European Association for the Development of Renewable Energies, Environment and Power Quality (EA4EPQ)

International Conference on Renewable Energies and Power Quality
(ICREPQ'10)
Granada (Spain), 23th to 25th March, 2010

Radiative parameters specific to Braşov urban area

L. Coste[1] and C. Şerban[1]

[1] Department of Product Design and Robotics
Transilvania University of Braşov
29, B-dul. Eroilor, 500036, Braşov (Romania)
Phone/Fax number: +0040 268 412921, e-mail: **andreea.coste@unitbv.ro, cristina.serban@unitbv.ro**

Abstract. The paper objective is to present the input data needed for the renewable systems design, namely the recording and the analysis of the local meteorological and climatological parameters such as the solar radiation, the wind speed, the clearness index and the atmospheric turbidity factor.

The diagrams presented are obtained on the basis of the meteorological data recorded during three years, 2006-2008. The used meteorological data, for this study, were recorded with a local weather station positioned on the building roof of the Transilvania University of Braşov.

The paper ends with an analysis of some very important diagrams concerning the solar and wind power for Braşov area, and there are worded conclusions derived from the comparative analysis of these values.

Key words

Direct irradiation, Linke turbidity factor, clearness index.

1. Introduction

Braşov city is located in eastern-central Romania at 25°36' east longitude and 45°39' northern latitude. Situated in Braşov basin, in Carpathians internal curvature, Braşov urban area is about 790m above the sea level.

This region exhibits some typical features with respect to the topology, the climatology and the environment. The build-up area is low in comparison with that of the neighbouring mountains, which circle the basin area. The lowest atmospheric layers in the basin are, especially in winter, under the influence of temperature gradient inversions that restrict the atmospheric conversion and, therefore the vertical dispersion of air pollutants and dust. The slope winds that alternatively move up and down along the basin are too weak (the wind speed monthly mean is lower than 2m/s) to carry the pollutants completely out of the basin. Consequently, crucial situations of atmospheric pollution are frequently observed in winter when cloudy air masses persistently stay in the bottom of the basin, stopping solar radiation and incidentally increasing temperature inversion [1].

In order to calculate the performance of an existing system or to estimate the energy generated from a system in the design stage, appropriate weather data are required.

To provide the necessary information about the weather, meteorological instrumentation was used. The meteorological data measurement was carried out with a Delta-T local weather station, positioned on the roof of ''Transilvania'' University of Braşov (Romania). The data sets have been collected since October 2005 until now and they comprise:

- ✓global solar radiation [W/m^2],
- ✓diffuse solar radiation [W/m^2],
- ✓air temperature [^{o}C],
- ✓wind speed [m/s],
- ✓wind direction [degrees],
- ✓relative humidity [%],
- ✓rainfall [pluviometric mm],
- ✓sunshine.

The horizontal global radiations G, diffuse radiation D, as well as all recorded data are related to 10 minutes range, in a continuous way.

2. Direct Irradiation

The information about solar radiation, from the collection and processing meteorological data is directly usable in the synthesis of the tracking discreet programs for the oriented PV panels and the oriented solar thermal collectors.

Knowledge of the solar radiation available on the earth's surface is essential for the development of solar energy devices and for estimating of their performance efficiencies.

The complete and accurate solar radiation data for a specific site are of considerable significance for research and application fields as architecture, industry, agriculture, environment, hydrology, agrology, meteorology, limnology, oceanography and ecology.

Solar radiation is a driving force behind a number of solar energy applications such as photovoltaic systems for electricity generation, solar collectors for heating, solar air conditioning climate control in buildings and passive solar devices. Thus, the determination of solar radiation data is important. Solar energy is free, its supplies are unlimited and using solar energy produces no air or water pollution. Taking into consideration the data above, the solar radiation data should be measured continuously and accurately over the long term.

Referring to Braşov area, Figure 1 presents the recorded values of the direct irradiations onto a horizontal surface.

The diagrams are plotted for complete three years, 2006-2008 and for 2009 until October.

Figure 2 presents the direct solar energy available, averages of the hourly values, for December, March and June 2008. For instance, the total solar energy in June represents the daily mean (the sum of the energy for every hour - kWh/m^2 / day) multiplied by the number of days for June.

Therefore, for June 2008 it was obtained a solar energy income of $102kWh/m^2$. In the same way, the total yearly solar energy can be calculated (the sum of the total monthly values); the following values were obtained:

- for 2006 the value of the direct solar radiation was $532.5kWh/m^2$; the highest monthly value was registered in July, $94kWh/m^2$;
- the yearly direct solar energy for 2007 was $588.67kWh/m^2$, the highest value being registered in July and it has the value of $114kWh/m^2$;
- in 2008, the yearly global solar radiation was $640kWh/m^2$, the monthly highest value of this being obtained in June, $102kWh/m^2$.

3. Wind Speed and Wind Power for Braşov Urban Area

This chapter proposes a study concerning the availability of wind power for Braşov city area. Speed and direction are the main characteristics of wind for a certain location. Wind is characterised by a steady variation either in speed or in direction, and therefore it takes at least ten years to get the most accurate data.

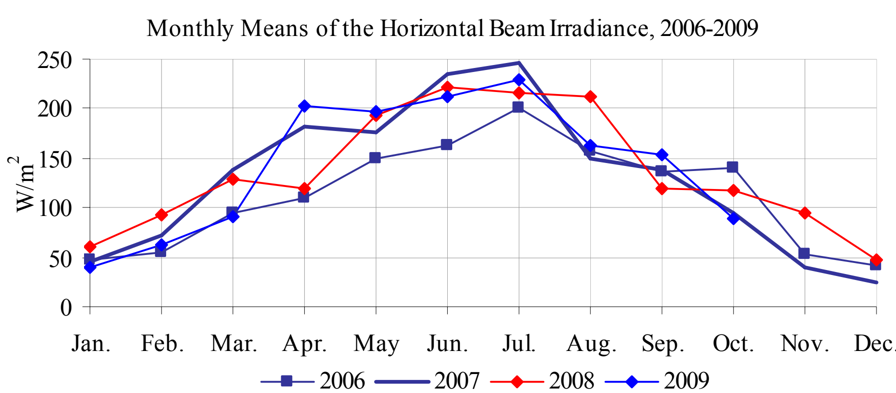

Fig. 1. Monthly means of the direct radiation for Braşov urban area

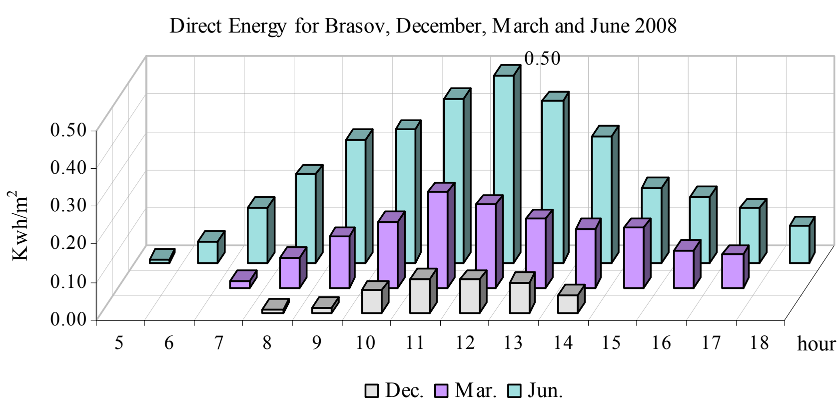

Fig. 2. Hourly means on month of the direct radiation for Braşov urban area

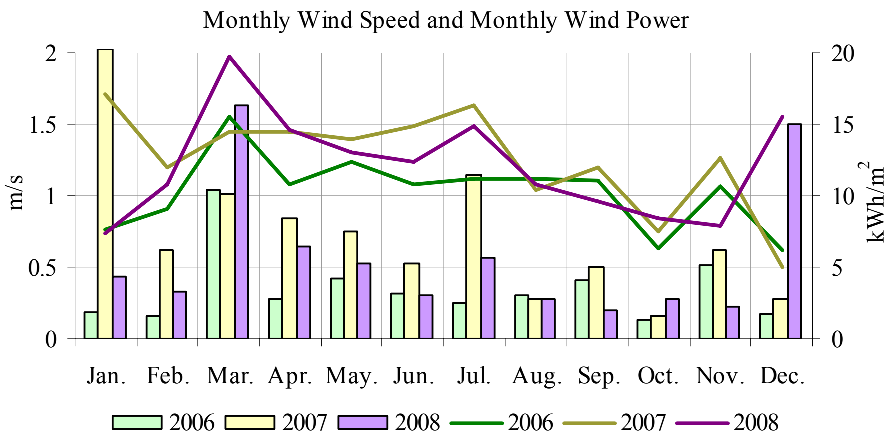

Fig. 3. Monthly means of the wind speed and wind power for Braşov urban area

Wind acts as "fuel" for wind power stations. For a more accurate prediction of the wind power for a certain location, it is very important to know the speed value variation depending on time.

Figure 3 presents the monthly mean values of the wind speed and the wind power recorded for Braşov urban area.

As it can be seen, the registered values of the wind speed characterize an area with a very small wind potential. The monthly mean wind speed is around 1-2m/s, values that cannot lead to important values of the wind power.

It must be mentioned, the wind speed is a random variable and it must be characterised in terms of the probability theory.

The aeolian regime of the Braşov depression comprises the characteristics of long intramountain depressions that favour an atmospheric circulation territorially divided.

The height and the morphological openings (passes) assure an active ventilation of the depression and imprinting its central area with less ordinary aeolian characteristics for the depression climates [1].

Considering the wind power calculations for Braşov urban area and the analysis of the diagrams presented (Fig. 3) there can be expressed the conclusions below:

- ✓ the yearly wind potential registered for the three years analysed was: in 2006 - 41.62kWh/m^2, in 2007 – 87.59kWh/m^2 and in 2008 - 68.91kWh/m^2.
- ✓ the highest values of the monthly wind power were registered in March 2006, January and July 2007 and in March and December 2008 (Fig. 3).
- ✓ because of the too low values recorded for the wind speed, the wind turbines' using is not recommended for this area.

4. Clearness Index

Clearness index is a parameter of a real importance in designing of a RES system; it can provide information concerning the real solar radiation compared with the available solar radiation. The parameter variation must be analysed during a year period, a month period and within a day (yearly, monthly and daily clearness index).

Clearness index (k_t) is a parameter that describes the attenuation of the solar radiation due to clouds and it depends on the geographical coordinates of the location for which is calculated.

Clearness index (k_t) is defined as the ratio of global solar radiation on a horizontal surface and the extraterrestrial global solar radiation.

The calculus and interpretation of the clearness index aroused the interest of many field researches because it can be very helpful in determining the helioenergetic potential of an area. Iqbal proposed that based on the daily values of the clearness index (k_t), the sky condition to be defined as follows [2]:

- ✓ for a clear day ($0.76k_t < 0.9$),
- ✓ for a partly cloudy day ($0.36k_t < 0.7$),
- ✓ for a cloudy day ($0.06k_t < 0.3$).

The study of the atmospheric permissiveness for Braşov urban area makes necessary the knowing of the clearness index and of its calculation algorithms. In this regard, using the meteorological data for the years 2006 - 2008, Figure 4 presents for Braşov urban area the monthly variation of the clearness index for the three considered years.

The analysis of the presented diagrams leads to the following conclusions:

- monthly average values of clearness index for Braşov urban area do not exceed the value of 0.55, that means, a large quantity of solar energy is absorbed and converted into diffuse radiation through the scattering phenomenon;
- taking into consideration all three years, the monthly averages of the clearness index, place Braşov area in a range of: 0.29-0.40, during January – April and September – December, respectively in a rage of 0.44-0.49 during May – August;
- the lowest values for the clearness index were obtained during the month of December (0.24 – 0.33);

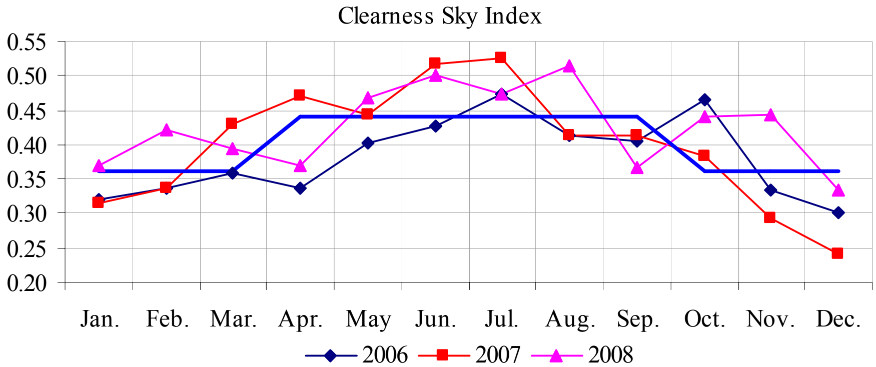

Fig. 4. Monthly means of the clearness index for Braşov urban area

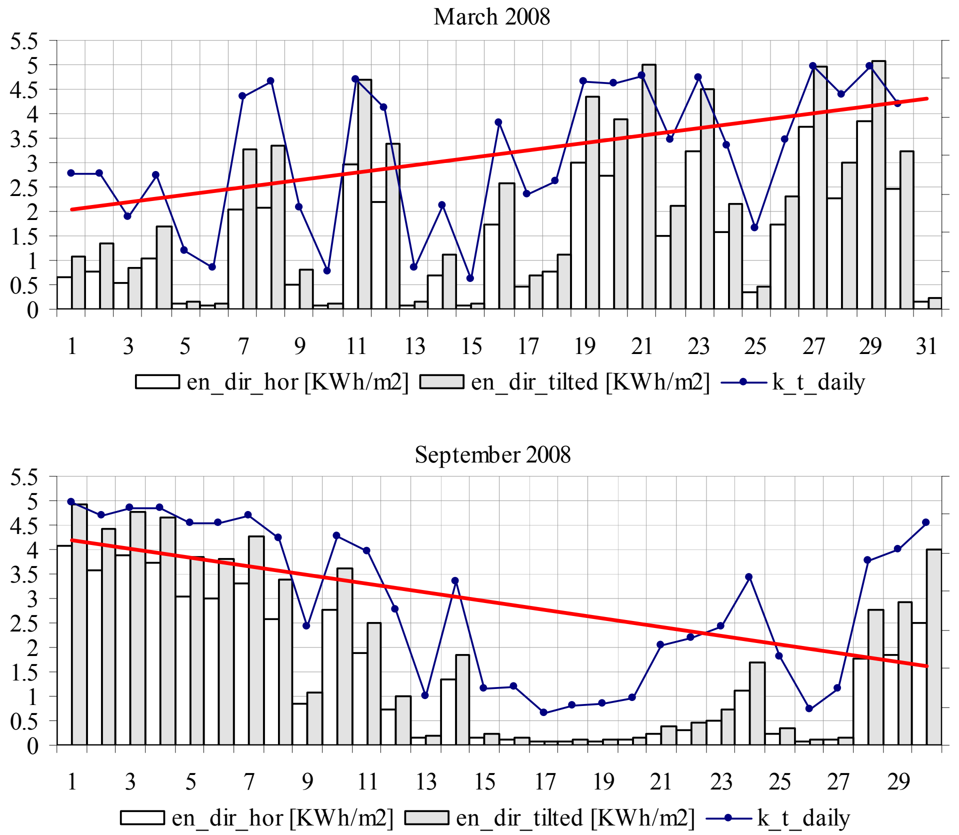

Fig. 5. Daily means of the clearness sky index and solar power on a horizontal and tilted surface for Braşov urban area

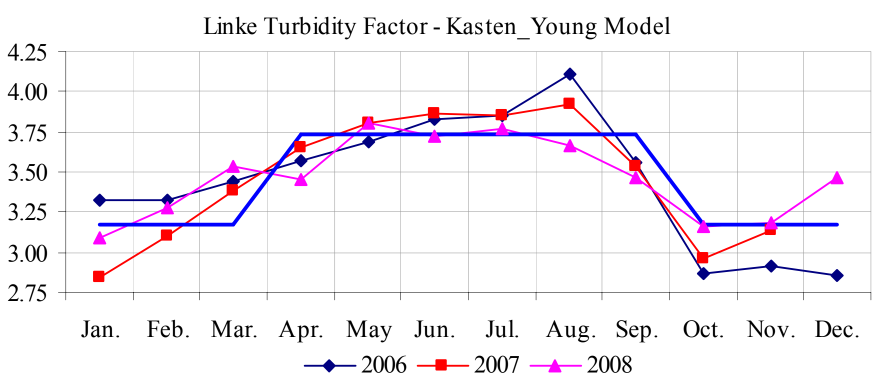

Fig. 6. Monthly means of the Linke turbidity factor for Braşov urban area

- March – April months respectively September – October can be considered transition months; in this time period, the major confrontations between worm and cold air masses take place; these meteorological phenomena provide a good environment and conditions for the precipitation, fog, smog, mist and drizzle appearance.

Figure 5 displays – for March and September 2008 – the superimposed diagrams of the clearness index variation (right axis) and the direct energy on a horizontal surface (en_dir_hor) and on an inclined surface with 45^o (en_dir_tilted).

For the presented diagrams, the inclination angle of 45^o was adopted, this value being the optimum angle for the spring and autumn equinoxes (taking into consideration that the latitude for Braşov city is 45^o39'and declination angle at equinoxes is 0˚, it results an inclination angle of $\beta \approx 45^o$).

The study of Figure 5 leads to the following conclusions:

- the amount of direct solar energy on an inclined surface (at 45^o) is higher than the direct energy on an horizontal surface, due to the optimum value of the inclined angle for the analyzed time period (March and September months);
- the decrease of the clearness index leads, obviously, to a decrease in solar energy; also the highest values of the clearness index correspond to the highest values obtained for the solar energy;
- taking into consideration, the two analyzed months are transitional months between seasons (winter – spring and summer - autumn), it can be observed that the daily values of the clearness index vary in a wide range of: 0.05 – 0.65; It is ascertained that during both months, March and September, worm and cold air masses migration occur, but also the air currents movements; these create a favouring environment for the occurrence of some climatic phenomena (fog, frost, mist, drizzle, etc..) that enhance in a substantially manner the absorption and refraction of solar radiation by the atmosphere and the amount of diffuse radiation increases;
- the clearness index has an upward trend during the month of March from low to high values, Figure 5 – the red curve (the transition is from a cold season to a warm one);
- during the month of September the clearness index has a decreasing trend, Figure 5 – the red curve (the transition is from a warm season to a cold one).

5. Linke Turbidity Factor

Another important parameter that helps, in a convenient way, to the study of the absorption and scattering phenomena that occur with the sun radiation passing trough the atmosphere (because of the water vapour, aerosols particles) is the Linke turbidity factor [3], [4]. A typical value of this factor for Europe is around 3.

In this chapter, the study of turbidity factor variation for Braşov urban area is proposed, during 2006-2008 period.

In Figure 6 are presented the variation curves corresponding to the monthly means of the Linke turbidity factor during the three years considered. Based on Figure 6 the following conclusions can be drawn:

- the monthly mean values of the turbidity factor registered for Braşov urban area, are between 2.75 and 4.25;
- the curve that describes the turbidity factor variation (Fig. 6) is, in terms of quality, similar to the one describing the clearness index variation (Fig. 4);
- the highest values of the turbidity factor were registered during the April – September months; this means an increased load of the atmosphere with aerosols, dust particles, but also a high humidity level and partly cloudy sky (accordingly also to the clearness index variation);
- the lowest values for the turbidity factor were registered during the months: January – March and October – December, that describes a smaller load with aerosols and dust particles of the atmosphere;
- as in the case of the clearness index, months March – April and September – October are transitions months from one season to another.

6. Conclusions

By its geographical position, the depression of Braşov is distinguished by the moderate continental climate. Towards the meridional direction, the climate of this geographical urban area is influenced by cold, polar air masses advections, as well as by warm air masses of southern provenience.

In Figure 7 are presented comparative diagrams of the solar and wind potential variation recorded for Braşov urban area for the three years studied, 2006-2008. Analysis of these diagrams leads to the following conclusions:

- ✓ the annual solar potential obtained for 2006 was 532.5kWh/m^2, while the wind potential was 41.62kWh/m^2; in 2007 were obtained 588.7kWh/m^2 for the solar potential compared with 87.6kWh/m^2 for the wind potential; the solar potential in 2008 was 640.1kWh/m^2 compared with the wind potential of 68.9kWh/m^2;
- ✓ the obtained wind power for the Braşov area is much lower than the solar power; for the Braşov area, the PV systems are recommended (Fig. 7);
- ✓ because of the too low values recorded for the wind speed, the wind turbines' using is not recommended for this area;
- ✓ in Braşov region the highest wind potential occurs on the mountain summits and peaks, where the wind exposure is high;
- ✓ more energy will be collected by the PV if it is installed on a sun tracker; the amount of the extra generated energy due to the tracking procedure can rise up to 40%; so the sun tracking is giving a higher efficiency of the PV systems and also the required area for installing other PV modules is saved.

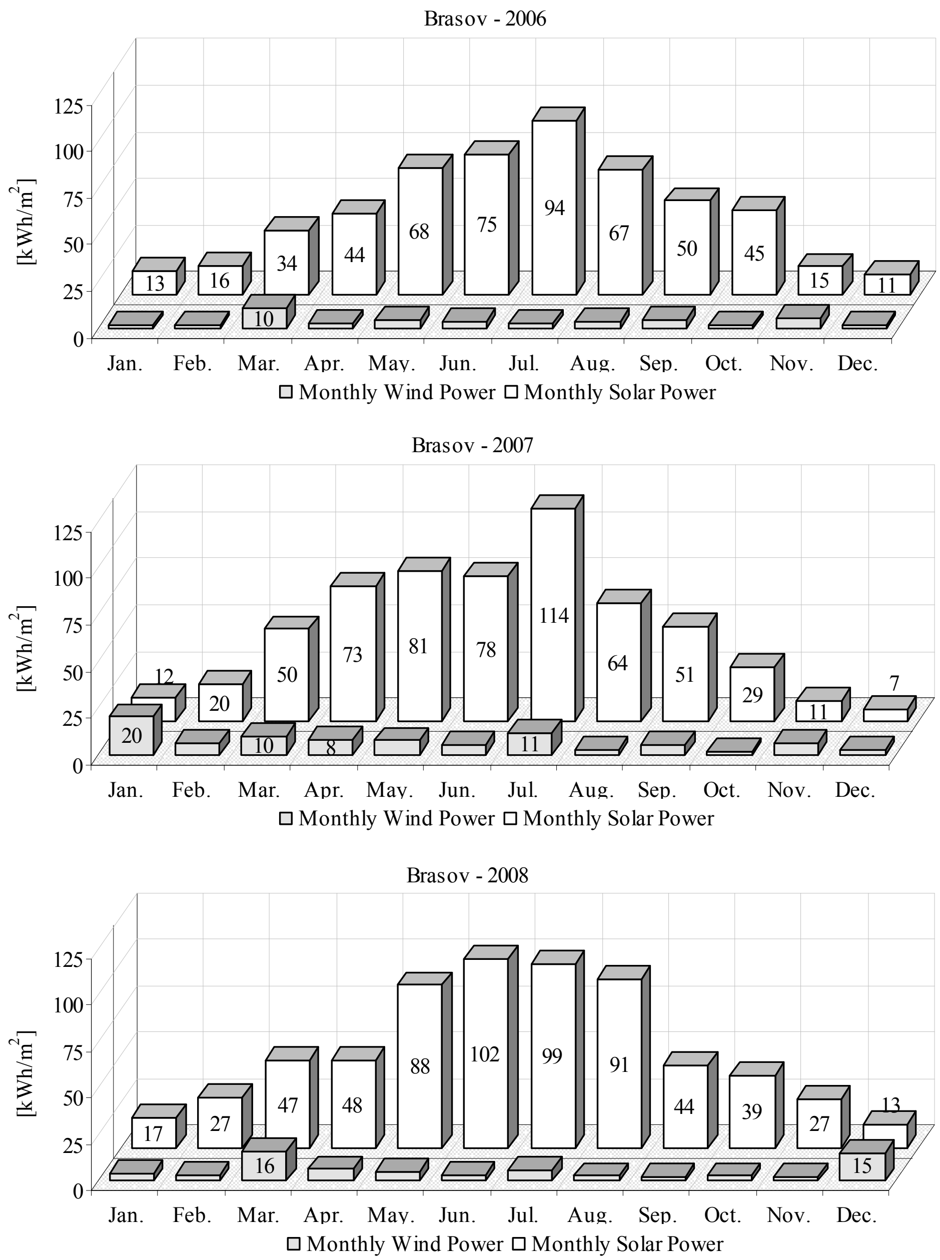

Fig. 7. Comparative diagrams regarding the solar and wind power for Braşov urban area

Acknowledgement

This paper is supported by the Sectoral Operational Programme Human Resources Development (SOP HRD), financed from the European Social Fund and by the Romanian Government under the contract number POSDRU/6/1.5/S/6".

References

[1] M. Marcu and V. Huber, “Air Thermal Stratification in the Depression Area Forms”, in Phytogeographical Implications. Anale I.C.A.S., 46, pp. 141-150.

[2] V. Ianetz, et al, “Inter-comparison of different models for estimating clear sky solar global radiation for the Negev region of Israel”, in Energy Conversion and Management 48 (2007) pp. 259–268.

[3] F. Kasten and A. Young, ’’Revised optical air mass tables and approximation formula’’, in Applied Optics 28, pp. 4735-4738.

[4] F. Kasten, ’’The Linke turbidity factor based on improved values of the integral Rayleigh optical thickness’’, in Solar Energy 56, 1996, pp. 239-44.