Over some ways for measurement of solar radiation

Katya Krasteva Stefanova[1)], Nadezhda Miteva Kafadarova[2)], Vergilij Zhelev Georgiev[3)], Beka Henrih Koen-Kukova[4)]

[1)]- TU Sofia - TK "John Atanasoff" Plovdiv, e-mail: k_stefanova@yahoo.com;

[2)] - TU Sofia - TK "John Atanasoff" Plovdiv, e-mail: n_kafadarova@yahoo.com;

[3)] - Agricultural Academy – Sofia; [4)] - TU Sofia - brunch Plovdiv

Abstract:

The magnitude of solar radiation is an important parameter for many fields of life. The authors have set themselves the task of examination some methods of measurement the solar radiation: direct- by pyranometer and indirect- by PV panels. The dynamometric method for measuring solar radiation uses a sensor- pyranometer and electronic system for processing and indication of the results. The second suggested method for measuring solar radiation is by PV- panels. There is made a short analysis of PV- effect, the ways for wiring the solar panels and their usage for obtaining electricity.

The work has a synopsis character. The further on direction of the investigation is a comparative analysis of the methods for the accuracy and reliability of the results.

Measurement of solar radiation by pyranometer

Solar radiation

The intensity of the Sun's radiation changes with the hour of the day, time of the year and weather conditions. To be able to make calculations in planning a solar power system, the total amount of solar radiation energy is expressed in hours of full sunlight per m^2, or Peak Sun Hours. This term, Peak Sun Hours, represents the average amount of sun available per day throughout the year.

It is presumed that at "peak sun", 1000 W/m^2 of energy reaches the surface of the earth.

So it can be concluded that the power of a solar system varies, depending on the intended geographical location.

The solar radiation consists of two parts- direct and scattered. In cloudless sky the ratio between direct and scattered component of solar radiation in different hours of the day changes according to the sun ungle towards zenith. It is influenced also by the quantity of water evaporations, CO2 and dust in the atmosphere. The direct component is ten times bigger than scattered when the sun is in zenith, but in sunrise and in sunset both components become equal.In clowdy days the scattered component prevail.

The quantity and the kind of clowds usually is evaluated in everyday program for control in a weather service. The digital indices depend on how many tenth parts of the sky are covered.

A device structure for direct determination the quantity of entering given orientation total solar radiation is given in fig. 1.

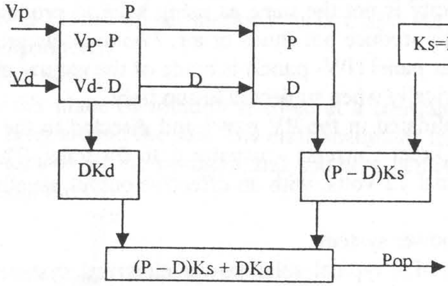


fig.1

where: - Kd - permeability coefficient of the cover for scattered solar radiation;

- Ks - permeability coefficient of direct radiation;
- P - daily motion of total solar radiation over horizontalsurface;
- D - scattered solar radiation;
- Vp, Vd – outcoming signals, measured by pyranometer.

Dynamics of the total solar radiation during a clear sunny day is shown on fig.2.

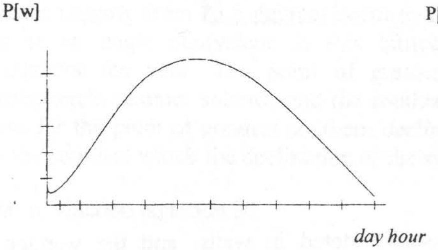


fig.2

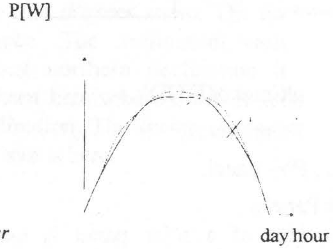


fig.3

Every transparent cover according to the optical characteristics of materialand its geometry modifies the curve line of the intensity P. For example the determined daily motion of direct solar radiation by this method (given in *fig.1) in a* hothouse (made from transparent glass) with north- south orientation is shown on fig.3.

This example reviels the modification of solar radiation by the cover. If we compare fig.2 with fig.3 we shall see essential decrease of its magnitude.

Measurement of solar radiation by PV- panels

Solar power to produce electricity is not the same as using solar to produce heat. Solar *thermal* principles are applied to produce hot fluids or air. *Photovoltaic* principles are used to produce electricity. A solar panel (PV- panel) is made of the natural element, silicon, which becomes charged electrically when subjected to sun light.

This electrical charge is consolidated in the PV panel and directed to the output terminals to produce low voltage (Direct Current) - usually 6 to 24 volts. The most common output is intended for nominal 12 volts, with an effective output usually up to 17 volts.

Components in a typical solar power system :

The four primary components of a typical solar power electrical system which produces common 110/220 volt power for daily use are: Solar panels, charge controller, battery and inverter. Solar panels charge the battery, and the charge regulator insures proper charging of the battery. The battery provides DC voltage to the inverter, and the inverter converts the DC voltage to normal AC voltage.

A block-scheme of the method for measuring the solar radiation by PV- panels is given in fig.4

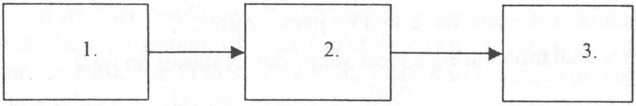


fig.4

Where: - 1) Multimer METEX;

- 2) Computer;
- 3) PV- panel.

Solar Power Panels:

The output of a solar panel is usually stated in watts, and the wattage is determined by multiplying the rated voltage by the rated measured amperage.

Solar panels can be wired in series or in parallel to increase voltage or amperage respectively, and they can be wired both in series and in parallel to increase both volts and amps. In series wiring the resulting outer positive and negative terminals will produce voltage the sum of the two panels, but the amperage stays the same as one panel. In parallel wiring the result is that voltage stays the same, but amperage becomes the sum of the number of panels. Series/parallel wiring refers to doing both of the above - increasing volts and amps to achieve the desired system voltage as in 24 or 48 volt systems.

The photoelectric converters of solar energy allow measuring of solar radiation by the photo element itself, which is the base of photoelectric solar batteries. The photo element is placed on an inclined surface and the received current is checked by low-Ohm ampermeter.

Declination:

The earth's plane of rotation is tilted at a constant 23.5 degrees from the plane of the earth's orbit around the sun. The earth maintains this tilt throughout the year, giving rise to the seasons as the northern and southern hemispheres alternatively face toward and away from the sun.

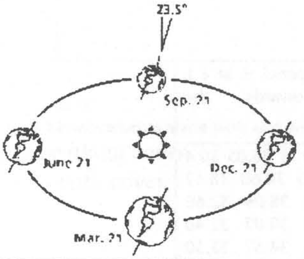


Fig. 5: The earth's seasons

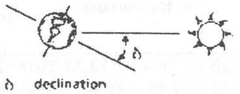


Fig. 6: Declination

At a given point in the earth's orbit, the sun will appear directly overhead at a latitude ranging from 23.5 degrees north to 23.5 degrees south. The declination of the sun is an angle equivalent to this latitude. The declination varies sinusoidally throughout the year. The point of greatest northern declination is the northern hemisphere's summer solstice and the southern hemisphere's winter solstice, and vice versa for the point of greatest southern declination. The spring and autumn equinoxes are the points at which the declination of the sun is zero.

The declination equation is:

$$x=23.45*\sin[360/365*(284+\text{day of the year})]$$

(angular measurements are in degrees)

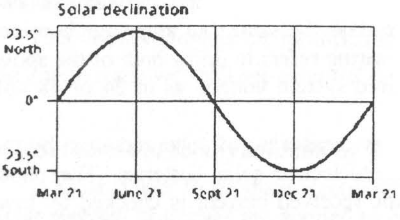


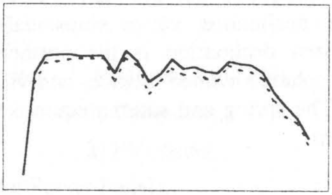
Fig. 7: Declination variation during the year.

Experimental results:

28th Feb, 2000

Hour of the day	U[v] (Solar panel is parallel to the horizon)	U[v] (Solar panel is at 8.1 degrees towards the horison)
8.00 8.20 8.40 9.00 9.20	5.76 7.93 13.33 20.09 26.4	9.6 11.20 19.71 26.05 30.4
9.40 10.00 10.20 10.40	29.48 35.90 36.45 37.0	32.50 38.15 38.60 38.67
11.00 11.20 11.40 12.00	37.24 37.26 37.28 30.21	38.05 38.08 38.09 32.60
12.20 12.40 13.00 13.20	37.47 35.06 26.31 30.42	39.80 36.45 30.07 32.40
13.40 14.00 14.20 14.40	34.37 32.03 33.04 31.60	37.13 34.16 34.67 33.30
15.00 15.20 15.40 16.00	30.41 35.18 33.83 33.14	32.65 36.40 35.67 35.19
16.20 16.40 17.00	30.26 27.17 24.04	33.0 30.69 27.09

U[V]



8.00 .... 17.00 day hour

fig. 8 Measurements according to the sun ungle.

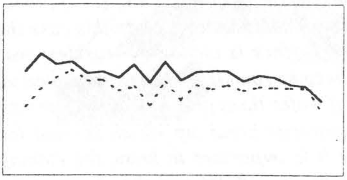
____ according to the sun declination

- - - - paralel to the horizon

8th March,2000

Hour of the day	U[v] without glass cover	U[v] with glass cover	Relative mistake
10.00 10.20 10.40 11.00 11.20 11.40 12.00 12.20 12.40 13.00 13.20 13.40 14.00 14.20 14.40 15.00 15.20 15.40 16.00	37.06 38.05 37.45 37.59 36.94 37.03 36.67 37.42 36.40 37.58 36.53 37.02 37.05 37.06 36.49 36.79 36.70 36.30 36.20	35.07 36.01 36.67 37.14 36.51 36.56 35.95 36.19 35.12 36.42 35.43 36.28 36.02 36.28 35.94 36.16 36.12 36.10 36.08	1.57 2.04 0.78 0.45 0.43 0.47 0.72 1.23 1.28 1.16 1.10 0.74 1.03 0.78 0.55 0.63 0.58 0.20 0.12

U[V]



10.00 ………………………………… 16.00 day hour

fig. 9 Measurements made with and without glass cover.

____without cover

- - - - with cover

Conclusions:

The comparative analysis of the described methods for measurement of solar radiation shows that the both methods are suitable and can be used for the purpose. The further investigations will be directed towards evaluation and improvement of the precision and complexity of particular links in both measurement systems and comparison of results.

References:

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