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Connection of Renewable Energy Sources to the Regional Power Systems. A Short Analyze

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Among the basic problems that are involved in the decision to implement an energy project with Renewable Energy Sources(RES) are the identification of resources and the assessment of their regional potential, the possibilities of connecting to the existing electricity network in the area, the efficiency of conversion of natural RES in electricity, sources of financing and the possibilities of expanding the regional energy system based on RES. Then there are problems of endowing with modern RES-based power plants, the quality of the electricity supplied in the grid, the reliability of the connection schemes and the continuity of the power supply while reducing the energy losses on the grids. All these problems can pose risks to prevent the construction of a RES power plant or the good functioning of RES connected to the regional power system. In the paper, these aspects are analyzed by the authors in accordance with the renewable energy resources and the existing RES on the territory of the Bihor County.

Keywords: *Power system(PWS), electric grids, renewable energy sources(RES)*

1. Introduction

The problems related to the practical realization of energy projects based on RES and their connection to the energy systems can be divided into four categories: technical, economic, ecological and social. However, the decision to implement these projects is based on identifying and analyzing the existence of resources and their potential. Each of the other issues mentioned then brings specific implications [1][4-8][17]. RES are those sources that are considered inexhaustible by permanently restoring them with variable time intervals. These sources have the following forms of natural energy[6][14][20]: biomass, geothermal energy, wind energy, the hydraulic power of the low-power running water, waves energy and solar energy. The energy obtained from RES and used by final consumers is mechanical, thermal or electric. We will consider for the analysis the electrical conversion of the primary renewable energy.

In the paper, these issues are analyzed by the authors in accordance with the renewable energy resources existing on the territory of the Bihor county. It also proposes solutions for the realization of regional energy subsystems based on the integration of RES that will contribute to the expansion of the Bihor PWS.

2. RES exploitation in Romania. Case of Bihor County

Romania has met its international commitments for 2020 to increase the share of RES to 24% of gross final energy consumption [12]. This fact was generated by the high potential of RES on the territory of the country and the dynamics of energy capacities in recent years, especially on the basis of solar and wind energy.

For some forms of renewable energy, the electricity conversion potential for Romania, in economic and technical form, is presented in Table 1 [19].

Table 1. Potential of RES in Romania

RES	u.m.	Economical	Technical
Vegetal biomass	TJ/year	289500	471000
	t.e.px10^3	6915	11249
Photovoltaic(PV)	MW	4000	6000
	Twh/year	4,800	6,000
Wind	MW	2400	3600
	Twh/year	5,300	8,000

The highest potential due to the location of geothermal resources is in the west and northwest of the country. With few exceptions, such as the resources from Herculane, Cozia-Caciulata, Geoagiu, Otopeni, most of the geothermal exploitations are located in Bihor County. Geothermal resources also exist in the counties of Satu-Mare, Arad and Timis. In Bihor County, geothermal water is widely used for energy purposes, especially for centralized district heating. It is the case of cities of Oradea and Beius. In order to obtain electricity there is a single power plant in the Oradea with the capacity of 50 kW. The hydrogeothermal system of Oradea has follow parameters: surface = 75 km^2, depth is about 2,2-3,2 km, production wells =14, output temperature = 80-110^{o}C. The installed capacities P_i and used capacities P_u, from power plants (PP) on the territory of Bihor County at the time of the study, are synthesized in the next table[21]:

Table 2. Installed capacities in PP with RES for Bihor County

Source	$P_{i(max)}$ [MW]	P_u[MW]
Biogas	1,754	0.498
Biomass	5,500	0,500
Wind	21,500	11,500
Solar PV	88,286	68,239
Geothermal	0,050	0,050

Appreciation of the solar and wind potential in the Bihor county can be done by following the figure 1(a,b), adapted from[19].

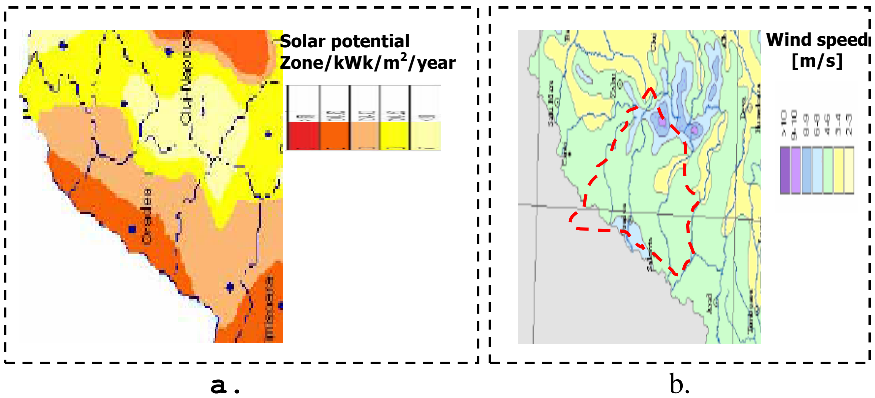

Figure 1. Bihor RES potential: a – solar energy; b – wind energy

From a hydro-energetic point of view, the territory of Romania was divided into 10 hydropower basins, as follows: 1. Tisa – Someş; 2. Crişuri; 3. Mureş; 4.Timiş – Nera – Bârzava; 5. Cerna – Jiu; 6. Olt; 7. Argeş; 8.Ialomiţa; 9. Siret – Prut; 10. Danube. Therefore, the hydro-energy in Bihor County is put to good use by exploiting the Crisuri basin. Its interest characteristics are: 5 basics water courses(Crisul Repede, Crisul Negru, Crisul Alb, Barcau, Ier) with 360 affluents, surface by 14 860 km^2 on country territory, total length of the rivers networks by 5785 km, energy micro-potential theoretical of 53, 7 MW and 147 dams, distributed across multiple counties.

3. Analysis of possibilities of RES integration into Bihor PWS

Studying the online database [23], it is found that at Bihor County there are for the year 2016 a number of 55 energy projects with RES, in operation or with authorization, especially on the basis of solar and wind energy. Of these we list: photo-voltaic parks from Biharia (2,67MW), Gepiu (2,74MW), Osorhei (2,99MW), Salonta (3,44MW), Lotus 1 Oradea(0,92MW), Lotus 2 Oradea(1,11MW)etc; wind farm from Budureasa (42MW), Avram Iancu (6,9MW), Auseu (54MW), Curcubata Mare (11,5MW), Salonta (9,72MW). Structure of electrical grids made up of 26 Power substation, 2170 transformer points and 583,95 km power lines by 110 kV level, currently allows the power outflow from these plants. However, besides the existence of resources, the implementation of a RES-based energy project for the enlargement of the Bihor PWS, implies other factors such as [2][6-8]:

- The proximity of human settlements;
- Concrete conditions in the field (land morphology, obstacles, land nature);
- Natural reservations, historical, tourist, archaeological sites;
- Special landmarks: forbidden areas, civil / military airport, special telecommunication installations;
- Existence and status of access paths;
- The conditions of land use: legal regime, concession / purchase;
- Possibility to connectivity at utilities;
- The existence of an important consumer in the area;
- Potential investors in the area;
- Potential autoproducers in the area;
- The possibility of a public / private partnership;
- Technical and economic performance indicators favorable to the investment approach at the selected site (resulting from a feasibility study).

In accordance with the existing potential and the possibilities for connection to the Bihor PWS(Power System), we propose an expansion scenario by realizing a sub-system located in the south of the county, according to the territorial distribution and the connection scheme presented in Figures 2 and 3. The model of analysis and representation is can also apply in other parts of the county.

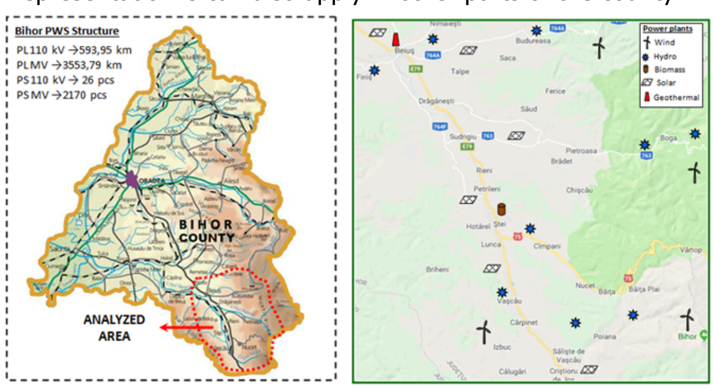

Figure 2. RES of interest area in southern of Bihor County

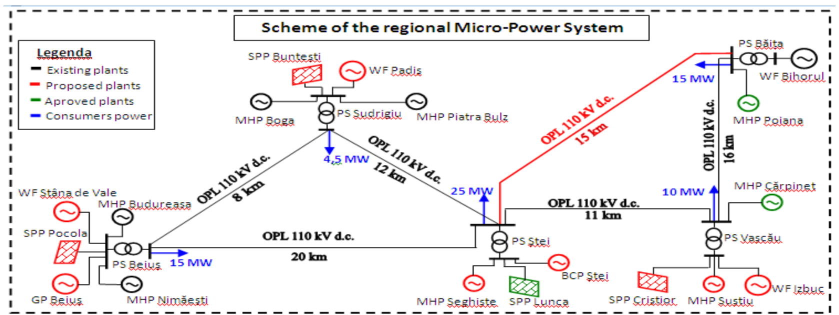

Figure 3. Scheme of power system expansion

4. Technical issues of regional PWS expansion by using RES

Renewable energy sources are intermittent in nature hence. It is therefore a challenging task to integrate renewable energy resources into the power grid. Challenges and issues associated with the grid integration of various renewable energy sources, further these challenges are included into technical issues which are described as fallow[1][5-7][10, 11][17]: power quality, power fluctuation, equipments protection, reliability of all components of RES connect to power system, power looses and islanding. Connection of small power plant (distributed sources) to the distribution network may be at low voltage level (0.4 kV) and at medium level (10, 20 kV), depending on the total power of the power plant, the nominal power of the generator, the circumstances of the distribution network , the power plants operation mode and other factors[13].

For the mathematical model of the optimal operation of a energy subsystem based on RES, we adapted a general model from technical literature based on the following hypotheses: power losses are a function of the power of the generators in the power plants; the structure of the installations in operation is fixed; the powers required by the consumer are constant for a period of analysis; the frequency of operation is fixed and constant at 50 Hz. Here are the expressions:

$$[MIN]C = \sum_{i \in I} C_i(P_i), \qquad (1)$$

$$\sum_{i \in I} P_i = \sum_{j \in J} P_i + p, \qquad (2)$$

$$\sum_{i \in I} Q_i = \sum_{j \in J} Q_i + q, \qquad (3)$$

where:

$i \in I = \{1,2\ldots,m\}$, is the lot of PP into subsystem;

$j \in J = \{1,2, \ldots, n\}$, is the lot of consumer nods of subsystem;

P_i, Q_i, are active power and reactive power generated by PP i;

C_i, (P_i), is spending in time unit of PP i

P_j, Q_j, are active power and reactive power requested by the consumer center j;

p is active power looses in sub-system grid;

q is reactive power looses in sub-system grid;

C is total cost, in time unit.

5. Conclusion

We can appreciate that the optimal and lasting functioning of interconnected power subsystems based on renewable energy sources implies the guarantee of several conditions. These include: at each moment, the power output of RES power plants should be equal to the power required by consumers; each energy emission must be comprised of the minimum technical powers and available power; must be introduced or removed from production to maintain the balance of the energy system in which the reference RES is interconnected. Ensuring these aspects requires investment in innovative and reliable equipment and technology, adopting and integrating into the intelligent networking system and ensuring a continuous flow of renewable resources, which is the primary form of energy. Finally, we should mention that for the realization of RES-based energy projects, a correlation of efficiency between technical, economic, environmental and social requirements must be maintained.

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