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PIPELINE OF DRINKING WATER BREZA AS A POSSIBLE SOURCE OF ENVIRONMENTAL POWER

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ABSTRACT
The increasing need for electricity has promted people to use different raw materials for its production, with no consideration, at the same time, the consequences that occurred in thedisruption of balance of the environment. Responses from the nature prompted the researchers and investors around the world to explore and invest in other, less harmful energy sources, even if they are not significantly profitable than the existing ones. Among these alternative sources are small energy hydroelectric plants incorporated into new or existing water supply network. As Bosnia and Herzegovina is among the countries which are mainly supplied with drinking water from natural sources and water intake are at higher altitudes of water treatment plant, we'll investigate the possibility of electricity generation in these systems. For example, water supply Breza. We will illustrate the possibility of economic feasibility of installing small power plants into the existing pipeline of drinking water in Breza. Based on the geodetic profile pipeline realistic calculations were done with an effort to engage all relevant factors that impact on the energy efficiency of water.
Keywords: Small hydro power plants, electricity, gross height, net height, hydraulic longitudinal profile, pipelines.

1.INTRODUCTION

The use of drinking water to produce electricity before it is supplied to the consumer, has long been known. It is probably the most environmentally friendly production of renewable energy that you can imagine, since it is an ancillary use of the vital water supply. The greatest potentials lie in the mountain area where the water supply is ensured primarily through the use of sources. If the sources are higher than the reservoir of supplies, usually wells or crushing pressure reducing valves are used to run the lines with the usual pressure ratings up to PN16 (160 m water column). Instead of destroying the energy in the printing equipment, they can be converted into mechanical and electrical energy and can be fed into the grid [1].

Further potential lies between two pressure zones in a village network, which is located on a slope. If spring water from the reservoir to an upper pressure zone transfers in the lower, the lower reservoir can be used in parallel with the controlled pressure holding a turbine. This is the ideal case, because the connection lines are usually dimensioned sufficiently large and out of the turbine and generator control and nothing is more needed.

In hilly areas, the reservoirs are of the highest consumers. Between such a reservoir and the lower-lying urban areas often reducing valves are available which bring the line pressure to the level of the city network. Also this pressure reduction can be achieved with a turbine. It does, however, a turbine that can operate under the pressure of the pipe network, yet also varied [1].

2. DRINKING WATER POWER PLANT

The hydroelectricity production is an energy conversion process in which the water is an efficient vehicle of transmission and transformation of the gravity potential flow energy in mechanical and electric energy. In this way, the available potential energy or gross head (Hg) will be converted through the main following components of the hydropower system Figure 1. [2].

Reservoir: constitute a storage form of the available potential energy.

Conveyance system that includes the intake, conveyance circuit (i.e. canal, penstock, galleries andtailrace or outlet).

Hydraulic turbine: where the net head is totally converted into kinetic energy of the flow that by impact on the runner (for impulse turbines), allows converting it into the rotor speed of the turbomachine.

Generator rotor: the mechanical energy transmitted to the shaft maintain the speed of the rotor producing electric energy according to electromagnetic laws.

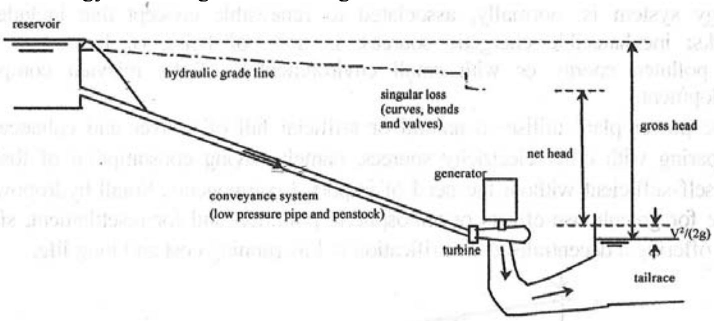

Figure 1. Components of a hydropower sheme

Potential and kinetic energy of a mass of water flowing from a higher level to a lower level can be converted into electrical energy. The hydrological potential of water is determined by two parameters: flow (Q) and head (H)

The Flow (Q) - expressed in m^3/s - is the volume of water flowing through a givencross-section of the stream per second.

The Gross Head (H_g) is the vertical distance between the top of the penstock that conveys the water under pressure and the point where the water discharges from the turbine. The turbine's actual head is less than the maximum, due to losses caused by friction with construction elements and the internal friction of the water.

The energy of the jet of water flowing through a pipe is specified by Bernoulli's rule [3]:

$$H = z + \frac{p}{\rho g} + \frac{v^2}{2g} + \Sigma H_v. \qquad ...(1)$$

vhere H is - The Gross Head, z- potential energy described by head, $p/\rho g$- energy of a pressure, $v^2/2g$ – kinetic energy, ΣH_v - hydraulic energy losses.

In practice, during the flow some energy is lost due to friction against the walls of the channel and specific internal friction determined by the viscosity of the liquid. These energy losses can be calculated by formula [3]:

$$H_v = \frac{v^2 L}{K^2 \left(\frac{D}{4}\right)^{\frac{4}{3}}} \qquad ...(2)$$

H_v - friction losses, K - roughness factor, D - the diameter of the pipe, L- length of pipelines.

The friction coeficient of the pipe walls (determined by the material, in this case the wall is made of HDPE and K-value is 100) is of great importance [3]. For the laminar flows and tubular draught of inlet water, the energy losses are proportional to the speed of the water and inversely proportional to the square of the diameter of the pipe. The available net head is so, [3].

$$H_n = H_g - \Sigma H_V - \frac{v^2}{2g}. \quad ...(3)$$

The conversion of the energy potential of the water into electricity requires a turbine (potential and kinetic energy into mechanical energy) [rotation] and a generator [rotation into electrical energy]. The output of a hydropower plant is given in terms of power [kW] and electricity production [kWh]. The result can be calculated as follows [4]:

$$P = \eta_{tot} \, Q H_n \rho g. \quad ...(4)$$

$$\eta_{tot} = \text{total efficiency } (\eta_{turbine} \; \eta_{generator} \; \eta_{\text{speed increaser}} \; \eta_{trafo}). \quad ...(5)$$

P - electrical power [W], ρ - water density, (1000 kg/m^3) , g - acceleration of gravity,
g = 9.81m/s^2, Q - flow volume of water, flowing through the turbine in time unit, [m^3/s],
H_n - head - effective pressure of water flowing into the turbine [m].
η_{tot} is the global efficiency of the plant. ($\eta < 1$).
When estimating the power of small hydro units, the global eficiency is usually assumed to be η_{tot} = 07-08. The annual electricity production of a Hydropower station is approximately calculated as [5]:
E (kWh) = 0,95 P (kW) 8760 (h). ...(6)

4. CALCULATION EXAMPLE FOR DRINKING WATER POWER PLANT BREZA
In Table 1. provide data on water supply Breza, current situation and the two variations as well as calculated values required for the selection of turbine and power plant. Figure 2. given hydraulic longitudinal profile of the considered pipeline [6].

Tabele 1. Details of the project and suggestions

Parameter	Section I			Section II			Section III	
	Current state	Variante 1	Variante 2	Current state	Variante 1	Variante 2	Current state	Variante 1
Length of pipelines (m)	3697,40	3697,40	3697,40	5751	5751	5751	3414	3414
Diameter pipes (m)	0,200	0,200	0,350	0,200	0,200	0,292	0,292	0,292
Gross Head(m)	97,90	97,90	97,90	98	98	98	35,71	35,71
Friction loss (m)	129,65	18,40	3,69	114	20,03	15	9,1	4,02
Net head (m)	-	79,5	94,21	-	77.97	83	26,61	31,69
Flow (l/s)	79,70	30	60	60	25	60	60	40
Flow velocity (m/s)	2.54	0,96	0,623	1,91	0,8	0,90	0,90	0,60
Elektrikal power(kW)	-	16,3	38	-	13,30	34	10,9	8,70
Annual energy (kWh)	0	135648	316236	0	110682	297840	90709,8	72401,4

Section I: Friction losing self constructed, about 129 meters turbine installation does not make sense. With existing pipeline, can be run turbines with about 30 l/s, with a net pressure of approximately 7,9bar. The Turbine would then generate an electrical output of 16,3kW. The alternative is to enlarge the pipe to 350mm. Then can 601/s be achieved and a net pressure of 9,4 bar with an electrical power of 38 kW.
Section II: Friction losing self constructed, about 114 meters turbine installation does not make sense. With existing pipeline, can operate a turbine with 25 l/s cash on a net gap of about 7,7 bar. The turbine would then generate an electrical output of 13,30 kW. The alternative is to enlarge the pipeline of 300 mm. Then pipeline can reach at 60 l/s and a net pressure of 8,3 bar an electric power of 34 kW. Section III: Friction losing self constructed 9,1 meter. Turbine plant is possible, about 26 meters in height with the effective discharge of 60 l/s of water can produce 10.9 kW of electricity. Such a plant costs approximately 20.000 € .The estimate revenues, the energy price 0,1434BAM ≈ 0,073€ may be assumed. When the Plant efficiency is assumed to be 95%, the revenues will be for curent state:

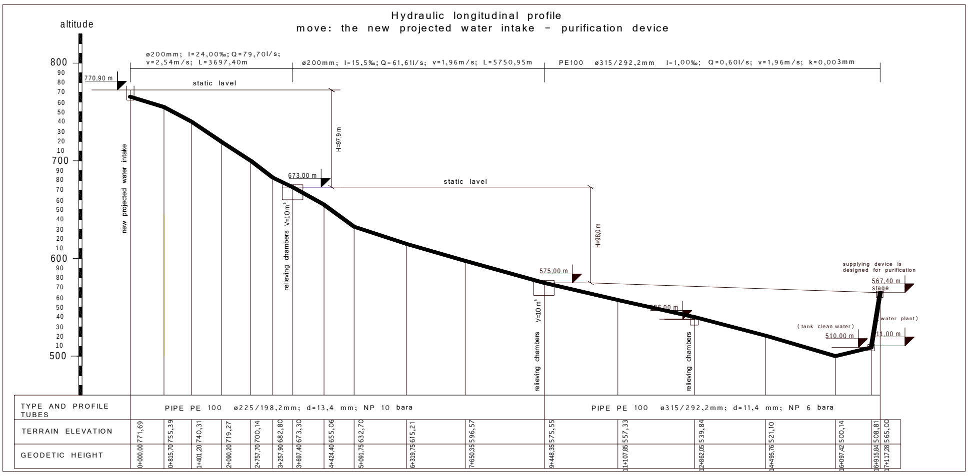

Figure 2. Hydraulic longitudinal profile of the pipeline, drinkig water Breza

E = 0,95 x 10,9kW x 8760 h = 90709,8 kWh. ...(7)

For variant 2 sections I and II and the current state of Section III:

E = 0,95 x 82,9 x 8760 = 689893,8 kWh. ...(8)

Cost price for existing state facilities and the production of the 11kWh is 22 000€ or approximately 2000/per kW instalid power. The cost level of 1000-2000€/kW is typical [4].

5. CONCLUSION

The existing water supply Breza can be fitted only to the third stage of the power plant 10,9kW the year for 8322 hours gives 90709,8 kWh electricity. As for the projected cost of 0,1434 BAM/kW gives a total annual income of 13007,78 KM/Year. Total investment for the power plant is amounted to 50000 BAM, which would be paid for four years. Depreciation time of the plant is 20 years [7].

At the time he designed this pipeline is not considered the possibility of the plant to produce electricity. From the considered variants of Table 1 (option 2) can be seen that the choice of a larger diameter pipe, it is possible to get a substantial amount of electric power and profitability of the project.

6.REFERENCES

[1] P. Eichenberger, Trinkwasserkraftwerke - Einsatzmöglichkeiten, Erfahrungen und Wirtschaftlichkeit mit der kostendeckenden Einspeisevergütung (KEV), Zeitschrift vta aktuell, Ausgabe, 2009.

[2] Ramos H., Betamio De Almeida A.: Small hydropower schemes as an importantant renewable energy source. Taken from http://www.civil.ist.utl.pt (accessed 25.05.2010.).

[3] Wahl, Dimensionirung und Abnahme einer Kleinturbine, Pacer, Copyright Bundesamt für Konjunkturfragen, 3003 Bern, Oktober, 1995.

[4] W. Bodrowicz.:Small Hydro Power-Investor Guide, koncern Energetyczny SA, Autumn, 2006.

[5] ESHA, Environmental integration of small hydropower plants. Taken from http//www.esha.be/ (accessed 28.05.2010.).

[6] Hidraulični uzdužni profil, projektna dokumentacija vodovoda Breza.

[7] Kleinwasserkraftwerke, Pacer, Bundesamt für Konjunkturfragen, 3003 Bern, Mai 1993.