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ENERGETIC POTENTIAL OF THE TRIBUTARY RIKA OF THE VRBAS RIVER IN THE MUNICIPALITY JAJCE

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ABSTRACT
Construction of large accumulations for the utilization of water potential in order to get electricity requires not only large amounts of money but also causes a series of other activities that significantly increase the cost of construction. Along the watercourse is the most fertile land, therefore the biggest part of the settlement is built in those areas, like roads, while river valleys represent the granary of entire regions. The next important problem is the displacement of the population which entails a number of unknowns starting from the choice of the new location of residence to the choice of employment.
The basic concept of the solution starts from the standpoint that, with the simple solutions of small hydropower plants on considered watercourses, at locations with significant concentration of energy, their capacity will be utilized at their maximum in order to get maximal power and energy with the minimal required investment.
Based on the analysis of the gross energy potential and the carried out reconnaissance of the terrain, i.e., on the parts of the watercourse where it was possible, possible solutions for hydropower exploitation have been considered regarding river Rika, right tributary of the river Vrbas.
Keywords: Small Hydropower plant, Watercourse, energy potential, tributary

1. INTRODUCTION
Hydropower capacity is the theoretical value which represents the total power, respectively the energy, of a watercourse regardless of the possible ways of energy utilization and thereby achieved energy losses. Knowing the gross energy potential along the watercourse is the basis for defining the rational utilization of the available water power. The corresponding graphical representation of the relative values of the calculations allows the simple and easy detection of the concentration of the energy potential of the individual stretches of the watercourse and thus refers to the disposition of hydropower facilities [1,2].
Assuming a stationary and uniform flow in the part of a watercourse, it is possible to define its power :

$$\Delta P = 9{,}81 \cdot Q_{tb} \cdot \Delta H \quad (kW) \qquad \ldots(1)$$

respectively its energy:

$$\Delta E = 9{,}81 \cdot Q_{tb} \cdot \Delta H \cdot \Delta t \ (kWh) \qquad \ldots(2)$$

where:
Q_{tb} – Average water flowing through the turbine in time unit (m^3/s),
ΔH – head – effective pressure of water flowing into the turbine (m),
Δt – interval time (h).

Integrating the two expressions above, between the delta and the spring, we obtain the total theoretical energetic capacity of the watercourse. This includes utilization of the entire potential quantities and the overall available head and the constant increase in discharge between two points. To calculate the energetic capacity it is necessary to understand the function of the distribution of the discharge along the flow (Q_{tb} = f (L)) for the studied watercourse [4,5]. This dependence is given pulsed function whose analytical expression is difficult to establish, so the energetic capacity is calculated using discrete changes in the value of the head and discharge at each point of the longitudinal profile. The growth rate in discharge between points of the watercourse is taken as linear by the length of the flow, taking into account the jumps on the locations of the tributaries.
The conducted calculations of the energetic capacity of the considered watercourse is given in Table 1.

Table 1. Display of a part of the calculations of the energetic capacity of the tributary Rika on the point from 17800,4 m to 15359,2 m.

Changes in lenght.	lavel	dL	dH	dH/dL	Q_{tb}	dQ/dL	dP	∑ P	dE	∑ E	E
m	a.s.l	m	m	m/m	m3/s	m3/s/m	kW	kW	MWh	MWh	MWh/m
17800,4	880,0				0,132						
17577,1	870,0	223	10,00	0,04	0,143	0,000049	13,5	13,5	118,2	118,2	0,529
17410,8	860,0	166	10,00	0,06	0,151	0,000049	14,4	27,9	126,4	244,5	0,760
17359,2	850,0	52	10,00	0,19	0,154	0,000049	15,0	42,9	131,0	375,5	2,539
17172,0	840,0	187	10,00	0,05	0,163	0,000049	15,5	58,4	136,0	511,6	0,727
16955,4	830,0	217	10,00	0,05	0,174	0,000049	16,5	74,9	144,6	656,2	0,668
16865,4	825,0	90	5,00	0,06	0,178	0,000049	8,6	83,5	75,5	731,7	0,839

Relations between the characteristic values of the watercourses Rika are illustrated by the following diagrams [3]::
- hydraulic longitudinal profile of the watercourse, Figure 1.
- growth of the fall height along the river Rika (ΔH/ΔL), Figure 2.
- increase in flow along the length of watercourses Rika (ΔQ/ΔL), Figure 3.
- increase in flow depending of the height along the river Rika (ΔQ/ΔH), Figure 4.
- gross energetic longitudinal profile in kW - summary P-H diagram (ΣP), Figure 5.
- gross energetic longitudinal profile in MWh - summary E-H diagram – (ΣE), Figure 6.
- specific hydropower potential of river Rika, GWh/km, (E), Figure 7.

For the listed calculations topographic maps at scale 1 : 25.000 were used.

2. DISPOSITION OF HYDROENERGETIC CAPACITY ALONG THE FLOW OF THE WATERCOURSE RIKA

The total natural energetic capacity of the flow Rika is 2981 kW respectively 3.0 MW or expressed in units of energy 26110 MWh respectively 26.11 GWh, which gives on the total length of 17.8 km and a total drop of 530 m a mean value of specific energetic capacity of
1, 47 GWh/km.

Tributary Rica has four interesting move for hydroenergetic utilization: [3]:
The first segment is the elevation of 880 a.s.l. to elevation 670 a.s.l., gross head of 210 m, respectively from the location 14178 m to the location 17800 m, the length of the watercourse.
The total energetic capacity of this stretch is 375 kW, or expressed in units of energy 3290 MWh respectively 3.3 GWh.
The second segment starts from the elevation of 635 a.s.l. to elevation of 537 m a.s.l., gross head of 98 m, respectively from the location 9447 m to the location 12557 m. the length of the watercourse.
The total energetic capacity of this stretch is 549 kW, or expressed in units of energy 4812 MWh , respectively 4.81 GWh.
The third segment starts from the elevation of 520 m a.s.l. to the elevation of 440 m a.s.l., gross head of 80 m, respectively from the location 5548 m to the location 8417 m.
The total energetic capacity of this stretch is 724 kW, or expressed in units of energy 6342 MWh, respectively 6.34 GWh.

The fourth segment starts from the elevation of 435 m a.s.l. to the elevation of 387 m a.s.l, gross head of 48m, respectively from the location 2532 m to the location 4932 m.
The total energetic capacity of this stretch is 543 kW, or expressed in units of energy 4753 MWh, respectively 4.75 GWh.

Sudden leaps of the specific energetic capacity can be explained by the increase of the head on a small part of the river, which can be seen by comparing the diagram of the growth rate of the head along the length of the flow with the disposition of specific energetic capacity along the flow Figures 2 and 7
For variant solutions for the exploitation of the basin of the river Rika and conducted calculations there have been determined total investments for each considered small hydroelectric power station. In Table 2 there are given the energetic-economic characteristics of the analyzed variants and their order on the basis of investments, respectively the investment ratio, in produced kWh.

Tabela 2. Energetic-economic characteristics of the analyzed variants on the tributary Rika

Watercours		Tributaries Rika			
Small Hydro Power		Dubrave	Zečjak	Šerići	Bukovica
Installed power	kW	271	495	695	355
Annual production	E_{anu}(GW)	1.363.666	2.472.175	3.400.280	2.001.594
Total investment costs	KM	1.350.207	2.050.531	2.751.612	2.106.267
Specifik investment costs	(KM/kW)	0,99	0,83	0,81	1,05
Ranking of the best investments		3	2	1	4

From Table 2 it is evident that the specific investment, the ratio of total investment and annual energy production at the site Šerići with a investment quotient of 0.81 is the most advantageous with the greatest return on the investment.

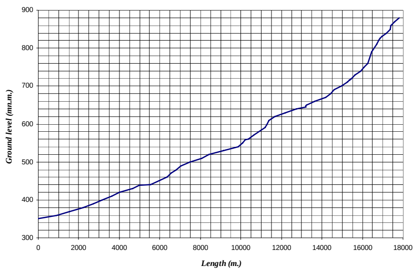

Figure 1. Hydraulic longitudinal profile of the riwer Rika

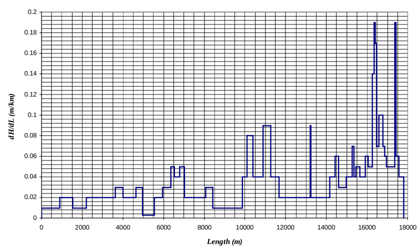

Figure 2. Growth of the fall height along the river Rika

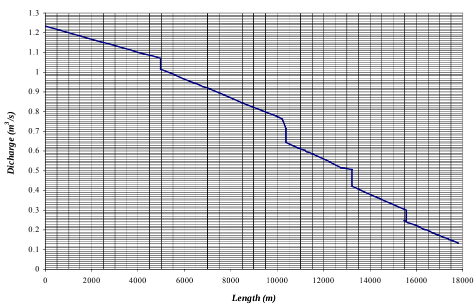

Figure 3. Increase in flow along the length of watercourses Rika

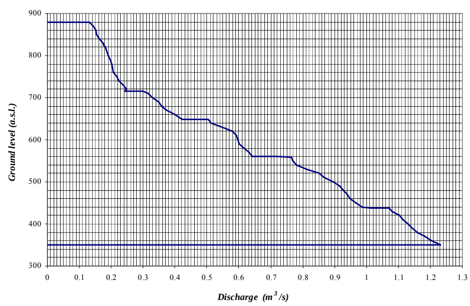

Figure 4. Increase in flow depending of the height along the river Rika

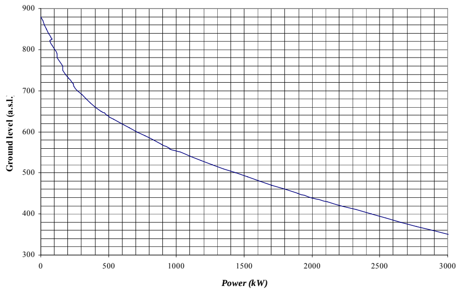

Figure 5. Summary P-A (Power-Altitude) diagram of the watercourse

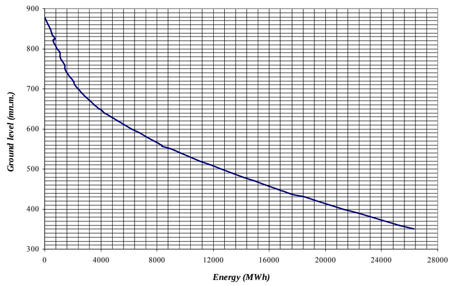

Figure 6. Summary E-A (Energia-Altitude) diagram

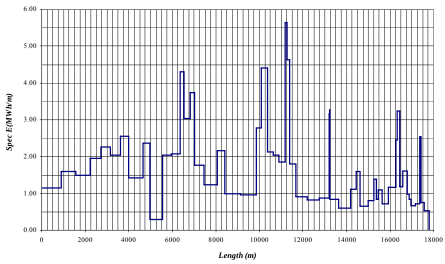

Figure 7. Specific hydropower potential of river Rika

3. CONCLUSION

During the processing of technical solutions, certain plant facilities, standardisation of facilities has been realised where the conditions of construction permitted it.

The most important items that are a burden for investments, for pressure plants, are the inlet pipelines, because they are long pipeline over one kilometer, and the access roads that need to be built because of the inaccessibility of most foreseen location of the facilities.

Regardless of how much the production of small hydropower plants is marginal in terms of F BiH's electroenergetic power system , and the relatively high specific investments, they have their own strategic importance in emergency situations, because they enable independent power supply for smaller areas and cities. During the setting of these small hydro power plants guidelines were followed to ensure that the same power plants wouldn't get placed in populated places, that there won't be usurpation of arable land, and that during the commissioning of the plants legally defined biological flow in the part of the river that goes along the pressure pipeline will be provided.

4. REFERENCES

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