RESEARCHES VIEWING THE OPTIMAL ELECTRIC ENERGY PRODUCING WITH PV

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Abstract – The paper proposes a study of photovoltaic systems that can contribute appreciably to electric energy produce, having as scope to reduce the electric energy consume produced by classical way.
In this sense, in the study has been used the simulation program of HOMER, that gives optimal solution regarding the utilization of renewable energies.

Key words: renewable energy, photovoltaic system, optimization

1. INTRODUCTION

Nowadays, when the consume of electric energy is in continuous growing and its production from conventional sources is expensive, and in some cases the transport, its distribution also has high cost, is very important to find new sources of energy that can satisfy the demands.

The renewable energy sources have many advantages compared to conventional energy sources, such as its reliability, sustainability and also its high environment friendly characteristic. The renewable energies are such the energy from the sun, the wind energy, the energy of the water and so on.

Regarding the green house gases reduction as well as the dependency of energy from the state are the objectives of the European Commission until 2020 are that 20% from the total requirements must be covered from renewable energy sources [1].

The development of European potential to use the renewable energies will have contribution on the security of energy supply, will reduce the imports and the dependency on fuel, also the emission of greenhouse gases, will increase the protection of the environment will be able to create new jobs and will enhance efforts towards a knowledge society [2,3,4].

The renewable energy sources, (RES), has a more and more importance in the European Electricity System.

The solar energy has become a very important topic when the humanity has realized that the energy is a vital component for existence in conditions of modern civilization. The sun offers a possibility to resolve the energy crisis that has become increasingly pronounced due to the growing number of the population, its life standards growth, with exhaustion of the fossils and nuclear fission [1,7].

In this article was proposed to study the possibilities to optimize the electric energy production from sun using PV panels.

Regarding the renewable energy resources, Romania has a good potential. Also, it was collected a special experience of research – development activities in this domain,

2. OPTIMIZATION OF A PV SYSTEM

Many simulation programmes are available for studying the renewable sources, as the wind, the sun, the energy of the water.
The HOMER software offers simulation results for optimal system and sensitivity analysis.

The basic diagram of a PV system is shown in figure 1 [5].

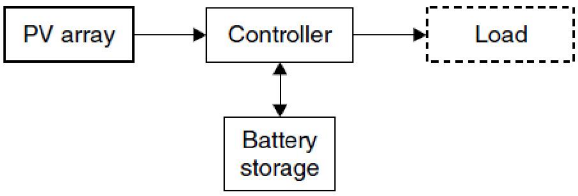

Fig.1 – Basic principle of solar energy system

The general diagram of a PV grid-connected energy system is used for the study, figure 2, [5] including the PV array, an inverter, and the distribution panel.

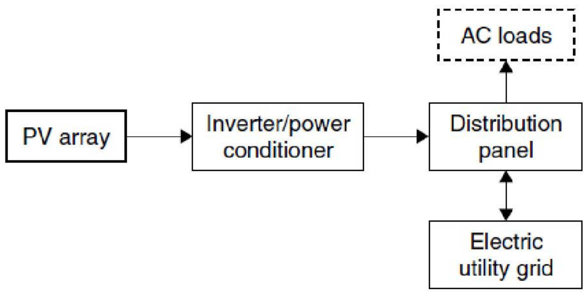

Fig.2 – General diagram of a PV grid connected system

In fig.3 is given the general diagram of PV stand alone system, where an important role has become the battery.

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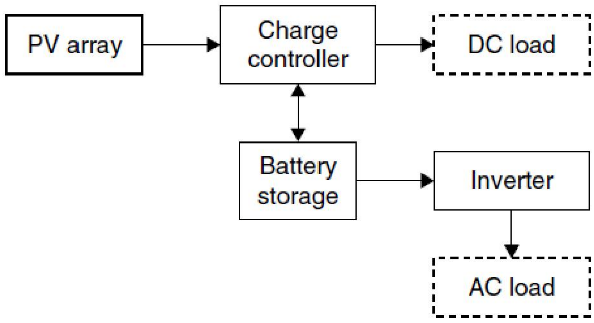


Fig.3 – Stand alone PV system

2.1. Optimization

After simulating all of the possible system configurations, HOMER displays a list of configurations, sorted by net present cost (sometimes called lifecycle cost), that you can use to compare system design options.

The inputs are the technical and economic data of the components within a system that reflects the climatic variables, the load, and the operation of the system. A system with PV panels, generates energy that can be greater than the load demand, in this case the surplus is stored in batteries. When the load requires a greater energy that is covered by the produced one the necessary energy is obtained from the batteries. So it can be make a comparison between the deficit of energy and that required.

3. A CASE STUDY

We proposed to study a PV system composed by PV array, battery, a converter a generator and a consumer with consume of 25 kWh / day, the characteristics given in table 1.

The results obtained from the measurements have been used to design a PV installation. For the simulation and optimization were various type of PV panels used, which are given together with the test conditions in table 1.

Tabel 1 – The panels and standard conditions of testing

PV module type	Modules in survey	Average values of efficiency at STC [%]
Silicon Polycrystalline	10	13.0
Monocrystalline silicon	8	13.5
Monocrystalline/amorphous silicon hybrid	1	16.4
Thin film amorphous silicon	4	5.5
Thin film CIS	1	8.2

In figure 4 is given the considered equipment

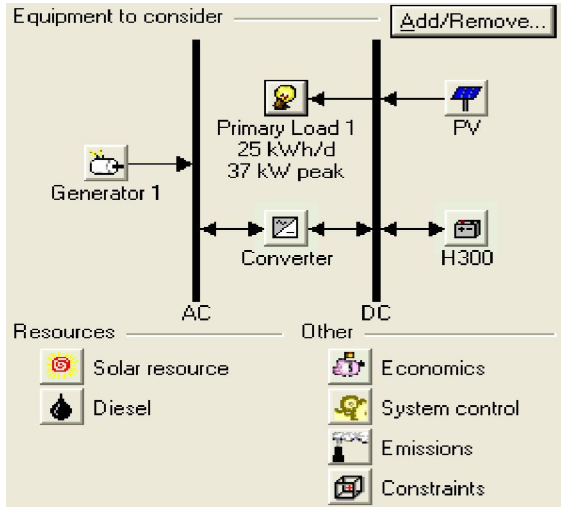


Fig.4. The structure of the photovoltaic system

The chosen battery is of Hoppecke 6 OPzS 600 type, produced by the German Hoppecke Company. From the capacity curve results that at the maximum current of 324 A the capacity of the battery is 324 Ah, as at 61 A the capacity is 610 Ah.

The main characteristics of the battery are presented in table 2.

Table 2 – The main characteristics of the battery

Nominal capacity [Ah]	Nominal voltage U_n [V]	Efficiency [%]	Minimum state of charge [%]	Lifetime [year]
600	2	86	30	20

The calculated parameters of the battery are:

- Maximum capacity 727 Ah;
- Capacity rate 0.335

As how results from the figure the architecture of the system is:

- A PV module of 30 kWp;
- Generator of 10 kW;
- A Hoppecke battery;
- Invertor of 10 kW;
- Convertor of 10 kW

An important role in the modelling and simulation of the PV system it has the solar radiation. Basing on the solar resource, it is defined the global horizontal radiation in function with the daily radiation and the clearness index. The global radiation is obtained introducing the values of the latitude and longitude of each location in case. In this case was used the values for Oradea municipality and time zone of (GMT + 02) Eastern Europe. In the following figure - fig.4 – for Oradea the average monthly values of the clearness index and the daily radiation have been plotted. For the average daily radiation it was obtained 3.42 kWh/m^2/day, as the clearness index average value is 0.482.

In the fig. 6, is given the result of the optimization, taking into account the input values and those that have a significant importance in the PV system.

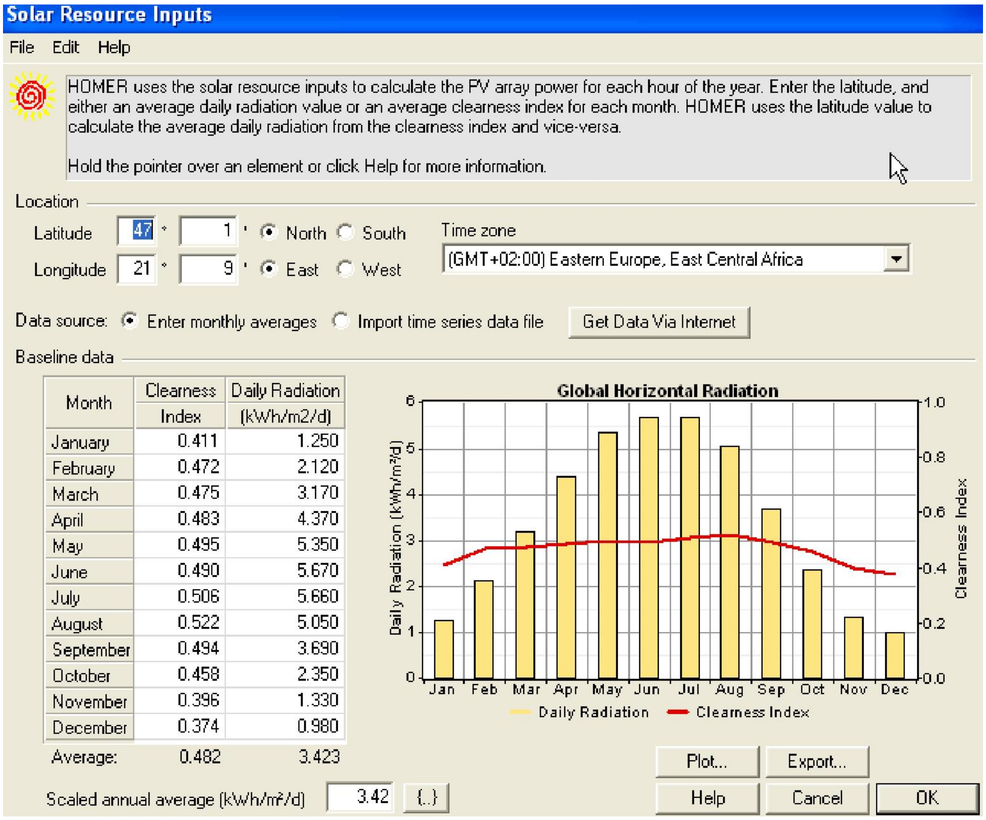


Fig.5 – Values of the global radiations

PV (kW)	Label (kW)	H300	Conv. (kW)	Disp. Strgy	Efficiency Measures	Initial Capital	Operating Cost ($/yr)	Total NPC	COE ($/kWh)	Ren. Frac.	Capacity Shortage	Diesel (L)	Label (hrs)
20	10	3	10	LF	Yes	$ 11,866	1,734	$ 34,028	0.405	0.86	0.29	1,640	756
15	10	3	10	LF	Yes	$ 10,699	1,838	$ 34,197	0.417	0.80	0.32	1,745	789
25	10	3	10	LF	Yes	$ 13,033	1,658	$ 34,224	0.400	0.89	0.27	1,568	728
20	10	2	10	LF	Yes	$ 10,066	1,930	$ 34,732	0.414	0.84	0.30	1,942	951
30	10	3	10	LF	Yes	$ 14,200	1,611	$ 34,794	0.403	0.91	0.24	1,516	708
25	10	2	10	LF	Yes	$ 11,233	1,845	$ 34,814	0.408	0.87	0.27	1,853	912
25	10	5	10	LF	Yes	$ 16,633	1,427	$ 34,879	0.406	0.90	0.26	1,283	544
15	10	2	10	LF	Yes	$ 8,899	2,041	$ 34,984	0.429	0.78	0.32	2,063	995
20	10	5	10	LF	Yes	$ 15,466	1,540	$ 35,150	0.415	0.87	0.28	1,378	587
30	10	2	10	LF	Yes	$ 12,400	1,793	$ 35,315	0.410	0.89	0.25	1,787	883
30	10	5	10	LF	Yes	$ 17,800	1,380	$ 35,442	0.409	0.92	0.24	1,239	529
15	10	5	10	LF	Yes	$ 14,299	1,657	$ 35,487	0.429	0.82	0.31	1,466	609
8	10	3	10	LF	Yes	$ 9,065	2,068	$ 35,501	0.459	0.66	0.36	1,985	875
8	10	2	10	LF	Yes	$ 7,265	2,285	$ 36,476	0.474	0.63	0.37	2,336	1,101
8	10	5	10	LF	Yes	$ 12,665	1,899	$ 36,945	0.473	0.68	0.35	1,689	684
20	10	3	10	LF	No	$ 11,866	2,067	$ 38,288	0.401	0.83	0.41	1,950	879
25	10	3	10	LF	No	$ 13,033	1,988	$ 38,444	0.395	0.86	0.38	1,878	852
25	10	1	10	LF	Yes	$ 9,433	2,275	$ 38,518	0.453	0.84	0.28	2,558	1,367
20	10	1	10	LF	Yes	$ 8,266	2,369	$ 38,553	0.462	0.80	0.30	2,672	1,421
30	10	3	10	LF	No	$ 14,200	1,917	$ 38,702	0.392	0.89	0.36	1,809	820
15	10	1	10	LF	Yes	$ 7,099	2,475	$ 38,736	0.477	0.74	0.33	2,801	1,471
15	10	3	10	LF	No	$ 10,699	2,211	$ 38,957	0.422	0.78	0.44	2,061	921
30	10	1	10	LF	Yes	$ 10,600	2,224	$ 39,027	0.454	0.87	0.25	2,490	1,336
20	10	2	10	LF	No	$ 10,066	2,272	$ 39,111	0.411	0.81	0.41	2,326	1,121
25	10	5	10	CC	Yes	$ 16,633	1,759	$ 39,120	0.455	0.88	0.26	1,667	784
30	10	5	10	CC	Yes	$ 17,800	1,670	$ 39,150	0.451	0.90	0.23	1,579	741
20	10	5	10	LF	No	$ 15,466	1,876	$ 39,450	0.411	0.85	0.40	1,627	671
25	10	2	10	LF	No	$ 11,233	2,210	$ 39,490	0.407	0.85	0.38	2,260	1,099
15	10	2	10	LF	No	$ 8,899	2,405	$ 39,641	0.431	0.75	0.44	2,456	1,176
25	10	5	10	LF	No	$ 16,633	1,802	$ 39,668	0.405	0.88	0.37	1,576	657
30	10	5	10	LF	No	$ 17,800	1,722	$ 39,810	0.402	0.90	0.35	1,519	633
30	10	2	10	LF	No	$ 12,400	2,151	$ 39,901	0.405	0.87	0.36	2,199	1,072
20	10	5	10	CC	Yes	$ 15,466	1,916	$ 39,956	0.471	0.84	0.28	1,812	857
15	10	5	10	LF	No	$ 14,299	2,036	$ 40,325	0.433	0.80	0.43	1,726	705
8	10	1	10	LF	Yes	$ 5,465	2,727	$ 40,326	0.527	0.57	0.37	3,103	1,596
25	10	3	10	CC	Yes	$ 13,033	2,137	$ 40,347	0.472	0.86	0.27	2,136	1,089
8	10	3	10	LF	No	$ 9,065	2,453	$ 40,423	0.472	0.62	0.48	2,334	1,033
30	10	3	10	CC	Yes	$ 14,200	2,058	$ 40,502	0.469	0.88	0.24	2,048	1,047
20	10	3	10	CC	Yes	$ 11,866	2,250	$ 40,633	0.483	0.82	0.29	2,253	1,145
25	10	2	10	CC	Yes	$ 11,233	2,312	$ 40,794	0.479	0.85	0.27	2,416	1,272
30	10	2	10	CC	Yes	$ 12,400	2,226	$ 40,861	0.474	0.87	0.25	2,312	1,219
8	10	2	10	LF	No	$ 7,265	2,642	$ 41,040	0.482	0.59	0.49	2,737	1,293
20	10	2	10	CC	Yes	$ 10,066	2,431	$ 41,147	0.491	0.81	0.30	2,545	1,336

Fig.5 – Optimization results

From these results can be seen that with a 30 kW PV panel i.e. the monthly average that is

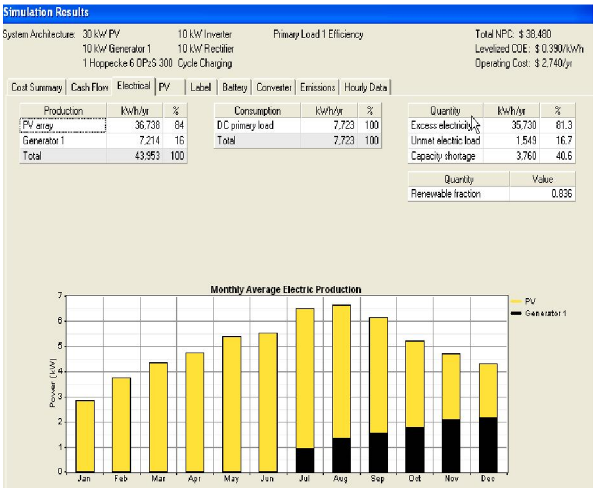


Fig. 7 – Result of the simulation

Regarding the produced electricity, the results of the simulation are (fig.7):

- The produced electricity by the PV is 36 738 kW / year;
- The capacity shortage is 3760 kWh / yr,

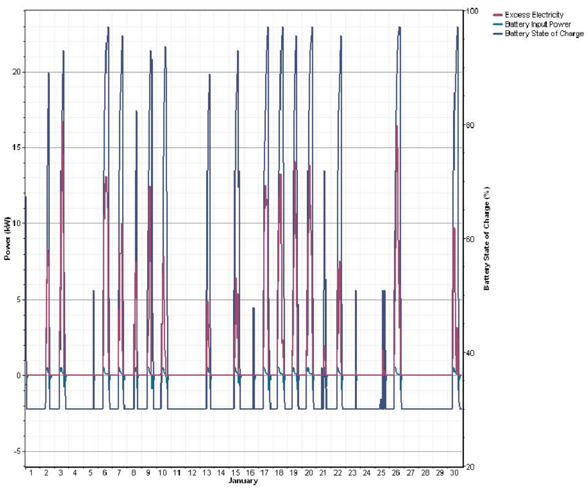
Homer for each case computes the unmet electric load for a year. It is obtained a total electric energy of 43,953 kWh/yr, from which 7.214 kWh/yr is produced by the generator, that is 16% of the total produced electricity, and the 84% is produced by the PV array.

The cost of the system 38.480 $ and the operating cost for a year is 2740 $.

Another type of analyzes considers a PV panel with the following characteristics:

- The PV has a nominal capacity of 30 kW;
- The average output is 4,2 kW;
- The capacity ratio is 14%;
- The total energy production is 43 953 kWh/yr

In the following figures fig.7 a – d are given the evolution of the excess electricity, the battery input and the battery state charge for winter and summer months, a comparison made for assessment of the evolution of the produced and the used energy.



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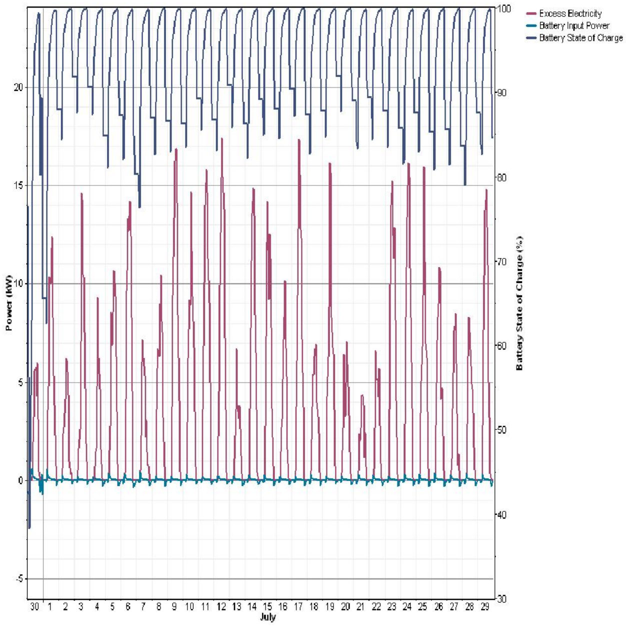

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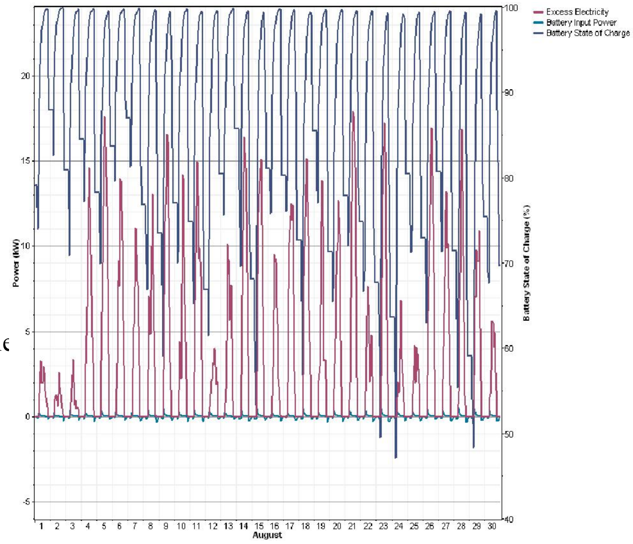

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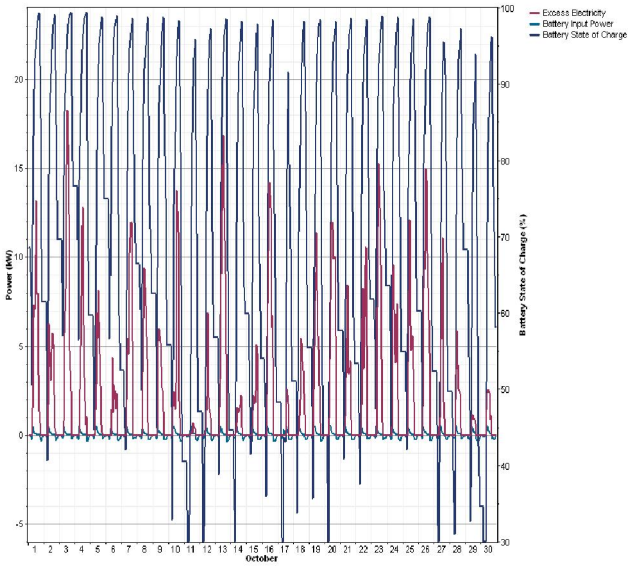
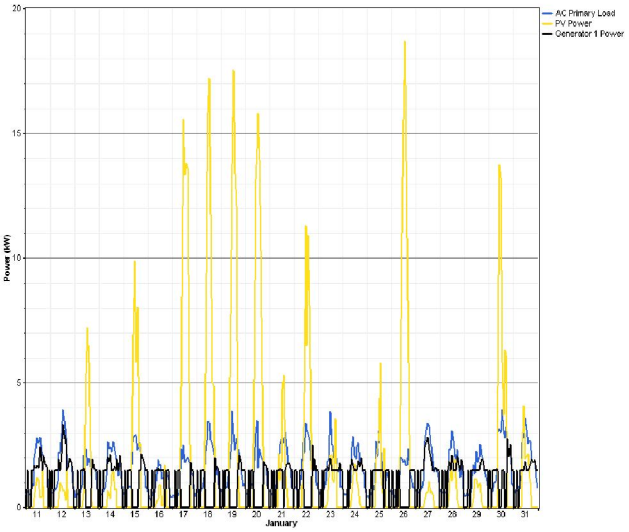


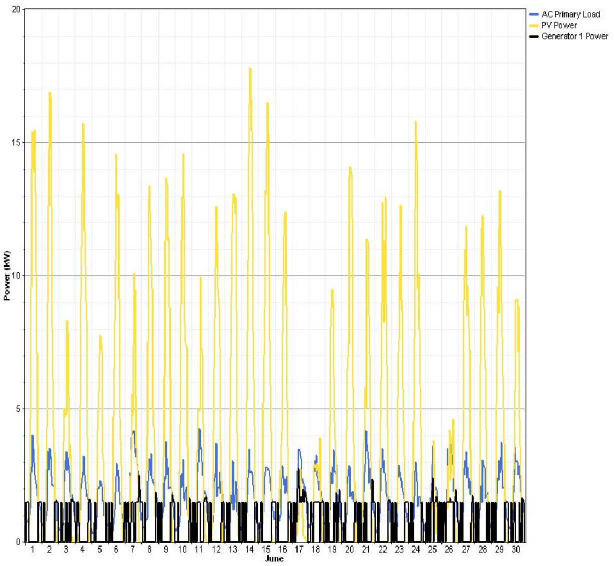
d)

Fig. 7 – Evolution of the excess energy

The evolution of the electricity required by the load and the energy supplied by the PV system is showed in the figures 8 a ÷ f.



a)



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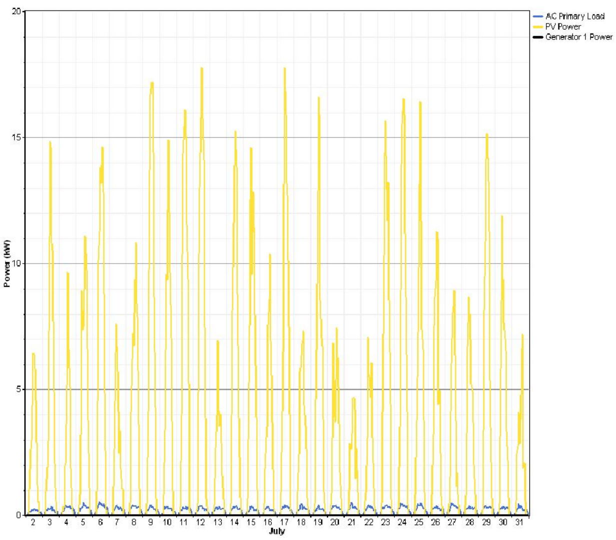

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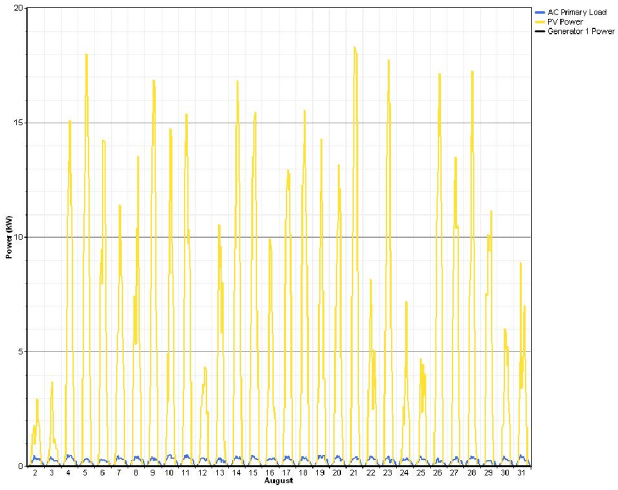

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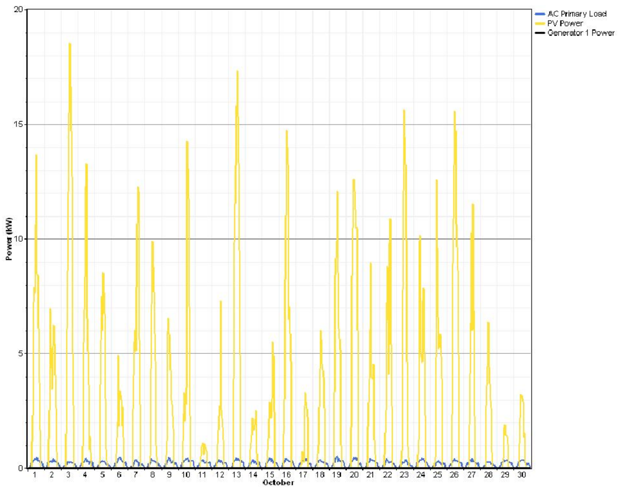

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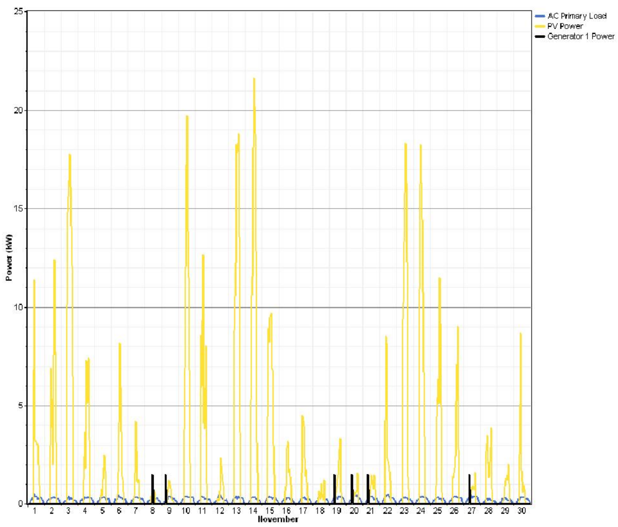

f)

Fig.8 – Evolution of the electricity required

It can observe that in the above cases in the summer months the produced power by the PV is enough to generate the energy that covers the required energy by the load, without to put in operation the generator. In other cases, there is necessary the operation of the generator to cover the required energy.

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5. CONCLUSION

Homer gives good results if the application input data are more accurate.

Simulation was done for a known area of Bihor County.

The analyzed case shows, that the utilization of the solar energy with PV modules, gives a solution that can assure a continuous supply with the required electric energy of the consumers, obtaining the optimal operation of the system in the given conditions.

With this configuration of the PV system with battery it was shown the effect of season factors on the reliable supply of the load.

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