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Research Paper :

Estimation and experimental validation of solar radiation by ASHRAE method for Bhubaneswar (India)

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ABSTRACT

The reliability of ASHRAE (American Society of Heating, Refrigerating and Air-conditioning Engineers) model for estimation of hourly solar radiation on earth's surface was tested with the measured data of bright sun shine hours throughout the year 2007 for Bhubaneswar (Latitude 21.12^0 N and Longitude 85.65^0 E) located in south-east India. Comparing the observed and predicted values of hourly solar radiation, a clearness number (correction factor) has been found out in this model for the place to estimate the solar radiation for design of solar energy devices without going through sophisticated measuring instruments. It was found that on clear day or cloudless skies, the predicted solar radiation by ASHRAE method was about 20 per cent higher than the observed value at Bhubaneswar. Thus, for the prediction of solar radiation at Bhubaneswar a clearness number of 0.8 was taken for further calculations. The observed and predicted values of solar radiation for different seasons at Bhubaneswar showed close agreement when the clearness number was taken as 0.8.

Key words : Solar radiation, Thermal modeling, Experimental validation

The amount of solar radiation incident on earth's surface is an important and important data for solar energy applications (Duffie and Beckman, 1991). This Solar radiation has temporal and spatial variation. To obtain these data, a net work of solar monitoring stations equipped with pyranometers and data acquisition systems are generally established in a target area. However, the number of stations in the network are usually not sufficient to provide solar radiation data of the area especially in developing countries. This is mainly due to the high equipment and maintenance costs. Though solar radiation can be estimated from sunshine duration and cloud cover data, the accuracy of estimation is relatively low (Iqbal, 1983) and the correct data from measuring stations are very rare. Therefore, a suitable correlation becomes important to predict the solar radiation data for a particular place with a view to design a solar energy device for optimum performance.

Hence, looking at the importance of theoretical models, many researchers have predicted different types of models to predict solar radiation data (ASHRAE, 1985; Garg and Garg, 1987; Singh *et al.*, 1997). ASHRAE model is one such method in the literature to predict hourly values of solar radiation and it is deterministic and independent of climatic parameters such as temperature and humidity. With the help of ASHRAE model, the solar radiation can be predicted on hourly basis on any day of the year at any latitude. It also provides the values at different inclinations of the surface facing in any direction. The constants used in this model was developed for United States conditions. Hence, there is a need to validate them for different cities under study for obtaining the accurate performance of various solar gadgets. An effort in this paper has, therefore, been made to test their validity for a place of interest like Bhubaneswar (Latitude 21.12^0 N and Longitude 85.65^0 E) city of India.

METHODOLOGY

Estimation of solar radiation:

The total irradiation on a surface is the sum of the direct solar radiation, I_D, the diffuse sky radiation, I_d and solar radiation reflected from surrounding surfaces, I_r.

Estimation of direct solar radiation:

The intensity of the direct component is the product of the direct normal irradiation, I_{DN} and the cosine of the angle of incidence θ between the incoming solar rays and a line normal to the surface. Angle of incidence is calculated using the relationship.

$$\cos \theta = l \cos Z + m \cos W + n \cos S \quad \text{..... (1)}$$

where,

θ= Incident angle on a surface

l, m, n are the direction cosines of the normal to the