Testing and shaping for the performance of a system, used for solar energy production

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Abstract-The solar energy, like a permanent source of energy, is the optimal solution, and also a very important solution, for our investigations, because this source could solve a part of the problems related with inaccesibility and the high costs.
A long series of projects are developing now, taking into consideration the importance of this problem.
At University Politehnica of Bucharest, like a result of the PV Enlargement project exists a photovoltaic station.
The actual system is analysed and a lot of conclusions are made, concerning the efficiency (as a result of these investigations we obtain an nergy excess of 73%) and the improving variances.

I. A case study for testing and shaping a solar system

A. Introduction

Solar energy, recognized like one of the five renewable sources of energy (wind energy, water energy, biomass and geothermal energy), with the wind energy, is considered in these times, like a solution for solving the energy problem in isolated areas, used like systems itself, and also like hybrid systems.

The renewable sources of energy are the cleanest sources of energy, from the ecological point of view, and they have two big essential qualities: zero emissions and they don’t depend on supply infrastructure, meaning self generation.

B. The frame for the practical application

The frame for the practical application is the faculty of Electrical Engineering, University Polytechnics of Bucharest, where is installed a photovoltaic station of 30 kW.

The station is part of European project „PV Enlargement”, the largest demonstrative project unrolling for photovoltaic technology.

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) and 3,72 kWp for amorphous Si technology (modulus ASITHRU-30).

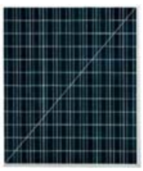

Fig.1 - Modulus ASE-250

Fig.2 - Modulus ASITHRU-30

For testing we have chosen a program for simulations, Homer. 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. 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.

For dates gathering we must refer at standard conditions for measurement, for testing and qualification of the conversion devices for solar energy, accepted like standards by the manufacturers and users, who use this systems for the conversion of solar energy in electric energy and or thermal energy.

The standard conditions for testing - STC for photovoltaic conversion are: cell temperature- 25±2° C; solar radiation- 1.000 W/m2; spectrum AM 1,5.

The standard conditions, STC, which are applied in labs, is the base for evaluation of the different components used in photovoltaic conversion. These conditions are very different by the real working conditions of this type of devices. This is way, were defined testing methods in normal working conditions -NOCT- which are standard also, but are much closer to what is happening in normal working conditions: gradient angle- perpendicular on the sun direction; solar radiation- 800 W/m2; environment temperature- 20° C; wind speed- 1 m/s.

For date’s acquisition, the system has a data logger DL 100, who is permanently checking the converters system, the dates acquisition about momentary parameters and assures the connection with a PC. DL 100, has the main purposes to monitories the inverters system, dates acquisition about the system parameters and assures the connection with a PC. The data logger is made for working with the SunProfi inverters.

Fig.3 – Data Logger Sun Power DL100

For converting the energy in cc, energy assured by the photovoltaic converters, the station has 9 DC/AC inverters, with automatic synchronization and tracking device for the maximal power transfer (MPPT). The inverters SunProfi are one of the most efficient and advanced at world level. The efficiency is 92-94%. The inverters has their own algorithms for diagnosis and communication with a central system for tracking the own parameters.

Those inverters are especially made for photovoltaic stations, and they have their own capacity for connecting to the electric network parameters.

Date de intrare	
Tensiune de intrare minimă Vpmin	196 Vdc
Curent de intrare maxim	15.5 Adc
Date de ieşire	
Putere	2800 W
Tensiune	196....253 Vac
Frecvenţă	49.8....50.2 Hz

Fig.4 – The interface with the electric network

For the implementation in the simulation program, we start with data base concerning the Load profile, kW, depending on it will be characterized the energy production of the system, like we can see below in the summary of the most important results. The important dates are collected hour by hour, during one day, read it on the electric meter. The characterization is made starting this profile. We will have graphical characterization by hours, by days, by months, by year, a frequency diagram, cumulative frequency.

For the analysis concerning the converters we will insert the dates concerning the acquisition costs for the converters type SP 2800-550 and PC interface D2-100.

But the simulation program will ask for the estimative acquisition cost and also the replacing cost, operation and maintenance cost for 1 kW. With those inputs, the program will show us the cost curve also.

The same analysis is made for 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 a 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 optimisation results and sensitivity analysis:

Component	**Initial Capital**	**Annualized Capital**	**Annualized Replacement**	**Annual O&M**	**Annual Fuel**	**Total Annualized**
	($)	($/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

Fig.5 – Results for the sensitivity analysis

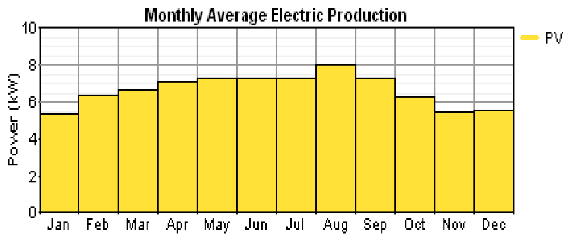

Fig.6 – Monthly average electric production

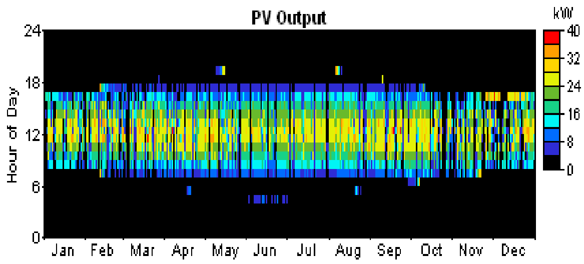

Fig.7 – PV output

Modalities for improving the present system:

All these, presented like an application, are concerning the analysis of the system, which is working at the faculty of Electrical Engineering. But, with the simulation program's help, is made an analysis of the system, if we work with another equips.

This analysis is necessary, because in the present project we have an energy excess of 73%.

Following this idea, we will analyse the following system variants, with their outputs:

a) The present system + generator;

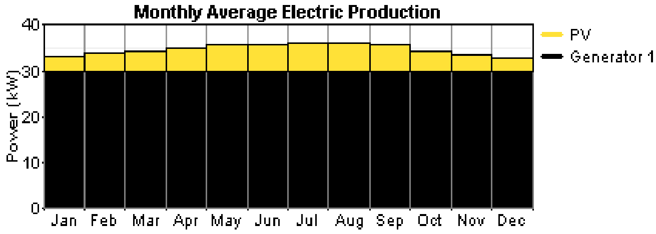

Fig.8 – Monthly average electric production

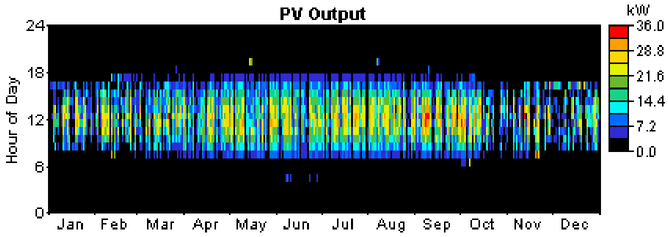

Fig.9 – PV Output

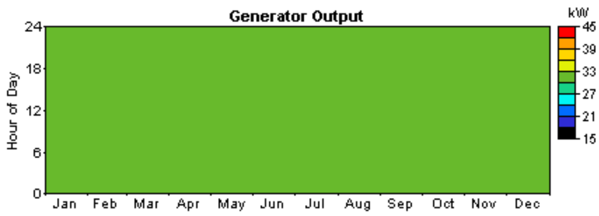

Fig.10 – Generator Output

b) The present system + battery;

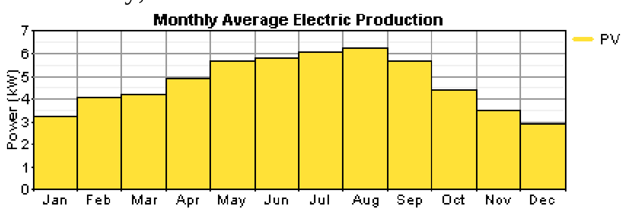

Fig.11 – Monthly average electric production

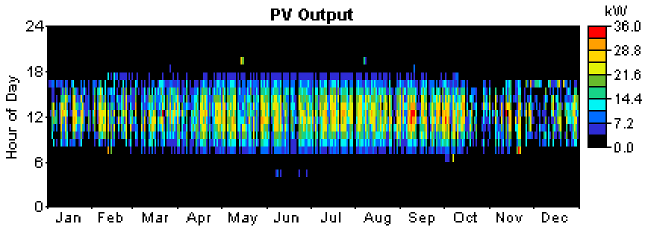

Fig.12 – PV Output

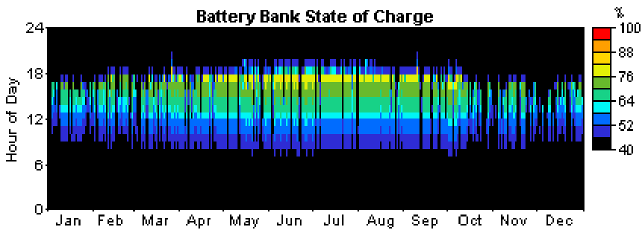

Fig.13 – Battery Bank State of Charge

c) The present system + generator + battery;

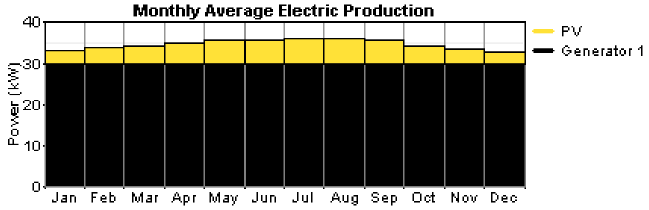

Fig.14 – Monthly average electric production

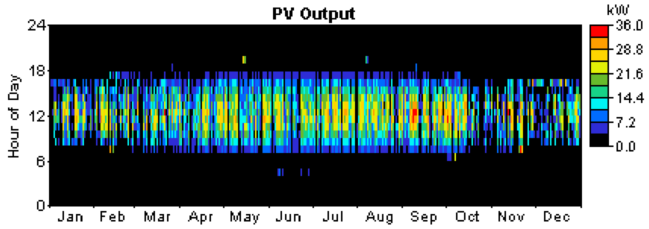

Fig.15 – PV Output

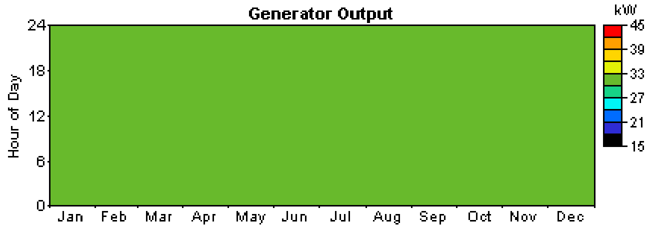

Fig.16 – Generator Output

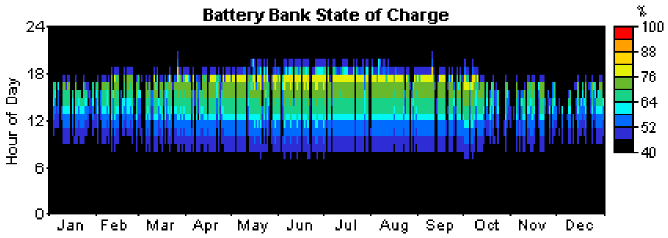

Fig.17 – Battery Bank State of Charge

II. Conclusions

After the presentation of all these systems, we will take into consideration in their comparison the analysis of the electricity excess, the hypothesis from which we started.

So, the a) system, to our present system we will add a generator, will offer me an electricity excess of 10%, so after the simulation we can admit that this one is the best of all.

The b) system, to our present we will add a battery, will offer me an electricity excess of 70%.

The c) system, to our present system we will add a generator and a battery also, we will offer me an electricity excess of 10%, but we will keep in mind that from the costs point of view, these will be higher than a) case.

The difference between all these systems, will not be only in electricity excess, although this is an disadvantage which must be eliminate, but also we must look for another important aspect of our days: the emissions. These are present in the a) and c) systems, and without pollutant emissions in the present system case and also b) system.

Another characteristic who is important is the cost. The cost for the a) and c) systems is obviously much more higher than in b) case (86.285, respective 86.324 dollars/year, comparative with 15.039 dollars/year).

Anyway regardless of advantages or disadvantages, the financial possibilities, once with our entrance in UE, Romania will be forced to change its position concerning the renewable sources of energy, by enacting laws which will stimulate the electricity production by photovoltaic technologies.

In conclusion, the minimum cost for which the photovoltaic technology is efficient, economically speaking, must be approximately 300 €/MWh for liquidation in 20 years, or approximately 550 €/MWh for liquidation in 10 years.

Reaching a target price of 79,2€/MWh, like ANRE said for the year 2010, must that the investment in photovoltaic systems must be 2000€/kWp, and this is a little too much, but represents a necessity.

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