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EFFICIENCY ANALYSIS OF A REAL SYSTEM, FOR ENERGY PRODUCTION FROM RENEWABLE SOURCES

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Abstract **– The solar energy is considered at this moment like a good solution for solving the energy crises in the isolated areas. The equipments for the applications of the solar energy can be used like normal systems and also like hybrid systems. As part of Electrical Engineering Faculty exist a photovoltaic station who uses the most known commercial technologies at world level. The financial aspects, the efficiency analysis of such a system can be made very well using simulation programs; in our case we used HOMER. We must establish a price for the photovoltaic technologies and in this way to obtain a successful business.**

Keywords*:* solar energy, models, efficiency analysis, optimization.

1. INTRODUCTION

Solar energy can be changed directly into electric energy, using the photoelectric effect or, more precise, a particular case of this: photovoltaic effect. The devices where is realized the conversion of solar light into electric energy using the photovoltaic effect are called photovoltaic generator (PV). The elementary photovoltaic generator is called photovoltaic cells or photocells.

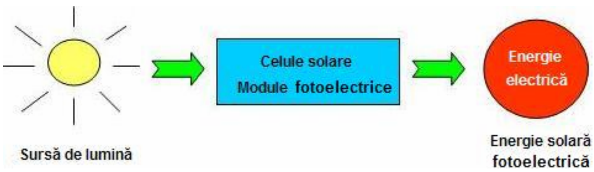

Figure 1: Changing the solar energy into electric energy.

The PV generator is known like the most promising sources of energy from many points of view. Like main advantage for the future is: the necessity. This equips are needed because in the present EU admit the necessity for solving the climatically problems. For solving this objective, EU countries must adhere to some measurements and most of them are about renewable sources. Also this sources of energy have many advantages: they don't pollute the environment (they don't need so much fuel and we have no pollute, and also without mobile components they don't produce phonic pollution), they are very secure (because the PV elements are elaborated in extreme and long duration conditions), they need very low maintenance costs and can be used anywhere, even at diffuse light.

2. APPLICATION

2.1. The main frame

As part as Electrical Engineering faculty, University Polytechnics of Bucharest, UPB, exists a photovoltaic station of 30 kW.

The stations is part of European project „PV Enlargement", with the following objectives: the increase of the photovoltaic technology impact for the potential investors, decision factors and to inform the public opinion concerning the clean technologies and to allow a quicker penetration of the photovoltaic technology; proving the possibility of decentralized energy production using the photovoltaic technology; the analysis of the technology efficiency in the Romanian climatically conditions; the evaluation of the electrical energy production using the photovoltaic technology; the education of the young researchers in photovoltaic technology.

The European project is the largest demonstrative project unrolling for photovoltaic technology. In this project are involved 28 partners from all Europe. The technology used is identical for all systems with a power higher than 1,2MWp.

The photovoltaic station installed by SC ICPE SA, UPB is using two of the commercial technologies, the most used on world level: unit Si and amorphous Si.

The power of photovoltaic under systems is: 26,46 kWp for unit Si technology (modulus ASE-250); 3,72 kWp for amorphous Si technology (modulus ASITHRU-30).

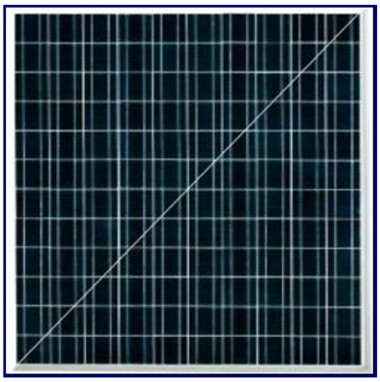

Figure 2: Modulus ASE 250.

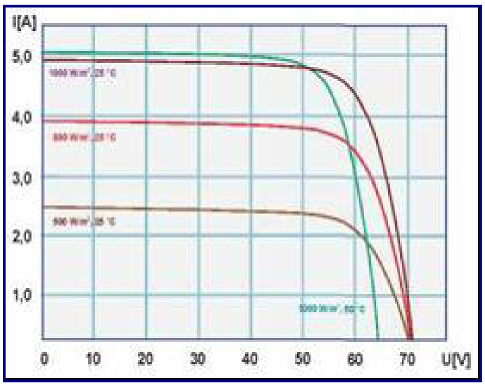

Figure 3: Technical characteristics for ASE 250.

Figure 4: Modulus ASITHRU 30.

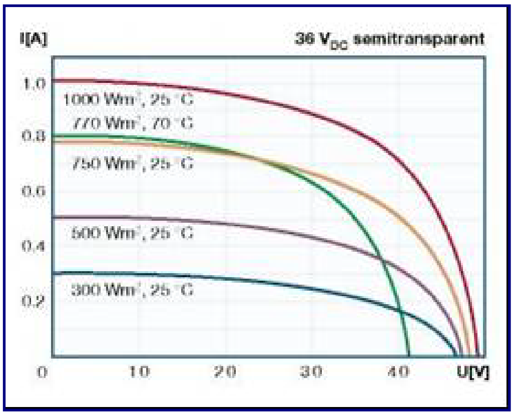

Figure 5: Technical characteristics for ASITHRU 30.

2.2. The case study

Homer is a micro power optimization model for a variety of applications. The simulation results in a wide variety of tables and graphs that help us compare configurations and evaluate them on their economic and technical merits. Homer simulates the operation of a system by making energy balance calculations for each of the 8,760 hours in a year. For each hour, Homer compares the electric and thermal demand in the hour to the energy that the system can supply in that hour, and calculates the flows of energy to and from each component of the system.
After all we said, it will be determined whether a configuration is feasible, whether it can meet the electric demand under the conditions that you specify, and estimates the cost of installing an operating the system over the lifetime of the project. The system cost calculations account for costs such as capital, replacement, operation and maintenance, fuel and interest.
After simulating all of the possible system configurations we will obtain a list of configurations, sorted by net present cost (lifecycle cost), that we will use to compare system design options.
One of the qualities of this program is sensitivity analysis. The results of this analysis are used for the factors identification that has the greatest impact on design and on the operation of a certain system of producing energy. In the same time, the results of sensitivity analysis can offer us some answers to general questions concerning the different technological optimizations, and we have in this way the information need it for planning and decisions. When are definite the sensitivity analysis variables like inputs, the optimization process will be repeated for each sensitivity variable specified.
We will use this program in our analysis, starting from the photovoltaic station installed in Electrical Engineering faculty, with ICPE support, and we will try to reach some of the objectives specified in PV Enlargement program.
The first part of the program follows the equip description. In our case: converters, the photovoltaic panels and of course some dates concerning the load. After this, in accordance with equipment, we will have the resources used by every equip component (in our case, the solar resources).

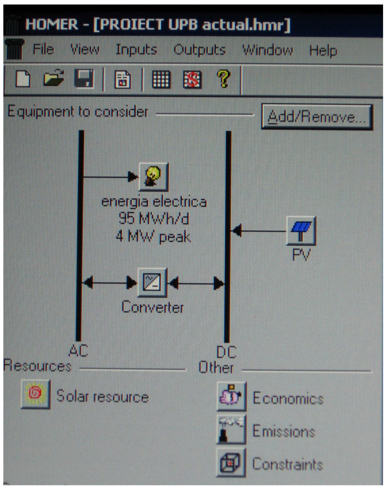

Figure 6: Equipments for the PV system

We have a data base concerning the load profile (kW), in accordance with this one, it will be characterized the equip energy production. The characterization will be made starting with a day of the year profile. We will have graphical characterization by hours, days, months, a year profile; we will have a characterization of the frequency.
The next step is about a equip component, converters. It will be made an economical analysis and some costs curves. The same analysis will be made also for the PV panels.
Also in the optimization part we have a characterization of the resources used by every equip component, in our case the solar resources. This are characterized monthly in accordance with clarity and solar radiation. We have a graphical characterization (hourly, daily, monthly, and yearly, frequency characterization), in accordance with two variables: global solar radiation and extraterritorial radiation. In the first step are insert the general dates concerning the location: latitude and longitude. We will use these values for a calculation of daily radiation mean starting with the clarity parameter and in reverse order.
Another part of the program, the optimization part, we have an economical analysis, of the emissions and of the constraints.
After all these analysis, we will have all the possible simulations and we will have also the optimization results and sensitivity analysis:
Sensitivity case: Solar Data Scaled Average: 6 kWh/m2/d
System architecture: PV Array: 30 kW+ Inverter: 2.8 kW+ Rectifier: 2.8 kW
Cost summary: Total net present cost: 191,745 $+ Levelized cost of energy: 1.384 $/kWh

Component	Initial Capital	Capital /year	Replacement/ year	O&M /year	Fuel/ year	Total/ year
	($)	($/yr)	($/yr)	($/yr)	($/yr)	($/yr)
PV Array	165,900	12,978	1,769	0	0	14,747
Converter	1,610	126	43	84	0	253
Totals	167,510	13,104	1,812	84	0	15,000

Table 1: Cost breakdown.

Table 2: Annual electric energy production.

Component	Production	Fraction
	(kWh/yr)	
PV array	58,504	100%
Total	58,504	100%

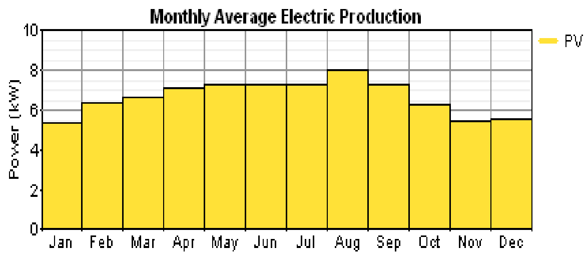

Figure 7: Monthly average electric production

Table 3: Annual electric energy consumption for PV.

Load	Consumption	Fraction
	(kWh/yr)	
AC primary load	10,840	100%
Total	10,840	100%

Variable	Value	Units
Renewable fraction:	1.000	
Excess electricity:	46,459	kWh/yr
Unmet load:	34,776,424	kWh/yr
Capacity shortage:	38,260,044	kWh/yr

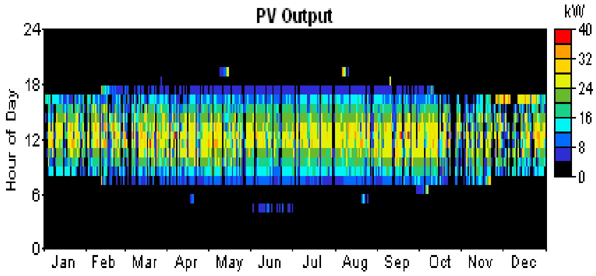

Figure 8: PV output

It is observed very easily that the maximum irradiation of the PV system with solar radiation is around 10-14, independent of the month of the year. It is also important to see that this system captured solar radiation also in bad conditions like diffuse radiation. Also we can see that the system is active the all period of the year, the variation between the months of the year is not so big. The energy production is lower around 22-04 o'clock.

3. CONCLUSIONS

Romania has a very good solar potential. Here all five forms for renewable sources are presented in good proportion for an energetic exploitation interest. The technical potential for solar energy conversion into electrical energy is significant (more than 40.000 TJ/year), taking into consideration that medium radiation is between 1100 and 1300 kWh/m² per year. Biomass is more used in Romania (it is contribution is 40.000 TJ/year). It is covered in this way 2.7% from primary energy consumption and 10.6% from the necessary of heating. Romania is on the third place for its geothermal potential in Europe (5.300 TJ/year), with low temperature waters (55-105°C).

Photovoltaic and Aeolian conversions are, in this moment, considered like very good solutions for solving the problems in isolated areas, those could be applied like hybrid systems also. The variable character of the wind and solar energy has created difficulties for economical solutions and a good management of the energetic processes in hybrid systems. Researches from Europe had elaborated some designing methodologies for the hybrid systems and optimal leadership of the energetic processes, but those are now experimented.

So, after we said all these, we can say like a conclusion that Romania can be a good electricity manufacturer using the photovoltaic technology.

The financial aspects are also very important. So, we have a very good potential but is worth?

The European community established a difficult objective for the countries with powerful industries: double the production of energy from renewable sources of energy. In the next table you can see the costs and benefits for the next years. The total capital for reaching the objectives in the next period until 2010 is 165 milliards lei. Most important is the fact that the net investments are 95 milliards lei (they have been calculated: total investment without the ones which have been necessary if the energy have been produced otherwise than renewable sources). Is very important to mention that in this way, is avoided important costs for fuel.

Total investments in energetic area, of which systems for renewable sources (SER)	248 milliarde euros of which 39 milliarde euros
Total investments SER in the action plan	165 milliarde euros
Net investments SER in the action plan	95 milliarde euros
Suplimentary net investments SER in the action plan	6.4 milliarde euros
The increase of the total investments in the energy sector	74 milliarde euros
New work places	
Annual costs for fuel avoided in 2010	3 milliarde euros
Total costs for fuel avoided in 1997-2010	21 milliarde euros
Reduction of the imports	17.4 %
Reduction of the CO_2 (raported to 1997, before Kyoto)	Under 402 mil. t/ year 250 mil. t/year
Anual benefits of the CO_2 reduction	5-45 milliarde euros

Table 5: Costs and benefits for the global strategy for 2010

If we consider that some of the investments in the renewable sources are made, the net investments needed for the plan success are 74 milliarde euros. Also double the actions in renewable sources domain, could need a investments increase with 30%, but it will produce between 500.000 and 900.000 new jobs, will save 3 milliard euros every year (it strats with 2010), representing the fuel costs, and a total amount of 21 milliard euros during the period 1997-2010, will decrease the imported fuel quantity with 17.4 % and also CO_2 emissions with 402 millions tones until 2010.

The financial aspects of the photovoltaic technology can be distinguished very well, using the estimation of the energy produced by photovoltaic system, 30.42 kWp, using one of the simulation programs, Homer in our case.

After the analysis of the Homer results, we can say that: the dates concerning the energy production have a normal distribution, which is characterize by Gauss graphic (dates per month, days, hours and so on); Homer analyses the system from the efficiency point of view. The actual system offers me an electricity excess of more or less than 73% (who represents 30,116 kWh), and the total capacity is more or less than 38,261 kWh. If the system architecture will be: PV 10 kW, and the converters of 2,8 kW, this electricity excess will be 38%. If the system architecture will be: PV 10 kW, the converters of 2,8 kW, and a battery this electricity excess will be 70%. If the system architecture will be: PV 10 kW, the converters of 2,8 kW, and a generator this electricity excess will be 10%; the same excess will be if we put a battery to this system.

Variable	Value	Units
Average output:	160.3	kWh/d
Minimum output:	0.0001107	kW
Maximum output:	37.2	kW
Solar penetration:	0.1682	%
Capacity factor:	22.3	%
Hours of operation:	4,740	hr/yr

Table 6: Annual electric outputs for PV.

Based on the numbers offered by the simulation program, we have the following results: the total incoming if the energy is sell to the line system: 888 €; UPB like a user can save 2100 €/year, by decreasing the electricity invoice (if the electricity is consumed by UPB); the estimated time of liquidation, if the energy is sold at the actual price: 101 years; the estimated time of liquidation, if the energy is consumed local: 99 years.

In conclusion, we must establish a price thus photovoltaic technology to become a profitable business, in a large frame for promoting the ecological technologies.

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