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CURRENT STATE AND PERSPECTIVES OF RENEWABLE ENERGY SOURCES USE IN SERBIA

Abstract: The paper presents information on the potentials of renewable energy sources, small and large hydropower plants, PV solar power plants, wind generators and biogas power plants in Serbia. In addition, an overview of the capacities for the generation of electricity from renewable sources and data on the planned electricity generation in 2019 in Serbia is given. Further information is provided on the perspectives of the generation of electricity from renewable energy sources in Serbia. In conclusion, it is pointed out that today Serbia produces about 27.51% of electricity from renewable energy sources.

Key words: *renewable energy, hydropower plants, wind generators, solar power plants, biogas power plants*

1. INTRODUCTION

Renewable energy sources include hydro-energy, solar energy, wind energy, biogas, biomass, etc. In Serbia, there are potentials, technical possibilities and legal regulations for wider use of renewable energy sources. There are also international agreements that Serbia has committed to using renewable energy sources for the generation of 27% of electricity from renewable energy sources. Education for the use of renewable energy sources in educational and other institutions is an ongoing process in Serbia. Using

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renewable energy sources contributes to increasing the country's energy independence, reducing harmful substances emissions, damaging the environment, creating new jobs, etc.

2. POTENTIAL OF RENEWABLE ENERGY SOURCES

Technically usable energy potential of the renewable energy sources in the Republic of Serbia is quite significant and is estimated at over 4.3 million tons of equivalent oil (ten) a year — of which about 2.7 million tons of equivalent oil is located annually in the utilization of biomass, 0.6 million tons of equivalent oil per year in unused hydro-potential, 0.2 million tons of equivalent oil per year in the existing geothermal sources, 0.2 million tons

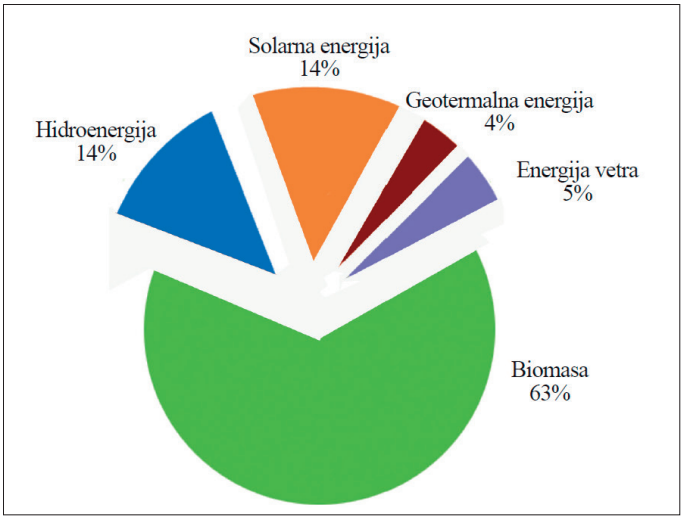

Fig. 1. Share of renewable energy sources in the total potential of Serbia

of equivalent oil per year in wind energy, and 0.6 million tons of equivalent oil per year in the exploitation of solar radiation. The share of certain renewable energy sources in the total potential of Serbia is given in Figure 1.

In the Republic of Serbia today there are almost no clearly declared producers and repairers of RES exploitation equipment. However, in the field of energy use of water currents, biomass, and the use of solar energy for heat purposes, there are good opportunities for active involvement of the domestic equipment manufacturers.

The state of RES research is well founded through the National Energy Efficiency Program of the Ministry of Science and Technological Development. However, the implementation of the adopted technological knowledge is lagging behind, and the implementation of demo projects is lagging behind as well, due to the lack of incentive measures.

The most significant obstacle to the increased use of renewable energy sources in Serbia is: slowness of the transmission and distribution system operators to prioritize the manufacturers using RES on the network and giving priority to renewable energy in distribution; lack of a significant number of equipment standards and procedures for the exploitation of RES; insufficient number of regulations for the design, construction, control and installation of devices using RES; insufficient number of accredited certification laboratories for installations using RES; non-economic prices of electricity, disparity of energy prices, etc. [1, 2].

3. HYDROPOWER PLANTS

In Serbia, within EPI (electric power industry), there are 16 large and 11 small hydropower plants and a number of small hydropower plants privately owned. Hydropower plants represent the most important power source for renewable energy sources in Serbia. By their importance in the Serbian electric power industry — EPI, they are far behind the solar power plants, wind farms and biogas power plants.

Small hydropower plants in Serbia are a thread that connects modern electricity with its beginnings, represented in the Tesla polyphase system, whose application in Serbia was promoted by prof. Djordje Stanojevic.

3. 1. SMALL SCALE HYDROPOWER PLANTS

The first small hydropower plant Obilicevo near Krusevac was put into operation on 4.8.1891. Initially, it generated a direct current using a dynamo machine, and from 1908 it started generating alternating current. The first small hydropower plant in Serbia, which began with the generation of alternating current in 1900, was the hydropower plant *Pod Gradom* near Uzice.

According to the data of the Ministry of Energy and Mining of Serbia from 2007 to date, 184 decisions for the construction of small hydropower plants have been issued. However, it is difficult to find information on the number and locations of newly built small hydropower plants in Serbia.

Basic characteristics of small hydropower plants within EPI are given in Table 1.

Table 1. Basic characteristics of small hydropower plants within EPI

Name	Location	Generator power (MW)	Annual generation (GWh)	Installation
Pod Gradom	Near Uzice	0.36	0.26	1900
Vucje	Near Leskovac	0.908	3.00	1903
Sveta Petka	Near Nis	0.750	3.3	1908
Gamzigrad	Near Zajecar	0.224	1.00	1909
Moravica	Ivanjica	0.160	1.40	1911
Jelasnica	Near Vranje	0.400	2.00	1925
Vrelo	Bajina Basta	0.160	0.48	1927
Turica	Near Uzice	0.400	1.95	1929
Sicevo	Near Nis	1.680	4.2	1931
Temac	Near Pirot	0.752	2.5	1940
Sokolovica	Near Zajecar	4.4	11	1948

Fig. 2. Hydropower plant *Pod Gradom*, Užice, 1900

Fig. 3. HE *Sićevo* near Niš, 1931

3.2. LARGE HYDROPOWER PLANTS

Within EPI in Serbia there are 16 large hydropower plants whose basic characteristics are given in Table 2.

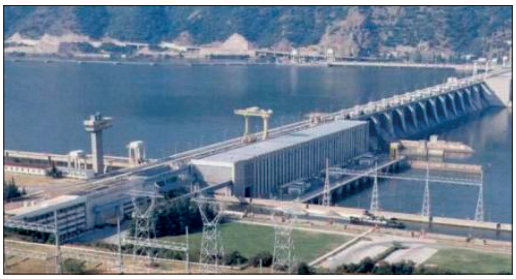

Fig. 4. Hydropower plant *Đerdap I*, 1970

Fig. 5. Hydropower plant *Đerdap II*, Kusjak, Negotin, 1985

Table 2. Basic characteristics of large hydropower plants in Serbia operating within EPI

NAME	Type	Number of generators	Power of generators (MW)	Total power (MW)	Annual generation (GWh)	Lake volume 10^6 m^3
DUNAV						
Đerdap I	Storage hydropower	4 2	176 205	1115	6000	2800
Đerdap II	Run-of-river hydropower	10	27	270	1500	716.5
DRINA						
Zvornik	Prestorage — Run-of-river hydropower	4	24	96	550	89
Bajina Bašta	Prestorage hydropower	4	105	420	1800	340
RH Bajina Bašta	Reverse hydropower	2	307	614	800–1000	170
LIM						
Uvac	Derivational hydropower	1	36	36	76	213
Kokin brod	Prestorage hydropower	2	11.75	23.5	45	250
Bistrica	Accumulation hydropower	2	54	108	220	7.6
Potpeć	Prestorage hydropower	3	17	51	100	27.5
ZAPADNA MORAVA						
Ovčar banja	Run-of-river hydropower	1 1	3.4 5,3	8.7	29	1.5
Međuvršje	Run-of-river hydropower	1 1	3.4 5.6	9	29	13
VISOČICA						
Pirot	Accumulation hydropower	2	40	80	87	180
VLASINA						
Vrla 1	Accumulation hydropower	2	11.2	52.8	95	165
		2	14.2			
Vrla 2	Accumulation hydropower	1	10.7	24	51	0.1
		1	13.3			
Vrla 3	Accumulation hydropower	1	12.8	29.4	73	-
		1	16.6			
Vrla 4	Accumulation hydropower	1	11.2	25.4	63	0.1
		1	14.2			

4. PV SOLAR POWER PLANTS

In Serbia there are two large and quite a few small scale PV solar power plants.

4. 1. LARGE PV SOLAR POWER PLANTS

Matarova

In the village of Matarova near Merdare, municipality of Kursumlija, on April 23, 2012 the Italian company *Gascom,* in cooperation with the local company *Solar Matarova* from Novi Sad began the construction of 2 MWp PV solar power plant. PV solar power plant *Matarova* was installed on August 23, 2013.

Fig. 6. PV solar power plant *Matarova* power of 2 MWp, 2013

PV solar power plant is located on an area of 4 hectares, has 8 100 polycrystalline solar modules and the total investment was € 3.6 million. The PV solar power plant was designed by the Mihajlo Pupin-Automatics Institute in Belgrade. Technical assessment was performed by the Jaroslav Černi Institute in Belgrade. Construction works at the plant's site were performed by the following companies Metalac Co. in Kušumlija, then companies in Nis and Prokuplje. For the purposes of solar power plant, the transmission network Merdare- Degremen a length of 2.3 km was built, which previously did not exist. Furthermore, for the connection, 10.7 km transmission lines Degremen-Kosanička Rača were reconstructed.

Kladovo

PV 2 MW solar park in the village Velesnica near Kladovo consists of two PV solar power plants, *Solaris 1* and *Solaris 2*.

Fig. 7. PV solar park in a village Velesnica near Kladovo, 2013.

PV solar park is located on a surface of 4.5 ha. The total area of solar modules is 13600 m2. The PV solar power plants *Solaris 1* and *Solaris 2* cost 3 million euros.

PV solar power plant *Solaris 1*, of 999 kWp, construction began in July 2013 and was completed in November 2013. It was installed on December 27, 2013. PV solar power plant *Solaris 1* consists of polycrystalline silicon modules each power of 245 Wp, manufactured by *Yingli Solar*. PV solar power plant *Solaris 1* was designed by Ceefor Ltd. from Belgrade. In the construction of PV solar power plant *Solaris* 1, companies Enertec from Maribor (Slovenia) and MT-Komex Ltd. from Belgrade participated.

PV solar power plant *Solaris 2*, of 999 kWp, construction began in August 2014, and it was completed in October 2014, and was installed in October 24, 2014. PV solar power plant *Solaris 2* consists of polycrystalline silicon modules each power of 250 Wp, manufactured by *Yingli Solar*. PV solar power plant *Solaris 2* was designed by Ceefor Ltd. from Belgrade. In the construction of PV solar power plant *Solaris* 2, a company MT-Komex Ltd. from Belgrade participated.

Between PV solar power plants *Solaris 1* and *Solaris 2* there is a transformer station 35/0.4 kV, rated power 2x1000 kVA, which allows the distribution

of the entire electricity produced in the electrical distribution system. In PV solar power plants, the inverter TRIO-27.6-TL-OUTD, ABB Aurora Power One, Co is used.

4. 2. SMALL SCALE PV SOLAR POWER PLANTS

The basic characteristics of some small scale PV solar plants in Serbia are given in Table 3.

Table 3. Basic characteristics of some small scale PV solar plants in Serbia

Company	**PV solar power plants**	**Power (kWp)**	**Year**
Alfatec Ltd. in Niš (www.alfatec.rs)	On the building of the private company Domit in Leskovac	34.32	2012
	On the building of the Technical School in Pirot	4.59	2013
	On the building of the Faculty of Sciences and Mathematics in Nis	2.08	2012
	On the building of the Faculty of Electronic Engineering in Nis	1.2	2011
Telephone Engineering Ltd. in Zemun (www.telephone-engineering.co.rs)	On the residential house in Batusinac	10	2012
	In the village of Cortanovci	10	2012
	In Backa Topola	7.5	
	In Ralja	4.5	
Netinvest Ltd. in Belgrade (www.netinvest.rs)	In the yard in village Blace near Kursumlija	10	2011
	On the building of the secondary school in Varvarin	5	2010
	On the building of the secondary electro -technical school *Rade Koncar* in Belgrade	5	2010
	On the building of the secondary technical school *Mihajlo Pupin* in Kula	5	2010
	On the roof of the daycare center in Bezanijska kosa	3	2012
Elektrovat Ltd. in Čačak	On the building of the *Elektrovat Ltd.* in Cacak	54.72	2012
Institut Mihajlo Pupin in Belgrade (www.imp.bg.ac.rs)	On the building of the *Institute Mihajlo Pupin* in Belgrade	50	2013
Energo Pro-Teh Ltd. in Zrenjanin	On the roof of the Faculty of Technical Sciences in Cacak	1.05	2008
Faculty of Technical Sciences in Novi Sad	On the building of the *Faculty of Technical Sciences* in Novi Sad FTS1	9.6	2011
	On the building of the *Faculty of Technical Sciences* in Novi Sad FTS2	15.9	2015
Elektromehanika Ltd. in Niš	On the building of the *Elektromehanika Ltd.* in Nis	30	2014

Fig. 8. PV solar power plant on the roof of Energoprojekt in Belgrade, 115.62 kWp, 2013

Fig. 9. PV solar power plant, 9.86 kW, 2014, municipality Dupci (*Plan-net-solar, Slovenia*)

5. WIND POWER PLANTS

According to the Register of the Ministry of Mining and Energy of the Republic of Serbia, the status of a privileged or temporarily privileged producer of electricity using wind generators was acquired by 17 claimants until 29.3.2017. The total installed power of the privileged producers amounted to 17 MW, and temporarily privileged 483 MW. In mid 2016, the Government of Serbia adopted by-laws for renewable energy sources, which brought the region in line with European standards and gave an incentive for the construction of wind farms near Vrsac, Kovin, Kovačica, Alibunar and Plandište.

In Serbia, a company *MK Fintel Wind* is the most famous investor and manufacturer of electricity with wind turbines.

5. 1. WIND GENERATOR IN TUTIN

The first 600 kW wind generator with the status of a privileged electricity producer in Serbia was put into operation in 2011 in Leskovo village, in the municipality of Tutin.

In the construction of a wind turbine in Tutin, the Slovenian-Serbian company *Hidrovind* invested about million euros, and the municipality of Tutin provided land. It is planned to build another seven wind generators in Tutin municipality.

5. 2. WIND PARK IN KULA

The company *MK Fintel Wind* built and installed in Kula power plant power of 9.9 MW on 16. 11. 2015. Wind park consists of 3 self-generators with a single power of 3.3 MW and a height of 175 m.

Fig. 10. Wind park power of 9.9 MW in Kula, 2015

5. 3. WIND PARK ZAGAJICA OR LA PICCOLINA IN VRŠAC

Wind park *Zagajica* or *La Piccolina* in the village of Zagajica near Vršac, with a power of 6.6 MW, consists of two power generators of 3.3 MW each. Wind park was installed on 3. 10. 2016. This is the second-largest wind farm in Serbia, built by *MK Fintel Wind*, and the first in southern Banat. The investment value was about 10 million euros. The construction of this wind farm started in April 2016.

Fig. 11. Wind park *Zagajica* (*La Piccolina*) of 6,6 MW in Vršac, 2016

5. 4. WIND PARK KOŠAVA IN VRŠAC

In June 2017 *MK Fintel Wind* started construction of the Kosava wind park in the village of Zagajica near Vrsac, in addition to the existing *Zagajica or La Piccolina* wind park. Wind park Kosava will have 20 power generators with a total power of 117 MW [14–16].

6. BIOGAS POWER PLANTS

According to the Register of the Ministry of Mining and Energy of the Republic of Serbia, in Serbia until 29. 03. 2017 there were 9 producers of electricity on biogas with the status of a privileged producer and 2 with the status of a temporarily privileged electricity producer with a total installed power of 12 967 kW.

Table 4. Producers of heat and electricity on biogas in Serbia

Company	Location	Power (kW)
Global Speed	Čurug	635
Mirotin Energo	Vrbas	1735
Lazar	Blace	1000
Gakovac	Stara Moravica	2000
BGS BP	Bač	1950
Bioelektra	Botoš	600
Biogas Energy	Ilandža	3570
Bioenergo 808	Stara Pazova	700
Alltech Fermin	Senta	1500
PUC waterworks and sewerage	Subotica	616
CPPOV	Vrbas	380
Carlsberg Serbia	Čelarevo	—
Apatin Brewery	Apatin	—
PIK Moravica	Pančevo	2 000
Total		**16 686**

Fig. 12. Three TEB biogas plants in Bač with digestate storage

Fig. 13. The gas tank of the TEB biogas plant in Čelarevo

Currently, Serbia has three types of biogas TEB plants. The operation of the first type is based on agricultural residues or some waste materials from the food industry, the second on the use of wastewater, and the third on the use of industrial organic waste.

In 2016, eight TEB plants with a total power of 15 MW on biogas from agricultural residues were active in Serbia. Apart from biogas plants from agricultural residues, other plant types are very rare [17–19].

7. CAPACITY FOR ELECTRICITY PRODUCTION

The capacities for electricity generation in Serbia in 2019 are given in Table 5.

Table 5. The capacities for electricity generation in Serbia in 2019

Power plants	Power (MW)
Thermal power plants (TE)	4079
Thermal power plants-heat plants (TE-TO)	297
Large hydropower plants Small scale hydropower plants	3000.6 102
Small scale hydropower plants that will use incentives	80
Wind power plants that will use incentives	398
Solar power plants that will use incentives	9
Biogas power plants	24
Biomass power plants	2.5

The planned electricity production in Serbia in 2019 is given in Table 6.

Table 6. Planned electricity production in Serbia in 2019

Planned electricity production	Gwh	%	RES power plants
Gross production	40005		%
Thermal power plants	28268	71	
Thermal power plants-heat plants	198	Less than 1	
Hydropower plants — Run-of-river 86% — Accumulation 2% — Reversible 9% — Small scale 3%	9623	24	24
Industry power plants	352	0.88	
Wind power plants	1230	3.07	3.07
Solar power plants	14.376	0.036	0.036
Biogas plants	154	0.38	0.38
Biomass plants	11	0.027	0.027
Landfill and sewage gas power plants	3	0.007	
Natural gas plants	15	0.037	
Total			27.513

Maximum energy produced in wind power plants that can be expected in 2019 is 1154 Gwh on the transmission network and 76.321 Gwh in the distribution network.

8. PERSPECTIVE OF RES USE IN SERBIA

In Serbia, there are good prospects for the use of renewable energy sources for the generation of heat and electricity. In Serbia, heat energy in households and small private enterprises is obtained through the use of biomass and solar collectors for heating domestic hot water.

Several small private hydropower plants are under construction in Serbia. In relation to this, there is a noticeable resistance in the construction of small hydropower plants in Serbia due to the environmental damage and ecosystems. In addition, measures are being taken in Serbia to build new wind generators, solar power plants and biogas power plants.

9. CONCLUSION

Based on the above stated, it can be concluded that there are potentials, technical possibilities and appropriate legislation in Serbia for the use of renewable energy sources for the generation of heat and electricity. Nowadays, in Serbia, renewable energy sources are used for the production of 27.513% of electricity. In Serbia, EPI owns 11 small scale and 16 large hydropower plants, which produce 24% of electricity annually. In Serbia, wind turbines generate about 3.07% of annual production, solar power plants 0.036%, biogas power plants 0.38% and biomass power plants 0.027% of electricity. In Serbia, several smaller private hydropower plants and PV plants are under construction. Also, certain measures are taken for the construction of new wind generators and biogas plants for the production of electricity.

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