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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.

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|-----|-------|-----------|-------|-------|----------|-------|-----------|----|-------|------------|-------|-------|
|-----|-------|-----------|-------|-------|----------|-------|-----------|----|-------|------------|-------|-------|

| Name        | Location      | Generator power (MW) | Annual generation<br>(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         |

Table 1. Basic characteristics of small hydropower plants within EPI



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 *Derdap I*, 1970



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

| NAME               | Туре                                     | Number of generators | Power of<br>generators<br>(MW) | Total<br>power<br>(MW) | Annual<br>generation<br>(GWh) | Lake<br>volume<br>10 <sup>6</sup> m <sup>3</sup> |
|--------------------|--|----------------------|--------------------------------|------------------------|-------------------------------|--|
| DUNAV              |  |                      | •                              |                        |                               |  |
| Đerdap I           | Storage hydropower                       | 4<br>2               | 176<br>205                     | 1115                   | 6000                          | 2800   |
| Đerdap II          | Run-of-river<br>hydropower               | 10                   | 27                             | 270                    | 1500                          | 716.5  |
| DRINA              |  |                      | •                              |                        |                               |  |
| Zvornik            | Prestorage — Run-<br>of-river hydropower | 4                    | 24                             | 96                     | 550                           | 89   |
| Bajina<br>Bašta    | Prestorage<br>hydropower                 | 4                    | 105                            | 420                    | 1800                          | 340  |
| RH Bajina<br>Bašta | Reverse<br>hydropower                    | 2                    | 307                            | 614                    | 800-1000                      | 170  |
| LIM                |  |                      |                                |                        |                               |  |
| Uvac               | Derivational<br>hydropower               | 1                    | 36                             | 36                     | 76                            | 213  |
| Kokin<br>brod      | Prestorage<br>hydropower                 | 2                    | 11.75                          | 23.5                   | 45                            | 250  |
| Bistrica           | Accumulation<br>hydropower               | 2                    | 54                             | 108                    | 220                           | 7.6  |
| Potpeć             | Prestorage<br>hydropower                 | 3                    | 17                             | 51                     | 100                           | 27.5   |
| ZAPADN             | A MORAVA                                 |                      |                                |                        |                               |  |
| Ovčar              | Run-of-river                             | 1                    | 3.4                            | 87                     | 29                            | 15   |
| banja              | hydropower                               | 1                    | 5,3                            | 0.7                    | 27                            | 1.9  |
| Međuvršje          | Run-of-river                             | 1                    | 3.4                            | 9                      | 29                            | 13   |
| VISOČIC            | A  | 1                    | 3.0                            |                        |                               |  |
| Pirot              | A<br>Accumulation<br>hydropower          | 2                    | 40                             | 80                     | 87                            | 180  |
| VLASINA            |  |                      |                                |                        |                               |  |
| Vrla 1             | Accumulation<br>hydropower               | 2                    | 11.2                           | 52.8                   | 95                            | 165  |
| ,                  |  | 2                    | 14.2                           |                        |                               |  |
| Vrla 2             | Accumulation<br>hydropower               | 1                    | 10.7                           | 24                     | 51                            | 0.1  |
|                    |  | 1                    | 13.3                           |                        |                               |  |
| Vrla 3             | Accumulation<br>hydropower               | 1                    | 12.8                           | 29.4                   | 73                            | -  |
|                    |  | 1                    | 16.6                           |                        |                               |  |
| Vrla 4             | Accumulation                             | 1                    | 11.2                           | 25.4                   | 63                            | 0.1  |
| vrla 4             | hydropower                               | 1                    | 14.2                           | 23.4                   | 03                            | 0.1  |

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

# 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.

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

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



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 secondlargest 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.

| 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     |  |

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



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.

| Power plants   | Power (MW) |
|--|------------|
| Thermal power plants (TE)                              | 4079       |
| Thermal power plants-heat plants (TE-TO)               | 297        |
| Large hydropower plants                                | 3000.6     |
| Small scale hydropower plants                          | 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        |

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

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

| 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<br>— Run-of-river 86%<br>— Accumulation 2%<br>— Reversible 9%<br>— 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           |

Table 6. Planned electricity production in Serbia in 2019

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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