POSSIBILITIES OF DEVELOPMENT AND INTEGRATION IN ZONAL POWER SYSTEM OF ELECTRICAL PLANTS BASED ON RENEWABLE ENERGY SOURCES LOCATED IN THE SOUTHERN OF BIHOR COUNTY

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ABSTRACT: possibilities of using or realizing and interconnecting some power plants that will lead to the optimization of the power flow, the increase of the performance and the reliability in the regional Power System where electricity is evacuated to supply local consumers. In this context, the work is structured in several parts, each assigned to a distinct direction of problems solving. The first part of the paper presents information on the potential of renewable resources in the region under investigation. The energy resources taken into account are: wind energy, solar energy, biomass and hydraulic energy. Then, in the second part, the current stage and prospects for the construction of power plants are based on the potential of renewable energy sources. In the third part there are possibilities of increasing the degree of optimization in the supply of the local electricity consumers by elaboration of interconnection solutions of the renewable power plants in the analyzed area. The criteria underlying the conception of the expansion of the local energy system are also highlighted in this part. Finally, the conclusions that have emerged as a result of the study and analysis carried out by the authors with the elaboration of the paper are presented.

KEYWORDS: renewable energy sources(RES), energy potential, power lines (PL), power substations(PS) optimization of power flow, regional power system (PWS)

1. INTRODUCTION

Renewable energy sources (RES) offer many advantages for use. Reaching the targets proposed by Romania in terms of obtaining electricity from renewable sources is possible after several studies have been carried out to identify the energy potential and to use any opportunity for the realization of green power plants. On the Territory of Bihor County there are opportunities to capitalize on the potential of renewable energy resources, but serious projects have been realized especially for the construction of photovoltaic power plants.

Aware of the importance of capitalizing on renewable energy sources, the authors propose in this paper, to highlight their potential, the analysis of energy projects developed until the present days, as well as future development scenarios for an area in the south of Bihor County in Romania.

In this area, were identified and analyzed for the first time the finalized projects for energy use of RES, especially on conversion to electricity. The accent was put on public projects which serve larger consumer groups. Individual projects for dwellings or single buildings have not been investigated.

Most of these second types are especially photovoltaic or solar hot water installations installed on residential or accommodation buildings, with a high tourist potential. Also included in this category are biomass burning plants, which are the main heat source of private homes, either using low-power thermal power plants or using stoves. It is the same situation encountered in almost all Romanian territory, in rural areas. The reference area is located in the south of Bihor County and is shown in figures 1 and 2.

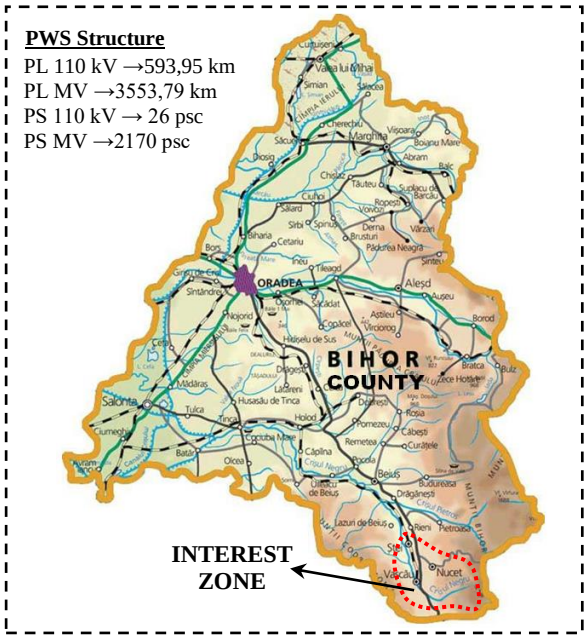


Figure 1. Area of analysis located in the south of the county

Within the area there are 3 small towns and 4 communes. The cities are Ştei, Vaşcău and Nucet. The communes are Criştior, Cărpinet, Lunca and

Câmpani. The town of Nucet also administratively belongs to the village of Băiţa. Also, there are several villages belonging to each commune from the analyzed region.

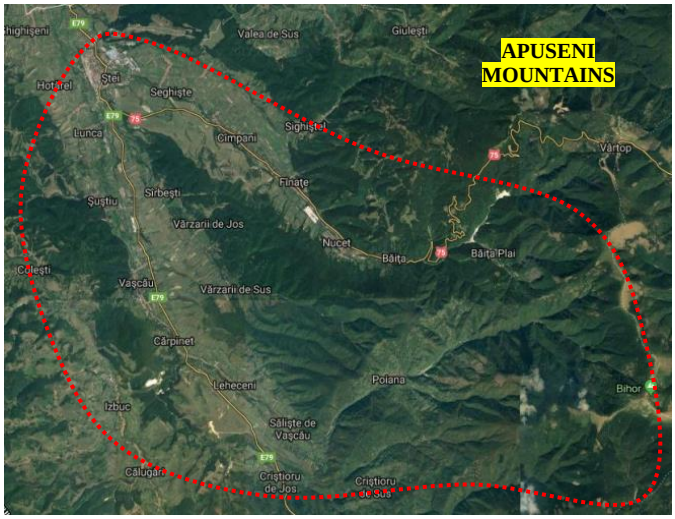


Figure 2. Territorial delimitation of Area of analysis

There are several forms of energy considered renewable in terms of current technical applications [2][3][5][6]. In the paper are analyzed only those are most widespread on the territory of Romania, namely: wind energy, hydraulic energy, solar energy and biomass energy.

2. THE LOCAL RES POTENTIAL

Highlighting data on the energy potential of renewable sources stems from the authors' investigation of maps or databases published as printed or existing online on the intranet. However, before the decision to practice an energy project, because the published information is often different, it is recommended to carry out practical measurements of some characteristic quantities of each type of energy.

2.1 For wind energy

In some parts of Romania the wind energy potential given by its speed is very high. The evidence consists of the many wind turbines that have appeared in recent years especially in the south-eastern part of the country and which in terms of dynamics have led Romania among the top 10 in the world as power installed in wind power plants[6].

A major energy project based on wind energy has also developed in the analyzed region, meaning that there is sufficient potential.

A regional section taken from the Romania Wind Map exposed in [8], is presented in the next figure. From Figure 3, the following statements can be made: there are 5 distinct wind potential areas; no location within the area of interest is included in the maximum potential; between these areas the wind speed ranges from 3 to 10 m / s. The highest wind speed is in the peak of the Bihor Mountains at about 1850 m altitude. The largest surface in the area of interest is within the wind speed range of 4-6 m / s.

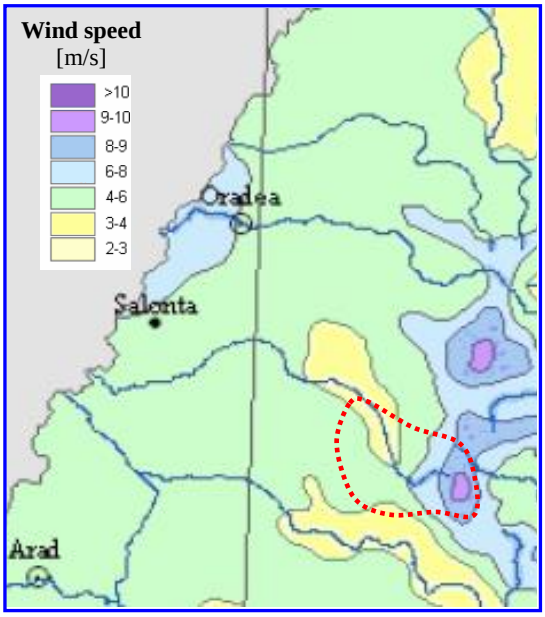


Figure 3. Regional Wind Map [8]

2.2 For biomass energy

From the point of view of the biomass resources with available energy potential, the Bihor County is included in high average values in Romania. For the area of interest of the paper, wood - forestry biomass is predominant and very little agricultural, because the most widespread forms of relief are the hills and mountains. If the forest biomass energy potential is appreciated as well as the Bihor County, it reaches an average value of 95,93 TJ in the area of interest compared to 4,07 TJ as the average value of the agricultural biomass potential [8].

2.3 For low power hydro – energy

The hydro-energetic micro-potential (groups below 10 MW) on the territory of Romania is characterized by the power and energy values that can be installed and produced [8]: the power as technical potential is 1100 MW and the economic potential of 400 MW; the electrical energy obtained has a technical potential of 3,6 TWh / year and an economic potential of 1,2 TWh / year. The area analyzed in the paper is included in the Crişuri catchment area with a total area of 13085 km^2 and a theoretical energy potential of 4,2 TWh / year and technical 2,2 TWh / year.

The local hydro-energy potential is given by the upper course of the Crişul Negru River, which is the largest flowing water in the analyzed region. This river springs from the Bihor Mountains and collects several smaller water courses. Thus, from

the Bihor Mountains, the main affluents of the Crişul Negru River are the Băiţa River and the Sighiştel Stream. The affluents of the Crişul Negru River that originate in the Codru-Moma Mountains are mainly collected by the Boiu Basin: the Runlet Cristiorel, the Runlet Izbuc, the Ţarinei Valley and the Valley of Briheni.

The Figures 4 and 5 show the images of two local rivers.

Figure 4. Crişul Negru river near Vaşcău City

Figure 5. Băiţa river near Ştei City

2.4 For solar energy

Analyzing the map of the distribution of solar radiation in Romania [8], Bihor County can be characterized as follows: there is an extended region in the western part of the entire North-South alignment, which is included in the solar radiation zone II. In the middle region, also extended from north to south, there is the radiation zone III; In the south-eastern part of the county, in the area of the Apuseni Mountains, the IV and V solar areas are predominantly low (1200-1250 for zone IV and below 1200 kWh / m^2 / year for zone V).

As variations in solar radiation, the monthly range of values in Romania reaches the peak in June (1.49 kWh / m^2 / day) and the minimum in February (0.34 kWh / m^2 / day). Solar energy is used in two directions: thermal and photovoltaic. Solar thermal - energy according to [8] for Romania is: technical potential on 40 GWh / year or 144000 TJ / year; economic potential on 17 GWh / year or 61200 TJ / year. Solar electric - energy according to [8] for national territory is: technical photovoltaic potential on 6 TWh / year; economic photovoltaic(PV) potential on 4,8 TWh / year. For the portion of interest there are three zonings from the point of view of the intensity of solar radiation. The solar radiation values are[8]: 1000 ÷ 1200 kWh / m^2 / year, which corresponds to higher mountain areas, 1200-1250 kWh / m^2 / year for low mountains area or high hills and 1250 ÷ 1300 kWh / m^2 / year for the depression zone and small hills area.

The potential of solar energy is highlighted based on the results presented in [9] but also by using the platform PVGIS (SOLAREC) of Joint Research Centre [9] – managed by the IET – Institute for Energy and Transport of European Commission. An example of using this platform to assess the photovoltaic potential for a point in the area of interest is shown in the Figures 6 and 7.

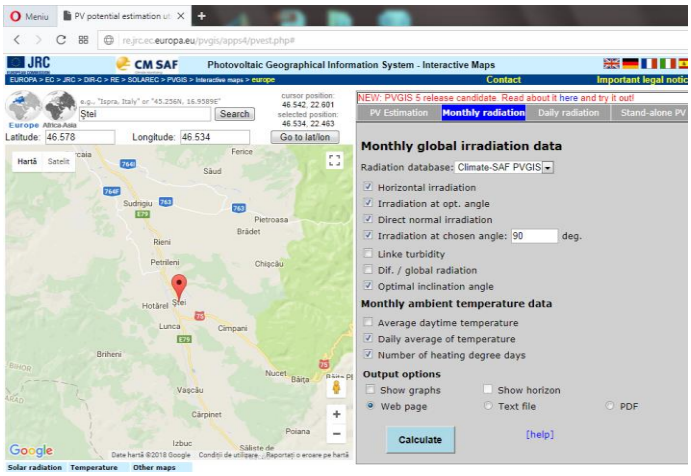
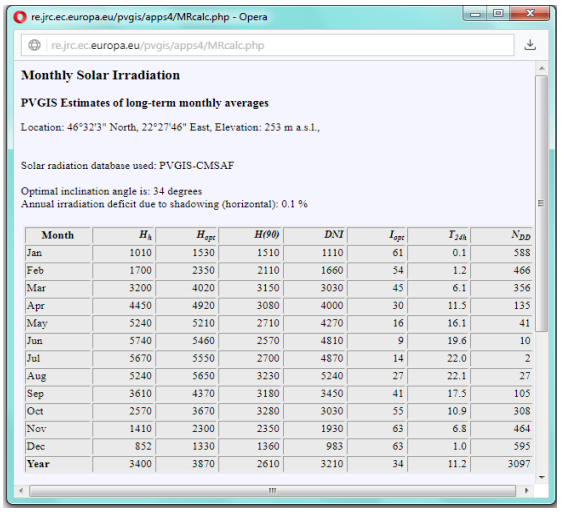


Figure 6. Photovoltaic geographical information for an interest place(Ştei)[9]



Month	H_h	H_{opt}	$H(90)$	DNI	I_{opt}	T_{24h}	N_{DD}
Jan	1010	1530	1510	1110	61	0.1	588
Feb	1700	2350	2110	1660	54	1.2	466
Mar	3200	4020	3150	3030	45	6.1	356
Apr	4450	4920	3080	4000	30	11.5	135
May	5240	5210	2710	4270	16	16.1	41
Jun	5740	5460	2570	4810	9	19.6	10
Jul	5670	5550	2700	4870	14	22.0	2
Aug	5240	5650	3230	5240	27	22.1	27
Sep	3610	4370	3180	3450	41	17.5	105
Oct	2570	3670	3280	3030	55	10.9	308
Nov	1410	2300	2350	1930	63	6.8	464
Dec	852	1330	1360	983	63	1.0	595
Year	3400	3870	2610	3210	34	11.2	3097

Figure 7. Informations about monthly solar radiation for an interest place-Ştei[9]

The simulations made by the paper authors for the cities and communes in the area analyzed with the

SOLAREC platform, led to the following results: Ștei - 1270 kWh / m^2 / year, Vașcău - 1260 kWh / m^2 / year, Nucet - 1220 kWh / m^2 / year, Cărpinet - 1150 kWh / m^2 / year, Criştior - 1240 kWh / m^2 / year, Lunca - 1270 kWh / m^2 / year, Câmpani - 1180 kWh / m^2 / year.

3. THE CURRENT SITUATION OF THE LOCAL EXPLOITATION OF RES IN ANALYZED AREA

Not many energy projects in the analysis area are finalized or / and achieved in practice. These are: the wind power farm (11,5 MW) located on the Peak of Bihorul in the Apuseni Mountains, the Poiana 1(0,53 MW) and Poiana 2(0,237 MW) hydroelectric installation on the upper course of the Crişul Negru River and the Lunca photovoltaic site(4.1 MW).

Images of some of these projects are shown in Figures 8 and 9.

Figure 8. Wind turbines near Bihorul peak from Apuseni Mountains

Figure 9. Hydraulic plants at Poaina/Cărpinet, on river Crişul Negru

There are possibilities for evacuating the electric power from the existing power plants in the analyzed area due to existing electric substations and power lines which also have a relatively high degree of interconnection. Two situations with local power objectives are presented in Figures 10 and 11 in the analyzed area.

Figure 10. Power Substation from Ștei, Bihor

Figure 11. OPL d.c. 110 kV Oradea – Beiuş - Vaşcău

There are 3 electric stations in the area built in localities Nucet (Băiţa Plai), Ștei and Vașcău. Their construction was justified by the electricity supply of the localities in the area with multiple categories of household or public low-power consumers, but also for the large industrial consumers that existed in the past: the Hiperion SA metal processing factory in Ștei, the woodworking factory for windows and doors in Ștei, marble processing factory from Vascău, Mioriţa textile factory from Ștei, mining of rare metals from Baița and others. Near these electric substations, but located outside the area of interest, yet interconnected by 110 kV overhead power lines, there are the substations Sudrigiu and Vârfurile. Existing overhead power lines have the possibility of transporting electricity to the rest of the county.

That is why major investments must be made in the installation of new power generation capacities. Careful consideration should be given to the possibilities of connecting to the Power System - PWS connecting points and to the loss of power and energy or its own technological consumption. Even if there are load capacities in new RES - based plants, evacuation installations require serious investment.

4. POSSIBLE SCENARIOUS ON THE FUTURE VALORISATION OF THE LOCAL RES POTENTIAL

For setting up scenarios, account is also taken of existing electrical installations such as PS(Power Substations) and HV-OPL (High Voltage – Overhead Power Lines), as well as the possibility of developing new ones as needed.

For local power substations (PS), also the authors consider that they are sufficient to take on possible loads by discharging from power plants or feeding consumers. Zonal power stations have been designed to supply more local consumers, but they are no longer functioning for various reasons. One of the existing industrial consumers is Company European Food SA Ştei, but its main power supply is made from a private PS located in the locality of Sudrigiu.

For the viability of a local power system extension, the authors propose the schemes of Figures 13 and 14 that are compared to the current situation outlined in Figure 12. The proposed schemes take into account several technical - economical parameters and including continuity in the power supply consumers and the reliability of the energy system.

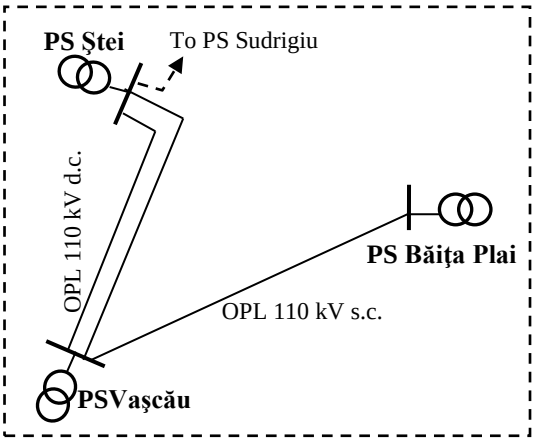


Figure 12. Interconnection of PS Ştei – Băiţa – Vaşcău (Actual status)

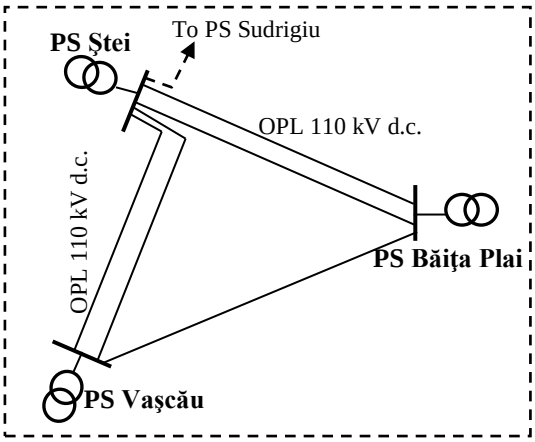


Figure 13. Interconnection of PS Ştei – Băiţa – Vaşcău (Scenario I)

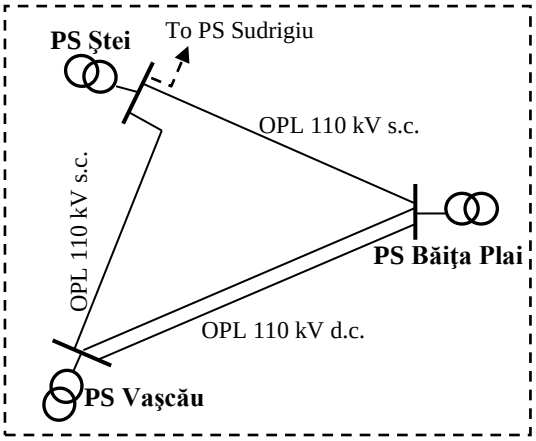


Figure 14. Interconnection of PS Ştei – Băiţa – Vaşcău (Scenario II)

Possibilities for additional location of extended solar parks on relatively more flat surfaces are: between Câmpani and Ştei; between the localities of Vaşcău and Cărpinet; between the localities of Cărpinet and Cristior.

The wind speed in the area of Bihor Mountains allows and requires the installation of additional wind turbines, especially since the available land area allows for this.

For each LEA configuration and equipment, the following issues should be considered and resolved optimally[1][4][7]: ensuring the electricity supply to consumers; ensure selectivity, sensitivity and coordination of relay protection; identify and implement the most appropriate layout schemes; reducing energy losses; reducing the own technological consumption; increase the reliability of consumer energy schemes; increasing the quality of electricity; choosing and purchasing equipment; training inventory of equipment and work materials; electromagnetic compatibility; reduced operating risks.

The location of the power plants based on RES, according to the authors' proposals is shown in Figure 15.

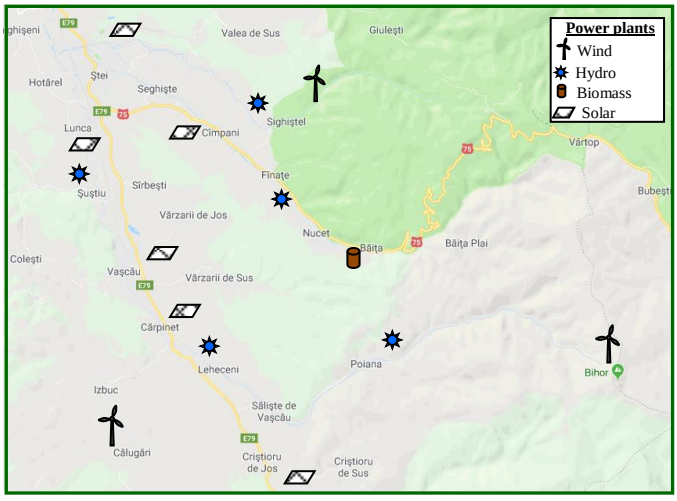


Figure 15. Map of RES Power Plants

We believe that the best solution for the location of a biomass plant to produce both heat and electricity will be near City of Nucet. This is justified by the proximity of the exploited wood resources in the Bihor Mountains. The thermal energy can be used for centralized heating of buildings in the town and electricity will be injected into the public grid by taking advantage of the proximity to Băiţa Plai power substation.

The installation of photovoltaic parks can be done in the vicinity of each commune or city in the analyzed area because there is the necessary and appropriate land. There will be electricity that can be used for street lighting and public buildings suply. The micro-hydro power stations can be located along the rivers Crişul Negru, Baiţa and Sighiştel, in addition to the existing ones. We propose their location in the neighborhood of Fânaţe, Sighiştel and Şuştiu. Wind farms can be located in the vicinity of Sighiştel and Călugări, in high hills and mountains.

The evacuation of the electric energy from the power plants on 20 kV Voltage level is as follows: at PS Băiţa Plai→ Bihorul peak (wind farm), Poiana 1 and 2(hydro plants); at PS Ştei → Lunca(PV site).

The development projects of the regional energy system also involve the realization of a vast network of electricity distribution installations on medium and low voltage levels. In this case, the problem of active power and active energy loss, in particular, begins to become more and more serious[1][4][7]. The evaluation of the power and energy losses in the elements of the distribution grids (lines and transformers) can be achieved by repeated mode calculations, considering in the network nodes the active and reactive daily load curves, modelled in the form of time steps (t). Energy losses over the range proposed for analysis are determined by summing up the hourly power loss $\Delta P_{l,j}$. Thus, the daily energy losses ΔW, on any element of the network l_j, can be calculated with the relation [1]:

$$\Delta W_{l,j} = \sum_{t=1}^{24} \Delta P_{i,j}(t)$$

To assess energy losses over a longer period of time, it is necessary to analyze the monthly regimes throughout the years of analysis.

5. CONCLUSIONS

The installation of small hydropower plants is limited because the local potential of the rivers is capped. With regard to the large photovoltaic and wind applications, they require solving problems related to: the financing of investments taking into account the high specific costs; the use of large areas of land; access to electricity transmission and distribution grids. All categories of installations under consideration must also be made taking into account the environmental impact.

An increasing number of city halls in the analyzed area, maintaining the trend in Bihor County, have expressed their willingness to make especially the photovoltaic parks.

The proposals for the realization of the power plants were made in compliance with the following general principles: the existence of RES, ease of exploitation, proximity to sources and proximity to consumers. A particular feature of the extension of the electrical grids is that they are integrated into a unique one - the Power system - and the parameters of the existing equipment within the system as well as its overall development must be taken into account.

Realizing the projects proposed in the present paper, through the cheap and ecological energy and thermal energy obtained on the basis of RES conversion can stimulate consumers to connect to the public network or to attract and stimulate entrepreneurs who, through future investments, will lead to the revival of the local industry.

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