POSSIBILITIES OF APPLYING BIOMASS FOR THE PURPOSES OF ENERGY PRODUCTION AND ENVIRONMENTAL PROTECTION

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Abstract
The aim of the paper is to raise, direct and encourage awareness of the importance of biomass in energy production, as well as to present various possibilities of its use. Increasing demands for energy and growing environmental issues impose the need for energy production from renewable resources. Fossil fuel reserves are finite and their deficit is projected for the coming period. Biogas is one of the renewable resources. The said gas consists of a large amount of methane gas produced by fermenting organic substances from biomass, manure or any other biodegradable material in anaerobic conditions. Electricity production from renewable resources on farms needs to meet numerous conditions, such as environmental protection, bio-safety and animal welfare, as well as a series of technical, organisational, construction, manufacturing and economic requirements imposed by this kind of production. The Lazar Company Ltd. from the town of Blace owns a farm with 600 dairy cows, a dairy which processes 60 000 litres of milk per day, as well as an energy production plant based on biogas, with the capacity of 1mW/hour. In addition, special attention is paid to organic farming, where biomass is said to have multiple applications in energy production in the context of a long-term development trends of certain industries.

Keywords: biomass, energy, agriculture, environment.

Introduction
Depending on the time necessary to produce energy, one can distinguish two types of energy resources: renewable and non-renewable. Non-renewable resources comprise resources whose formation time is incomparably longer than the time of their exploitation. These resources include coal, oil and oil gas, oil shale and nuclear energy. The energy generated from such resources has a very high coefficient of energy utilisation. As a result, the aforesaid resources are still among the most prevalent ones and world economies are directly dependent on them. However, the manners of their exploitation have caused the presence of large amounts of toxic chemical substances in the air, water and soil, which exerts a range of negative effects on human health, as well as on the entire biosphere. In addition, an accelerated industrial development increases the demand for energy which, by and large, imposes the need to attend to additional, alternative and renewable energy resources (Owusu and Asumadu-Sarkodie, 2016). Renewable or everlasting energy resources are those used for the purposes of producing electricity or heat, as well as those the reserves of which are uniformly or continually renewed. The name itself derives from the fact that energy is consumed in the amount which does not exceed the speed in which it is produced in nature. Among the renewable energy resources one can assort the resources which are claimed to have the reserves so considerable that they can be exploited for millions of years. Renewable energy resources, hydropower excluded, provide less than 1% of the total energy required on a global level.
Biomass as a renewable energy resource
Biomass is the oldest renewable energy resource that has ever been used. The term biomass implies biodegradable substances of either plant or animal origin, by-products of lumber industry, agricultural waste and residues of biological origin, as well as industrial and communal waste. The

use of biomass as an energy resource is rather diverse. It is used in combustion processes or converted in the systems which produce either heat or electricity or both. Likewise, it is used in the production of liquid fuels (bio-ethanol, bio-methane and biodiesel) and gas fuels (biogas, the gas from waste disposal sites). The main advantage of biomass in comparison with fossil fuels is a reduced emission of harmful gasses, as well as reduced discharge of wastewaters. Additional advantages include the disposal and utilisation of waste and residues produced by agriculture, forestry and timber industry, a reduction in energy import, investment in agriculture and underdeveloped areas. It is anticipated that the share of biomass in energy consumption shall be between 30% and 40% by the middle of the century (Kriz et al.2016).

The status of biomass in Serbia

Depending on the source, biomass can be divided into forest biomass (wood waste biomass), energy plantations, farm animal biomass, urban waste (waste biomass). A considerable potential for biomass production in the Republic of Serbia lies in agricultural residues and wood biomass, amounting to 2.7 million tons in total (1.7 million tons in agricultural residue and around 1 million tons in wood biomass). Furthermore, the livestock production residue can also be identified as a significant biomass source. The second group of biomass sources includes plantations of energy plants (for example, Miscanthus, fast-growing poplar, etc.), as well as plants which are used as a raw material for biodiesel, bio-ethanol (rapeseed, sunflower, corn, etc.) (http:// www.mre.gov.rs). As a country with large agricultural and forest areas, Serbia possesses a considerable potential for biomass production. Biomass comprises around 63% of the total renewable energy resources. Forests cover around 30% of the territory and around 55% of the territory is covered by arable land. In addition to crop residues intended for food production, there are enormous opportunities for dedicated biomass cultivation which will not trammel food production. Biomass can be used for obtaining bio-fuel, bio-ethanol, biodiesel and biogas. Biogas is produced via anaerobic digestion whereby organic carbon is translated into the highest level of oxidation (CO_2) and the highest degree of reduction (CH_4) by resorting to oxidation-reduction processes. The process takes place without the presence of oxygen under the influence of a large number of microorganisms. The result of this process is a mixture of gasses: methane 55%-75%, carbon dioxide 25%-45%, hydrogen sulphide 0%-1%, nitrogen 0%-2%, hydrogen 0%-1%, aqueous vapour 0%-2%, ammonia 0%-2%, oxygen 0%-0.5%. The composition and yield vary depending on the used raw materials as well as on technological conditions of the process (Manyi-Loh et al. 2013, Neshat et al., 2017). The process of anaerobic digestion is an efficient method of treating biological waste and it offers significant advantages in comparison with other forms of treatment: less sludge is produced in comparison to other techniques which resort to aerobic processes and the waste containing less than 40% of dry matter is successfully treated. Likewise, this process is more efficient in removing pathogens, the emission of unpleasant odours is at the minimum because 99% of volatile components are decomposed through oxidation in the process of combustion (for example, H_2S forms SO_2) and the obtained residue (sludge) is used for the purposes of improving soil fertility (Milosavljević et al, 2010, Babic et al.2010). Manure is present in significant amounts as a by-product on the farm which currently has more than 1000 heads of cattle, which comprise 600 milking cows in the production cycle, and if the aforementioned manure is not properly handled it can become a significant pollutant of the environment. It is necessary to apply a series of methods which would make liquid manure ready for storing and removing. The methods include a mechanical treatment which implies the following phases: separation and homogenisation and biological treatment. Liquid manure is an example of suitable raw materials intended for biogas production, which can further be used as an energy source, i.e. for obtaining electricity from renewable resources. The utilisation of liquid manure in this fashion contributes to the reduction of dangers of polluting the environment and groundwater, which affects the conservation of biodiversity and the environment (Šarić and Obradović, 2012, Neshat et al., 2017).

Material and methods

In recent years, the biogas production on the "Lazar" dairy farm located in the town of Blace (http://www.lazar.co.rs/) occupies the primary place with respect to the assessment of secondary products on livestock farms with the main aim of preserving the environment and producing energy from renewable resources. After the process of fermentation in a digester, a mechanical separator of fertilisers separates the residual waste into solid and liquid parts. The solid part is used as a cowshed bedding while the liquid part is discharged into a storage located below the energy plant and it is later used as a fertiliser in the fields. In addition, on this farm they also use dairy by-products (whey). Dairy is a part of the farm complex and it processes 60.000 litres of milk per day. An anaerobic partially buried mixed-flow digestion system, with the input of beef manure, whey and biomass, produces 482 Nm3/h of biogas of the lower thermal power between 5,5 and 6,5 kW/Nm3, a solid bio-fertiliser phase with 30% of DM, a liquid fertiliser phase with 5% of DM, whereby the JENBACHER JMS 320 GSB/LC co-generation plant with a biogas engine, which consists of a gas engine, generator, interchanger and noise suppressor on exhaust gasses, achieves a power output of 1000 kW, a heat output of 1060 kW and an annual electricity production of over 7.000.000 kW. Table 1 presents the composition of biomass as an input raw material which is inserted daily into an anaerobic digester. The preparation of mixture is carried out in the reception pit by mixing pure water with the liquid phase from the lagoon due to the DM correction which is necessary for the digestion. The digester is filled with 160 m^3 of mixture per day in two-hour intervals. The mixture passes through a chopper for the purposes of shredding the silage. The digester has got three chambers and each chamber has got its own heating and mixing systems. This kind of production does not require a reservoir, i.e. gas reserves. The digester is provided with a safety system against the excess of gas and increased pressure. The material is kept in the digester for 21 days. After that period the material is transferred to the separator for the purposes of separating the solid phase.

Table 1. The structure of a daily input of raw materials in the digester

MANURE	30% (12.045 t/year) (33 t/day)
WHEY	40% (16.060 t/year) (40 t/day)
SILAGE	30% (12.045 t/year) (33 t/day)

Results and discussion

Figure 1 presents the data on the annual production of biogas and electricity for the period between 2011 and 2015. During the first year of the use of the digester the amount of produced biogas was 2.104.985 m^3, while in 2015 this amount was 3.151.775 m^3, which indicates the growth of 49.73%. The increase of 56.23% in electricity production is also visible, i.e. the increase went from 4,740.428 kWh to 7.406.070 kWh. This growth is a result of an efficient performance of the digester, of a competent process management, as well as of an increase in the total annual amount of biomass necessary for the production of biogas. The latter is also the result of an increased number of heads on the farm, as well as of an increase in the milk production and processing in the dairy. Table 2 presents one with the energy balance of the digester for the year 2015, where one can see that the Electric Power Industry of Serbia was delivered with 6.813.584 kWh of electricity, while 592.486 kWh were spent for personal needs and losses. Generally speaking, the realisation of processes in this plant is the best possible manner of utilising all outputs from the "Lazar Ltd". which comprises three production sectors:

- farm – milk production - manure
- dairy – milk processing – whey
- husbandry – cow nutrition – silage

Furthermore, all advantages of anaerobic digestion which have a positive effect on the environment are gained and these comprise the following: reducing the vaporisation of methane and ammonia, lowering the amount of nitrate in groundwater, limiting the emission of carbon dioxide, reducing unpleasant odours, viscosity and the amount of pathogenic bacteria as well as improving conditions for storing manure, etc.

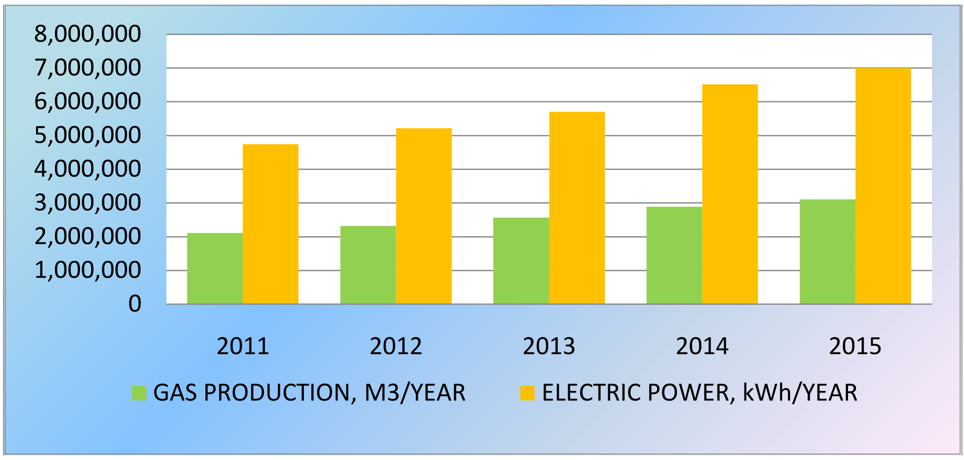

Figure 1**.** The total production of biogas and electricty in the period between 2011 and 2015

Table 2. Energy balance of the digester for 2015

	Manure	Whey	Silage	Total
Material input t/year	12.045	16.060	12.045	40.150
Gas production m^3/t	45	35	170	/
Gas production m^3/year	542.025	562.100	2.047.650	3.151.775
Methane %	55	53	55	/
Energy production kWh	2.981.137	2.979.130	11.262.075	17.222.342
Electric power production kWh	Personal consumption and losses 8%			7.406.070
Electric Power in the Serbian Power Network kWh	17,3%	13,3%	65,4%	6.813.584

Conclusions

Biomass is a biodegradable part of products, waste and residues of biological origin which comes from agriculture (including plant and animal substances), forestry and related industries, as well as a biodegradable part of industrial and communal waste. Although there is a significant potential of renewable energy resources, the Republic of Serbia has a small number of manure collection systems – open lagoons, manure is rarely used as a fertiliser, there is a lack of mechanisation for handling manure, there are no modern plants for biogas production, nor is there sufficient knowledge of and information on modern technologies. However, one can notice a growing interest among the owners of agricultural farmsteads in using new methods and technologies. The process of biogas production is at the same time a smart and efficient manner of waste management and it prevents the release of harmful and toxic compounds which greatly affect the environment. In relation to that, the project of the biogas plant of the "Lazar Ltd." is extremely significant in the field of renewable energy sources as it significantly contributes to sustainable development since this biogas power plant is one of the first on the territory of the Republic of Serbia.

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