Proceedings of the 4th WSEAS Int. Conf. on HEAT TRANSFER, THERMAL ENGINEERING and ENVIRONMENT, Elounda, Greece, August 21-23, 2006 (pp78-82)

Solar potential assessment and comparison between the available solar energy for Brasov and Heraklion area

MIHAELA VOINEA[1], CLAUDIU COVRIG[2]
[1]Centre: Product Design for Sustainable Development
[2]Economic Engineering and Production Systems
Transilvania University of Brasov
Eroilor 29, 500036, Brasov, Romania
Romania

Abstract: - The solar energy is the most important energy source available because, besides the fact that it is not polluting the environment and it helps to the reduction of green house effect, it is free of charge and it can be easily converted to other forms of energy. The design of solar applications must be based on the local solar potential assessment. This work represents the first part of a model for assessing the solar potential in the area of the Brasov County placed in the center part of Romania. The determined potential will be compared with the potential available in Heraklion Greece using the data from the Laboratory of Meteorological measurements and Hybrid Energy Systems, of T.E.I. Crete.

Key-Words: - solar trends, solar potential assessment, solar irradiation

1 Introduction

In the last century, the greatest damages brought to the environment were caused by the consumption of conventional energy sources. The energy generated from fossil fuels led to very high concentrations of harmful gases in the atmosphere, creating a series of problems, such as global warming and the ozone layer rarefaction. Therefore, renewable sources of energy are very important as they produce small emissions, they can be used at local level and also they require little maintenance, compared with other electricity or thermal energy generating systems. If these sources are used at a large area they reduce the quantity of chemical elements daily released in the atmosphere, the thermal pollution and indirect the radioactivity. These sources are considered viable and infinite sources of clean energy [1, 2].

The solar energy is the most important energy source available because, besides the fact that it is not polluting the environment and it helps to the reduction of green house effect, it is free of charge and it can be easily converted to other forms of energy such as thermal and electricity. The amount of energy that can be obtained from the sun is enormous considering that all the energy stored in the conventional fuels is equivalent with 20 days of sunshine [3].

In the last 10 years, in Europe and all over the world a great increasing in thermal and electrical renewable energy sources based on solar collectors and photovoltaic modules was registered.

2 Problem Formulation

2.1 Solar application development

The majority of the world's solar systems are shipped to developing countries for a variety of applications, such as domestic heat water, heat spacing, crop drying, solar desalination, rural electrification, telecommunication, water pumping, street lighting, etc [4].

The design of solar applications must be based on the local solar potential assessment. In order to obtain an accurate approximation of the solar potential for an area it is very important to know the climatic elements for the respective area.

The evolution of solar applications at European countries level is due to the legislation policies for encouraging the development of solar collectors and photovoltaic modules and for creating a working market in this area. The cumulated capacity of solar thermal collectors installed in the first 10 countries from the European Union, for the years 2003 and 2004, are presented in Table 1 [5].

Table 2 presents the cumulated capacity of solar thermal collectors for the countries that joined the E.U. in 2004. From this table it can be observed that besides

Cyprus, for the countries that were under the communist regime the surfaces of installed thermal collectors are very small and this is due to the fact that no governmental programs and policies were sustaining these systems.

Table 1 Cumulated capacity of solar thermal collectors installed in the first 10 EU countries

Position	Country	Year 2003	Year 2004
		Total m^2 installed	Total m^2 installed
1.	Germany	5.478.000	6.199.900
2.	Greece	2.779.200	2.826.700
3.	Austria	2.267.557	2.399.791
4.	France	716.380	792.500
5.	The Netherland	457.740	503.829
6.	Italy	415.211	457.711
7.	Cyprus	451.000	450.200
8.	Spain	361.351	440.151
9.	Denmark	314.410	328.380
10.	Sweeden	205.989	224.774
	TOTAL E.U. (25 members)	*14.115.810*	*15.361.824*

Table 2 Cumulated capacity of solar thermal collectors installed in the countries that joined the E.U. in 2004

Position	Country	Year 2003	Year 2004
		Total m^2 installed	Total m^2 installed
7	Cyprus	451.000	450.200
16	Slovenia	99.200	101.500
17	Poland	65.690	94.587
18	Slovakia	51.250	56.750
20	Czech Republic	41.500	50.000
21	Hungary	45.000	48.000
22	Malta	11.145	15.360
23	Latvia	1.150	1.650
24	Lithuania	1.150	1.650
25	Estonia	320	570
	TOTAL E.U. (25members)	*14.115.810*	*15.361.824*

Even though it did have a third consecutive year of growth, the sector is not presently at the rate needed to reach European Commission objectives. This situation is due to the fact that the European market is supported by a minority of countries. Germany, Austria, Greece and the very active Cyprus represent 77.3% of European thermal solar capacity for 22.5% of EU population. These countries alone can not bring the European Union up to the objectives that have been set [5].

Romania does not exist in the statistics because the surface of solar collectors is insignificant and it cannot be determined exactly. However, in the '80s, in Romania there were implemented solar systems for preparing domestic hot water for some hotels placed near the Black Sea coast and for some buildings from Bucharest and Brasov. Their performance was between the expected parameters only one year during 1984-1985. The bad quality of the equipments, materials and installations combined with an inadequate maintenance caused problems and unsatisfied customers, thus generating barriers in the future development of the solar thermal systems. The failure was due to inappropriate design and because local weather conditions were not considered [6].

2.2 Solar potential assessment needs

The design of solar applications must be based on the local solar potential assessment. In order to obtain an accurate approximation of the solar potential for an area it is very important to know the meteorological data recorded for the respective area.

This work represents the first part of a model for assessing the solar potential in the area of the Brasov County placed in the center part of Romania. The determined potential will be compared with the potential available in Heraklion Greece using the data from the Laboratory of Meteorological measurements and Hybrid Energy Systems, of T.E.I. Crete.

The determinations and calculations' lack regarding the solar potential in the whole country of Romania opens an opportunity for developing systems and models for solar energy assessment and predictions. The access for the meteorological data regarding the area of Brasov was very difficult; therefore, data from the Mars Global Radiation Database for Brasov region are used [7].

3 Problem Solution

The model created is based on the solar radiation for a representative day, 21st of July 2005, from the Bioclimatic House Meteo Station Database (Fig. 1). Although the model was using information only from a day, it can be extended for the whole year data analysis and it can be improved with a part of energy predictions when having sufficient data recorded. Because solar radiation data for Brasov are available only for the satellite, the model was not applied yet in the Brasov case. However, using the Mars Global Radiation Database a comparison between the monthly available energy in the two areas was done.

3.1 Data measurements

The total or global solar radiation over a surface at a certain moment (IT) is defined as the sum of three components:

$$I_T = I_b R_b + I_d R_d + (I_b + I_d) R_r, \text{ [kW]} \tag{1}$$

where:

- I_b is the direct solar radiation, [kW];
- I_d is the diffuse solar radiation , [kW];
- $(I_b + I_d)$ is the ground reflected part of the global solar radiation, [kW];
- R_b, R_d, R_r are the radiations factors.

In practice global radiation I_T was measured at the horizontal level with the help of a Pyranometer from the meteo station installed at the Bioclimatic house from the Technological Educational Institute of Crete – Heraklion (Latitude: 35.20, Longitude: 25.8.). This information was used for the model created in Matlab to calculate the solar potential both for solar collectors and PV's.

Fig. 1 *The Bioclimatic house and the meteo station Technological Educational Institute of Crete, Heraklion*

3.2 Methodology

The Matlab program developed is using statistics tools, numerical analysis and probabilities.

After the functional relation that describes the solar radiation was found (using *cftool* Matlab function), the solar power potential was calculated in the case of solar collector and a PV module. The solar module factor was considered 0.70 for the solar thermal panels and 0.11 for the PV module. After this, the solar energy gain was calculated (using *trapz* Matlab function) in both cases. The recommendation of the International Energy Agency's Solar Heating and Cooling Programme (IEA SHC) – "Typical collector efficiency", were taken into consideration for calculations [8].

3.2 Results and discussion

In the following, the results are presented as tables and graphs.

For the chosen case the best fitting parameters were those of Gaussian 5 and they have been used for further calculations (see Table 3). Also, the polynomial fitting was used, but the fitting parameters did not have appropriate values in this case.

After calculation, the energy gain for 1 m^2 of solar collector during 21st of July 2005 is 8.5818 kWh_{th}, and for 1 m^2 photovoltaic module is 0.9440 kWh. Figure 2 presents the power provided by the solar collectors and PV modules for Heraklion area considering the same day.

Table 3 Goodness of fitting – 21 August 2005

Location	Mean solar radiation	Type of fit	SSE (→ 0)	RSquare (→ 1)	RMSE (→ 0)
Heraklion	0.1509 kW/m^2	Gauss5	0.00788	0.9996	0.007816
		Gauss6	0.009141	0.9996	0.008518
		Gauss7	0.008388	0.9996	0.008258

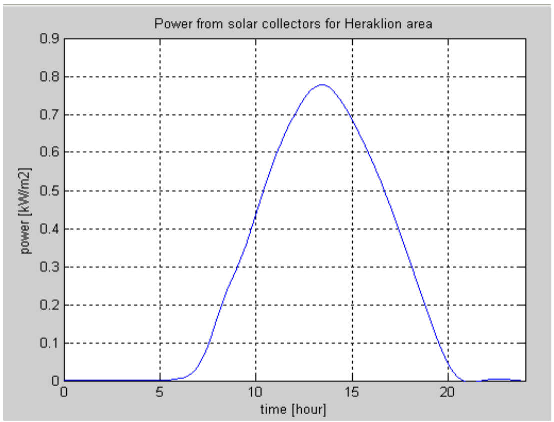

Fig. 2 Power from solar collectors – Heraklion area, 21st of July 2005

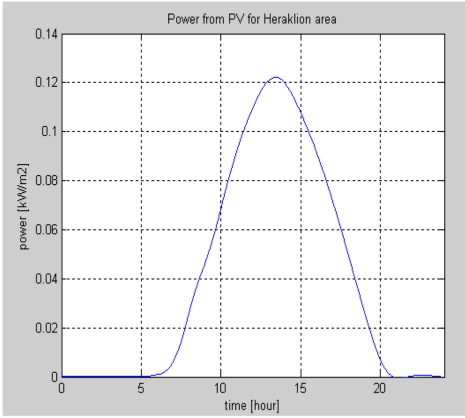

Fig. 3 Power from PV's – Heraklion area, 21st of July 2005

Table 4 Solar radiation and solar energy gain comparison

Month	Solar radiation [kWh/m^2]		Solar energy gain [kWh/m^2]			
	Brasov	Heraklion	Brasov		Heraklion	
			Solar collectors	PV	Solar collectors	PV
January	44.763	62.917	31.3341	4.92393	44.0419	6.92087
February	62.42	76.423	43.694	6.8662	53.4961	8.40653
March	104.688	120.349	73.2816	11.5157	84.2443	13.2384
April	152.14	145.101	106.498	16.7354	101.5707	15.9611
May	181.269	187.21	126.888	19.9396	131.047	20.5931
June	194.524	203.233	136.167	21.3976	142.2631	22.3556
July	174.348	209.29	122.044	19.1783	146.503	23.0219
August	145.424	190.793	101.797	15.9966	133.5551	20.9872
September	101.502	146.839	71.0514	11.1652	102.7873	16.1523
October	82.24	106.431	57.568	9.0464	74.5017	11.7074
November	44.913	65.407	31.4391	4.94043	45.7849	7.19477
December	30.765	58.113	21.5355	3.38415	40.6791	6.39243
Yearly	1318.996	1572.1060	923.2977	145.0895	1100.4742	172.9316

Table 4 presents the monthly solar radiation for both Brasov and Heraklion area. The total solar radiation for Brasov is 1318.996 [kWh/m^2] which represents 83.9% from the corresponding value for Heraklion, which is a very good value for this region. However, there is a possibility that the values from the Mars Global Radiation Database might be not so precise. For accurate calculations and for predicting the produced energy from the wind and solar radiation, data recorded by a local meteo station are needed.

Figures 4 and 5 show the comparison between the solar radiation and the solar energy gain for the regions considered, using the data from the Mars Global Radiation Database.

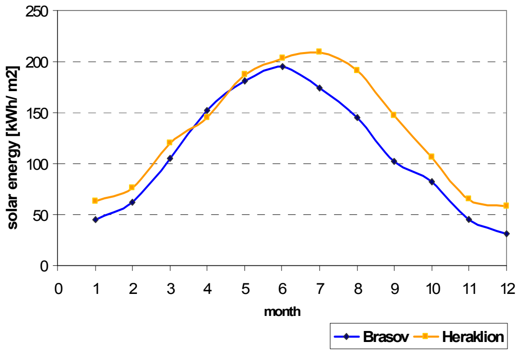

Fig. 4 Solar radiation comparison

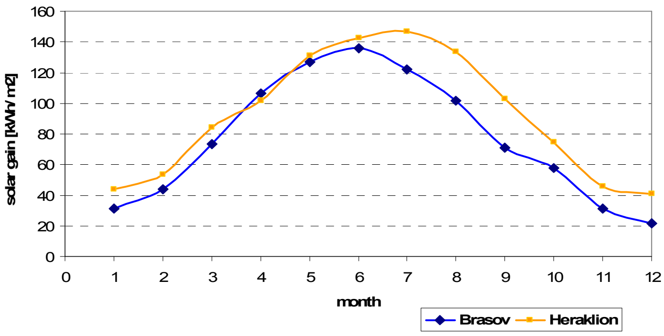

Fig. 5 Solar energy gain for a solar collector comparison

4 Conclusions

As it can be observed from the graphics and from the table above mentioned, the assessment of the solar potential of Brasov area is very encouraging. This is the first step for designing solar systems and it is a very important key factor for their operating in optimum conditions.

Knowing that the specific heat gained from the sun varies according to the latitude, best results being obtained in countries closer to the Equator (characterized by 0º lat.), it results a big opportunity to exploit this solar potential in Brasov and also for Romania. Countries such as Germany (40.36% from the total E.U. installed capacity), Austria (15.62% of the E.U. capacity), Denmark (2.14%) and even Sweeden (1.46%) are showing a keen interest in developing solar thermal collectors even if their geographical position is not as encouraging as it is in Romania [5].

In order to exploit this solar potential all the decision factors must be involved for creating a future structure which will lead to an independent energy market and to a cleaner environment.

The price of the energy generated from fossil fuels is in a continuous growth creating questions regarding our future activities. For that reason, if we cannot find more conventional energy sources because the first lesson of any economy is that "the resources are limited", at least we can develop and encourage the renewable energy sources, taking advantages from the solar potential determined in different areas.

Most probably, Romania will join the E.U. in January 2007 and as a member state will have to adopt measures and laws for encouraging the investments and for developing a market in the sector of renewable energy sources. This fact will open new opportunities for the entire energetic sector, for industry, for people living in remote areas and also for young scientists activating in the domain of renewable energy especially in the solar energy domain.

References:

[1] Claudiu COVRIG, Mircea IVAN, The efficiency of the energetic system of an enterprise using renewable energy sources, Part I and II, International Conference on Economical Engineering and Manufacturing Systems, Brasov, Romania 2005.

[2] Claudiu COVRIG, Photovoltaic systems-characteristics, opportunities and economical analysis, Transilvania University of Braşov, International Conference on Sustainable Energy, Brasov, Romania 2005.

[3] Ion VISA, Anca DUTA, *Renewable Energy Systems*, Ed. Univ. Transilvania Brasov, 2005.

[4] Mihaela VOINEA, Andreas VLISIDISS, Performance monitoring system for PV's used in street lighting, Transilvania University of Braşov, International Conference on Sustainable Energy, Brasov, Romania 2005.

[5] Projet EurOserv'ER – Observ'Er Eurec Agency Le Baromètre Européen 2005 des Énergies Renouvelables, 5e Bilan - Le Barometre du Solaire thermique, Décembre 2005.

[6] Florin Teodor TANASESCU, Doina MORARU, Cornel POPESCU, *Conversia energiei – Tehnici neconventionale*, Ed. Tehnica, Bucuresti, 1986.

[7] www.soda-is.com.

[8] Converting solar thermal collector area into installed capacity (m2 to kWth), Technical note from International Energy Agency's Solar Heating and Cooling Programme, 2004.