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METEOROLOGICAL PARAMETERS SPECIFIC TO THE URBAN AREA OF BRAŞOV

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Abstract: For an optimum design of a feasible and reliable RES (renewable energy system) system a thoroughly study and analyse of the site specific meteorological parameters must be made. This paper presents the interdependence of climatologic parameters specific for Braşov urban area. Due to its geographical location the site exhibits some typical features with respect to the topology, the climatology and the environment.

1. INTRODUCTION

Nature offers a variety of freely available options for producing energy. It is mainly a question of how to convert sun radiation, wind, biomass or water into electricity, heat or power in an efficiently, sustainable and cost effectively manner.

For a good design of RES systems the objectives that must be reached are the minimisation of the overall cost and the maximisation of the energy performance of the system. In order to calculate the performance of an existing system or one that is designed, appropriate and accurate weather and climatological data must be required and analysed for the specific geographic area (the most important input parameter in designing a solar system is the direct component of the global solar radiation). This task requires handling and processing a significant data volume. For collecting and processing weather data (global and diffuse solar radiation, air temperature, relative air humidity, wind speed and direction, rainfall), Product Design Center for Sustainable Development, of the "*Transilvania*" University of Braşov, uses a Delta-T Weather Station.

In this regard, both an analysis of the influence of the measurement interval of solar radiation and wind speed, and a good fit for the data measured in a typical hybrid energy system are of paramount importance, not only with regard to technical reliability but also in the minimisation of total system cost (kWh costs).

Braşov city is situated in east-central Romania at 25°36' east longitude and 45°39' northern latitude, in Braşov basin, in a Carpathian internal curvature, at 790 m altitude. 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 [2].

General features of the regional climate are heavily modified by local physical-geographical conditions. Under the influence of a mountainous terrain, provides a subdivision of the general climate and layering climatic phenomena, so the local interdependence between the meteorological parameters (temperature, relative air humidity, wind speed) must be determined [3].

Air temperature, is an important parameter in defining air condition and is measured by instruments (thermometers and thermographs) in direct contact with air and protected from direct sunlight. Air temperature is very variable in time and space, its oscillations may be periodic (diurnal and annual) or non-periodic due to the general circulation of the atmosphere. Temperature varies with height and in the troposphere decreases with it. In the atmosphere, water vapors are always found as they come from evaporation of sea water, oceans and rivers and of perspiration, breathing, etc. The content of water vapor in the atmosphere can be expressed in absolute or relative humidity of ambient air [9].

Relative humidity is defined by the percentage ratio of vapor pressure and maximum saturated vapor pressure at a given temperature [4].

Absolute humidity of the atmosphere is defined as the mass of water vapor, expressed in grams of one cubic meter of moist air [4].

Wind is a meteorological vector element, with an important variation of both speed and direction; the variation is conditioned by the horizontal pressure contrast created in the general circulation of the atmosphere. Moving air currents from one place to another (wind regime) is determined mainly by the development of various pressure systems (due to air temperature, landform and water surface) [4, 6]. The wind is characterized by two elements highly variable in time and space: direction of the wind, assessed after 16 sectors of the horizon, and speed - expressed in m/s - representing the distance traveled by the air particles in time unit.

Solar radiation is the electromagnetic radiation emitted by the Sun in the wavelength of the entire spectrum of electromagnetic waves. Passing through Earth's atmosphere, parts of solar radiation is absorbed, warming the air, another part is scattered by air molecules, water vapor, dust in the atmosphere (constituted diffuse solar radiation), but most reach the Earth's surface (constituting direct solar radiation) [5].

Solar radiation intensity is the amount of solar radiation that falls on land in a given area over a period of time and is determined using a solar radiation sensor (pyreliometer, pyranometer and/or a radiometer) [6].

2. WEATHER STATIONS INSTRUMENTS AND DATA ACQUISITION

For collecting and processing weather data, Product Design Center for Sustainable Development, of the "*Transilvania*" University of Braşov, uses a Delta-T Weather Station and a Data Logger.

Delta-T automatic weather station was installed in similar conditions to those that solar energy installations and small wind turbine operate (the weather station was installed to comply with the meteorological requirements of the Braşov urban area).

Automatic weather stations have a flexible structure, being composed of a variable set of sensors that measure various meteorological factors (solar radiation, air temperature and humidity, etc.) and a data logger that records the measured data.

Data on meteorological parameters are calculated according to the signals received from sensors in analogue or digital form, then displayed on an LCD screen, printed or stored in internal memory for later transfer to a computer

Weather data sets used for this complex study of the specific meteorological parameters for Braşov urban area are collected since October 2005 in a continuous way and comprise measurements for solar radiation (global and diffuse), sunshine duration, wind speed and direction, air temperature and humidity and rainfall.

Solar radiation [W/m^2] - measured by a solar energy sensor type BF3 - UM -1.0; a modern sensor that simultaneously measures total and diffuse solar radiation, that makes possible to calculate the intensity of direct solar radiation. Thus for each recorded data (every 10 minutes) minutely readings are made (the recorded value representing the average of the readings). The primary obtained data are processed in hourly, daily or monthly means as required in the solar systems design process (one important input parameter in designing RES systems is the direct solar radiation).

Air temperature [^0C] - is measured by an air temperature sensor type RHT2 - UM - 1.0, installed inside a defender away from direct sunlight.

Relative air humidity [%] - is measured by a relative humidity sensor type AT2.

Rainfall [pluviometric mm] - is measured by a rain gauge type RG2-UM-1.1; number of discharges cup is counted and sent to a digital channel to the data logger, that records quantities fallen in 10 minutes intervals.

Wind speed [m/s] – is measured by an electromagnetic induction anemometer type AN4 - UM -1.0;

Wind direction [degrees] – is measured by an automatic weathercock; the wind direction is expressed by azimuth angle (formed by the direction of the wind to the north, clockwise).

For the Data Logger's programming is available a user-friendly software with a menu that can program the weather station, this software runs on any PC model.

After the weather station programming, the automated data acquisition can start the readings storing with a PC or a printer without interruption of data recording. Weather station is provided with a program to download data, automation system contains two separate modules:

- A physical module, in which the whole complex assembly, consisting of the data logger and the PC becomes independent from an energetic point of view, by installing a UPC-type sources (Uninterruptible Power Supply) with 400VA capacity. In this way, the system can acquire data from sensors and download recordings, even if a power failure;
- A programming module, which consists of implementing two scripts that allow the execution of the same operations that human user doses when downloads data. The Scheduled Task Manager in Windows XP operating system component runs these at predetermined intervals. In this way, the PC is in stand-by state until time is reached in which the downloaded data; Scheduled Task Manager starts the PC, and this using the first script, downloads the stored data in Data Logger. The second script is for the PC transition from state to state, run stand-by.

3. WIND SPEED AND TEMPERATURE; WIND SPEED AND RELATIVE HUMIDITY

General climate characteristics are strongly influenced by local physical-geographical conditions. Braşov depression is characterized by a climate regime with excessive variations - high thermal amplitude, frequent temperature inversions, frequent early and late frosts; pluviometer system is affected by the surrounding mountain crown, wind regime is also dependent on local orographic characteristics. Using the meteorological data base the superimposed diagrams presented in Figure 1, 2 and 3 were plotted to observe and analyze the dependence between the temperature, wind speed and humidity.

The meteorological parameters variation curves were plotted for 24 hours time period not only for daylight. Analyzing Figure 1 the following conclusions can be made:

- Air temperature and wind speed variation curves have the same qualitative variation;
- The highest values for booth parameters (air temperature and wind speed) are registered after solar noon, namely for 17-18 solar time, then the values decrees till 03-05 solar time and have a smooth value increase until the maximum values ;
- Between the air humidity and wind speed variation curves exists an inverse qualitative variation; the air humidity has a range variation with maximum value at 05-07 solar time and minimum value at 17-19 solar time; for the wind speed variation curve, values increase until 17-18 solar time and decrease until 04-05 solar time;
- During daytime because of the solar radiation spectral components air temperature and wind speed have an ascending variation and the relative air humidity a descending one.

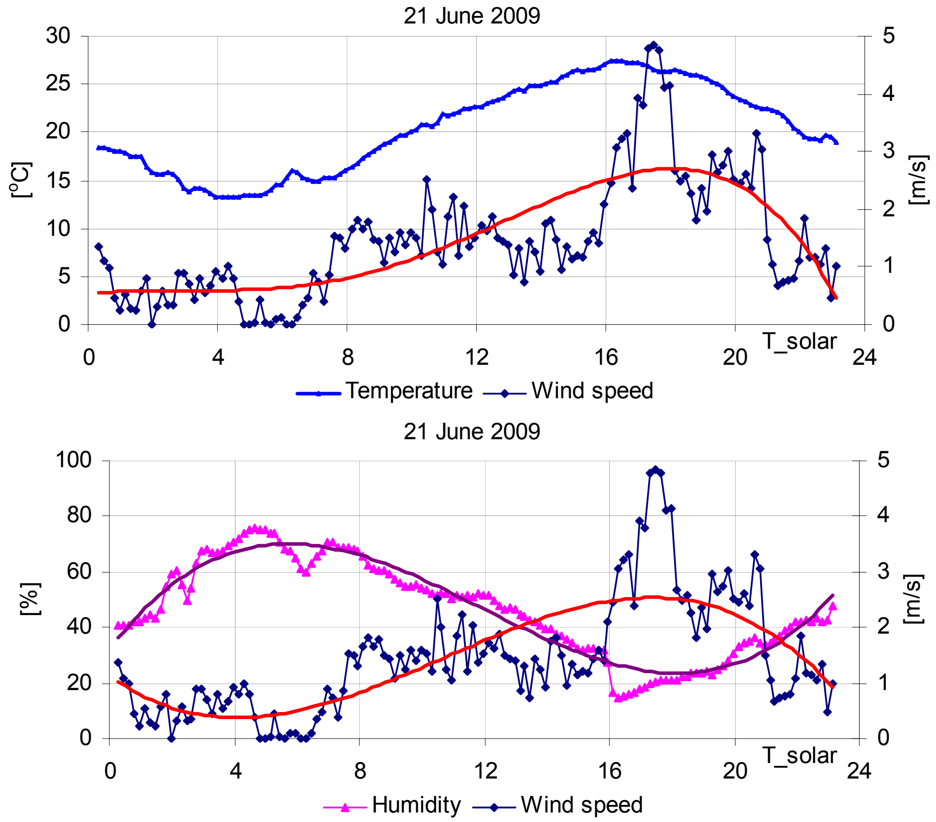

Fig. 1. The dependence between wind speed – temperature and wind speed – relative humidity

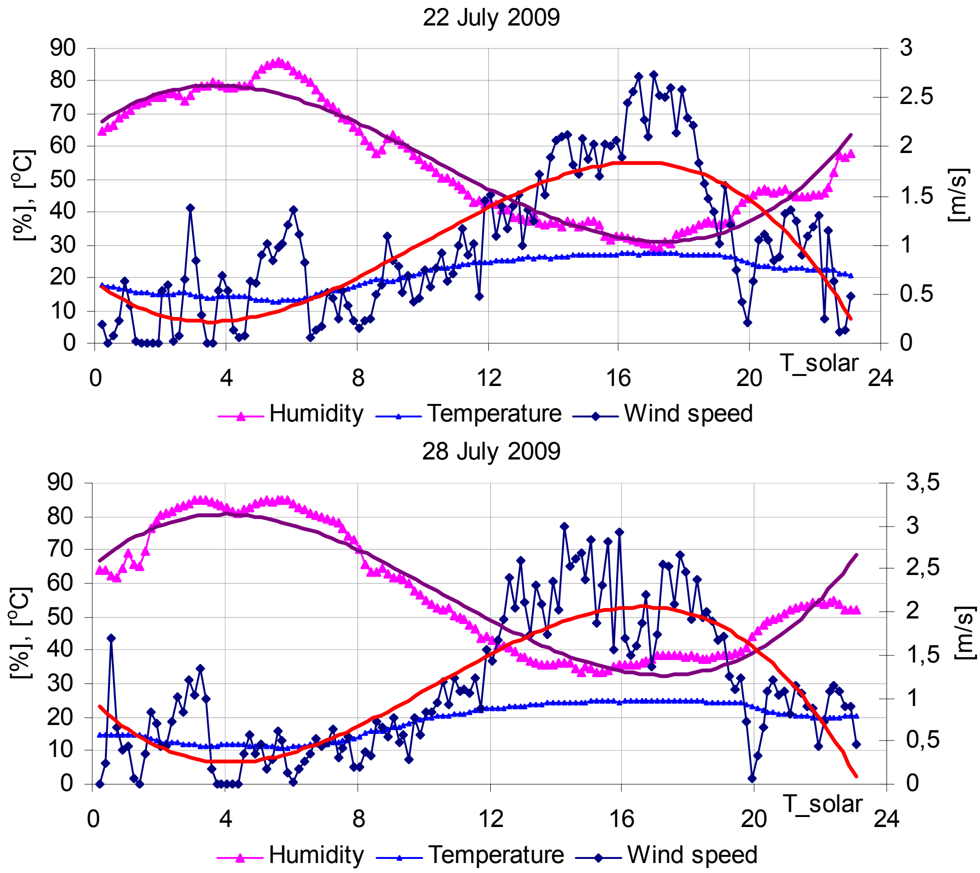

Fig. 2. Dependence of the meteorological parameters for a clear sky day (2009)

To confirm the conclusions worded from Figure 1 analysis, from the meteorological data base, two days that comply with the clear sky condition were extracted and the variation curves for the above discussed meteorological parameters were plotted, see Figure 2.

For both days, 22 and 28 July 2009 (Figure 3), the wind speed variation, although it does not have a wide variation range (0-3 m/s) it complies with the qualitative aspect of the curve presented in Figure 2.

In both Figures 1 and 2, the inflexion points of the relative air humidity and wind speed curves variation are at noon time when the solar radiation expresses its maximum potential.

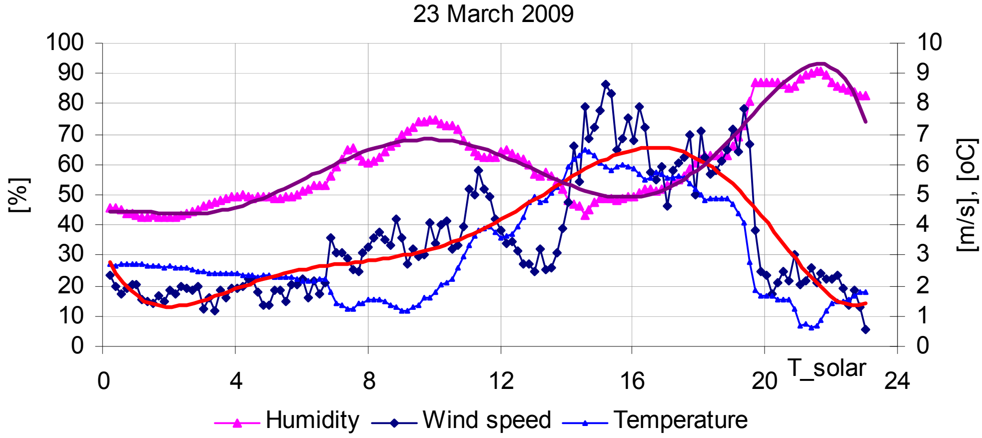

Fig. 3. Dependence of the meteorological parameters for a windy day (2009)

Because in the extracted days the wind speed does not have a large variation range, characteristic for this area, to observe the meteorological parameters interdependence, a windy day was also extracted, see Figure 3.

Based on Figure 3 analysis the following conclusions can be made:

- Although the wind speed variation range is higher (8,8 m/s) the maximum value was recorded around 16-17 solar time and the qualitative aspect of the curve was maintained;
- The air temperature qualitative aspect of the curve was maintained, but the variations between close records manifest in a greater interval;
- The relative air humidity curve has a smaller range variation and a smother variation slope.

4. CLEARNESS INDEX

Clearness index is a parameter of real importance in designing RES systems; it can provide information concerning the real solar radiation compared with the available solar radiation. The parameter variation should be analyzed 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 and it depends on the geographical coordinates of the location for which is calculated and can be used in prediction for solar energy gain, for a specific site.

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 [1]:

- for a clear day (0.76* k_t < 0.9);
- for a partly cloudy day (0.36* k_t < 0.7);
- for a cloudy day (0.06* k_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.

$$k_t = \frac{I_o}{G \cdot \sin\alpha}; \quad (1.1)$$

where: I_0 – extraterrestrial solar radiation; G – global solar radiation on a horizontal surface; α – altitude angle.

The clearness index was calculated using formula (1.1), for Braşov area for every global solar radiation record, also hourly, daily and monthly means.

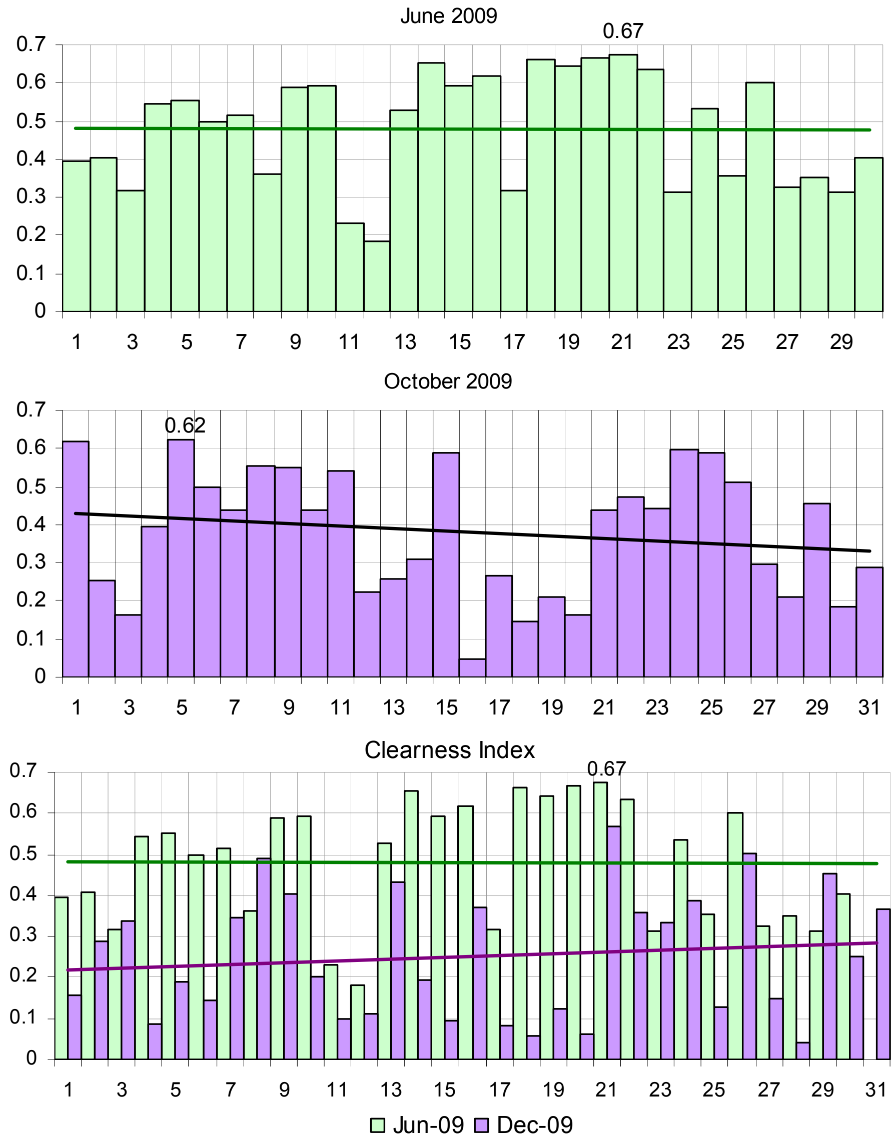

Fig.4. Clearness index variation

In this respect, Figure 4 presents the clearness index daily variation for June and October 2009 and a superimposed diagram for December and June; analysing the Figure

4, the following conclusions can be made:

- Variation of the clearness index recorded for June shows, that this month has more clear sky days than partly cloudy or cloudy days; the highest calculated daily index value is 0.67 and an average above 0,4;
- October is a month with a wide range variation of the clearness index, that demonstrates that is a transition month with strong variation in the meteorological local parameters (stronger winds, greater temperature difference between day and night, liquid and solid precipitations that influence the relative air humidity), registers small values of the clearness index - cloudy days, but also a daily value close to the highest value for June – clear sky day;
- The superimposed diagram with daily variation shows that an average value for December is 02 - 03, although some days complies with the clear sky day.
- It can be observed that due to the strong variation of the clearness index during October (from days with k_t =0.62 - that complies with clear sky conditions, characteristic for June and July - to k_t values that characterises very cloudy days, with high diffuse solar radiation). It is very difficult to find a mathematic model that approximates in a satisfactory way the parameter variation.

5. CONCLUSIONS

For this purpose, it is helpful to know the probability density of the clearness index specific for the area, see Figure 5, and study of the irradiance attenuation by the atmosphere, in terms of fundamental quantities, including clearness index, water vapour content and aerosols.

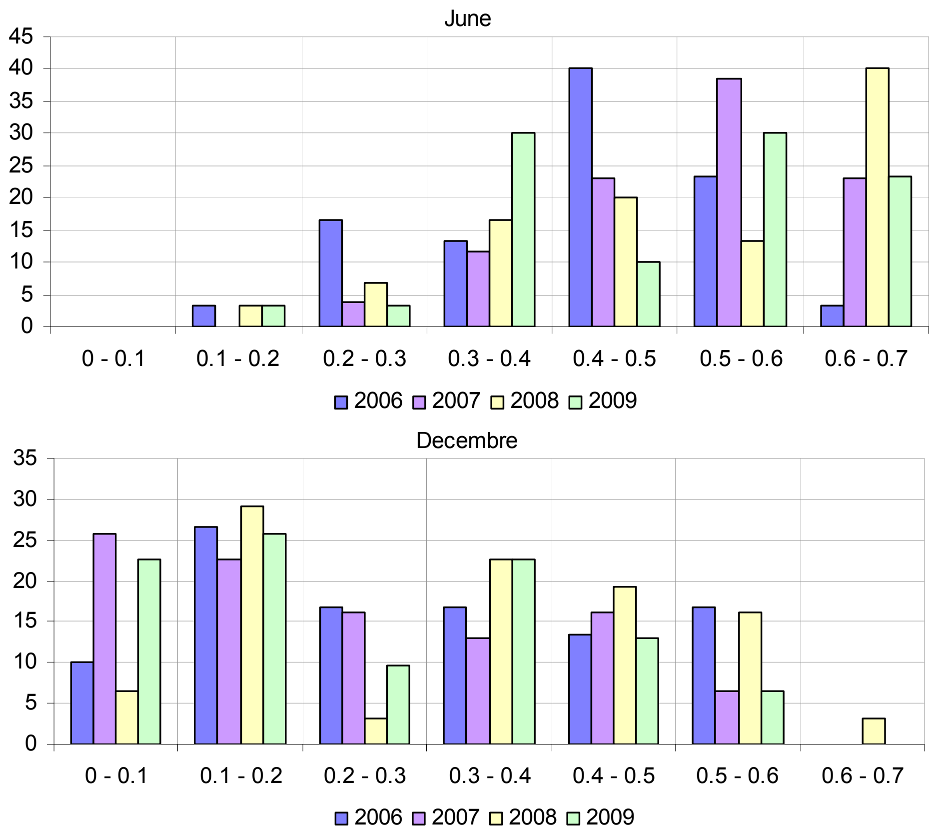

Fig. 5. Comparative diagrams regarding the probability density of the clearness index for Braşov urban area

Based on Figure 5 analysis the following conclusions can be made:

- It can be observed that for June the probability that the clearness index values exceed a value of 0.5 is very high;
- 2008 for June according to the probability density of the clearness index was a month with 40% days with clear sky, that translates in sunny days with high solar potential because the direct solar component does not encounter clouds that can absorbed or scatter it;
- For December the highest rate of the probability density of the clearness index it has the smaller values under 0.4; the probability to have cloudy days is higher that means that a large quantity of solar energy is absorbed and converted into diffuse radiation through the scattering phenomenon - solar potential is low;
- For both months the probability density of the clearness index has the highest rate for 2008, that means that the year 2008 had a good solar potential;
- We can observe that for the same month the probability density of the clearness index can have a significant variation in the percentage rate for the same value; this shows the variable climatic profile of the area.

Knowledge of the local meteorological parameters variation and their interdependence due to specific geographic and climatic conditions helps to quantify the energetic potential of the area from solar radiation and wind, essential for developing of solar energy devices and for estimating of their performance efficiencies and life cycle.

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