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ABSTRACT

Solar energy technologies offer a clean, renewable and domestic energy source and are essential components of a sustainable energy future. For solar power generation, knowledge of global solar irradiance at a particular location is utmost important. Global solar irradiance can be divided into two components: the first is the diffuse solar radiation, which results from scattering caused by gases in the earth's atmosphere, dispersed water droplets and particulates; and the second is the direct solar irradiance, which is not scattered. Knowledge of global and diffuse solar irradiance is essential for research and engineering applications.

Solar irradiance data are important not only for the optimum site selection for solar power generating plants but also for their design, sizing, operation and economic assessment. However, the network of solar irradiance measuring stations is relatively rare throughout the world. In India, only IMD (India Meteorological Department) Pune provides data for quite few stations, which is considered as the base data for research purposes. However, hourly data of measured irradiance is not available even for those stations where measurement has already been done. Due to lack of hourly measured data, the estimation of solar irradiance at the earth's surface is essential.

There are number of models for the estimation of solar energy under cloudless skies. Three broadband models namely REST (Reference evaluation of solar transmittance), REST2 (Reference evaluation of solar transmittance, 2 band) and CPCR2 (Code for physical computation of radiation, 2 band) are discussed. Regression model for estimating the solar energy considering sunshine duration as input is also presented in this thesis. These models are not suitable to estimate the solar irradiance during monsoon months (June to September) or cloudy sky. The results obtained were satisfactory, but it is only applicable for clear sky weather condition. As we know that, in India

around 50 to 100 days in a year are cloudy, so it is very difficult to predict the accurate results of solar irradiance using mathematical or regression model.

The uncertainty in atmosphere may occur due to the existence of dust, moisture, aerosols, clouds, or temperature differences in the lower atmosphere. Of all these factors, clouds can cause the maximum losses in the extraterrestrial solar energy reaching the surface at ground level. The atmosphere causes a reduction of the extraterrestrial solar input by about 30% on a very clear day to nearly 100% on a very cloudy day. Therefore, due to uncertainty in weather conditions, fuzzy based model is developed and presented to estimate the solar energy at a given location using different meteorological parameters such as sunshine duration and temperature as inputs. The performance of the fuzzy based models is found better as compared to the mathematical and regression models. However percentage error in fuzzy models also found more than 5% that may not be appropriate for many solar energy applications. Therefore, there is the need to develop alternative ways for solar energy estimation.

An artificial neural network (ANN) provides computationally efficient way of determining an empirical, possibly non linear relationship between a number of inputs and one or more outputs. In the ANN based model the percentage RMSE (root mean square error) in solar energy estimation considering latitude, longitude, altitude, sunshine hours, temperature and the month of the year as input parameters is found between 3% to 5%. However, there are certain drawbacks of conventional neural networks like large training time, huge data requirement for training, unknown ANN structure, the relatively larger number of hidden nodes required, problem of local minima etc. To overcome some of the problems of ANN and to improve its training and testing performance, generalized neuron network based model is developed and implemented for the estimation of solar energy.

In the present work, generalized neural network (GNN) model has been developed to estimate the solar energy considering latitude of location, longitude of location, altitude, months of the year, mean duration sunshine per hour (it is the ratio of average daily actual sunshine duration at the location to the theoretical sunshine duration), and temperature ratio as input parameters. The results obtained from the proposed GNN based model are compared with actual data and it is found that the percentage error is less than 3% for all stations considered whereas the same was more than 5% from other intelligent techniques.