Climatologic Influences on Photovoltaic Production

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For around two decades, technological improvements of semi conductors has allowed the growth of photovoltaic devices (PV) for domestic and industrial use. This energy, which does not create greenhouse effect gases or environmental risks, could be considered as extremely clean. For home use, owners need PV cells deployed with an adequate orientation and a tilt angle directly linked to the latitude of the deployment site. The production will, of course, depend on the panel conversion factor but also on the sun's elevation in the day time and finally; on several climatologic parameters like water vapour along the optical path, aerosols and, above all, by cloud cover.

Interaction Solar Radiation with PV Cells

The conversion factor of solar cells is a parameter described by each manufacturer and measured along a normal axis to the panel surface. Much of the conversion factor will depend on the type of panel used(polycrystalline or amorphous). Over time and exposure to environmental conditions this value could decrease, this could be measured using a reference total pyranometer, at the same location, deployed along the same optical axis as the PV cells. An issue, apparently too often neglected for domestic use of PV panels, is the fact that the direct component of the effective energy received should be balanced by the cosine level of the device. If we consider E0 as direct down welling radiation created by the sun, Eeff as direct energy effectively seen by PV cells and SZA (solar zenith angle) the angle between vertical and solar spot position, the ratio will change as follow:

$$E_{eff}/E_0 = 1 \text{ if } \cos(SZA)=0°$$

$$E_{eff}/E_0 = 0 \text{ if } \cos(SZA)=90°$$

As the direct component of the solar direct down welling radiations represents around 50 % of the global energy, this effect is not negligible. The sun elevation has been studied and several formulas provide an accurate knowledge of this parameter as well as the azimuths for sunrise and sunset. These data are used for sun tracking PV cells, however; fixed panel production will be significantly affected by this aspect.

Effect of Clouds on Down Welling Irradiance

Most PV cells have a spectral range of between 300 and 1200 nm. Using an atmospheric radioactive transfer model, the effect of cloud layers can be observed and will not be overlooked. The figure hereafter has been obtained using a MODTRAN radiative transfer model. It effectively shows this influence on the total irradiance. These results have been obtained for the location of Brussels with average aerosol conditions under a clear sky and with a cloud layer of 4 octas at 3000 m high. The simulations have been performed with very thick clouds which are not always present, which is an important aspect to consider. Thinner clouds will show a lower decrease of the effective irradiance reaching the ground and will also affect the ratio of direct/ diffuse radiation reductions as explained above the electrical production.

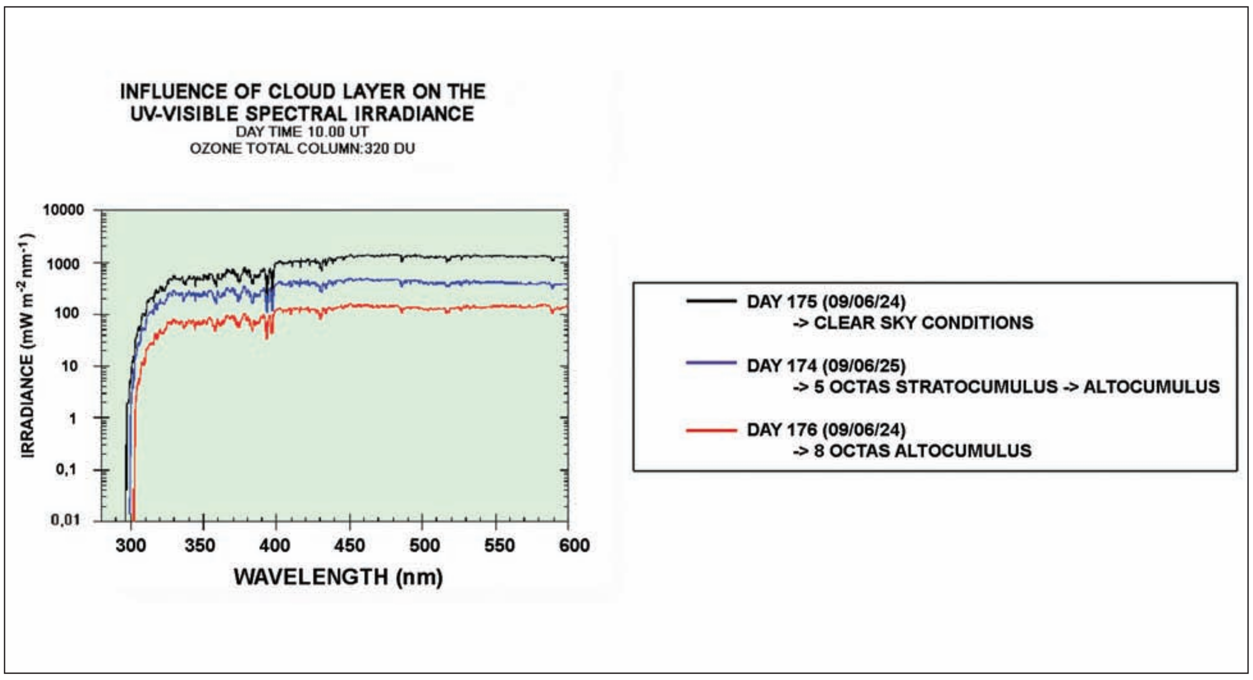

Fig 1.

The Importance of Cloud Monitoring

For the energy production from domestic systems the situation is relatively obvious. In this case a yearly average production associated to average climatologic conditions will match goals and expectations.

For industrial production, things are more complicated. In such a situation PV devices are included in the supply network with other means of energy generation such as wind or thermal production facilities. This means that production should be monitored on an hourly basis. In such situations, cloud cover should be monitored at the production facility scale. Several instruments are now available on the market like the CIR-4V manufactured by ATMOS Cy in France.

Conclusion

For domestic use, it is recommended to verify the PV conversion efficiency by monitoring the global radiation by use of a total pyranometer. For industrial uses, the monitoring of cloud cover allows one to efficiently manage the difference sources of green energy.

Fig 2: CIR-4V

Acknowledgements

The authors would like to sincerely thank Marine Ferrante (ATMOS) for her great help in producing this article.