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Exploitation Solution of the Wind Potential in the Danube Gorge

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This paper proposes a solution to exploit the wind potential of the Danube cluster by storing it in the Iron Gates I reservoir lake, through pumping the water downstream of the hydroelectric power plant. Storing energy by pumping water, i.e. turning the plant into a pumped storage hydroelectric plant, will chancel the unstable character of wind energy, also achieving peak load coverage under conditions of investment much be-lower to those of building a hydroelectric power plant with accumulation by pumping the Danube.

Keywords*: wind energy system, energy storage, energy production, renewable energy*

1. Introduction.

The Danube Gorge is a particularly favorable area due to the specific geography (strong local wind “Cosava”) [1], which favors the development of wind power plant projects, that operates more than 25% of the time in full load [2].

The objective of producing energy from renewable resources can be addressed using wind and hydraulic energy combinations. [3], [4]. Currently the power system faces difficulties when it absorbs large amounts of fluctuating energy, produced from unpredictable sources (wind, solar, etc.) [5], [6].

In this way, the unstable nature of wind energy is canceled by the stable energy of the hydraulic power, and energy will not be lost when the wind turbines are not able to inject in the grid, and the potential hydraulic energy would provide the hedge load [7].

2. Solution exploiting the wind potential of the Danube Gorge

The main means of storing wind energy are: superconductors, chemical energy and potential energy of water [8], [9]. The energy storage through water pumping has long been done in pumped storage hydroelectric power stations, but these require considerable investment considering only the construction of upstream and downstream accumulation dams. [10], [11].

In the analyzed case, the two free natural resources can be associated: wind and water, respectively the production of wind energy and its storage through the potential energy of water [12]. In order to remove network instability, disturbances and quality deterioration of the energy, the energy storage is done by pumping water through a system consisting of a power grid that interconnects wind farms and supplies the downstream pumping station to the Hydroelectric Plant at Iron Gates I (Fig. 1).

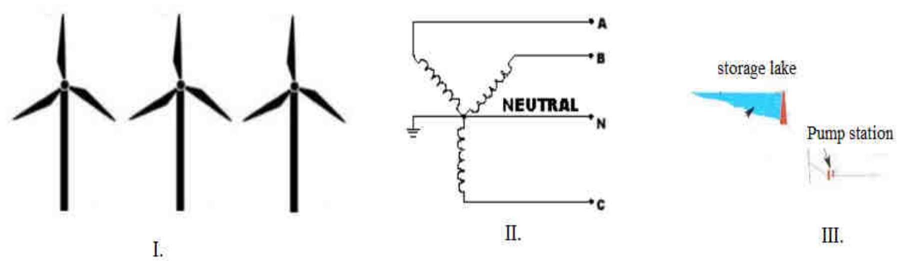

Figure 1. Interconnection system for wind farms and pumping station supply.
I – wind turbines, II – power transformer, III – pumping station

The advantages of the solution are long-term storage without energy loss, and 70-80% of the energy used for pumping can be recovered, plus the rapid response to energy system demands. The proposed solution involves the use of the existing hydropower plant (reservoir), avoiding damages to the ecosystem and with a sensible reduction in costs.

Figure 2 shows the stand-alone storage system for wind energy through pumping water.

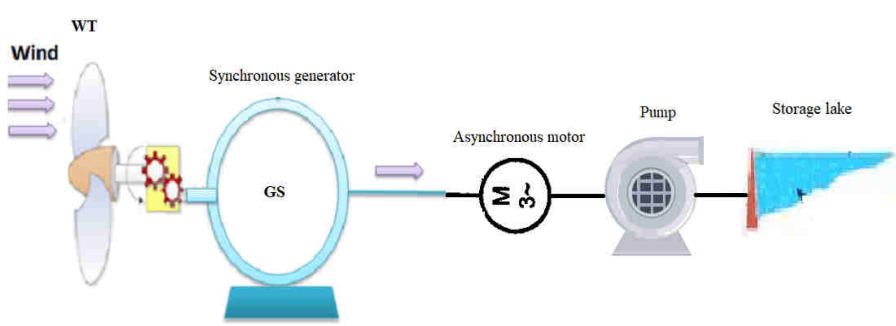

Figure 2. Autonomous storage of wind energy by pumping water.

The system yield is defined as the ratio between the output power P_E to the input power, P_I. the input power is given by the available wind power (v – wind speed) and the output power is the remained power for water pumping. For a multi-component system, the yield is obtained by multiplying the yield of each element.

Thus, the efficiency of the wind-hydro system is:

$$\eta = \frac{P_P}{P_v} = c_P \cdot \eta_{cv} \cdot \eta_G \cdot \eta_C \cdot \eta_{AM} \cdot \eta_P \tag{1}$$

where: c_P – wind turbine performance coefficient,

η - global efficiency,

P_P – available pumping power,

P_W – available wind power, gear efficiency

η_G, wind generator yield, electric converter yield

η_C, asynchronous motor power to drive the pump

η_{AM}, pump efficiency η_P.

The overall efficiency of the wind-hydro conversion system under normal operating conditions of the energy chain elements is around 25%. The overall yield can be increased through a series of measures, such as choosing items with a high yield, so that the yield can exceed 30%.

The proposed solution is a safe way of integrating wind energy on a large scale and enables energy demand to be met at any time. The unstable character of wind energy is attenuated by the stable energy of the hydraulic power and does not lose energy produced by wind power plants when the network connection is not available, allowing in the same time to use the stored energy in peak consumptions time intervals [13], [14].

Ensuring the network stability is one of the main gains that the national dispatcher must provide. In the context of the development and extension of the interconnectivity of the networks between the EU countries, in the same time, the available energy reserves will have to increase. In this direction, the solution represented be the water pumped storage plants, are considered to represent a good completion in the green energy mix.

Figure 3 shows the principle scheme of replacing the classic batteries with pumped storage "lake battery", case study [15].

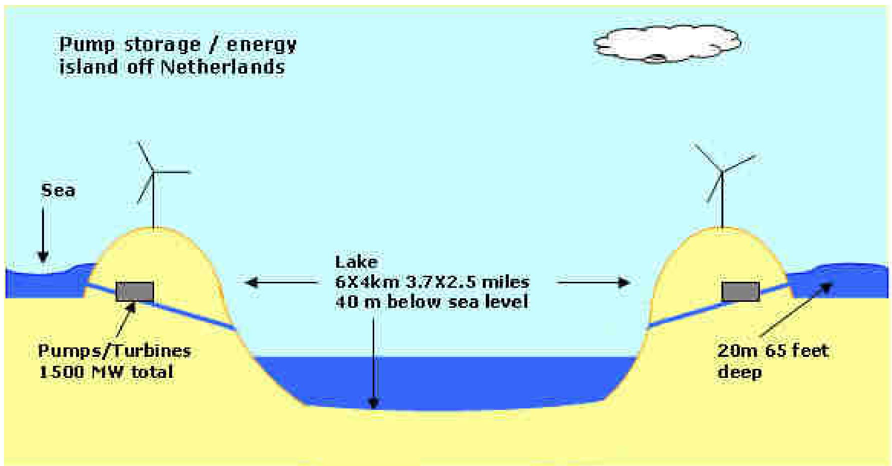

Figure 3. Pumped storage as "lake battery"

Figure 4 shows the operating status of the wind turbine system and pumps that reflect the performance in a wide range of revolutions.

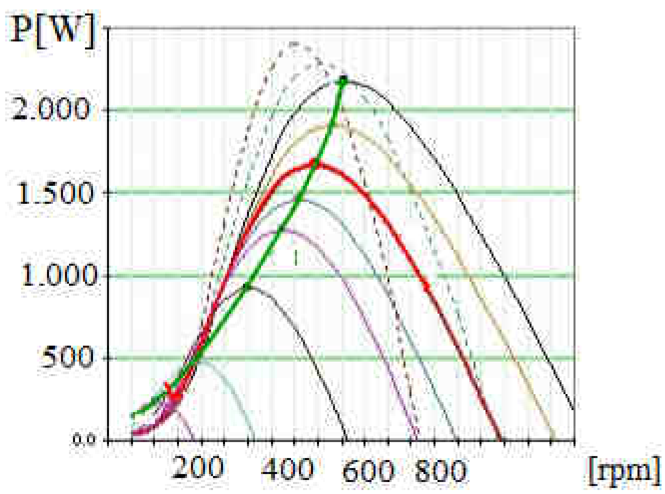

Figure 4. Pump characteristic overlapped with the wind turbine characteristics.

3. Conclusion

In the context of the EU-wide regulation of the renewable energy strategy, it will be necessary to integrate into the energy systems a higher amount of energy produced from unpredictable and variable resources, such as wind energy. An important energy transfer characterized through fluctuations to electrical networks, causes their instability through perturbations and deterioration of the energy quality. Thus, storing energy by pumping water is always a safe way of integrating the energy produced in wind power plants, on a large scale, increasing in the same time the fulfillment of the energy demand. The mentioned desideratum of the use of renewable resources is closer to be full field using wind and hydraulic energy, being perfectly applicable in the mentioned case of the Danube Gorge and the Iron Gate I hydropower plant.

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