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Conclusions and Future Works

As mentioned earlier, the thesis was objected to forecast the solar irradiation using data driven models. The data was obtained from Indian Meteorological Department and IIT Jodhpur for different duration with different time horizons. As observed by various researchers that hybrid methods, combination of two or more methods, perform better than stand alone methods, we employed it as a principle to combine some data preprocessing methods with forecasting techniques. A review of data driven forecasting techniques suggests that short term behavior can be better understood by time series models. However, when the underlying data is far from stationarity, these models are observed as under-performing models. They do not capture the desired variability of the underlying data. This motivates us to use learning methods which are non-linear in nature. The error metrics, RMSE and MAE, suggest that these learning methods perform better than AR, MA or ARMA due to the non-stationary behavior of solar data. When two or more learning methods are combined to define a hybrid model, the combination achieved better forecast accuracy.

We defined a hybrid model of combination of DWT and FFNN for short term prediction of GHI data. Prediction errors are calculated using error metrics, RMSE and MAE. These prediction errors indicate that application of FFNN alone results in good prediction but it cannot handle the spikes present in the data series. Wavelet decomposed input to the FFNN improves the learning of FFNN and results in better forecast accuracy.

We proposed another hybrid framework that comprises of STL, WT and FFNN for hourly GHI forecasting. The developed model is compared with other candidate models such as persistence model, FFNN and SFFNN. RMSE and MAE values of each month for the proposed model are evaluated. The prediction errors of proposed model are significantly low compared to the candidate models throughout the year. The calculated RMSE and MAE values are more for FFNN and gradually decreases for SFFNN and are further low for proposed model (SWFFNN). It is observed that the values of prediction errors are minimum for the month of October and maximum for the month of August and the same trend is followed for forecast skill. August month has the maximum error because the climatic conditions of this month are more uncertain as compared to rest of the months and converse is the case for October month. The improvement in the value of forecast skill re-established the fact that preprocessing significantly reduces the complexity of the data and improves the forecast accuracy by enabling us to handle a group of data separately.

Finally we present operating performance analysis of the 58 kW multicrystalline-silicon and 43 kW amorphous-silicon grid connected roof-top PV systems. Widely used performance indices such as total yield, specific yield and performance ratio are used for analysis purpose. These normalized performance indicators can conveniently be used to compare the plant performance with the plants of different size and locations. We introduced modified PVUSA based performance indicator which takes into account actual measured module temperature for calculating $P_{ac,PTC}$ from $P_{dc,STC}$. The plant performance ratio was found in the range of 0.16-0.98 and 0.52-0.81 for 58 kW and 43 kW plant respectively. The extremely low values of PR are attributed to the system faults in the form of burnt connections and tripping of a group of inverters. The amorphous-silicon thin-film modules are very delicate and require careful handling during installation and cleaning etc. Cracks in some of the modules have been observed leading to partial to full loss of module generation capacity. Other operation and maintenance issues of importance have also been discussed.

Further there is a need of development of more accurate solar forecasting tools for long term planing and short term network management. Development of more accurate hybrid framework can play a key role for more accurate solar irradiance forecasting with high temporal resolution to handle solar intermittency issues. This thesis opens the door for the construction of various ensemble framework for more accurate solar irradiance forecast. Further, both time domain decomposition techniques like STL and frequency domain decomposition techniques like DWT can be simultaneously used for development of ensemble models. The impact of solar intermittency on power quality need to be investigated properly to implement the forecast information and reap its benefits. Further study is needed for modeling and real world experimental analysis of different large and small scale PV architectures. Further innovation of highly efficient PV materials and module design is required to make solar energy for viable.

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