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THE NECESSITY OF INTENSIVE USE OF RENEWABLE ENERGY RESOURCES IN THE REPUBLIC OF SERBIA

At the end of the last and particularly at the beginning of this century, the global emphasis has been placed on intensive use of renewable energy resources. At the current stage of scientific and technological development, their exploitation cannot be economically viable when compared to non-renewable, primarily fossil fuels, so they need different incentives to be competitive. Their more significant utilization requires an essential role of the state whose economic policy measures have to make renewable energy resources competitive with conventional ones. Methods of theoretical and empirical research to be used in this paper are based on qualitative and quantitative analysis of the collected material with regards to the availability of renewable energy resources in Serbia. With the means of these methods, the paper will show the structure of available renewable energy resources in Serbia and give recommendations on how these resources should be valorized in the most effective manner. Increasing energy efficiency arises as a key factor to future energy development of Serbia, and the intensive use of renewable energy resources is a logical response to such requests.

Keywords: *renewable energy resources, exploitation, efficiency, Serbia.*

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НЕОБХІДНІСТЬ ІНТЕНСИВНОГО ВИКОРИСТАННЯ ВІДНОВЛЮВАНИХ ДЖЕРЕЛ ЕНЕРГІЇ В РЕСПУБЛІЦІ СЕРБІЯ

У статті піднято питання інтенсивного використання відновлюваних джерел енергії. На сучасному етапі науково-технічного розвитку їх експлуатація не може бути економічно вигідною в порівнянні з невідновлюваними джерелами (у першу чергу, паливом на основі нафти), тому вони потребують підтримки їхньої конкурентоспроможності. Більш значне їх використання вимагає істотної ролі держави, заходи економічної політики дозволять поновлюваним джерелам енергії конкурувати зі звичайними. Методи теоретичного та емпіричного досліджень засновано на якісному і кількісному аналізі зібраного матеріалу про наявність поновлюваних джерел енергії в Сербії. Показано структуру доступних поновлюваних джерел енергії та подано рекомендації про найбільш ефективні способи монетизації цих ресурсів. Підвищення енергоефективності - ключовий фактор подальшого розвитку енергетики Сербії та інтенсивного використання відновлюваних джерел енергії.

Ключові слова: *поновлювані джерела енергії, експлуатація, ефективність, Сербія.*

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НЕОБХОДИМОСТЬ ИНТЕНСИВНОГО ИСПОЛЬЗОВАНИЯ ВОЗОБНОВЛЯЕМЫХ ИСТОЧНИКОВ ЭНЕРГИИ В РЕСПУБЛИКЕ СЕРБИЯ

В статье поднят вопрос интенсивного использования возобновляемых источников энергии. На современном этапе научно-технического развития их эксплуатация не может быть экономически выгодной по сравнению с невозобновляемыми источниками (в первую очередь, топливом на основе нефти), поэтому они нуждаются в поддержке их конкурентоспособности. Более значительное их использование требует существенной роли государства, меры экономической политики позволят возобновляемым источникам энергии конкурировать с обычными. Методы теоретического и эмпирического

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исследований основаны на качественном и количественном анализе собранного материала о наличии возобновляемых источников энергии в Сербии. Показана структура доступных возобновляемых источников энергии и поданы рекомендации о наиболее эффективных способах монетизации этих ресурсов. Повышение энергоэффективности - ключевой фактор дальнейшего развития энергетики Сербии и интенсивного использования возобновляемых источников энергии.

Ключевые слова: *возобновляемые источники энергии, эксплуатация, эффективность, Сербия.*

1. Introduction. Energy resources are the most critical ones: without it, life would cease (Tietenberg, 2006: 150). Every country, whether developed or not, is forced to use energy resources. Utilization of energy resources increases production and economic efficiency, brings about rationalization of the production process and makes labour productivity grow. It also encourages greater efficiency of the application of scientific and technological achievements, as well as a greater return on investment and other production resources. In this way, it achieves growth of high productivity material production, and production in every branch and sector of the economy. Apart from the impact on economic efficiency, energy resources are important for functioning of any household. Since energy resources are a heterogeneous category, for more detailed economic analysis it is necessary to make their classification. The economic theory finds the division between renewable and non-renewable energy resources most acceptable.

Non-renewable resources are formed by geological processes that usually take millions of years, so that they can be viewed as existing in the form of fixed stocks of reserves which, once extracted, cannot be renewed (Perman et al., 1999: 184). The category of non-renewable energy resources includes: fossil fuels (coal, oil and natural gas) and nuclear fuel mining. The share of fossil fuels in the commercial energy consumption is 87%, and nuclear power mines about 5% (BP, 2012), which indicates the non-renewable energy resources account for 92% of the total production/consumption of commercial energy on the global level. From the long-term perspective, the situation is unsustainable for two key reasons. The first reason is the availability of non-renewable energy resources. Oil reserves will peak in 40 years, natural gas in 65 and coal in about 155 years. Another reason for unsustainable use of non-renewable energy resources lies in the excessive environmental pollution resulting from the exploitation of these resources, especially fossil fuels.

Renewable energy usually refers to those energies that do not pollute environment and could be recycled in nature (Peidong et al., 2009: 440). Renewable energy is a basic ingredient for sustainable development. Such sources can supply the energy we need for indefinite periods of time polluting far less overall than fossil or nuclear fuels. The advantages of renewables are well known, as far as they enhance diversity in energy supply markets; secure long-term sustainable energy supplies; reduce local and global atmospheric emissions; create new employment opportunities offering possibilities for local manufacturing and enhance security of supply since they do not require imports that characterize the supply of fossil fuels (Goldembetg and Coelho, 2004: 712).

In order that this resource category the energy potential of exceeds the requirements of modern society and creates the minimum adverse environmental impact

becomes an economic reality, it is necessary to ensure a more active support of national and international institutions stimulating more intensive use of renewable energy resources.

2. Potential of renewable energy resources in Serbia. Serbia possesses a relatively modest potential of energy resources. This especially goes for the category of non-renewable resources, except for low-calorie lignite.

Table 1. **The structure of energy resources reserves in Serbia**

Types of non-renewable energy resources	Energy value of reserves, in Mtoe	The share of total reserves of non-renewable resources, in%
Coal	**3.538**	90,86
Oil shale	**193**	4,97
Nuclear fuel	**103**	2,66
Oil and natural gas	**60**	1,51
Total available energy potential of non-renewable resources	**3.894**	100,00
Types of renewable energy resources	**Energy value of reserves, in Mtoe**	**The share of total reserves of renewable resources, in %**
Hydropotential	**1,59**	31,67
Biomass	**2,40**	47,81
Solar energy	**0,64**	12,75
Wind energy	**0,19**	3,87
Geothermal energy	**0,20**	3,90
Total annual energy potential of renewable resources	**5,02**	100,00

Source: Government of the Republic of Serbia. Energy Development Strategy of the Republic of Serbia until 2015. www.mem.sr.gov.rs. (accessed: 2 September 2012).

As to the level and structure of the renewable energy resource potential, it is about 5 Mtoe[3] a year. Of the biggest resource potential are biomass (2.4 Mtoe) and hydropower (1.59 Mtoe). Other renewable energy sources have significantly lower potential totalling about 1Mtoe. Among all the renewable sources, hydropower is the most intensively used (especially the potential of huge rivers which account for 30% of the total electricity production), with the annual production of final energy of about 1Mtoe, which stands for two thirds of the resource potential. The other renewable energy sources are not filed in the energy balance of Serbia, which shows they have no commercial use.

Water resources are the second most important energy resource in Serbia, right after coal. Flowing water energy is a type of renewable energy sources which is of high importance both for the construction of power plants and electricity generation on one hand, and use for other purposes, primarily irrigating agricultural lands. The total theoretical hydropower potential of the Republic of Serbia is 30.000 GWh of electricity per year, about 19.000 GWh of which is technically and 12.000 GWh economically usable electric power, which represents about 40% of the theoretical, or more than twice global average of 22% (Caille et al., 2008: 279). This indicates that the untapped energy potential amounts to about 7.000 GWh of electricity annually. It is mostly concentrated on the Drina and Lim (about 1.900 GWh), Morava (about 1.700 GWh) and Danube (app. 1.000 GWh), which can be utilized for the construc-

[3] Mtoe-milion tonnes of oil equivalent. To achieve comparability of data for different energy resources, all data on the quantities are converted to a common comparable size

tion of stand-alone objects with the installed capacity above 10 MW (the large hydroelectric power plants), with the total annual production of more than 4.800 GWh of electricity. The rest of the production, about 2.400 GWh, can be generated in over 1,000 potential microplants on small hydro streams, where it is possible to build small hydroelectric power plants with the installed capacity below 10 MW.

Biomass is the most promising renewable alternative energy source in Serbia, which is among the states with a large potential of biomass energy, however still underutilized in our country. The total annual energy potential of biomass is about 2.40 Mtoe, 1.40 Mtoe of which refers to agricultural, and about 1Mtoe to forestry potential. The biomass resource potential, both for agriculture and forestry, is marked by an unbalanced regional distribution. The agricultural resource potential is concentrated in the plains of northern Serbia – Vojvodina, Macva, Stig and northern parts of Sumadija, while the forestry potential prevails in the southern parts of the country. Given that the net import of primary energy in Serbia hovers around 6.5Mtoe, it is clear that the intensive use of biomass as an energy resource could significantly reduce the deficit. Also, the import is dominated by liquid fuels, with about 3.5 Mtoe per year (Caille et al., 2008: 279) which can be significantly reduced through the production of biodiesel.

The annual potential of solar energy as a renewable energy resource is 0.60 Mtoe. The average annual amount of solar energy in Serbia is around 1.450KWh/m^2, which is well above the European average of around 1.000KWh/m^2 (Caille et al., 2008: 383–384). However, the utilization of solar energy in Europe is much higher than in our country, due to the subsidies for production of commercial forms of energy (electric and thermal) based on this resource.

Serbia possesses significant potential of geothermal energy (about 0.20 Mtoe per year), but it is poorly utilized. The main advantages of geothermal energy comparing to other renewable sources are almost unlimited availability and its independence of weather conditions, through which security of supply is ensured. By the resource potential of geothermal energy, Serbia falls under rich European countries. The average value of the so-called geothermal flow in Serbia is over 100 mW/m^2, which is much higher than the European average of around 60 mW/m^2 (Caille et al., 2008: 440–442). The average temperature of all geothermal energy sources in Serbia is 47.90 °C, with 14 sites having temperature over 1000 °C.

The wind energy has the potential of around 0.19 Mtoe per year. The highest potential for wind energy is in the Banat area with 270 and Backa with 200 windy days a year. The availability of wind energy in Serbia varies markedly from region to region. It is more present in lower than in higher areas, because the wind speed is greater at a downward movement. In some areas, particularly in the area of Vojvodina, the wind energy is used for irrigation.

Although the presented potential of renewable energy is huge and accounts for over 50% of the energy production in Serbia and about 35% of the total consumption, it has not been used properly in the past.

3. Role of renewable energy resources in economic development of Serbia. Apart from the generally accepted classification of energy resources as renewable and non-renewable, from the viewpoint of the achieved utilization level and the importance

certain energy resources have for economic development, the economic literature differentiates conventional and alternative energy resources (Ristien and Kranshaar, 2006: 25). The conventional energy resources include those which are exploited and recorded in an energy balance of the country, while the alternative ones refer to those which are not exploited but do exist as a resource potential (Milenkovic and Boskovic, 2011: 296).

Serbia has relatively modest reserves of conventional sources of energy. The most important are low-calorie lignite and hydropower. Due to the increasing energy consumption, the adopted Energy Development Strategy of Serbia predicts growth from the current 15 Mtoe to over 18 Mtoe by 2015 (Govetnment of the Republic of Servia, 2012). In order to reduce the high dependence on imported energy resources, there must be more intensive use of alternative energy resources.

Table 2. **The energy balance of Serbia for the period 1990 to 2010, in Mtoe**

	1990	2000	2005	2010
Primary energy production	**9,601**	**7,843**	**8,347**	**8,939**
- Coal	7,224	5,975	6,483	7,171
- Oil	1,068	0,667	0,665	0,634
- Natural gas	0,560	0,268	0,243	0,183
- Giant hydro power	0,749	0,934	0,956	0,890
- New renewable energy sources (NRES)	0,000	0,000	0,000	0,061
Net imports of energy	**6,243**	**4,599**	**5,765**	**6,490**
- Coal	0,600	0,324	0,582	0,991
- Oil	4,367	2,693	3,360	3,541
- Natural gas	1,700	1,417	1,802	1,897
- Electricity	-0,424	0,165	0,021	0,062
Gross primary energy consumption	**15,844**	**12,442**	**14,122**	**15,583**
- Coal	7,824	6,229	7,065	8,161
- Oil	5,435	3,360	4,025	4,329
- Natural gas	2,260	1,685	2,045	2,080
- Electricity	-0,424	0,165	0,021	0,062
- Renewable energy sources (hydro + other)	0,749	0,933	0,956	0,951
Import dependence (in %)	**39,40**	**36,90**	**40,85**	**41,65**

Government of the Republic of Serbia. Energy Development Strategy of the Republic of Serbia until 2015. www.mem.sr.gov.rs. (accessed: 2 September 2012).

So, out of different renewable energy resources the only exploited so far was the potential of huge rivers through the so-called large hydropower plants. The share of hydropower in the total primary energy consumption in Serbia is 10.6%, and in the electricity generation 25.55%, well above the world average. Specifically, the share of water resources in the total worldwide primary energy consumption is 2.2% and in the electricity production 16% (International Energy Agency, 2008: 24).

In order to distinguish between recently used renewable energy resources and those that are not formerly exploited, the new Law on Energy of the Republic of Serbia (Govetnment of the Republic of Servia, 2011) introduces a special category, the so-called new renewable energy sources (NRES), which include biomass, hydropower potential of small rivers with capacity up to 10 MW, geothermal, solar and wind energy.

In the period up to 2010, the exploitation of NRES in Serbia was negligibly low. The number of existing facilities for NRES exploitation, as well as their annual ener-

gy production is also negligible, and the related investments small and largely domestic. The financial effects of NRES exploitation within the existing facilities are also minimal at the national level.

The aforementioned development strategy does not attach high importance to the new renewable energy sources. It is considered, thus, that the total use of these energy forms in Serbia by 2015 will be only 0.5 Mtoe, that is to say just under 2% of the total consumption or 2.8% of the total energy production.

It is clear that the possibilities of using renewable energy resources did not attract much attention in the past. This came as a result of numerous factors, the following being the most important:

1. Relatively low cost of electricity in Serbia;
2. Insufficient knowledge of the expert and general public about the benefits of using renewable energy resources;
3. Lack of competition in the sector of renewable energy resources;
4. Distrust of population towards the use of new technologies;
5. Lack of financial support, and
6. Lack of knowledge on energy issues.

The future should bring more active promotion of the use of renewable energy resources potential.

4. Different ways to stimulate more intensive use of renewable energy resources in Serbia. The available energy potential of renewable resources in Serbia is not sufficiently used in the function of encouraging economic development. The limitation reflected in the need for quality reserves of non-renewable resources, has led to the country's high dependence on imported fossil fuels, mostly oil and natural gas, but also quality coal (hard and brown) in recent times. The important resource potential lies in the abundance of renewable resources (biomass energy, solar and wind energy, geothermal energy, and particularly the potential of large and small rivers). During the previous period of the energy sector development in Serbia there have been no detailed and adequate exploration of the potential of renewable energy resources and its favourable benefits in particular.

Integration of the renewable energy sector into the country's energy development strategy yields significant benefits, as renewable energy technologies have a far lower environmental impact than fossil fuels and nuclear power; in this way, they contribute to reduce greenhouse emissions and consequently, to meet Kyoto targets and slow down global warming (Aune et al., 2008: 25).

Serbia ratified the Agreement on South East European Energy Community (EPSU) in 2006, the document signed by the EU and the countries of Southeast Europe, thus accepting the obligation to implement the Directives 2001/77/EC and 2003/30/EC which promote the production of electricity out of renewable sources and the use of biofuels and other RES in the transport sector respectively (Mihajelov, 2010: 873). These and other RES related EU directives are valid in all states that have applied for the EU membership.

By accepting major European recommendations for using renewable energy resources, the Republic of Serbia introduces (Govetnment of the Republic of Servia, 2011; 2012) a category of privileged electrical/thermal energy producers in its strategic energy documents on the basis of their production being based on NRES. The

most important characteristic of privileged producers is their priority status at the established energy market as compared to other producers. Secondly, they are eligible for subsidies, tax, customs and other benefits, which are necessary for the profitability of electricity generation with NRES.

Here are the incentives for more intensive use of renewable energy resources outlined in the key EU documents (2001; 2009; 2012):

1. stimulating tariffs (feed-in-tariffs) refer to minimum price certainty, i.e premiums to producers of electricity through renewable sources;
2. investment subsidies is the mechanism aimed to overcome the problem of high initial investment for the installation of renewable energy facilities;
3. fiscal measures which include investment tax reductions;
4. mandatory quotas (the so-called green certificates) are aimed at establishing a minimum share of electricity generated from renewable sources.

The incentives in Serbia are mostly oriented on the implementation of the first measure, feed-in tariffs, which is widely spread in all developed countries.

Table 3. **Feed-in-tariffs for various types of power plants in Serbia, in eurocent per KWh**

Power plant type	Installed power (MW)	Incentives-feed-in-tariffs (EURc/KWh)
New hydropower plants	< 0.5	9.7
	0.5–2	10.3
	2–10	7.85
Existing hydropower plants	< 2	7.35
	2–10	5.9
Biomass power plants	< 0.5	13.6
	0.5–5	13.8
	5–10	11.4
Biomass power plants	< 0.2	16.0
	0.2–2	16.4
	> 2	12.7
Wind plants		9.3
Solar energy plants		23.0
Geothermal energy plants		7.5

Source: Government of the Republic of Serbia, Ministry of Mining and Energy. Decree on Measures of Incentives for the Production of Electricity Using Renewable Energy Sources and Combined Electric and Thermal Power, Official Gazette RS 72/09.

We see that the incentive tariffs have been determined for all forms of renewable energy resources and made compliant with the similar measures in the EU. It seems indicative that the incentives for hydropower development are oriented solely to the use of small water flows with the installed capacity up to 10 MW. This is quite understandable and in compliance with the recommendations of the EU, as incentives for building large hydropower plants are not needed, because they are price-competitive with those using non-renewable energy resources. In the previous 5-year period (2006–2011), the total amount of subsidies to encourage the use of renewable resources in Serbia reached about 200 mln EUR, which is small taking into account the availability of the resources and allocations Serbia is giving to import fossil fuels (over 1 bln EUR per year).

The energy and economy policy makers have to encourage more intensive use of renewable energy sources and increase energy end-use effeciency. Harmonization of

the future energy policy of Serbia with the EU energy policy, particularly in the area of promoting the use of renewable sources, should lead to increased energy efficiency and reduction of final energy consumption per unit of gross domestic product.

5. Conclusion. The mechanisms to support more intensive use of renewable energy resources are aimed to make them competitive with conventional resources. The total resource potential of renewable energy sources in Serbia is about 5Mtoe per year, which makes up over 50% of the total production from conventional resources or about 30% of the total energy consumption. The resource potential has only been partly used – 20%, which includes only the potential of large rivers. The introduction of feed-in tariffs for electricity produced from renewable sources and the relief of taxes, customs and import duties on renewable energy equipment would be the first steps to help making the renewable energy sector competitive.

It is of utmost importance to establish favorable financing sources (interest-free loans and a grace period until the renewable resources start to be exploited) through the effective cooperation of public and private institutions. Having in mind the current financial situation in the country, for the formation of funding sources it is necessary to attract foreign capital. Besides direct financial assistance for building capacities for and exploiting renewable energy sources, it is necessary to ensure quality training and education of all human resources likely to encourage greater use of renewable sources. Thanks to its decentralized nature, many renewable energy technologies are much closer to end users than conventional power capacities, which makes the promotion of renewable energy sources much more effective at local and regional than at national level.

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