Promotion of renewable energy in Rosia Career

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Abstract

This paper will present a renewable energy solution, using the potential energy of water results from the aquifer formations by dewatering the mining area of the Roşia Jiu in order operating safely of lignite deposit. In the perimeter of the Rosia Jiu the exploitation of lignite is realize in heavy hydrogeology condition, the quantities of waters comes from three different sources:

- *Surface water from precipitation inside the perimeter as well as the surrounding areas with positive landforms - a seasonal sources but can be torrential,*
- *The water coming from aquifers with hydrostatic level to download free natural slopes of working career, and is collected and routed to specific work stations for evacuation pump stations outside the perimeter,*
- *The water from captive horizons and horizon artesian pressure in layer V couch horizons are tension release by specific works, the water from this work are directed to the central station pumps.*
- *The disposal of water from Rosia Jiu area is realize by some high capacity pumps station to the guard channel that are build on the contour perimeter, water that are disposal trough these to the Jiu river.*

The volume of water discharged from the perimeter Rosia Jiu in the one year reported to one extracted lignite tones is 6:1 m3/tone.

Key Words: renewable energy, water storage basin, micro hydroelectric power plant, hydropower potential.

1. Hydrological potential of the perimeter of the Jiu

The perimeter Rosia de Jiu is situated on the administrative territory of village Farcasesti and the rest of it is situated on the administrative territory of the town Rovinari, at 25 kilometers south of Targu-Jiu, Gorj county, Romania.

In order to operate safely the lignite deposits from the perimeter Rosia de Jiu, in the superior aquifers horizons of the VII lignite layer was applied a preliminary method of dewatering through a system of 10 lines of drilling. The drainage works of the aquifer horizons in the perimeter Rosia de Jiu started in 1969 with large diameter drainage drillings placed on the career's edge, equipped with submersible pumps [1].

The waters coming from the process of tension release of the artesian aquifer horizon and from the dewatering of the other aquifer horizons are collected in storage basins – Fig. 1 (sumps) and evacuated from the career through 18 high capacity pump stations.

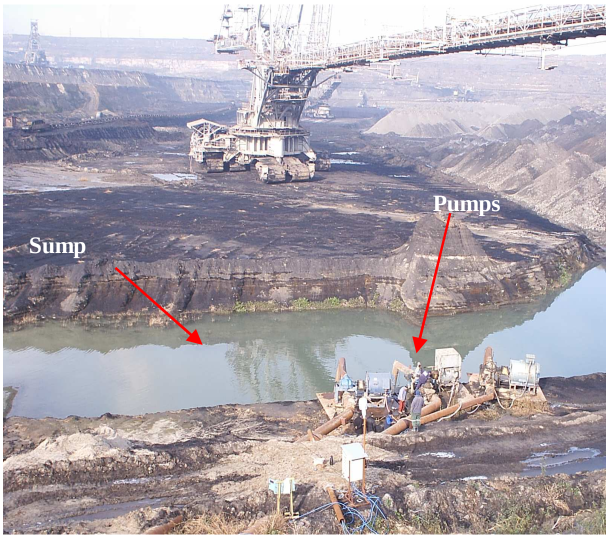

Fig. 1. General view of catchments of water – pump station system

Based on natural factors (morphological, geological, petrographic, stratigraphic, structural, geotechnical, hydrogeological) the lignite deposit of the perimeter Rosia de Jiu was classified as class II of geological complexity [2].

The drainage of groundwater aquifers from the career Rosia de Jiu was achieved with 10 lines of drainage parallel to the front of advance in career. These drainage

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lines were completed with 20 drillings which drained individually only the groundwater aquifer.

Considering the hydrodynamic calculations about the sizing of the irrigation scheme of the groundwater aquifer were dimensioned 10 drainage drillings located on the outer contour of the career on an alignment of about 1000 meters starting from the distribution node zone and extending to the old riverbed of the river Jiu. The average length of these drillings is 24 meters situated at a distance of 100 meters.

The evacuation of the water from the draining drillings of the groundwater aquifer is expected to be realized through a gathering pipeline to the concreted canal.

The analysis of geological and hydro geological conditions of the lignite deposit from the perimeter of the career Rosia de Jiu showed that the exploitation of the V layer is conditioned by the tension release of the artesian aquifer below the allowable pressure supported by the protector screen from the floor of the seam.

The hydrodynamic calculations done to establish the oscillation of level and sizing equations have established the necessity to execute 15 drillings for tension release, located on 3 drainage alignments parallel to the excavation technological lines. The distance between the alignments is 140 meters, the drillings being situated at a distance of 167 meters on the alignment.

In order to check the process of tension release of the artesian aquifer were provided two drillings located on the final slopes North and South at depths of 64.05 meters and 83.93 meters [2].

For draining the aquifer from the production complex, after making the calculations resulted a number of 31 drillings located on two alignments.

From the tension release and drainage works above important amounts of water are discharged. So, at the level of the year 2010, the volumes of water evacuated from the career Rosia de Jiu have the values shown in Table 1 [2].

Tabel 1. Quantities of water evacuated in 2010

Volumes of water evacuated in 2010	Artesian aquifer[m^3]	Superior artesian aquifers[m^3]	Total
January	1.082.691	241.313	1.324.004
February	1.142.400	238.495	1.380.895
March	1.156.323	210.768	1.367.091
April	1.094.741	166.213	1.260.954
Mai	1.060.469	214.546	1.275.015
June	1.076.533	207.281	1.283.814
July	1.083.496	212.874	1.296.370
August	1.066.895	220.607	1.287.502
September	1.062.076	206.792	1.268.868
October	1.074.392	222.201	1.289.924
November	1.076.266	213.658	1.289.924
December	1.065.556	210.625	1.276.181

2. Theoretical aspects of the hydropower potential capitalization [3]

The energy of hydro origin is part of the renewable energies category. Hydropower potential means the energy equivalent corresponding to a volume of water in a fixed time period (1 year) on a specified surface (area). Hydropower potential can be classified into several categories:

- theoretical hydropower potential (gross):
  - of surface
  - of rainfalls
  - of flows
- linear theoretical potential (of rivers)
- technically arranged
- economically arranged
- exploitable.

The theoretical hydropower potential is considered to be the energy equivalent to the volume of water without introducing the losses of energy associated with the practical use of this potential, as the efficiency of conversion into mechanical energy and/or electrical would be 100%.

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The technically arranged hydropoer potential represents the production of electric energy that could be obtained by arranging a water course (in full or on a section) corresponding to a certain stage of development of the associated technologies

The economically arranged hidropower potential represents that part of the arranged technical potential that can be capitalized by efficient economically arrangements. The economically arranged hydropower potential is the measure most often modified, being influenced by the technical progress, the type of plants, the dynamic of plants, the territorial location of primary energy sources and mainly the economical conditions of the country ore region. That`s why the value of this potential must be reported to a certain date, and the evaluation must be repeated periodically. The exploitable hydropoer potential represents the part of economically arranged potential which can be effectively exploited if one takes into account the environmental impact restrictions.

To be able to use the potential of a sector of the river on a 1-2 sector is needed to achieve a concentration of power in section 2 (Figure 2).

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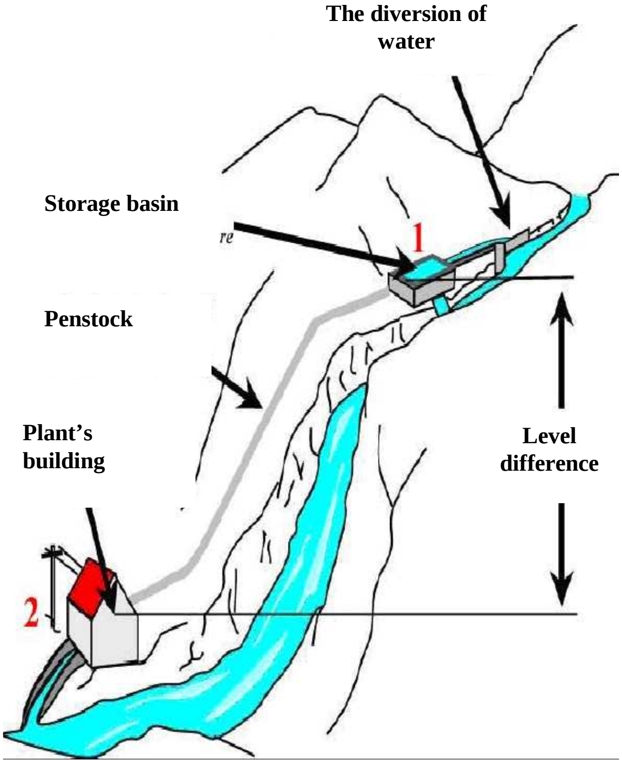

Figure 2. Sketch of a hydropower harnessing

The concentration refers to the intensiv factor (fall).

The linear theoretic potential is calculated generally using the multi-annual awerage flow of the analysed river. In this potential the calculs are determined according to the formulas:

$$P = 9{,}81 \cdot Q_m \cdot (Z_1 - Z_2)[kW]$$
$$E = 9{,}81 \cdot Q_m \cdot (Z_1 - Z_2) \cdot n[kWh] \quad (1)$$

where:

- Q_m - the annual average flow of the river analyzed [m^3/s]
- Z_1 - share of the river upstream sector [m]
- Z_2 - share of the river downstream sector [m]
- n – number of hours of function [h].

The arranged technical potential is that part of the theoretical potential can be capitalized transforming the hydraulic energy of the rivers into electricity by hydropower arranging the sector of the river analyzed.

If it's calculated the technical potential of the same sector of the river it will be obtained the value of the energy that could be produced using a sector of river as follows:

$$E = 9{,}81 \cdot \eta_{total} \cdot Q_m \cdot (Z_1 - Z_2) \cdot T \quad (2)$$

where:

- Q_m – the multi-annual average flow for that sector [m^3/s]
- T – time for calculating (for annual energy it takes 8760 hours)
  - o η_{total} – total efficiency per plant consisting of:

$$\eta_{total} = \eta_h \cdot \eta_t \cdot \eta_g ,$$

where:

- η_h - hydraulic efficiency
- η_t - the efficiency of the turbine or generator
- η_g - the efficiency of the generator

3. Technical and functional aspects of capitalizing hydro energy

In a **microhidroelectric power plant** (**MHPP**) available potential energy or the gross falling is converted into electric energy through the main components of the hydropower system schematically represented in figures 2 and 3.

The main components of **MHPP** are:

Storage: is a form of storage the available potential energy.

The transfer system: includes the water intake (equipped with grill) and the transfer circuit (channel, penstock, galleries and disposal) where a part of the available energy is converted into kinetic energy.

Hydraulic turbine: is the component of the plant where hydro energy is converted into mechanical energy

Generator rotor: the mechanical energy transmitted through the transmission shaft to the rotor leads to producing electric energy, according to electromagnetic laws.

Line of connection to the network: through it **MHPP** is connected to the network to provide electricity to consumers.

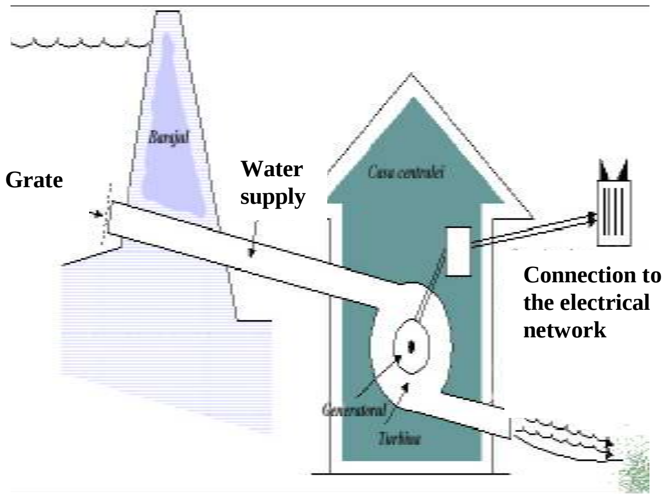

Figure 3. Scheme of micro hydroelectric power plant

The power that a hydro plant can produce depends on the fall, for example the height H[m] water comes from (figure 3) and on water flow Q [m^3/s]. The fall determines the available potential energy of a location. The river flow represents the volume of water [$m^{3]}$ that crosses a transversal section of the river in a second. The available gross theoretical power (P[kW]) can be then calculated using a simplified relation:

$$P = 9{,}81 \cdot Q \cdot H[kW] \qquad (3)$$

However, energy is always lost when this is converted from a form to another. The small water turbines rarely have efficiencies greater than 80%. The power will be lost also in the pipeline through which the water goes to the turbine due to the friction losses.

The water must be stored in a reservoir in order to a hydraulic central delivers at order, or to realize a load range, or to provide power at the peak of the daily task graphic. If a natural lake can't be closed, the providing of the storage space implies building a dam or dams and creating several new lakes. For micro hydroelectric power plants isn't generally speaking economically feasible creating new lake for accumulation, maybe only excepting isolated locations where the value of energy is very high. Storage, for a micro hydroelectric power plant is generally limited at small amounts of water from a new lake for accumulation or from an existing one. The term used to describe accumulations of small volumes of water is **compensation tank.**

In schemes of small falling, there are two possible configurations. One uses weirs, although the channel is, most of the time, short and the penstock short or nonexistent (figure 4). The other configuration requires a dam with an integral water intake and the plant's building (figure 5).

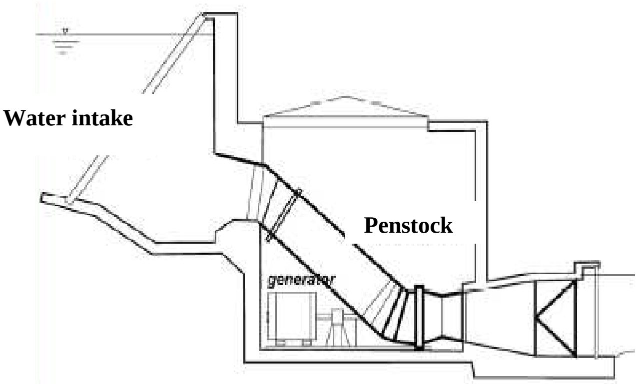

Figure 4. Scheme with derivation dam and penstock short

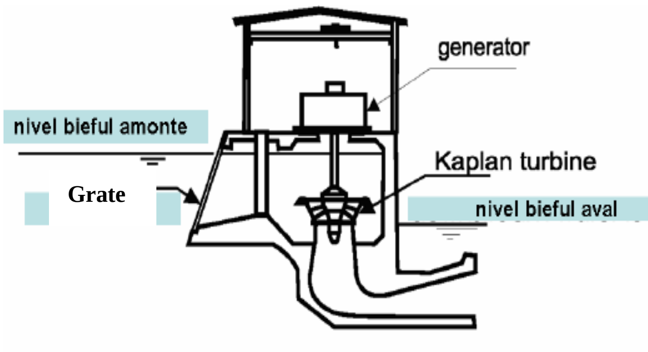

Figure 5. Scheme with integral water intake plant's building

4. The main components of a microhidroelectric power plants (MHPP)

A microhidroelectric power plants can be described as two major categories:
- civil works (building itself)
- mechanical and electrical equipments

Civil works

The main civil works to improve a micro hydroelectric power plants are: the dam or the weir, the pipelines to transport the water and the building of the electrical plant (figure 3). Basically, in order that the project of a SHP has minimum costs, the most important concerns are on the simplicity of the project, focusing on practical and easy to do civil buildings. The dam or the weir makes a reservoir, directs the water into a channel, a tunnel, a valve or into the entry to the turbine. The cost of a dam to realize a large storage of water can't be normally justified for micro hydroelectric power plants projects, so it is used a simpler building, a small deviation dam, or a wire. The construction can be of concrete, wood, bricks, local materials or a combination of these materials. Further substantial efforts are made to lower the cost of dams and weirs for the micro hydroelectric power plants projects, because often this cost can make a project unprofitable.

Hydraulic line in a micro hydroelectric power plant includes:

A water intake which includes the grate for floats, a gate and an entrance into a channel, into a penstock or directly into the turbine, depending of the type of planning, The water intake is generally built of reinforced concrete, the grate of steel and the gate of wood or steel. A channel and/or a culvert tunnel and/or a penstock which lead the water to the electric plant, to the improvements where this is situated at a random distance downstream the water intake. The channels are generally excavated by drilling and they follow the contour of the land. The tunnels are underground and are excavated by drilling, explosions or using a drilling machine. The penstocks which transport water under pressure can be made of steel, iron, fiberglass, polymer, concrete or wood. The entrance and the exit of the turbine, which include valves and the gates needed to stop the access of water to the turbine, for stopping the plant and for technical revisions - those components are generally made of steel or iron. The gates downstream of the turbine, if they are necessary for revision can be made of wood. The running channel which transports the evacuated water from the turbine back to river – is realized by excavation, also the supply channel.

The building of the plant contains turbines or the turbines and most of the mechanical and electrical equipment. The microhidroelectric power plants buildings are usually realized at dimensions as small as possible, but having a strong foundation, access for maintenance and safety. The main mechanic and electric components of a microhidroelectric power plants are the turbine and the generator.

5.Conclusions

Microhidroelectric power plants design needs technical and financial studies in order to determine if a location is technically and economically feasible. These studies are related on:

- Topography and geomorphology of the location,
- Assessment of water resources and their potential
- Choosing the location and basic arrangements,
- Dimensions, choices, projects for the turbines and the hydraulic generators and also associated control equipment,
- Measures for environmental protection and reduction of the impact,
- Economic evaluation of the project and of the financial potential,
- The institutional and administrative procedures in order to obtain the necessary permits.

In order to decide if a scheme is viable it is necessary to begin the evaluation of the water resources existing in the location. The energetic potential of the scheme is proportional to the multiplication of the flaw and fall. The grass fall can be considered generally constant, but the flaw varies during the year.

The purpose of this work is to show that there is the possibility of capitalizing the waters from Rosia de Jiu, which, as it is shown in table 1, have considerable values.

The advantage of this approach is that, during flow calculation, are not taken into account the recipitations, because the water collected from the career comes from the drillings made in the aquifers horizons and, in a very small measure, from precipitations.

Regarding to the civil constructions that must be done, we consider that are necessary:

- the diversion of delivery pipes from the running channel (which discharge in the river Jiu) to the storage pool. From the storage basin the used water can be discharged also into the running channel or in Jiu
- the construction of the storage basin (can be located on the outside dump of the career Rosia de Jiu, figure 6).

Figure 6. A possible location for the storage basin

At first, rough evaluation the theoretical hydropower potential can be estimated as follows:

- considering the medium volume of water evacuated in a month of approximately 1.250.000 m^3 and the lever difference of minimum 60 meters we calculate the theoretical hydropower potential:

$$P = 9,81 \cdot Q_1 \cdot H = 9,81 \cdot 0,483 \cdot 60 = 284,29[kW] \quad (4)$$

where:

- Q_1 - the average continuous flow [m^3/s]
- H - level difference [m]

The value given by relation (4) applies in circumstances where production is expected to be continued.

A micro hydroelectric power plant is built especially to support peak load, when the energy consumption is high and energy prices are much higher. In this case, considering mainly micro hydroelectric power plant functioning at peak hours: in the morning between 6 and 10, in the evening between 18^{00}-20^{00}, the theoretical hydropower potential becomes:

$$\begin{aligned} P &= 9,81 \cdot Q_2 \cdot H = \\ &= 9,81 \cdot 1,44 \cdot 60 = 847,575[kW] \end{aligned} \tag{5}$$

where:
- Q_2 - water flow at rush hours [m^3/s]
- H - level difference [m].

If it is considered the approximate number of functioning at peak hours in a month to be 240h, results that using these waters from the career can be produced at peak load, in a month a quantity of electric energy according tot the relation:

$$\begin{aligned} W &= 9,81 \cdot Q_2 \cdot H \cdot h \cdot \eta = \\ &= 9,81 \cdot 1,44 \cdot 60 \cdot 240 \cdot 0,8 = 162,736 MWh \end{aligned} \tag{6}$$

where:
- Q_2 - the water flow at peak hours [m^3/s]
- H – level difference [m]
- h – number of functioning hours in a month
- η - plant's efficiency

As the benefits of capitalizing the energy potential of career waters are mentioned the instruments to promote energy production from renewable sources, which are promote by the Law no. 139/2010 regarding to modify and complete the Law no. 220/2008 for the establishment the system of promoting the production of energy from renewable energy sources.

According to this law, for the electricity from hydroelectric plants with installed powers of maximum 10 MW are given tree green certificates for each 1 MWh produced and delivered, if the hydroelectric plants are new[4].

A **green certificate** is a document which shows a quantity of 1MWh of electricity produced by renewable sources of energy.

Therefore, in Rosia career there is a hydropower potential high enough which must be exploited. Producing energy from renewable sources is encouraged also by the Report of the European Commission regarding to Strategy Europe 2020, according to that, the share of energy from renewable sources in final gross energy consumption must reach 24% in Romania until 2020 [6].

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