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Contents **Pages**

Biomass potentials–the most important renewable energy source in Serbia

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Abstract

The paper discusses the possibilities of using renewable energy sources (RES) in Serbia with a special focus on the potential of use of biomass. Starting from the very unfavorable structure of energy reserves and resources which is predominantly based on coal reserves and hydro potentials, the solution is given in the use of RES. Of all RES, biomass is the most important potential with approximately 63% share. In addition to biomass from forestry and agriculture, the paper present the researching results of the possibility of producing biomass from short rotation plantations on the disposal sites of overburden in open pit lignite mining.

Key words: renewable energy, biomass potentials, short rotation plantations, Serbia

INTRODUCTION

Most of the electricity production in Serbia is currently produced in coal-fired power plants and hydroelectric plants.

The energy sector consists of the following systems:

- Electrical energy sources, with 7120 MW installed capacity of which 3936 MW was installed in lignite-fired power plants, 353 MW in tthermal power station in the crude oil/natural gas and 2831 MW in hydroelectric power plants. In addition to these sources (within the public company) Electric Power Industry of Serbia (EPS) lessee additional 500 MW.

- System for power transmission (high voltage networks with appropriate transformer stations), voltage 400, 220 and 110 kV, total length of over 9 500 km.

The scope and structure of energy reserves and resources is very unfavorable. Reserves of quality energy such as oil and gas are symbolic and represent less than 1% of the total balance reserves

of Serbia, while the remaining 99% of energy reserves are various types of coal, dominated by low-quality lignite, with a share of over 92% in the total balance reserves. This especially refers to lignite that is exploited in the mines with surface exploitation.

The following table presents total reserves of fossil fuels in Serbia:

Table 1. Total reserves of fossil fuels in Serbia

Energy resource	Exploitation reserves (Mten)	Geological reserves (Mten)
Lignite (surface mining)	2616	3753
The black and brown coal (underground mining)	125	130
Oil and natural gas	20	60

The annual production of solid fuel (coal) is about 33 million tons. The most dominant is the raw lignite, which is mostly consumed in power plants for electricity production. In total, of this energy source in our country produces about 32 million tons, and as much are spend, so this is the only type of fuel that is not needed to be imported. The situation, however, is quite the opposite with the higher quality of coal, because these types of from abroad purchases in quantities of about 660 thousand tons per year, while total consumption reaches nearly two million tons. Of this brown coal in our country gets about 550 thousand tons of coal from underground mining.

MATERIALS AND METHODS

Existing documentation materials and legislative regulations related to the energy sector has been analyzed, as well as the researching results from Project "The possibility of growing short rotation plantations of dendroflora species on overburden disposal sites of open pit coal mines".

RESULTS AND DISCUSSION

Potentials of renewable energy in serbia

The energy potential of renewable energy sources (RES) in Serbia is significant. Estimates are that there are possibilities for production of over 4 million tons of oil equivalent (toe) per year, which is almost half of the country's annual demand for energy.

The highest potential is considered to be biomass. The potential of biomass are estimated at around 2.7 million tons of oil equivalent or 63% of the total RES potentials. In addition to, 0.6 million (ten) are unused hydro potentials (14%), 0.2 million (ten) are in geothermal sources (4.5%), 0.2 million (ten) in wind power (4.5%) and 0.6 million ten in the sunlight radiation (14%). However, a very small part of these potentials are used.

As it was outlined above, most of the energy originates from coal, then from oil and natural gas. Coal is the dominant raw material in the production of electricity, and in the heating is mainly used gas. In Serbia, from renewable sources in greater extent, are used only hydropower and biomass. According to EU regulations, in the production and consumption of energy from renewable sources are considered large hydropower plants, but in the field of environmental protection they are not considered as ecological facilities because of the adverse effects of dams on the environment. In this context, without large hydropower plants the share of electricity from renewable sources is very small.

Under the obligations resulting from membership in the Energy Community of Southeast Europe, the Serbian authorities have set targets for the five year period up to end of 2012. According to the Programme for the Strategy of Energy Development of Serbia for that period, which last modified were adopted in 2009, Serbia planned until 2012 to increase the share of electricity from renewable sources by 2.2% compared to the total domestic consumption of electricity in 2007. Also, in the period 2007-2012 production of electricity from renewable sources was planned to increase by 7.4% from 9974 gigawatt-hours (GWh) in 2007 to 10713.1(GWh) in 2012 year. This means that the production of electricity from renewable sources should be increased by 739.1 million kilowatt-hours until 2012 which is enough to cover the annual energy needs of 179 thousand households with average monthly consumption of 350 kilowatt-hours.

For the mentioned period, the aim was to build at least 45 megawatts of capacity in the small hydropower plants, 45 MW plants using wind energy, five-megawatt solar photovoltaic plants, two megawatts of biomass and five megawatts on biogas.

It was planned that the share of biofuels and other renewable fuels on the Serbian market till 2012 amounts to at least 2.2% compared to the total fuel consumption in transport, which would ensure the marketing of more than 130,000 tons of biodiesel to the market. That increase in the participation of biofuels in transport in Serbia is possible to provide by using of biodiesel, since there is a possibility of its production.

Hydro potential and small hydro power plants

The total hydropower potential in Serbia is estimated at 17 000 gigawatt-hours of which has been utilized about 10,000 gigawatt-hours. The remaining hydro potential is estimated at about 7,000 gigawatt-hours in river basin Morava, Drina and Lim, and the Danube. These areas are suitable for the construction of power over 10 MW and annual production of about 5,200 gigawatt-hours.

The potential of small water flows, where can be build a small hydropower plants, amounts about 0.4 million ten - or 3% of the total potential of RES in Serbia. Small hydro power facilities are up to 10 megawatts, and they are in the category of privileged energy producers. According to announcements, the next directive will have stimulatory measures that the status of privileged producer has these with mini hydro power plants power of 30 megawatts.

If the total energy potential of small hydro power plants could be used, it will be about 4.7% of total electricity production in Serbia and about 15% of annual production of electricity from hydro power plants, which amounts approximately 10,000 gigawatt-hours.

Small hydro power plants are the most promising form of electricity production from RES, but certain rules make difficult investment in their construction.

Nearly a third of annual production of EPS (depending on weather conditions) comes from hydro power plants. It is from 10 to 12 billion kilowatt-hours of electricity annually. The estimates are that there is potential for another seven billion kilowatt-hours, of which 1.8 billion kilowatt-hours could be produced from small hydro power plants. To take advantage of this potential EPS is planned to revitalize the 17 old and new constructions of 18 small hydro power plants of total capacity 80 MW, with an investment of 80 million Euros.

Wind energy

Wind energy potential in Serbia is estimated at installed capacity of about 1,300 megawatts. The eastern mountain region of Serbia, the Pannonian plain and the Pester plateau are suitable for the construction of wind farms. The number of favorable sites is limited. Construction of wind farm is not cheap, but wind energy is currently the most economical source of renewable energy used. However, the heating value of wind power is unstable and unpredictable, so it is necessary to provide spare capacities in order to electricity system function. Variable wind power plants in operation costs and requires effort at balancing the electrical system. For the connection of wind farms it is necessary larger capacity expansion and reconstruction of the transmission system.

Production technologies for electricity from wind includes small wind turbines for households, hybrid systems that combine wind and solar energy or hydro system, and batteries, small systems with connection to the distribution network and wind farm or a large number of wind turbines, which functions as a power plant.

Plans to invest in the construction of wind turbines announced the EPS and also Serbian Association of Wind Energy (SEWE).

According to the data of Electric Power Coordination Center, which prepared the study for the Electric Network of Serbia, is registered 16 projects for the construction of wind farms with total output of 2600 megawatts, and so far has issued five licenses for wind farms with total power of 1135 MW.

Solar energy

The greatest potential for using solar of energy is the south of Serbia. The average intensity of solar radiation on the territory of Serbia is a 1.1 kilowatt-hours per square meter per day ($kWh/m^2/day$) in the north to 1.7 kilowatt-hours per square meter per day in January, from 5.9 to 6.6 kilowatt-hours per square meter per day in July. On an annual basis, the average annual value of radiation energy in the territory of Serbia is 1,200 kilowatt-hours per square meter ($kWh/m^2/year$) in northwestern Serbia up to 1,550 kilowatt-hours per square meter in southeastern Serbia, while in the central area is about 1,400 kilowatt-hours per square meter.

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Depending on the heat capacity of the receiver, the average value of the useful energy available to Serbia was 700 kilowatt-hours per square meter per year. During the emits of one square meter of house roof in Serbia the solar energy is equal to the energy which is obtained by burning 130 liters of oil. If every fifth household has solar receiver of 4 square meters per year in Serbia, in this way would be produced about 1,750 gigawatt-hours of thermal energy.

Serbia has good conditions for the use of solar energy and the most appropriate are solar thermal energy systems for heating water. However, since the price of electricity is not economic, population is not motivated to installs solar panels.

Geothermal sources

There are natural and artificial sources of thermal waters on the territory of more than 60 municipalities. Because of low water temperature this energy potential is not sufficient for production of electricity, but could be used for the heat production in different areas. This energy of low temperature could be used for heating greenhouses, rooms, pools and other purposes, but the local government, investors and users do not have enough experience in using this source.

For the production of electricity from geothermal sources temperature must be 100 degrees Celsius, while the temperature of the water from geothermal resources in Serbia, usually is within the range up to 40 degrees Celsius. Only on the territory of six municipalities the water temperature is above 60 degrees

The total thermal power that could be realize by using the thermal water in Serbia is about 216 MWt, which is equivalent approximately 180,000 tons of oil equivalent.

The legal framework

Some key dates for implementation RES in Serbia were:

- 2004 - Adoption of the Law on Energy, which provides measures for creating conditions for stimulating the use of renewable energy sources
- May 2005 - The Energy Development Strategy of the Republic of Serbia until 2015. The priority is set using renewable energy and new energy-efficient and environmentally friendly energy technologies and equipment for the use of energy.

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- 25th October 2005 - Energy Community of Southeast Europe, which has defined common market of electricity and gas for Serbia, Montenegro, Croatia, Bosnia and Herzegovina, Macedonia, Bulgaria, Romania, Albania and Kosovo under UN Resolution 1244. Serbia has ratified the contract in 2006.
- 26th January 2009 - Serbia becomes a member and founder of the International Renewable Energy Agency (IRENA), the first international organization that deals exclusively with renewable energy and which aim is to encourage the use of these energy sources in the world.
- September 2009 - Decree on conditions for granting the status of privileged power producers and criteria for assessing the fulfillment of these conditions.
- November 2009 - Adopted amendments to the Regulation on the program implementation energy development strategy of Serbia in the period 2007-2012.
- November 2009 - Regulation of the tariff for production of electricity using renewable energy sources and combined generation of electricity and heat which established feed-in tariffs and guaranteed purchase period of 12 years.
- 28th July 2011 - Adopted a new law on Energy

In order to incorporate in the Energy Community and to harmonize with EU, Serbia has undertaken the following measures:

- With ratification of the contract for establishing the Energy Community (2006), Serbia has accepted the obligation to implement European directives in the field of RES. The latest EU directive on renewable energy (2009) set up obligatory targets for member states to ensure that by 2020 the renewable energy accounts for 20% of total energy consumption in the European Union. Economically most powerful nations also have more demanding targets
- After the adoption of commitments Members of the EU have within a period of a year to make a plan for achieving this goal.
- According to some assessments, the share of renewable energy in Serbia is 21.6% (14% from Serbian sources to 25% from Greek Centre for renewable energy and savings-CRES). Target for 2020 is 25%.

- Serbia suggests that the annual rate of increasing should be 0, 5% and the total coefficient of increasing 4%.
- In order to comply with EU targets by 2020 in the field of renewable energy and energy efficiency, EPS has published a strategy document, the White Book, which contains an overview of planned activities and obligations. In the field of renewable energy EPS is planning the construction and rehabilitation of 35 small hydropower plants, investment in wind farms and solar plants. To increase energy efficiency and reduce power plant emissions of carbon dioxide EPS plans to close several old power plants of total capacity 1100 MW by 2020.

Serbia is taking its first steps in developing a sustainable energy market. *The Energy Law* (2004) predicted the measures for creating the conditions for stimulating the use of renewable energy sources. Also, in *The Energy Development Strategy for Serbia by 2015*, one of the priorities of the energy sector is the greater use of renewable energy sources, and this is also a priority in *Strategy for sustainable development* in the context of improving environmental protection and rational use of natural resources.

A particularly important step was adopting regulations in 2009 year, which introduced incentives for energy production from renewable energy sources - *Regulation on conditions for obtaining the status of privileged producer of electricity from renewable sources* and the *Regulation imposing the guaranteed purchase price* (feed-in tariff) for electricity generated by the purchase of a guaranteed period 12 years. In order to achieve one of its priorities - greater use of renewable energy, the Government adopted the amendments to the regulations implementing the Program of the Energy Development Strategy.

However, there are still many obstacles in the way of greater use of renewable energy - the procedures for investment are long and complex, regulations are inadequate , and standards are only partially defined. A specific obstacle is non-economic price of electricity, so that energy from renewable sources would not be competitive.

It is an open question how the distribution network could support the connection of capacity from RES without the investment and how it would be reflected on the price of electricity. There is also the question of supply stability from such sources. Production of electricity from RES is

more expensive than energy production from fossil fuels and therefore the incentives for investment in the plant is necessary.

Except hydropower plants, in Serbia there are only a few facilities for the exploitation of renewable sources of energy. But in this area progress can be noticed since it been announced a construction of several new facilities. There are almost no declared equipment manufacturers, until recently there were no technical standards for equipment and manufacturers. Serbia has already produced boilers for biomass, and the German Siemens manufactures generators for wind turbines. Law Concerning the Rational Use of Energy which is in preparation predicts specific measures to encourage the production and import of energy efficient appliances and equipment for renewable energy.

A key step in starting market development of renewable energy was establishing the feed-in tariffs and guaranteed purchase prices for electricity produced from renewable energy sources 12 years from the beginning of production. The introduction of these measures was an encouragement for investors who subsequently showed more interest for investment in this area. This regulation expires in 2012 year, which opens the question how the prices will be regulated after its expiration. It is expected that the Serbian government by the end of this year adopt new regulations on stimulative measures in the field of renewable energy sources.

As in the most of European countries, Serbia also implements feed-in tariffs, as well as stimulating measures. Criteria for the selection of renewable energy sources and technologies are energy potential, economic development, level of technology and international market.

One of the first steps in the development of RES in Serbia was the establishment of all necessary procedures for investors to help them in one place with information about what they need from the licenses and approvals. For this purpose the data were collected from all relevant ministries and presented in four booklets - for small hydropower plants, wind turbines, biomass and hydrothermal energy. It has been shown, however, that the procedures are long and complicated, so the next phase should be the simplification of procedures. Some benefits for the construction of renewable energy sources are enabled with amendments to the Law on planning and building, as well as the possibility of building on agricultural land.

The energy policy of Serbia, including the area of renewable energy sources, has been re-defined with new Energy Law, adopted in July 2011. The adoption of this law is one of the steps that Serbia had to undertake to fulfill the requirements for candidate status for EU membership.

The new law encourages investment in renewable energy, through simplifying procedures for investment and the introduction of privileged producers of energy from biomass, hydro, wind, solar and geothermal energy. The temporary status of privileged producer of electricity from wind and sun for a period of three years with possible extension of one year has been introduced. Conditions for temporary granting status are the energy and building permits and bank guarantees in amount of 2% of the project. The aim of this legal solution is to enable investors to more easily provide funds for construction.

Under the new law, the money for electricity from a privileged producer will provide that the final customer pay a special fee for the incentive, which is separately recorded and paid through the electricity bill.

The new energy law introduces the guarantees of origin for electricity and thermal energy produced from renewable energy sources that will allow producers to export "green energy".

It is planned that energy permits are issued for a period of three years instead of the current two years. Energy licenses will be valid for 10 years, except for producers of electricity and thermal energy which licenses will be valid 30 years.

For the investors, the status of a privileged producer is priority, because it guarantees the purchase of produced energy at a certain price in a given period, and thereby insures the repayment on investment.

The new law also provides incentives for the production of heat from renewable energy sources, since according to EU directives it enters into the energy balance. It is planned that the stimulating measures for the production of thermal energy transfer to the local level. Serbia's goal is to use biomass, which is less expensive, and to use it more efficiently.

Serbia will start soon working on new Energy Development Strategy of from 2015 by 2025 year. One of the eight parts of the future Strategy will be related exclusively to renewable energy sources.

Biomass potentials

In order to contribute to the fight against climate change, the European Union has set itself ambitious goal – that until to 2020, 20% of energy must be obtained from renewable sources and 37% of electricity should be obtained from renewable sources.

By adopting the main principles of the Kyoto Protocol and the strategy of replacing a part of fossil fuels by RES, for Serbia one of them - biomass - becomes the real alternative and a globally important option for reducing the level of CO_2 by carbon sequestration.

In addition to numerous advantages of renewable resources, biomass combustion for energy emits 1/10 CO_2 to the atmosphere compared to fossil fuels, which is significant for environmental protection and reduction of the "greenhouse effect".

The most important renewable energy source in Serbia is biomass. Its energy potential is estimated at about 2.7 million toe. According to estimates, biomass could satisfy about 30% of Serbia's energy needs. It consists of residues in the forestry and wood industry (about ten million), and remains in farming, animal husbandry, fruit growing, wine growing and primary processing of fruits (1.7 million toe). The energy potential of biomass from livestock that is suitable for biogas production is estimated at 42 000 ten. In southern part of Serbia the most common is forest and woody biomass, and in the north part is agricultural biomass such as straw, cornstalks, branches, seeds, shells and animal excrement. According to the aggregate state, there are three types of biomass: solid (wood residues), liquid (biodiesel and bioethanol) and gaseous (biogas).

Today, biomass is mainly used for household heating and district heating, and electricity production. It is also used for the production of biofuels for transport, as well as for production of chemicals and bioplastic materials. According to some estimates, only using wood residues could provide enough energy for 800,000 households.

The Serbian Government adopted a Biomass Action Plan which includes procedures for investments, identify problems and suggest solutions and deadlines, as well as relevant institutions which should work on that.

A key problem with biomass is to ensure long term supply of this raw material. For the investors it is crucial that when enter into large investments to ensure supply of biomass for several years,

so that would not happen to have for one year raw materials while others do not. It is also one of the preconditions required by banks to finance such projects. Serbia has started construction of the first plants to biomass, biogas plants and there are conditions for the production of biofuels - bioethanol and biodiesel, based on molasses and grains.

Short rotation plantations

The Government of The Republic of Serbia, within the framework of National Programme for Energy Efficiency, supported the projects EE273015 and TR18201"Opportunities for biomass energy production from wood short rotation plantation within the framework of electro energy systems in Serbia", led by The Institute for Forestry – Belgrade, whose objectives and research content were the following:

- Biomass volume production increase in fast growing dendroflora plantations in surface coal mine tailing ponds in Serbia;
- Increased share of energy generated from biomass in our country and enabling partial fossil fuels substitution according to the Kyoto Protocol regulations, The Davos summit conclusions and other international treaties;
- Determining ecologically and economically most suitable tree species
- Determining optimal technologies for setting up plantations
- Determining care, protection and supplementary nourishment measures with the aim to obtain the largest possible amount and best quality biomass;
- Determining the opportunities for use of waste mud from coal processing as a rational and accessible growth stimulus (fertilizers);
- Phytoremediation of contaminated substratum;
- Determining the economically most acceptable solution;
- Employment of local inhabitants and surplus work force, which will emerge in the process of public company restructuring in energy sector .

The reserves of lignite occupy the area of more than 1,000 km^2. Previous foreign experiences, e.g. from Germany shows that post-exploitation landscapes of minespoil banks of opencast lignite mines are very interesting for the establishment of short rotation plantations. Even under

unfavourable soil conditions, increment was from 5.3 to 19.6 t of dry matter/ha at the age of 4 years. The biomass produced in this way is characterised by low concentration of heavy metals, high calorific value, and favourable properties of ash - high concentration of macronutrients. The application of ash for land reclamation can compensate the loss of nutrients caused by biomass removal. Domestic experience shows that in the procedure of biological restoration of minespoil banks, the ratio of forest and agricultural revegetation is mostly 60:40, which means that finally it can be expected that forest ecosystems are established on about 600 km^2, and agricultural areas, urban ecosystems and infrastructure - on about 400 km^2.

The approximate estimation of biomass from anthropogenic forest ecosystems on minespoil banks of opencast coal mines is: from short rotation plantations - 190 956 tons and from forest plantations: 27 000 tons, totally - 217 000 tons of air-dry mass, annually. The study data point to significant, so far unutilised potentials of woody biomass from the existing and future forest and non-forest resources of biomass, which could be used for energy.

Their share in the national energy potential can reach about 20%, which would be of exceptional significance, not only from the economic, but also from the ecological aspects.

CONCLUSION

In addition to significant non-renewable energy resources, primarily coal, Serbia also has a variety of RES. Biomass is the most important one. Its share is estimated at about 63%. Biomass from forest resources dominate. A significant is share of the biomass from the agricultural sector. Particular importance is given to energy crops - plantations of short rotation woody species. Significant areas of waste open pits on postexploitation areas could be used for their establishment. In this way it could be integrated production of non-renewable and renewable resources, use of power plants and heating plants, as well as machinery and labor.

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