BIOMASS AS A RENEWABLE ENERGY SOURCE

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A R T I C L E I N F O

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A B S T R A C T

The use of RESs reduces the emission of gases and hazardous materials into the atmosphere, which has an impact on the improvement of the quality of the environment. The use of biomass, especially that from municipal waste and agriculture, reduces the need for importing energy sources. Energy production from RES is a fast-growing economy branch employing a significant workforce.

Of 5.6 Mtoe of the total annual usable technical potential of the RES in Serbia, 1.96 Mtoe (i.e. 35%) is used up, whereas only 1.1 Mtoe (i.e. 32%) is used up of 3.4 Mtoe of the total biomass.

The paper is aimed at indicating the significance of the production of renewable energy from biomass, the available quantities, the structure and the advantages of using it in the future development of the energy sector.

Some states, Serbia included, have prescribed stimuli to green energy kW delivered to power distribution enterprises.

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Introduction

Energy is the basis for every activity undertaken by man. Economic development increases the need for and consumption of energy. The current structure of the primary energy sources at a global level can't satisfy the accelerated trend of increasing energy consumption. The world is faced with a severe crisis in its further economic development. The disturbances we are witnesses of are a consequence of the reduction in natural resource stocks, first of all in fossil fuel reserves (coal, oil, natural gas). It is exactly due to this fact that an effort should be made towards finding alternative renewable energy sources as a replacement for oil and its derivatives.

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Serbia has a high energy consumption growth rate, whereas it is much poorer in the primary energy reserves concerning to the world average. The previously mentioned indicates the need for the rational use of the existing energy reserves and for searching for RESs: solar energy, wind energy, geothermal energy, hydro-energy, biomass, tide and sea and ocean wave energy, and so on. The available nonrenewable energy source reserves that would meet Serbia's needs for energy are modest, but there are big RES energy potentials, first of all in biomass. Agriculture is a major energy consumer and simultaneously it can become an energy producer as well. Today, the amount of the biomass used as an energy source is negligible concerning to the amount of the biomass produced in agriculture. In world developed countries, biomass as an RES plays a particularly important role, great attention being paid to the environment protection, since combustion does not lead to an increased emission of CO_2 in the atmosphere (Jordanović-Vasić, 2009).

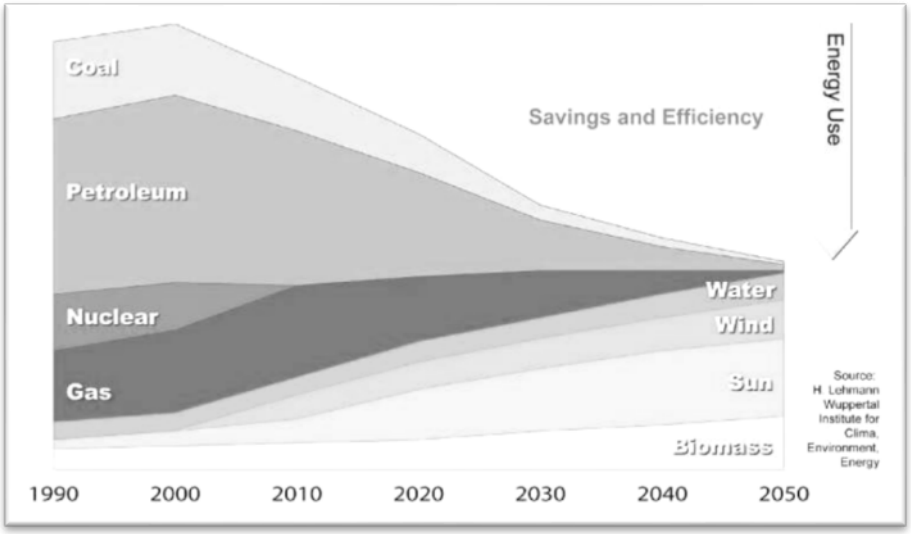
In the paper, the significance of the production of primary energy from biomass as a renewable energy source is pointed out, with a special reference to the available amounts, the structure, significance to the economy, the safety of energy production and the low energy efficiency of energy consumption in Serbia. The significance of renewable energy sources in the future development of Serbia's energy sector is highlighted. The new institutional ambience that would enable the stimulation of the development of energy production from renewable sources aimed at reducing gas emission with the greenhouse gas effect (GHG) is also suggested.

The Biomass Potential for Energy Production

A question is raised regarding the amounts of energy in RESs. It is estimated that mankind needs about 10^{14} kWh of energy per annum. About 15000 times more energy reaches the Earth from the Sun every day than man's overall needs are. Only 2% of solar energy is transformed into the energy of the wind, which is also 300 times more than the overall energy consumption. The energy of waves, tidal energy, is about 70 times greater than the overall energy consumption of mankind. The biomass potential is about 15 times greater than its present use in energy production. The present use of hydro-energy may only ensure one-half of the need for energy (NPEE, 2004).

The fact that there have been changes in the world energy market, that many nonrenewable energy sources have already reached the very verge of exhaustion, and that energy management is one of the major environmental polluters as well must be acknowledged as such (Kokeza, 2020). Renewable energy sources impose themselves as an alternative to nonrenewable energy sources, whose excessive use led to the drastic pollution of the environment at the end of the 20th century. The condition of available resources in the future will exert an influence on the structure of energy consumption worldwide (Figure 1).

Figure 1. Changes in the structure of energy consumption in the world in the period from 1990 to 2050



Source: Wuppertal Institute for Climate, Environment and Energy (https://wupperinst.org/en/)

Biomass is a renewable and biodegradable material of an organic (plant or animal) origin. Its possibilities are big, but they have insufficiently been utilized in the field of the production of thermal and electrical energy from biomass. First of all, we think of briquette and pellet production. The greater use of briquettes and pellets in energy production, especially in households, will depend on the parity between these products and other energy sources, especially electrical energy, and on the prescribed standards for their production and distribution as well.

For the convenience of an easier study of the same, biomass has been classified into woody biomass, non-woody biomass, animal origin biomass, industrial and municipal waste.

Woody biomass originates from forestry, fruit growing and viticulture, waste wood and residuals of the wood processing industry (sawdust, wood slabs, etc.). Besides, biomass production may also originate from fast-growing trees (the willow tree, the poplar tree, the ash tree, the sequoia tree, etc.).

Secondary and tertiary agricultural byproducts are made by collecting agricultural products in plant fruit or viticulture production (cereal straw, corn stover and stalks).

Residuals of agricultural-processing industries (skins, shells, corncob, etc.).

Non-woody grown biomass (fast-growing algae and grasses).

Animal wastes and remains, and

Municipal and industrial waste (Janjić et al., 2010).

In order to stimulate energy production from renewable sources, states have prescribed incentives for each kW of renewable energy delivered to electrical power distribution enterprises. So has Serbia. According to the Energy Sector Law (ZE, 2108), an energy entity may acquire the status of a producer of electrical energy from renewable sources for that particular electrical power plant, if:

1. it uses RESs in the electrical energy production process;
2. it was built to be used and is suitable for being used in compliance with the law regulating the construction of buildings;
3. it has ensured the special measuring separated from the measuring performed in other technological processes that serves to measure the received and delivered electrical energy, or thermal energy into the system;
4. it has a license to perform the activity in compliance with this Law; and if
5. it also meets the other conditions in compliance with the deed from Article 74 of this Law.

No entity may acquire the privileged producer status if it produces electrical energy from a reversible hydropower plant. The stimulating measures for electrical energy privileged producers encompass the following:

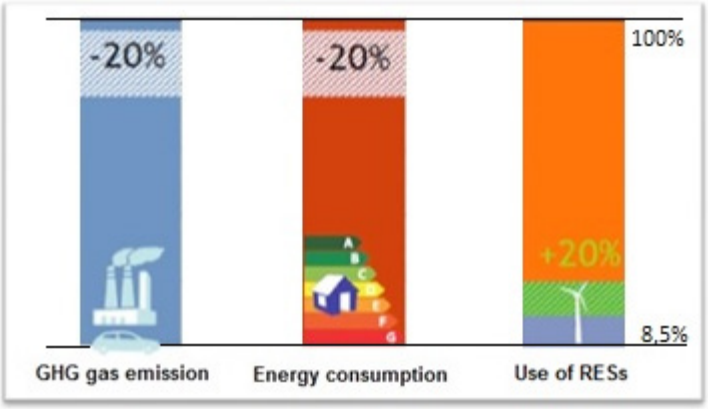
1. an obligation upon the entity to purchase all the amounts of the energy produced from renewable sources from the privileged producer;
2. the prices at which that energy is purchased;
3. the period of the validity of the obligation to purchase electrical energy;
4. assuming balance responsibility;
5. and the other incentive measures prescribed by the deed based on this Law and the other laws and regulations, too, by which taxes, customs duties and other duties, the environment protection and energy efficiency (ZE, 2018).

Projections of the production of energy from renewable sources are based on the forecasts for the economic development of the country, the energy market development dynamism and the like, due to which fact deviations of real data from projected data may also be expected to appear. Therefore, there is the need for the permanent adjustment of the energy production projection in compliance with Serbia's needs in the energy management sector. Article 52 of the Law on Energy Management envisages that the ministry relevant for the energy management field shall monitor the implementation of the National Action Plan and that the Government shall submit an annual report. Also, Article 15 of the Energy Community Ministerial Council imposes the obligation to have it constantly updated because of the preparation and submission of appropriate reports to the Energy Community Secretariat on the progress made in the implementation of the National Action Plan until the Year 2020 (SNSRES, 2013).

There is an assumption that energy supply will be both economically and ecologically completely sustainable in the future. The use of renewable sources and forming a closed circle of energy production and use, as well as using waste energy, is becoming the most important item of all future development and energy supply strategies.

The Club of Rome's report entitled "Beyond the Age of Waste" indicates the problem of the production of sufficient amounts of the energy that would be economically cost-effective as well. They are still warning that national economies should be managing energy balance, not only the monetary dimension, since money is only relative and ephemeral, whereas on the other hand, energy is necessary and eternal (Jovanović, 2018).

Figure 2. The EU Energy Policy until the 2020



Source: Authors' modification (http://banisaenergy.com/en/novosti-otrasli/20-20-20-eu-program-renewable-energy-and-emission-reduction)

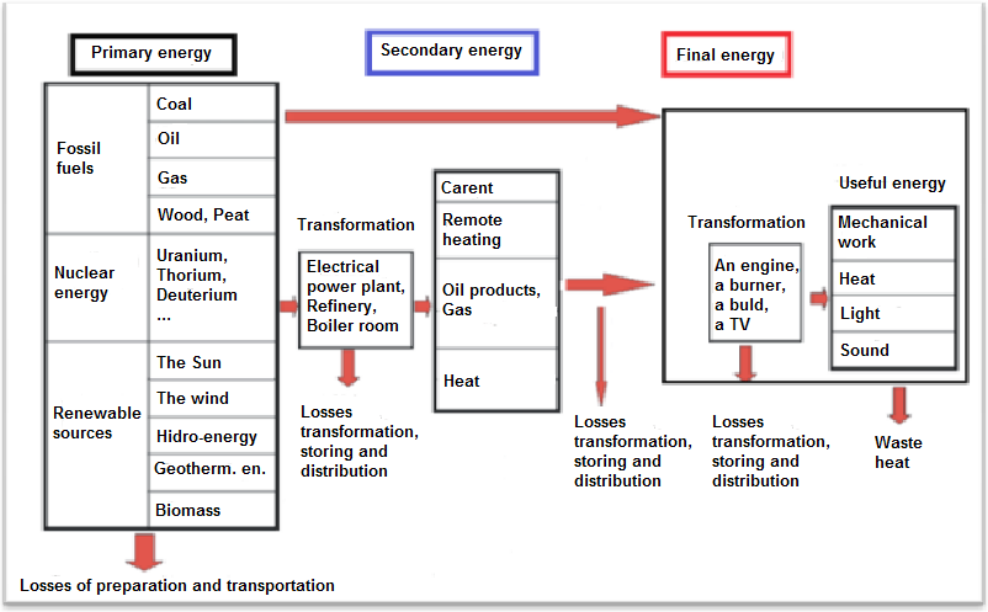
In compliance with Directive 2009/28/EC, the mandatory goals have been set for all the EU member states so as to ensure that, in the year 2020, RESs have a 20% share in the gross final energy consumption (GFEC) at the EU level. The mandatory national goals of the EU member states are defined in the section of Annex I and are consistent with the goal that the RES share in the GFEC should be at least 20%. Each member state is also obliged to ensure at least 10% share of energy from RESs in the GFEC in traffic by the year 2020 (***, Energy, 2020)

Bearing in mind Directive 2009/28/EC, as a country in the EU association process, Serbia has the obligation to ensure that 20% of primary energy production should be from RESs by the year 2020. The total RESs available in Serbia with a technically usable potential is 5.6 Mtoe (million tons of the oil equivalent[3]) per annum. The biomass potential is 3.4 Mtoe (of which as much as 1.1 Mtoe is already being used today). The biomass potential still unused is 2.3 Mtoe. The hydro-energy potentials are 1.7 Mtoe (0.9 Mtoe is already being used). The geothermal energy potentials are estimated at

3 1 toe = 7.33 barrels of the oil equivalent

0.2 Mtoe, the energy of the wind 0.1 Mtoe, solar energy 0.2 Mtoe and biodegradable waste energy 0.04 Mtoe. Of the total available RES technical potential, Serbia uses 35% (NSOIE, 2013). A greater use of RESs may significantly reduce the use of fossil fuels and reach the goal related to the RES share in the total final energy consumption.

Figure 3. Energy production classification



Source: (Banjac, 2012)

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Legal Regulations on Renewable Energy Sources

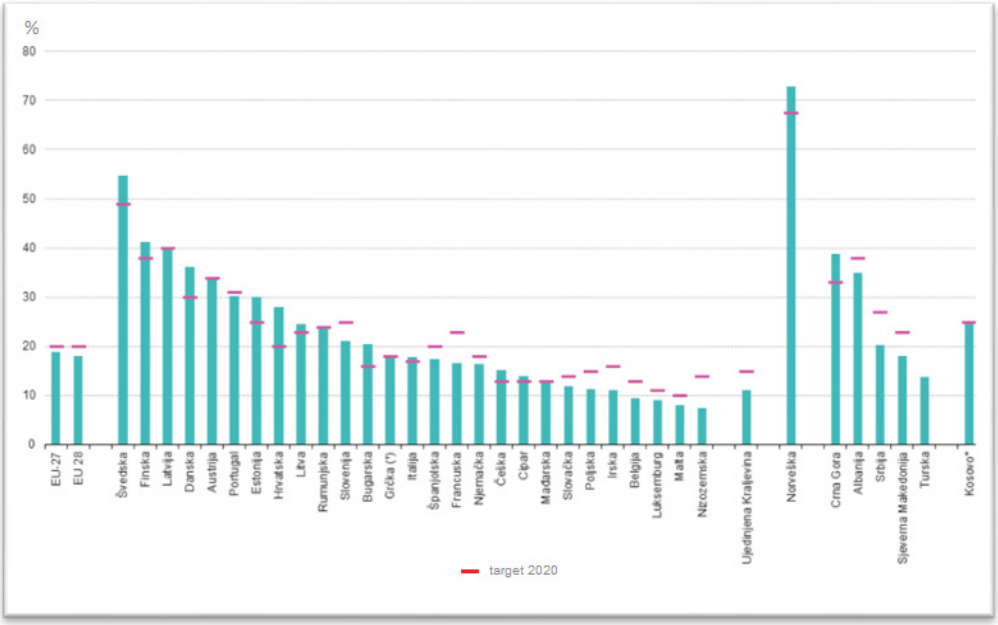
EU Directives on renewable energy sources. In 2001, the EU adopted the Directive on Renewable Sources (2001/77/EC), which is the obligation for the legislations of the EU member states in the sense of increasing the share of renewable sources in electrical

4 1toe = 7.33 barrels of the oil equivalent

energy production. The average share of renewable sources in the total production of electrical energy in 1997 was 13.9%. In 2010, that share had to be 22.1%. According to the Directive, that percentage also included big Hydropower Plants (HPs) although it was about a conventional energy source.

The new EU directive (2009/28/EC) on the RES use promotion is aimed at achieving a 20% share of RESs in overall energy consumption and a 10% share of biofuels in total EU transportation by 2020. Yet another request also refers to the adjustment of the national goals of all the EU member states. The year 2007 is taken as the reference year. The main goal of the Directive 2009/28/EC is the so-called 3 x 20 by 2020 (20% less CO_2 emission; 20% of renewable energy sources, and 20% greater energy efficiency). Namely, in September 2008, the European Parliament adopted a package of regulations on climate changes, whose aim was to ensure a 20% reduction in the greenhouse effect gas emission, a 20% improvement of energy efficiency and a 20% share of renewable energy in total energy consumption in the EU by 2020, as perceived in relation to 1990 (Petrović, 2018).

Figure 4. The share of renewable energy sources in total energy consumption in the EU member states in 2018 and the goals for the year 2020 as defined by Directive 2009/28/EC



Source: https://ec.europa.eu/eurostat

The EU policy and legislation in the RES field. The EU policy is formed through the standards and rules known as the EU Directives. The Directives are common for all nations, but they do respect national specificities, so they determine the minimum requirements. For the first time in 1983, the EEC adopted a common regulation (Council Directive 83/189/EEC), which prescribed the standards for the equipment for using RESs. The recommendation for an increase in the RES share in total energy production

and consumption was adopted by the EEC in 1988. By the adoption of the Directive (EC 96/92), the EU started a serious reform of the electrical-energy system in 1997. The gas system reform began in 1998 by the Directive (EC98/30). These directives lead towards the liberalization of the internal electrical energy market and the energy sector as a whole.

At the end of 1996, the European Commission adopted the Green Paper that defines the priority measures needed to be undertaken by the EU and its member states as the first step towards a joint strategy for the production of energy from renewable sources. A special emphasis was placed on the importance of RESs in the reduction of the emission of the greenhouse effect gases and an increase in energy self-sufficiency, as well as the opening of new jobs, especially in rural areas, in the fields of the production of energy from renewable sources. As a result of an extensive debate on RESs, a document (the so-called White Book on Renewable Sources) was adopted. Based on the current condition of the environment and the energy sector, the Book proposed a national energy activities program.

The research study revealed that the goals set in Directive EC 96/92 in its relevant parts had not been achieved, so in 2003, the EU adopted another Directive 2003/59/EC[5] on the electrical energy market, wishing to liberalize the energy source market, which is expected to be completely satisfied by the introduction of a uniform financial market in the EU (Milenković, 2017)

As early as in 2017, as many as nine EU countries (Sweden, Finland, Italy, the Czech Republic, Estonia, Latvia, Romania, Bulgaria and Croatia) achieved the goal of 20% of energy originating from renewable sources. Austria, France and the Netherlands are quite close to achieving the goal. In the last few years, 24 of the 28 EU member states have been accelerating the transfer-to-renewable-energy-sources procedure (http://www.rts.rs, 2021). Since 2008 to date, the EU has doubled the amount of the energy produced from RESs. Once the prior goal has been achieved by 2020 (20% of the production of energy from renewable sources), the EU will start realizing a new goal – 27% of the production of energy from renewable sources. In some countries, such as Romania and Croatia, there has been an investment boom in the RES sector.

An increase in the production of energy from renewable sources leads to the opening of new jobs in this fast-growing branch. The number of employees in the production of energy from renewable sources in the world increase from 5.0 million in 2012 to 9.8 million in 2016[6], the leaders in this increase being China, India, Brazil, Japan, the USA and Germany. Only in the RES field in China, 3.5 million workers are employed. Worthy of mention is also an increase in the number of the employed in Malaysia and Thailand. Asia employs over 60% of the total population employed in the production

5 The directive started being applied in July 2004, until when the EU member states had a deadline to bring their legal regulations into compliance with the provisions of the Directive.

6 International Renewable Energy Agency (IRENA)

of energy from renewable sources. According to estimations, more than 25 million workers will have been employed in the sector of the production of energy from RES by the year 2030, and this sector will have been acknowledged as one of the main sectors generating economic growth. There are 85,000 workers engaged in the research and development program in Germany (Vorlop, 2005).

The EU founds its new Energy Policy Strategy on the diversification of energy sources, especially renewable ones, and the application of new contemporary energy production technologies. In this manner, the EU will achieve greater energy independence.

The data pertaining to Serbia are all but encouraging. Only 25% of Serbia's needs for energy are satisfied by the production of energy from own sources. A low percentage of self-sufficiency in energy production like this will turn Serbia into a country whose further economic development will be conditioned by the possibility of ensuring energy sources on the world market. There is increasingly less time for that, given the fact that the estimated coal reserves will be exhausted in about 50 years, and those of oil and gas in only 20 years from now.

Biomass as an Energy Source

Ever since fire was discovered, biomass has been the main energy source for mankind. Biomass is specific because of the "storing" of CO_2 and solar energy during its creation. The use of biomass for a biofuel, bioenergy, chemical and other products does not increase the concentration of CO_2 in the atmosphere. By the transformation of biomass into energy (electrical/thermal, a fuel for engines or raw materials for the chemical industry), CO_2 is released, but in a considerably smaller amount in relation to the combustion of other energy sources. Differently from the fossil fuels that are a product of the effect the Sun makes on plants, then their transformation into energy sources several thousand years later, biomass as an energy source is most frequently used immediately after its creation. The EU has been imposing an additional stimulus for using biomass as an RES to a greater extent due to its increasingly stricter regulations on the environment protection. The combustion of agricultural and forest remains, as well as solid waste for energy production, is twice as beneficial since it represents an efficient use of waste products, simultaneously also solving the waste disposal issue.

Because of its characteristics during combustion, the production and use of biomass protects the environment, stimulates the growth of the economy and ensures additional energy safety. The biomass potential for bioenergy is quite a big one and very widespread throughout the world. Today, biomass is the main source of the world energy resources, ensuring 13% of total energy. In developing countries, 35% of energy is generated from biomass. The European countries such as Austria, Sweden and Finland are already producing around 20% of commercial energy from biomass today. It is estimated that approximately 38% of the world's needs for fuels and 17% of its needs for electrical energy might be satisfied from biomass by 2050. (Janjić et al., 2010)

Differently from the energy of the Sun and the energy of the wind, whose production

significantly depends on the weather factors, biomass can be used to produce energy throughout the year. If energy produced from biomass is cogenerationally[7] used to produce electrical and thermal energy, then the heat effect ranges from 70% to 80%. In case biomass is only used to produce electrical energy, that effect ranges from 10% to 25%.

Using biomass as an energy source is of a general interest due to the following advantages:

1. biomass is a renewable, sustainable and relatively ecologically clean energy source;
2. biomass can be used to generate from it a larger number of the materials of a new structure of different physical and chemical features (Bozell, 1999);
3. an increased use of biomass will prolong the lifecycle of reduced crude oil reserves;
4. the fuels obtained from biomass are with an insignificant concentration of sulfur, and because of that they do not contribute to the emission of the sulfur-dioxide that causes acid rains;
5. by biomass combustion, smaller amounts of ash are produced than in the case of coal, and ash products may be used as additives for farm soils, etc.
6. the combustion of agricultural and forest remains, as well as municipal solid waste (MSW), for energy production is an efficient use of waste products which reduces the significant issue of waste disposal, especially in municipal areas;
7. biomass is a domestic resource which is not subject to price changes in the world, or imported fuel supply uncertainties;
8. biomass offers a clean and renewable energy source so as to enable the improvement of the conditions of our environment, economy, energy management and market, too; and
9. the use of biomass may be a way to prevent a greater share of carbon-dioxide in the atmosphere, since it does not increase the atmospheric level of carbon-dioxide (White and Plasket, 1981).

Because of the mentioned specificities, biomass imposes itself as an alternative RES today, especially in the conditions of deficient solid, liquid and gas fuels, and unused land areas on which biomass could be produced for the needs of energy production.

At the beginning of 2021, it was for the first time that the EU produced more electrical energy from RESs than separately from coal and nuclear power plants. When the EU member states are looked at individually, there are big differences. In one group of them, the number of green kW grew, whereas in the other group no step forward was made. Irrespective of the modest results obtained so far, the EU does not give up on the plan to stop using coal in electrical energy production in the next ten years. The same is also required from Serbia and the other Balkan countries. In the past five years, the EU

7 Cogeneration is the procedure of the simultaneous production of thermal and electrical energy (combined heat and power, or CHP). In this procedure, the thermal energy created by producing electrical energy in thermal power plants is used to remotely heat buildings and settlements.

has halved coal consumption, and in 2020, it made a "green" turn. In 2020, the largest number of the new capacities built from RESs were built for the purpose of producing electrical energy from the wind, then from solar energy, whereas the construction of hydropower plants and biomass-operated plants was stagnating. The EU generated 19% of electrical energy from the energy of the wind and solar energy in 2020. Yet about 20% of electrical energy in the EU is generated from hydropower plants and biomass. So, the EU generates 38% of electrical energy production from RESs, 37% from fossil fuels (coal, oil and gas), and the rest of it from nuclear energy (https://euractiv.rs, 2021). Research studies show that the leaders in the production of electrical energy from RESs are Denmark, Ireland, the Netherlands, Spain and Germany. A total of the seven EU member countries, however, have not made any progress in the production of energy from RESs so far. The EU Eastern European countries that have obliged themselves to adhere to the EU ecological plan envisaging that, by 2050, Europe will be the first energy-neutral continent in the world are being faced with the same problem as well. It will be all but easy for Poland and Czechoslovakia, as well as the other countries whose electrical energy production is dominantly based on coal-operated thermal power plants, to achieve that goal. The Balkan countries whose electrical energy supply depends on the performance of coal-operated thermal power plants will also have to do the same work. Serbia generates 70% of electrical energy from thermal power plants by lignite combustion.

Decision-makers are now expected to make the best possible concept, bearing also in mind the goals taken over on the occasion of joining the Energy Community, as well as the goals that we should set on our own as a country, bearing in mind the present level of the environment pollution. A gradual increase in the share of green kilowatts in electrical energy production will make better the adoption of the Law on Renewable Energy Sources, which itself envisages that at least 50% of produced electrical energy and thermal energy will originate from RESs by 2050.

The largest share in the production of energy from RESs in Serbia is realized via hydro-energy, i.e. through hydro-power plants, from which about 10,200 GWh per annum are generated using quite outdated pieces of equipment, with an estimation that the upgrading of the capacities from those sources at the annual level could enable the generation of around 14,200 GWh. Even in such an uncertain situation, only 20% to 25% of total real RES potentials is used in Serbia. With the present technological-technical development and investment possibilities, around 80% of unutilized potentials are found in biomass exploitation (woody biomass and biomass from agricultural production), whereas 20% accounts for the micro-hydro-plant and geothermal source potentials (Janić et al., 2010).

Energy sources consumption in Serbia is at the level of 15 million tons of the oil equivalent (Mtoe), of which 7.4 Mtoe accounts for net consumption, and 3 Mtoe accounts for electrical energy consumption. Of the total consumption, 7.9 Mtoe (i.e. 52%) is from coal, 4 Mtoe (i.e. 27%) is from liquid fuel, 2.1 Mtoe (14%) is natural gas, and 1 Mtoe (i.e. 7%) is hydro-energy. Of the total consumption, only 7% originates

from renewable sources, which are related to big hydro-power plants (Dakić and Kragić, 2008). On the other hand, Serbia is estimated to have 3.2 Mtoe in RESs, which are used in an insignificant amount. As far as the RES potential is concerned, 2.6 Mtoe accounts for biomass, 0.15 Mtoe accounts for small-sized hydro-power plants, 0.18 Mtoe accounts for geothermal energy, and 0.1 Mtoe accounts for solar energy, whereas the rest accounts for the energy of the wind[8] (SEEA).

This analysis allows us to see that biomass is Serbia's basic potential in RESs. Of the estimated amount of biomass, 60% accounts for the biomass of an agricultural origin, whereas 40% accounts for forest biomass. Forest biomass combustion plants have been developed to a high level, whereas plants for using agricultural biomass are still being developed. (Dakić and Kragić, 2008).

Conclusions

In the conditions of deficient and limited available amounts of solid, liquid and gas nonrenewable energy sources, as well as the unutilized land areas on which it could be produced, biomass imposes itself as an alternative RES due to its production specificities. Apart from the reduced emission of CO_2 and the environment protection during combustion, the use of biomass through an additional engagement of the workforce stimulates the growth of the economy and ensures a country's greater energy safety.

The production of energy by combusting municipal waste generates double effects. On the one hand, the amount of waste is reduced and disposed of to landfills, thus polluting the environment less, whereas on the other, foreign-exchange funds necessary for importing energy.

Today, 13% of total energy is generated from biomass. Developed countries, such as Austria, Sweden and Finland, produce around 20% of energy from biomass. It is estimated that, by the year 2050, approximately 38% of the world's needs for fuel and 17% of the world's needs for electrical energy will be satisfied from biomass. Transition towards the production of electrical energy from RESs must, first of all, rest on the decisiveness of the state to subsidize the producers of this energy. That decisiveness is also stimulated by the financial institutions that will not support the construction of coal-run energy capacities.

Due to increasingly stricter regulations on the environment protections, the EU has introduced additional stimuli for each kWh of delivered energy produced from RESs. Serbia also applies similar regulations in the field of the production of energy from RESs. Regulations will positively influence the construction of new capacities for the production of energy from RESs.

Given the potentials of the biomass available in Serbia, it is necessary that own technologies for its use should be developed. A greater use of biomass might satisfy 25% of Serbia's needs for energy. In order to make a more significant progress in increasing the use of biomass as an RES, it is necessary that the country should have a well-devised and well-coordinated energy policy.

8 Serbian Energy Efficiency Agency (SEEA).

By building plants for the combined production (cogeneration) of thermal and electrical energy in the future, the issue of heating and a greater production of electrical energy would be solved. Simultaneously, the use of electrical energy for heating would be reduced, and the total energy efficiency of the country would be increased.

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Conflict of interests

The authors declare no conflict of interest.

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