7
Conclusions and Future Work

Solar power forecasting is a vibrant and complex research problem in the electricity system operation and smart grid energy management system. Solar power generation forecasting helps in better scheduling and grid integration of solar power into power systems. It can help in proper scheduling for a particular time interval and meet the needs of power markets. It can help solve the energy imbalance problem in electricity grid which is very important for grid stability.

In this work, neural network based forecasting models were proposed to rooftop and ground-based solar photovoltaic plants for different forecasting horizons. Artificial neural network and generalized neural network models were used to forecast the solar power generation for considered case studies. In this work, series of case studies were considered to test and validate the forecasting models.

In these case studies, historical data of ambient conditions and module temperature are also considered as input parameters for forecasting model. Different forecasting horizons like averaged 15 minutes, daily average monthly data and seasonal data are used. Because of changes in ambient conditions and seasonal variation, there is fluctuation in solar power generation which makes this problem complex and dynamic in nature. Neural network models were shown to provide better solution compared to conventional statistical regression models.

Based on the work presented in this thesis following key points can be listed:

- The multilayered feed-forward neural networks with backpropagation have great potential in modeling and simulation of highly nonlinear and dynamic problem like solar power generation forecasting.
- Aggregation and activation functions are playing an important role in the performance of the neural network.
- A forecasting model has been developed by using the generalized neural network with the help of sigmoidal and Gaussian function as aggregation and activation functions respectively. Use of sigmoidal and Gaussian function in generalized neural network improves the learning speed considerably.
- To train a forecasting problem by ANN proper architecture of the network should be selected. Proposed GNN based forecasting model is capable of calculating and providing accurate forecasting results. It takes minimum number of training epochs and time compared to ANN model.
- Proposed forecasting model using GNN shows the best performance among all the case studies.
- It is demonstrated that the highest accuracy of solar power generation forecasting is obtained when there is less variation in ambient conditions and on clear sky days.

Finally, On the basis of a comparative study of artificial neural network and generalized neural network based forecasting models, it is found that generalized neural network model provides better and accurate forecasting output for considered case studies in this work.

There is lot of scope to extend this work further as listed below:

- Other meteorological parameters can also be included on the basis of availability at the solar PV plant such as the ground-based total cloud cover images for the concerned PV plant and cloud moving speed for power generation forecasting. Further analysis on

correlation between inputs parameters such as GHI and Global Tilted Radiation and their impact on neural network results may be necessary as shown in Annexure A.

- Because of the transformation of the conventional electric grid into the smart grid, we need online monitoring. There is a need to develop an online forecasting model which can forecast the power generation in real time and send the online forecast values to dispatch center.
- Real time solar power generation forecasting model provides better scheduling of solar power.
- Due to the high load shedding problem and high penetration of solar power into the electricity grid, we need to develop a forecasting model and synchronize with load forecasting model which can help in demand side management.
- In the future, whenever common grid code is introduced for renewable energy system in Indian market then solar power forecasting plays an important role in safe, secure and economic way of distributed generation. Renewable Energy Management Centers (REMC) in India need a perfect and accurate Power Scheduling, Unit Commitment, Energy exchange, Grid integration.

…