethanol for production of ethyl tert-butyl ether (*ETBE*) that contains 74% of bio-ethanol. *ETBE* can be used as a replacement for methyl tert-butyl ether (*MTBE*), which is derived exclusively from non-renewable sources, and as an additive to reduce the knocking in an engine.

Since 2004 is intensified the production of bio-ethanol as a fuel. In 2007, the world production ranged about 40 millions m^3 of bioethanol. Brazil is the world's leading producer of bioethanol from sugar cane.

The production costs of biofuels and the requirement for competitiveness affecting the prices of agricultural raw materials. In addition to increasing efficiency in converting raw materials into fuel, introduction of new materials will also generally encourage the use of biofuels.

Placing of by-products of biofuel production on the market is also very important for the final cost-effectiveness of biofuels. For example, glycerin generated during the manufacture of biodiesel can be purified to pharmaceutical quality, and by-products of bioethanol production can be used as animal feed enriched with proteins.

* * * * *