Design and Simulation of a Small Wind-Hydro Power Plant

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***Abstract*—Due to climate changes that have been observed in regions all over the world and which are believed to be caused by the use of conventional energy sources, we must draw our attention to renewable energy sources which are the most suitable in the future. This paper presents a study about designing and simulation of a small wind-hydro power plant which will be located in the Didactical and Agreement Base Marisel belonging to the Technical University of Cluj Napoca, Romania, and which will be used in didactical and research purposes. After execution, this pilot station will be used mainly for studying the possibilities of pumped hydro power plant to store the wind energy in the form of hydro-energy of water.**

***Keywords*—hybrid power systems, micro hydro power, wind energy generation.**

I. INTRODUCTION

In the current condition of human society's development, the need for energy consumption reaches higher values. Justified desire to achieve a better life involves high energy consumption.

Continuing to use fossil fuels is bound to pollute the atmosphere, and consequently, unwanted greenhouse and climate change effects will come to dominate every part of the earth. It is, therefore, advisable to use clean energy resources, such as wind energy and water energy, which are more and more attractive, being the most suitable solution for the future.

In Fig. 1 one can see the technical solution of the small wind-hydro power plant from MARISEL.

Inside the touristic base MARISEL, we'll place a wind turbine 6 which will generate electrical energy to the electric panel 7. This energy will be used to pump water in storage basin 1 which will be arranged on a rivulet close to the touristic base, as shown in Fig. 1.

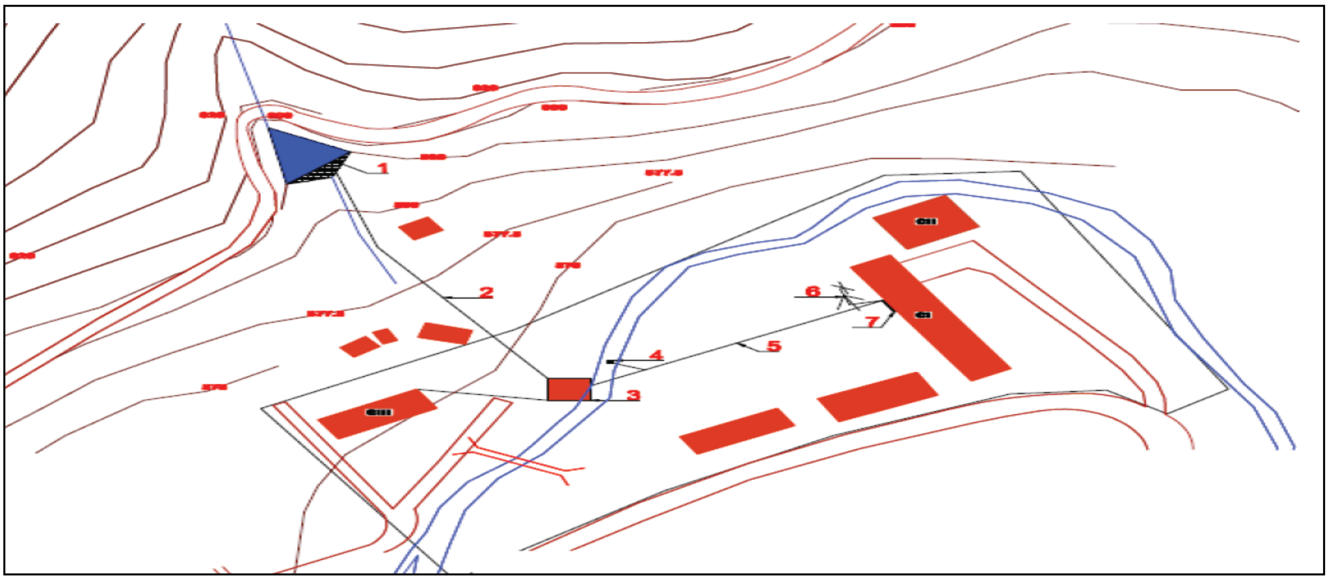


Fig. 1. *Hybrid wind hydro power plant structure: 1. dam 2. pipe abduction 3. pumped storage power plant 4. river 5. power cable 6. wind turbine 7. electric panel.*

II. Design of the Small Hybrid Power Plant

The design data are presented in the Table I.

TABLE I. Hybrid Power Plant Characteristics

No.	Data	Symbol	MU	Value
1	Average wind speed	v	m/s	4
2	Water head	h	m	40
3	Pump power	P_P	kW	3
4	Storage basin volume	V_l	m^3	600
5	Hydro turbine power	P_{TM}	kW	2

The volume of the storage basin results from the scale construction from Fig. 1.

$$V = \frac{1}{3} L \cdot l \cdot h = \frac{1}{3} \cdot 25 \cdot 12 \cdot 6 = 600\,\mathrm{m}^3 \qquad (1)$$

A hydro power turbine with:

$$P_n = 2\ \mathrm{kW} \qquad (2)$$

and a rated flow of:

$$Q = 0.01 \frac{m^3}{\mathrm{sec.}} \qquad (3)$$

has been chosen.

This basin will assure the turbine functioning for:

$$T = \frac{V_{lac}}{D_t} = \frac{0.8 \cdot 600\,\mathrm{m}^3}{0.007\,\frac{\mathrm{m}^3}{\mathrm{sec.}}} = 68571\,\mathrm{sec.} \approx 19\,\mathrm{h} \qquad (4)$$

at maximum capacity, but for a less capacity demand the time will be much bigger.

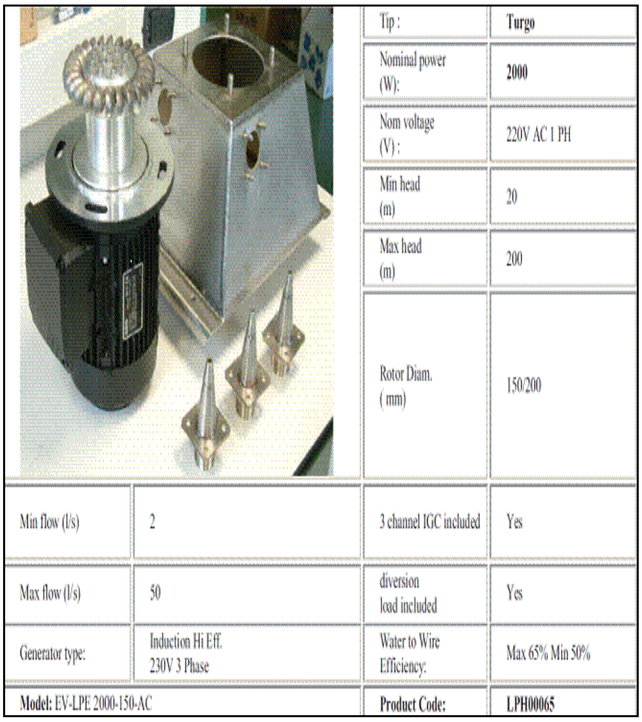
When there is wind, the lake will be filled with water pumped by means of using wind energy from the wind turbine.

The necessarily flow pump will be:

$$P_P = \frac{9.8 \cdot D \cdot h}{\eta} = \frac{9.8 \cdot 0.006 \cdot 40}{0.8} 3.2\,\mathrm{kW} \qquad (5)$$

For this study, one LPH00064 hydro turbine has been chosen. In Fig. 2 one can see this turbine, and its technical characteristics.

One LpElectric wind turbine LPE 00339, presented in Fig. 3 has also been chosen.



		Tip :	Turgo
		Nominal power (W):	2000
		Nom voltage (V) :	220V AC 1 PH
		Min head (m)	20
		Max head (m)	200
		Rotor Diam. (mm)	150/200
Min flow (l/s)	2	3 channel IGC included	Yes
Max flow (l/s)	50	diversion load included	Yes
Generator type:	Induction Hi Eff. 230V 3 Phase	Water to Wire Efficiency:	Max 65% Min 50%
Model: EV-LPE 2000-150-AC		Product Code:	LPH00065

Fig. 2. *Hydro turbine.*

	Model	WHI-500
	Rotor Diameter	4,5m
	Weight	70kg
	Wind speed	12m/s
	Rated output	3200W at 12m/s
	Voltage	230 Vca-50Hz
	Old name	H175
	Country	USA

Type	LPE00339	230V	WHI 500 ,

Fig. 3. *Wind turbine WHI-500.*

III. Simulation of the Hybrid Power Plant

The design of a wind-hydro power plant was simulated using the Matlab/Simulink platform. The Simulink model is depicted in Fig. 4.

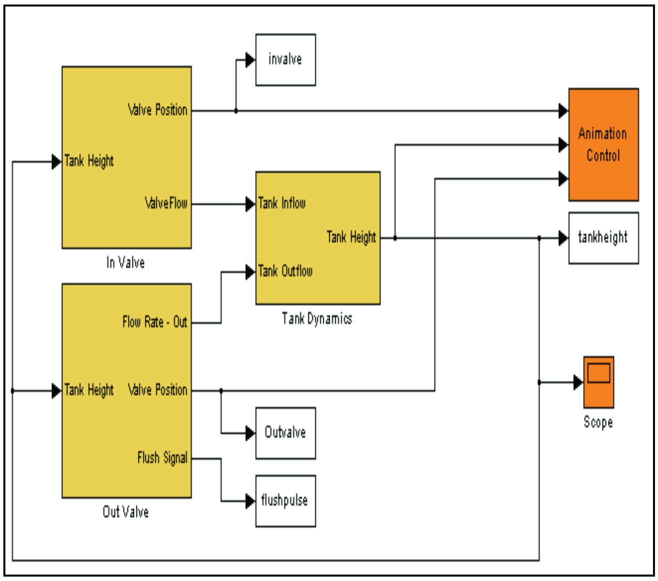


Fig. 4. *Simulink model of the hybrid wind hydro power plant.*

This model consists of the following blocks:

- Dynamic block of the superior tank (Tank Dynamics)
- Wind turbine – pump block (In Valve)
- Hydro turbine block (Out Valve)
- Animation block (Animation Control)
- Display block (Scope)

A logical scheme ensures the obtaining of the logical variable "Valve Position" depending on the existence of wind and water levels in the upper tank. When the tank is full the pumping stops even if there is wind. The output of the block gives the pump flow in time (Fig. 5).

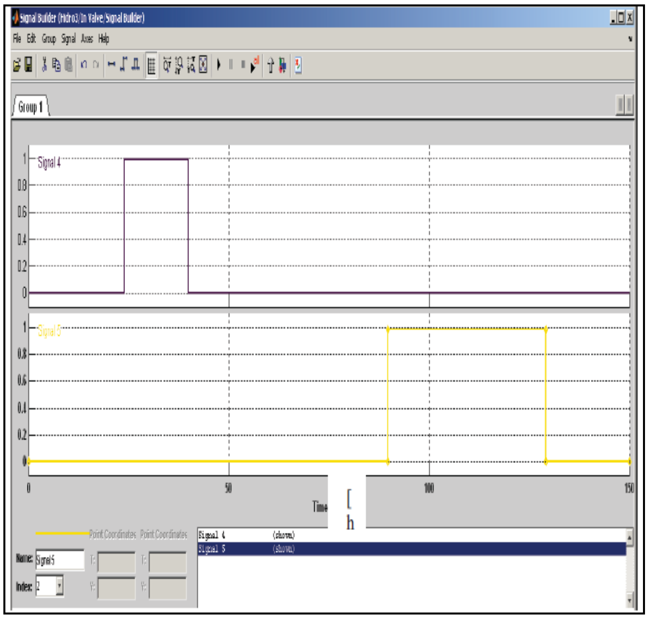


Fig. 5. *Wind turbine pump block programming.*

In Fig. 6 one can see the Simulink model of the hydro turbine block.

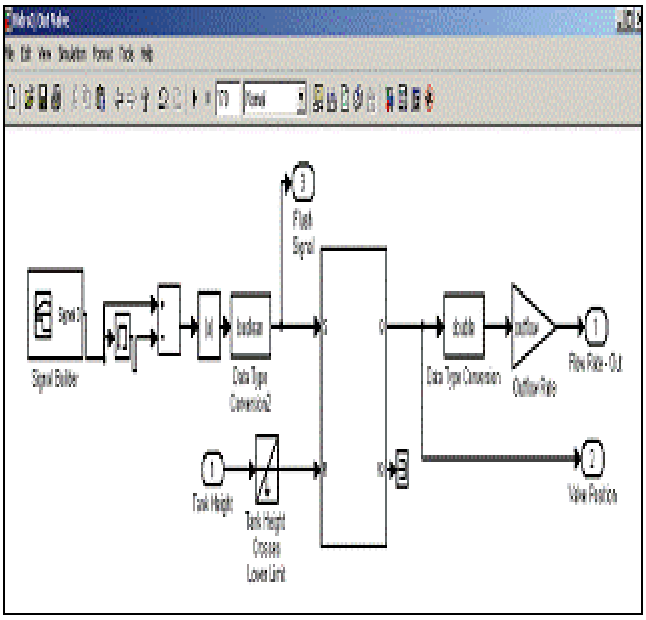


Fig. 6. *Hydro turbine block model.*

This block has as input the height of water in the upper tank. There's also a time programmer (Signal Builder) for water running scheduling, whose structure is shown in Fig. 7.

At the output we have a signal for water flow rate and information about valve position.

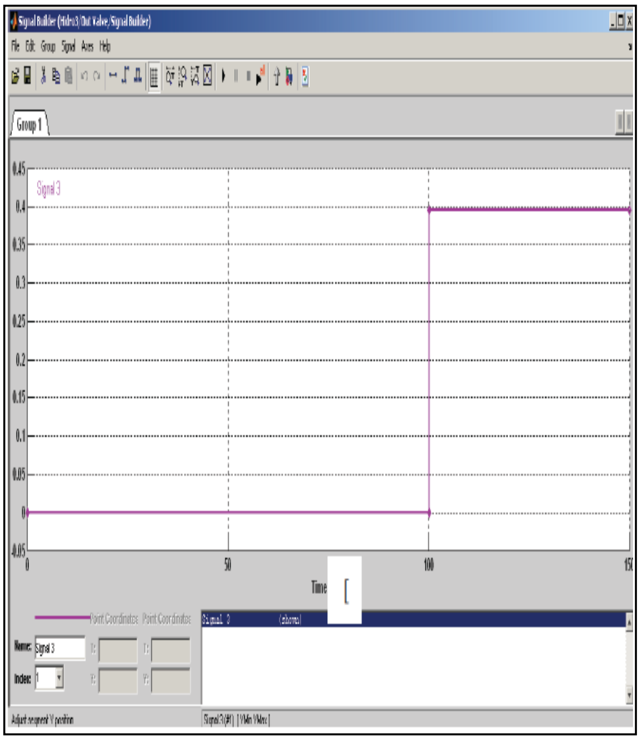


Fig. 7. *Time programmer for water running scheduling.*

IV. RESULTS

In Fig. 8 one can see an animation block which shows the tank level variation during the simulation process. It can be seen that we've set a maximum height of 10 m tank top and a minimum height of 2 m, the level where the water intake is located. Also, we set the pump flow rate to 16 m3/h, and the hydro turbine flow rate at 25 m^3/h.

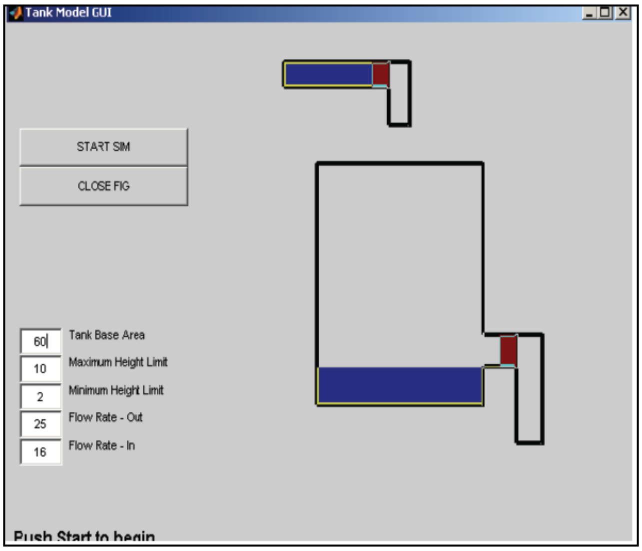


Fig. 8. *Animation block.*

The display block displays the simulation results:

- Water height variation;
- The hydro-turbine flow rate variation;
- The pumping flow rate variation.

The simulations were made for 170 h covering a period of seven days.

We considered that the wind blows only two times a week in that location:

- Monday 12 a.m. until Tuesday 8 p.m.
- Thursday 8 p.m. until Saturday 12 p.m.

Also, the hydro-turbine running will coincide with the weekend: from Saturday 6 a.m. until Sunday 3 p.m. But can be seen that the hydro-turbine stopped earlier, namely Sunday at 6 a.m. because there wasn't any water in the tank.

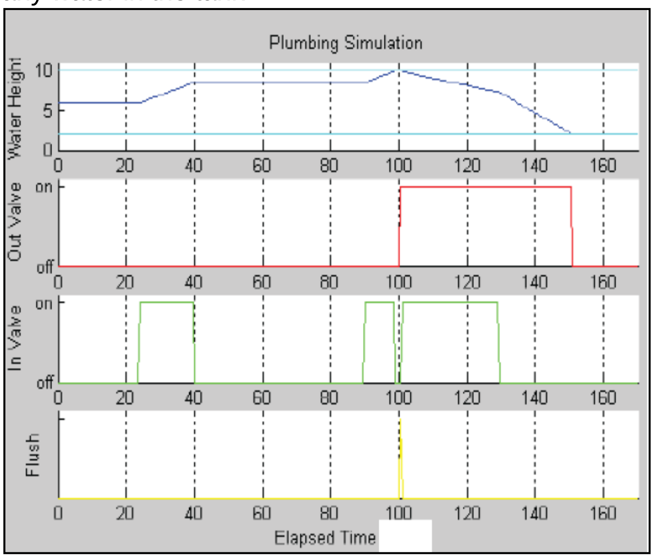


Fig. 9. *Display block*

V. CONCLUSIONS

Romania has a very low level of power installed in pumping storage hydropower plants.

The paper described a pilot station project for studying the combining of the wind power plants with pumped hydropower plants in so called small wind-hydro power plant, which can operates like a conventional power plant despite the variability of wind speed and of the consumers load curve.

In the future this pilot station will be used by PhD students for studying the wind power integration in the electric power system, but also can be used for educational purposes for teaching the students the renewable power generating, as wind-power and hydro-power.

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