UNITECH 2022 GABROVO

INTERNATIONAL SCIENTIFIC CONFERENCE
18-19 November 2022, GABROVO

LARGE HYDROPOWER PLANTS IN THE VLASINA MICROREGION

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Abstract

In the paper are given basic information on the geographical position of Vlasina microregion in Serbia. Also, are given the information about geographical position and construction and power of four large hydropower plants Vrla 1, Vrla 2, Vrla 3 and Vrla 4 in Vlasina microregion At the end are given information about total annual output of large hydropower plants in Vlasina microregion in 2019 and 2020.

Keywords: electrical energy, large hydropower plant, Vlasina, Vrla River, Serbia.

INTRODUCTION

The Vlasina microregion is located in the southeastern Serbia and stretches between the South Morava valley and the Serbian-Bulgarian border and belongs to the Vlasina river basin. In the northwest, the Vlasina microregion extends to the mountains Čemernik and Vardenik. The eastern border of the Vlasina microregion encompasses the state border between Serbia and Bulgaria. In the north, above the Vlasina microregion the Plana Mountain rises sharply, and in the southeast the Miljevska mountains [1, 2].

According to the regional division, the Vlasina microregion belongs to the region of the Southern Serbia located between the Toplica and Pirot districts in the north, the Republic of Bulgaria in the east, the Republic of Northern Macedonia in the south, and the Autonomous Province of Kosovo and Metohija in the west. It covers the territory of two districts (Jablanica and Pčinja) and three municipalities (Vlasotince, Crna Trava and Surdulica). The municipalities of Vlasotince and Crna Trava belong to the Jablanica district, and Surdulica to the Pčinja district [1, 2].

The central part of the Vlasina microregion accommodates the Vlasina plateau at an altitude of 1000-1300 m, which is the watershed of the rivers Struma (Aegean Sea basin), Jerma and South Morava (Black Sea basin). In the southwest, the Vlasina plateau is bordered by the Vrla River, in the northwest by the Vlasina River, in the northeast by the Jerma River, and in the southeast the Božička River. The Vlasina Lake is located in the center of the Vlasina Plateau. Based on the previously mentioned facts, it can be concluded that the Vlasina microregion is very rich in water resources of the fast mountain rivers, which in turn indicates its great hydropower potential [3]. In the Vlasina microregion exist four large hydropower plants (HPP), Vrla 1, Vrla 2, Vrla 3 and Vrla 4.

LARGE HYDROPOWER PLANTS

Hydropower plant "Vrla 1"

Fig. 1. *HPP "Vrla 1", village Valjavica, 1955 [4]*

HPP "Vrla 1" is located 12 km from Surdulica, near the village Valjavica. HPP

"Vrla 1" uses water from the Vlasina Lake, Vrla River and Gradski Potok. Water from the Vlasina Lake is brought through a pressure tunnel through the entrance building to HPP "Vrla 1" and introduced into turbines. The length of the tunnel is 2065 m, and the pipeline is 1330 m long. The machine building of HPP "Vrla 1" is elliptical in shape and is located underground. The length of the machine building is 68 m, width 13,6 m and height 27 m. HPP "Vrla 1" has four Pelton turbines, four generators and a power of 50.66 MW. HPP "Vrla 1" was installed on November 6, 1955 and produces annually about 95 GWh of electricity. HPP "Vrla 1" produces 0.74 kWh of electricity per cubic meter of water. In the middle rainy year, about $140 \cdot 10^6$ m^3 of water passes through HPP "Vrla 1".

The height difference between the Vlasina Lake and HPP "Vrla 1" is 343 m. Command devices are located underground, while transformers and switchyards are located on the plateau next to the hydropower plant. In the machine building of HPP "Vrla 1" there is a command, distribution of 10 kV and 0.4 kV, accumulator batteries and other devices. On the plateau, in front of the hydropower plant, there is a 110 kV distribution plant through which HPP "Vrla 1" is connected with HPP "Vrla 2" and HPP "Vrla 3" and with the power system of Serbia and Bulgaria. When the water from the lake and its tributaries passes through all four hydropower plants "Vrla 1- 4" 1858 kWh of electricity per cubic meter of water is generated [3, 5].

Hydropower plant "Vrla 2"

Fig. 2. *HE "Vrla 2", village Bitvrđa, 1954 [5]*

HPP "Vrla 2" is located 7 km from Surdulica near the village Bitvrđa. The HPP "Vrla 1" uses water that passes through the HPP "Vrla 1" and the waters of the rivers Vrla, Bitvrđa and Gradski Potok. HPP "Vrla 2" uses the total water drop between elevation 868 m and 710 m, or 158 m. HPP "Vrla 2" was installed in September, 1954. HPP "Vrla 2" starts with an accumulation basin with a volume of 100 000 m^3 of water, just below the outlet waters of HPP "Vrla 1". The accumulation pool was constructed by building a dam over 23 m high and 80.5 m long. The dam is on a rocky ground, with an injected bottom of up to 15 m. The body of the dam is homogeneous, made of slate from the gallery of HPP "Vrla 1" which are firmly packed in layers of 50 cm. On the upstream side is a concrete wall with a reinforced, waterproof screen. Water is brought to the machine building which is above ground, through a tunnel 3568 m long, with a flow of 18 m^3/s.

The hydropower plant has two turbines, two generators and a power of 24 MW. HPP "Vrla 2" produces annually about 51 GWh of electricity. In the middle rainy year, $160 \cdot 10^6$ m^3 of water passes through HPP "Vrla 2". HPP "Vrla 2" produces 0.34 kWh of electricity per cubic meter of water. Transformers and switchyards are located on the plateau next to the building [3, 5].

Hydropower plant "Vrla 3"

Fig. 3. *HPP "Vrla 3", village Masurica, 1955 [5]*

HPP "Vrla 3" is located 2 km from Surdulica near the village Masurica. HPP "Vrla 3" has a gross water drop between

elevation 710 m and 503.6 m, i.e., 206.4 m on the stretch between HPP "Vrla 2" and the machine building located on the right bank of the river Masurica. HPP "Vrla 3" uses water from HPP "Vrla 2", the rivers Romanovska and Masurica. HPP "Vrla 3" was installed in 1955 and comprises two turbines, two generators and has a power of 28.95 MW. It generates about 73 GWh of electricity annually. In the middle rainy year about $195 \cdot 10^6$ m^3 of water passes through HPP "Vrla 3". The HPP "Vrla 3" uses an underground basin in order to avoid expensive work on the protection of the above-ground basin from the sediments of the river Vrla. The machine hall of HPP "Vrla 3" is structurally the same as the one in HPP "Vrla 2". In addition to the plant itself, the 110 kV central distribution plant, the 135 kV central command, the central machine workshop, the main warehouse and the vehicle fleet, part of the technical and other professional services are located in HPP "Vrla 3". VF and UKT telephone connection systems are also located there. The HPP "Vrla 3" monitors the work of the entire Vlasina system of hydropower plants through the central command and connects them to the electric power system of Serbia.

The reservoir for water leveling in HPP "Vrla 3" consists of the labyrinths of underground, horizontal and vertical tunnels, total length of 2000 m and capacity of 50000 m^3 water. HPP "Vrla 3" generates 0.44 kWh of electricity per cubic meter of water [3, 5].

Hydropower plant "Vrla 4"

Fig. 4. *HPP "Vrla 4", villagePolomnear Vladičin Han, 1955 [6]*

HPP "Vrla 4" is located 15 km from Surdulica along the highway in the village of Polom, not far from Vladičin Han. HPP "Vrla 4" uses a water drop of 171 m. Waters from HPP "Vrla 3" and the remaining waters of the Masurica River and some smaller streams pass through HPP "Vrla 4". HPP "Vrla 4" was installedin 1955 and has two turbines, two generators and a power of 24.84 MW. It generates about 68 GWh of electricity annually. In the middle rainy year, $195 \cdot 10^6$ m^3 of water passes through HPP "Vrla 4".

HPP "Vrla 4" differs from other Vlasina hydropower plants with a 35 kV switchyard which, in addition to transmission to the central switchyard at HPP "Vrla 3" is connected to the distribution system of Vladičin Han by a low voltage transmission line. This is very important for the secure supply of electricity to the south of Serbia and the electricity system of Serbia.

HPP "Vrla 4" generates 0.33 kWh of electricity per cubic meter of water. Water leveling for HPP "Vrla 4" was solved by widening the canal in Masuričko polje (450 x 100 x 1.75 m^3) and thus accumulated 60,000 m^3 of water, plus 20,000 m^3 using steel canals. With the last utilization in HPP "Vrla 4" all Vlasina and incidental waters after 25 km from the lake go through a beautifully arranged open canal to the South Morava [3, 5].

TOTAL ANNUAL OUTPUT OF LARGE HYDROPOWER PLANTS

Total annual output of large hydropower plants in the Vlasina microregion in 2019 and 2020 is given in Table 1.

Tab. 1. *The power and total annual output of large hydropower plants in the Vlasina microregion in 2019 and 2020*

Power plant	Power (MW)	Generation (kWh)	
		2019	2020
Vrla 1	50.66	158 089 499	77 623 205
Vrla 2	24	34 139 160	44 582 010
Vrla 3	28.95	53 655 360	71 128 860
Vrla 4	24.84	44 403 639	60 621 120
Total	128.45	190 287 658	253955195

CONCLUSION

Based on the above, it can be concluded that Vlasina microregion is located in the Southeast Serbia close to the Serbian-

Bulgarian border and belongs to the Vlasina river basin. In the Vlasina microregion are located four large hydropower plants Vrla 1, Vrla 2, vrla 3 and Vrla 4. The power of Vrla 1 is 50.66 MW, Vrla 2 is 24 MW, Vrla 3 is 28.95 MW and Vrla 4 is 24.84 MW. The total power of large hydropower plants in the Vlasina microregion is 128.45 MW. The annual output in 2020 year for Vrla 1 is 77 623 205 kWh, Vrla 2 is 44 582 010 kWh, Vrla 3 is 71 128 860 kWh and Vrla 4 is 60 621 120 kWh. The total output of Vrla1-4 large hydropower plants in the Vlasina microregion are 253 955 195 kWh.

ACKNOWLEDGEMENT

This paper was done with the financial support of the Faculty of Sciences and Mathematics, University of Niš, Republic of Serbia, and of the Agreement 451-03-68/2022-14/200124 on the realization and financing of scientific research work of the Faculty of Sciences and Mathematics, University of Niš in 2022 by the Ministry of Education and Science of the Republic of Serbia.

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