Research and graphical representation of the amount of accumulated solar energy for different time periods on the Earth's surface.

Veselin Tashev[1] , Rolf Werner[1], Angel Manev[1], Mariana Goranova[2]
1. Space Research and Technology Institute (SRTI) – BAS
Stara Zagora Department, Bulgaria.
2. Technical University of Sofia, Faculty of Computer Systems and Management.

Abstract

A Davis meteorological station Vantage Pro 2 Plus is operating in Stara Zagora since 2011. The station is of a semi-professional type, and one of its sensors is designed especially for measuring of the solar radiation. The amount of solar energy is measured in continuous mode every 15 seconds. The collected data from the sensor were integrated and the data were recalculated in order to obtain results for the solar energy that is absorbed during a certain time interval per unit Earth`s surface. The purpose of this research is to trace the repeatability during different periods. A high annual repetition provides a good opportunity to forecast of the energy yields for the coming years. The monitoring was carried out for the region of Stara Zagora.

Introduction

In the period of 7 years data for solar energy are measured and collected using the weather station Vantage Pro 2 Plus [1]. During the 7 year time frame the data was captured every 15 minutes for total of more than 274 000 data points. The raw data was recorded by the solar radiation sensors of the station which was after that converted to solar energy absorbed over a given period of time per unit area. Quantitative accumulation of solar energy has been processed and aggregated in daily, monthly and annually periods. The results obtained are shown in graphic form. From the graphs shown the degree of repeatability during different periods.

Investigation of solar energy falling on the Earth.

As is well-known the solar radiation depends on many factors. Given that we can say that the solar energy which is directly related to the solar radiation would be different for the different places on the earth surface. This is based on the fact that only part of the solar energy is able to reach the earth surface. Some of the solar radiation is reflected right back into the space, some is absorbed by the stratosphere and troposphere. Overall, around 19% of the solar radiation does not reach the lower layers of the atmosphere (Roedel. 1994) [4].

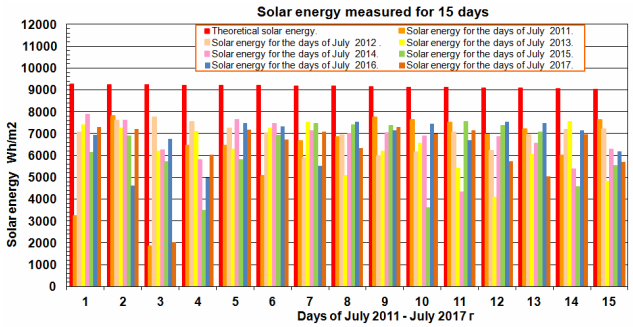

Fig.1. Solar energy measured for each day.

The daily measurements of solar energy for 15 days in July for 6 years is shown in fig. 1. The theoretical values of the solar energy dependent on the direct solar radiation are marked by red bars and did not varied a lot. The measured solar energy, however, significantly varies in the different days as it is seen from the graph. For example, the values are almost the same for the 7th and 13th days, while for the 1st and 3rd days the values are changed from 2000 to 7500 wh/m2. Although the sun position is not significantly changed, the measured values differ due to actual atmosphere composition in the different days. The atmosphere permeability is significantly affected by clouds, moisture, dust and other contaminants that absorb the solar energy.

In Fig. 2, the daily measured average values of the solar energy in July are shown for 6 years. The daily deviation from the average value is marked by red lines. The dynamic change in values in the third, sixteenth and twenty-first days compared to the fifth, twenty-fourth and thirty days is significantly higher. Here even more clearly shows the changed dynamics due to changes in the atmosphere.

In Fig. 3, solar energy values are measured and presented for different months in different colors over a period of 7 years. The seasonal nature in the solar energy change is well followed. The solar energy is maximum in June and July and a minimum in January and December. It is worth to indicate that the dynamic change of the values for the corresponding months during the years is much less than the dynamic change of the values for the corresponding days as shown in fig 2.

In Fig. 4, the measured average solar energy per month in a period of 7 years is presented. The deviation from the average value for each month is given with red lines. It is well seen the smaller monthly deviation in comparison with the daily one. The figure shows that the smaller the deviations are during on the winter month January and December during the summer month of August. This is due to the fact that these seasons are with more stable dynamics of the atmosphere. The largest deviation in the transition months of April and May.

In fig. 5, a centered moving average value of solar energy for 12 months is presented for a period of about 7 years. It is shown in the chart with a red line. Monthly values of solar energy are shown with orange bars. As it is seen the value of moving average is substantially constant, i.e. the annual deviation is less than monthly one.

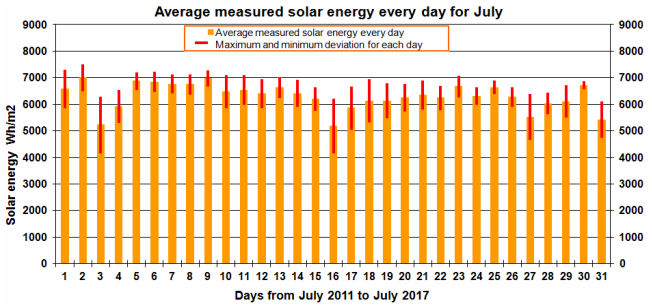

Fig.2. The average measured solar energy for every day for July.

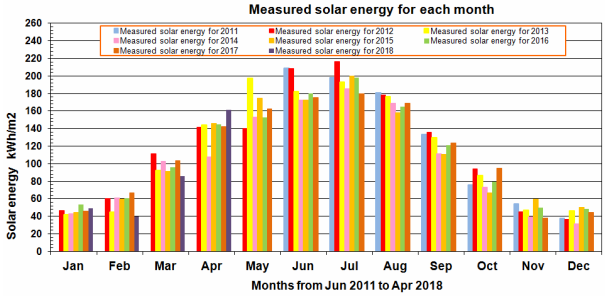

Fig.3. Solar energy measured for each month from 2011 to 2017.

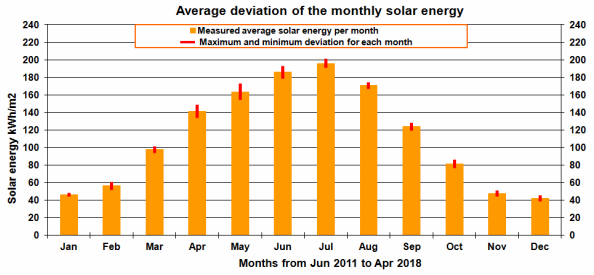

Fig.4. Average measured solar energy for each month.

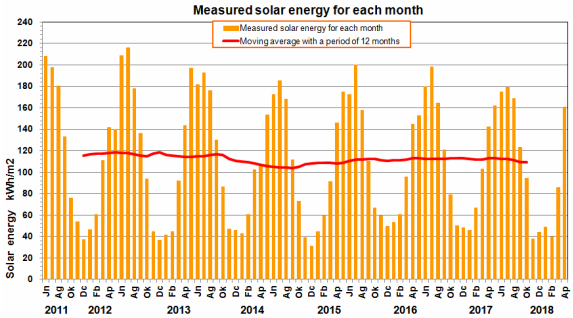

Fig .5. Centered moving average with a period of 12 months for 7 years.

Conclusion

The research presented so far proved that the sunshine deviations for the corres ponding months are less than the daily sunshine deviations, while the annual solar energy deviations are less than the monthly. Consequently, the calculated deviation of the corresponding values is smaller at a longer period of monitoring. From the results obtained we can state that the expected energy from the photovoltaic converter for an annual period can be calculated and predicted with relatively good accuracy.

References

1. D a v I s I n s t r u m e n t s C o r p. Vantage Pro2 Plus. Referen. Guide.
2. J. M e e u s, Astronomische Algorithmen, Johann Ambrosius BarthVerlag, Leipzig-Berlin-Heidelberg, 1993
3. Lean, J.L., Solar irradiance and climate forcing in the near future, Geophzs. Res. Lett. 28, pp. 4119-4122, 2001.
4. Roedel, W. Physik unserer Umwelt, 2. Aufl., Springer-Verlag Berlin Heidelberg, S.48, 1994.