BUILDING SMALL HYDRO POWER PLANT IN TERRITORY ELECTRICITY UTILITY "KRUSEVAC" AS A POSSIBILITY FOR IMPROVEMENT QUALITY OF ELECTRICAL ENERGY IN MV

D. Boskovic, Elektrosrbija D.o.o. Kraljevo, Elektrodistribucija Krusevac
R. Jotic, Elektrosrbija D.o.o Kraljevo, Elektrodistribucija Kruseavac

1. INTRODUCION

About 20% electrical energy in the world is produced at hydroelectric power plants. In different countries this percent varies from 0% to 100% and dependences of geographical, climatic and economic factors. Norway, for example, produces almost 100% electrical energy at hydroelectric power plants because of fortune strong sources and terrains convenient for construction large dams. New Zealand produces about 75% electrical energy at hydroelectric power station, while America 10%. Some countries have not got hydroelectric plants at all, because of precisely terrains and faintly existential river's potential. Canada is a country that yearly produces most electrical energy using water and then USA. In Serbia, production of electricity from hydroelectric power plants is about 30% cumulative production. An overview of the small hydropower capacity in Serbia and Former Yugoslav Republics is shown in table 1.

Table 1

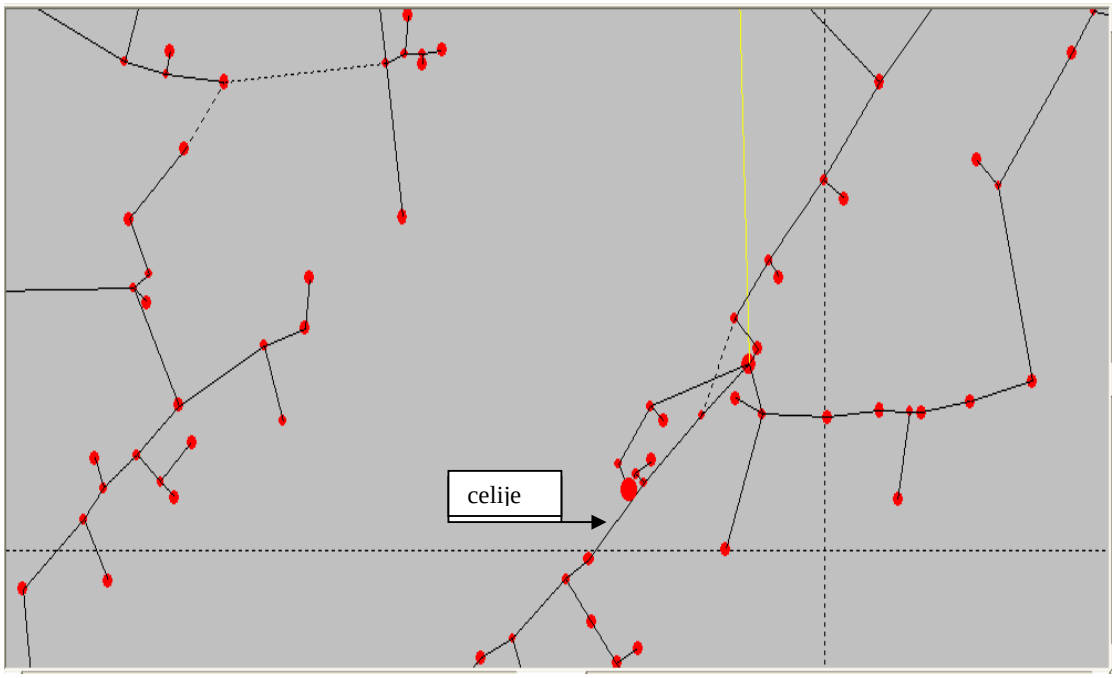
Republic	Number SHPS	Capacity
Bosnia and Herzegovina	192	477 MW
Montenegro	59	184 MW
Croatia	703	182 MW
FYR Macedonia	493	384 MW
Slovenia	392	125 MW
Serbia without Territory	856	443 M

In Serbia there are 814 possible locations (2MW) with altogether installed 287 MW; 2 to 5 MW 35 pieces with installed 112 MW, 5 to 7 MW 7 pieces with installed 44 MW. Small hydroelectric power plants (100 kW) estimated 93 pieces with capacity 21,3 MW. Total number of small hydroelectric power plants (10 MW) in Serbia is estimated about 1000 with installation power of 500 MW.

2. SMALL HYDROELECTRIC POWER PLANTS IN THE ELECTRICITY UTILITY "KRUSEVAC"

There are lot of locations for small and mini hydroelectric power plants in territory electricity utility "Krusevac". Small hydroelectric power plant (4 MW) is located on the river Rasina at location Celije. In context water power system planning for water supply Krusevac with the environment, is built on the river Rasina, earth dam altitude 51,5 m wherewith is cut out accumulation volume about 60 million cubic meters water. Immediately downstream beside the dam existed possibility for building the mechanical building with electromechanical aggregate, turbine, generator and regulation commissioned force (4 MW) where we could produce over 12 million kWh electric energy yearly. The project is economic very valuable, because it's evaluated capital expenditures below 1000 euro per kW so the investment has defrayed only for several years and the sales electrical energy counting the price about 4 euro-cent/kWh.
Some base data about this powerhouse are:
The elevation krone of dam is 285 m altitude, installed issue 10 cubic meters in a second, normal gross fall 45 m, capacity 4 MW, production 12 million kWh for a year, time building 1 year, the type hydroaggregate Francis 1. The function power system planning worked by hydroelectric power plant must not derange, only hydroenergetic can operate water surpluses at accumulation. Water for biological minimum can use through separately small house hydroaggregate with installed issue 0,6 cubic meters water in a second. Operation of accumulation analysis will examine, if it can be right- minded benefit and reserved space at accumulation for defense from flood, what can be relevantly for greatly increase production of electrical energy. Water supply from accumulation through evacuator to hydroaggregate at mechanical building will solve with steely pipe length about 35 m, diameter 1300 mm. The mechanical building will be located on the river bank on the ashore and will be provided for accommodation necessarily equipment and automatic operation without the crew. The outlet waste water is in the river bed through short drain canal. The major and domestic aggregate will be near the building wherefrom will link with the new power cable with dedicated electro distribution network. This small hydroelectric power plant is in the immediate vicinity of substation 35/10 kV "Kupci" and also near 10 kV overhead line "Majdevo" like in picture 1.

Picture 1



The values of voltage in 10 kV electricity network, before building small hydro power station “Celije”, are shown in table 2.

Table 2

Substation 10/0,4 kV	Voltage (kV)	Losses (MW) in 10 kV ele.net.
Majdevo 1	10, 18	0.003
Majdevo 3	10,17	
Celije 2	10,16	
Celije 4	10,14	
Majdevo 2	10,16	
Brana Celije	10,17	

After building small hydro power station “Celije” we will get the following results in 10 kV electricity network in Majdevo (table 3).

Table 3

Substation 10/0,4 kV	Voltage (kV)	Losses (MW) in 10 kV ele.net.
Majdevo 1	11, 07	0.001
Majdevo 3	11,07	
Celije 2	11,06	
Celije 4	11,06	
Majdevo 2	11,04	
Brana Celije	11,04	

As the result of building small hydro power plant “Celije” the voltage in 10 kV electricity network has been increased. Technical losses have been decreased.

3. Mini hydroelectric power station

There are also lot of locations for mini hydroelectric power plants at territory Aleksandrovac on the river Rasina and at territory Brus on the river Grasevka (table 4).

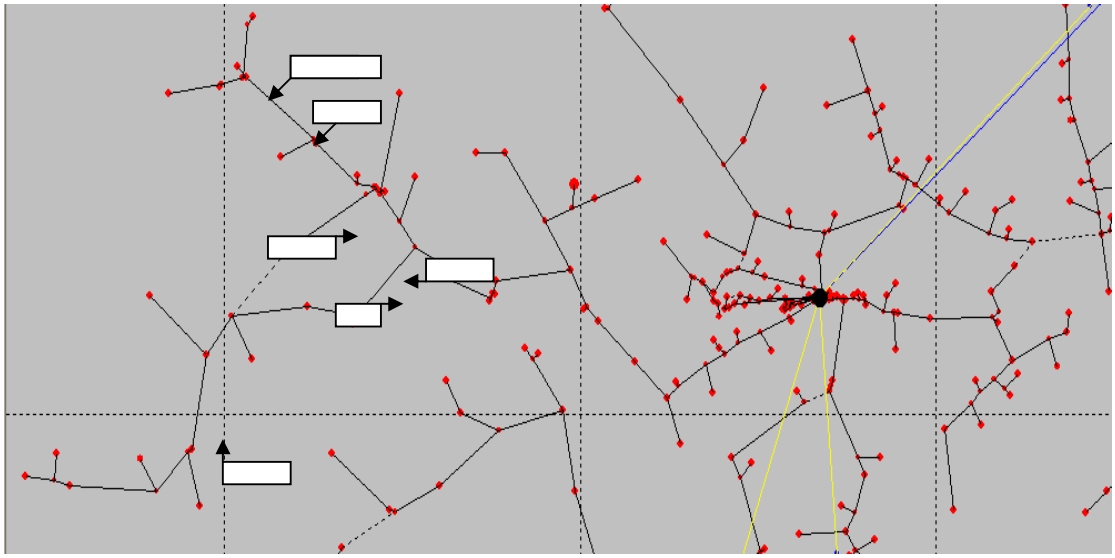
Table 4

Community	Watershed	River	Affluent	Name of MHPS	Land registry number	Power MW	Capacity x1000 kWh
Aleksandrovac	Z.Morava	Rasina	Kriva	Rakići	573	90	400
Aleksandrovac	Z.Morava	Rasina	Koznica	Koznik	410	110	480
Aleksandrovac	Z.Morava	Rasina		Tucanj	416	115	502
Aleksandrovac	Z.Morava	Rasina		Mašinerija	393	115	502
Aleksandrovac	Z.Morava	Rasina	Bundzicka	Vragolija	411	140	612
Aleksandrovac	Z.Morava	Rasina	Kriva	Rokci	572	185	812
Aleksandrovac	Z.Morava	Rasina		Dobroljupci	415	230	1,000
Aleksandrovac	Z.Morava	Rasina	Zagrza	Pogled	412	270	1,176
Aleksandrovac	Z.Morava	Rasina		Bzenica	392	285	1,245
Brus	Z.Morava	Grasev.	Batotska	Lipnjak	399	105	451
Brus	Z. Morava	Grasev.	Grasev-Brzecka	Sikijan	406	115	507
Brus	Toplica	Grasev.	Blazevska	Kovizle	245	118	479
Brus	Toplica	Grasev.	Mala r.	Zarevo	243	122	482
Brus	Z. Morava	Grasev.	Grasev-Brzecka	Gradiste	408	125	565
Brus	Z. Morava	Grasev.	Grasev-Brzecka	Stevanovdo	407	130	574
Brus	Z. Morava	Grasev.	Grasevacka	Brus	400	145	631

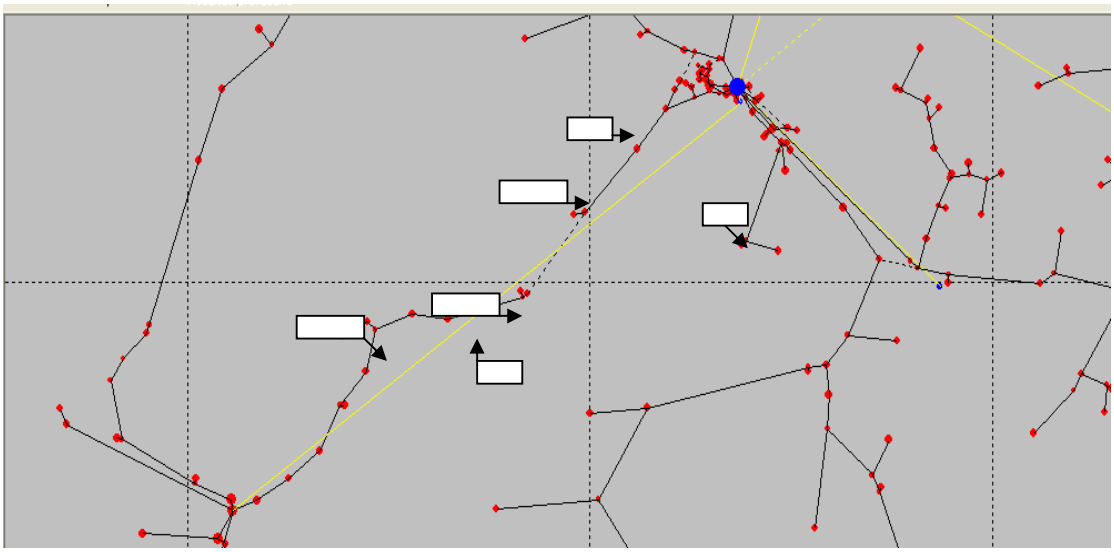
Brus	Z. Morava	Grasev.	Grabovacka	Lansnica	409	145	632
Brus	Ibar	Grasev.	Kriva	Prsici	570	160	705
Brus	Ibar	Grasev.	Kriva	Đurići	571	170	755
Brus	Z. Morava	Grasev.		Ribari	389	210	1,152
Brus	Z. Morava	Grasev.	Batotska	Rakicevici	398	240	1,053
Brus	Toplica	Grasev.		Djerekari	247	272	1,097
Brus	Toplica	Grasev.	Duboka	Ravniste	248	292	1,177
Brus	Ibar	Grasev.	Kriva	Katići	568	300	1,300
Brus	Z. Morava	Grasev.	Grasev-Brzecka	Pešter	404	330	1,445
Brus	Z. Morava	Grasev.	Grasev-Brzecka	Đorđevići	403	335	1,472
Brus	Z. Morava	Grasev.	Grasevacka	Kolenica	401	385	1,691
Brus	Toplica	Grasev.	Blazevska	Belo polje	244	404	1,606
Brus	Z. Morava	Grasev.	Blatasnica	Donje polje	397	415	1,804
Brus	Z. Morava	Grasev.		Lapcevici	385	445	1,948
Brus	Z. Morava	Grasev.	Grasev-Brzecka	Kresaja	405	450	1,975
Brus	Toplica	Grasev.		Stenica	246	456	1,840
Brus	Z. Morava	Grasev.		Segratovica	386	485	2,119
Brus	Z. Morava	Grasev.		Dupci	383	525	2,304
Brus	Z. Morava	Grasev.		Drtevci	388	530	2,322
Brus	Z. Morava	Grasev.	Grasevacka	Vlajkovci	402	555	2,441
Brus	Z. Morava	Grasev.		Mosute	384	665	3,077
Brus	Z. Morava	Grasev.		Bakastak	387	925	4,053
Brus	Ibar	Grasev.	Kriva	Savkovići	569	1,420	3,734

From table 4 it is obvious that the largest number of mini hydroelectric power plants can be found at territory Aleksandrovac and Brus, located on the rivers Rasina and Grasevka. These two rivers are quickly mountain with quite convenient locations for building mini hydroelectric power stations. There is also 10 kV electricity network along both rivers, for supplying mountain villages with electricity. The electricity lines are very long, so it generates large technical losses. The voltages in substations 10/0.4 kV are quite lower than regular so that voltage controls on transformers are adjusted on the last position. It is necessary to build a new substation 35/10 kV as well as overhead line 35 kV if we want to get better voltages in this part of the network. This project is very expensive one, considering that existing lines are under loaded. Because of the enormous length, it also produces technical losses. It is possible to solve this problem with construction of small hydroelectric power plants located beside these electricity lines. As the result, we can expect to improve the state of voltage in the MV network and to decrease the technical losses. Considering that locations of small hydroelectric power plants are situated in the area of the National park “Kopaonik” it will be necessary to fit the hole construction in to the environment of National park.

Picture 2- Mini hydroelectric power plant in 10 kV overhead line Mitrovo Polje



Picture 3- Mini hydroelectric power plant in 10 kV overhead line Vlajkovci



As you can see in pictures 2 and 3 mini hydroelectric power plants are situated near to the overhead electricity line so there is no need to invest in the electricity network. If we analyze the state of voltage in 10 kV electricity line Mitrovo Polje before building mini hydroelectric power station, it will be as in table 5.

Table 5

Substation 10/0,4 kV	Voltage (kV)	Technical losses (MW)
Rogavcina	9,23	0,152
MUP Mitrovo Polje	9,24	
Strmenica	9,26	
Jelakci 1	9,16	
Jelakci 2	9,17	
Jelakci 3	9,17	
Rokci 1	9,18	
Ples 1	9,31	
Bzenice 1	9,28	
Ples 2	9,30	

The last substation 10/0.4 kV in overhead line 10 kV Mitrovo Polje, has poorly voltage value and the generating losses are (152 kW). The full length of overhead line 10 kV Mitrovo Polje is about 60 km, including branches, and the load of the line is about 1,5 MW.
In the table 6 the results, after building mini hydroelectric power plants on the location gave in the table 3, are shown.

Table 6

Substation 10/0,4 kV	Voltage (kV)	Losses (MW)
Rogavcina	9,98	0,112
MUP Mitrovo Polje	9,99	
Strmenica	10,01	
Jelakci 1	9,74	
Jelakci 2	9,75	
Jelakci 3	9,84	
Rokci 1	9,85	
Ples 1	10,15	
Bzenice 1	10,12	
Ples 2	10,06	

It is obvious that, after building these mini hydroelectric power plants, state of voltage in substation 10/0.4 kV is significantly improved as well as the technical losses in the network. These results show us that valid investment to build mini hydroelectric power plant is relative to build new substation 35/10 kV with 35 kV overhead line which the investment would be something less and relative to building mini hydroelectric power plant. Besides improving the quality of electrical energy in this area there is also benefit from the production of electrical energy, what is growing deficit in Serbia.
The overhead line 10 kV Vlajkovci is shorter than overhead line 10 kV Mitrovo Polje, so voltages in substation 10/0.4 kV before building mini hydroelectric power plants are much better. However, building mini hydroelectric power plants in this area is payable because of improving quality of electrical energy and because benefits from production. After building mini hydroelectric power plants, the voltage increases and the technical losses in the network are minimizing.

4. CONCLUSION

The advantages of small hydroelectric power plants, as a renewable energy source, are as it follows:
1. It is the cheapest way for electricity production.
2. The hydroelectric power plant can start with the production very fast, so it can follows quickly increase of consumption and answered in express purposes for power supply.
3. Hydro energy is the most effective because hydroturbine can convert about 97% water energy in electricity, while powerhouse fossil fuel can only about 50%.
4. The growth of fuel price does not affect on hydroenergy.
5. Water is naturally renewable power source irrespective from foreign provision.
6. Waterpower is the major renewable power source and represents about 97% of energy caused from renewable sources.
7. Waterpower is clean, there is no junk, pollution and no affair effect vitreous garden.
8. Artificial lakes made for the purpose of hydroelectric power plants, can be use to improve the economy - fishing and tourism, as well as for irrigation and water supply.

5. LITERATURE

1. Development study, Institute Nikola Tesla 2001,S. Minic, E. Turkovic
2. Cigra, Zlatibor 2005, Small hydroelectric power station, S. Stojkovic