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Predicting generated Power through Wind Energy – A Survey

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Abstract: there is a lot of buzz going around with regards to the Green Computing and global carbon reduction strategies. Accordingly, the need for development and deployment of Renewable Energy sources is of great concern for practitioners and strategic planners across the globe. Renewable energy sources have to be highly reliable during all seasons and circumstances, given the chance of adoption involves a great risk in failure of the same. It is also seen that huge deployment charges are incurred for use of Renewable Energy sources. There are many organizations and institutes gathering weather forecasting related information from various places. This work is an attempt to realize the work done by various researchers to achieve a remarkable prediction working with these renewable energy sources. Conclusions are thereby drawn about the motivation for future work in this domain.
Keywords: forecasting, asynchronous machines, neural networks, turbines.

I. Introduction

People are motivated to use the renewable energy sources exclusively for their personal as well as industrial applications for conservation of non-renewable energy and handling the problems associated with global warming. Energy is generated in different ways in India. Coal contributes to the highest energy generation in the country amounting to about 58.60%. About 17% of energy is generated through hydroelectric power stations. Natural gas contributes to 11% while Petroleum products contribute to 30% of the requirement of total energy [1].

Biofuel, biomass, geothermal, hydropower, solar energy, tidal power, wave power and wind power are the various sources of renewable energy. Renewable energy sources are particularly of interest as they are naturally replenished on a human timescale such as sunlight, wind, rain, tides, waves and geothermal heat. Hence, it is obviously the foremost interest for environment friendly conservationists.

Biofuel and biomass power generation are time consuming process as they require integrating the organic waste from various places manually and going through a biogas or bio fuel plant. Hence, it involves the human intervention. So this approach cannot be considered as a primary source of energy for home or the industry at large.

Geothermal energy is an energy source for which not much research has been done till date. It is the heat energy generated in the surface of earth and cone out over a surface. Hydropower incurs a huge deployment charge and even the minute problem with the hydroelectric power plant leads to a huge risk to manpower and the region.

It is felt that the deployment and usage charges associated with Wind Mills are very optimal. The basic problem with the working of wind mill is its unpredictability in generating power. This paper focuses on the various activities pursed by the researchers to achieve the required prediction of wind power generation.

Energy forecasting enables the planner to decide about the short term, midterm and long term operation scheduling activities like energy reservation and maintenance of the system.

Organization of the paper is as follows: Section II explores the literature in the area of Wind Energy Prediction. Section III discusses the proposed approach for predicting the wind energy and the analytical results expected therein. Section IV concludes the paper with future scope.

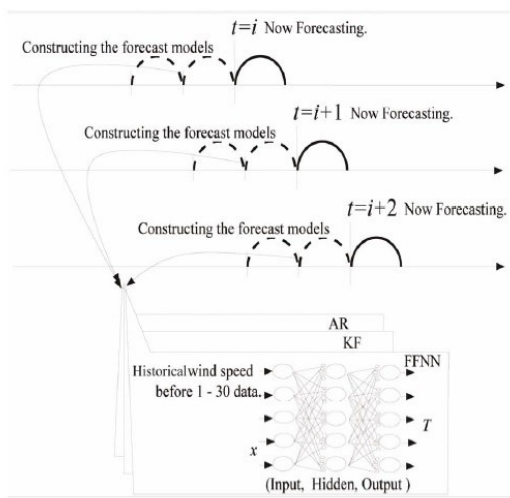
2. LITERATURE SURVEY

Artificial intelligence based approaches have been applied to midterm load forecasting in several ways as per [2] work has been done to use statistical method and artificial intelligence technology in order to achieve the midterm load forecasting. The forecasting results in energy generation can be used for energy reservation and energy scheduling and maintenance. Load forecasting can be used for operational planning. It can be classified in 3 types. That is short term, midterm and long term [3]. For short term load forecasting neural networks are used on historical load and temperature as input data, also day, time, humidity, wind velocity, and season are choose as input in many paper for short term forecasting. In most of the cases supervised learning along with back propagation algorithm is referred [4-10]. Even fuzzy logic is used with back propagation for short term load forecasting [11]. Genetic algorithm along with neural network are used for short term forecasting [12] while it is observed that for speeding up the computation and increasing the forecasting genetic algorithm is used [13]. Time is divided in to eight triangular membership functions for short term load forecasting using fuzzy logic algorithm where input data taken is time and temperature. These membership functions are mid night, dawn, morning, noon, forenoon afternoon, dusk and night. Even temperature is divided in to below normal, above normal and high membership functions[14].Various models have been proposed using regressive, auto regressive integrated moving average (ARIMA), along with artificial neural network for giving high accuracy results [15-16].Using the data set of the 10year period from a state meteorological depart. Of Turkey and from this short term forecasting was done in turkey. Different ANN models were used. It is concluded that the one with sixty neuron was most suitable for a short term wind speed forecasting [33].this model was satisfactorily implemented at electricity utility control center of turkey. Statistical model for wind speed and wind power forecasting using ARMA and ANN was proposed in [34]. ARMA achieves better forecasting as compared to ANN however with more time consumption. Predicted wind speed is accurate when forecast is done within an hour in advance than several hours in advance. Hence this work seems to be more appropriate for short term prediction compare to midterm and long term prediction and ARMA is preferable for short term prediction. A review of wind power forecasting models was done by Wang etal whereby several internationally developed models like WPMS [35], WPPT [36], Prediktor [37], ARMINS [38], Previento [39], WPFS ver. 1.0 etc. [40], were reviewed with an emphasis on accuracy and the source of measure errors. ANN was used to predict short term wind power. Using back propagation neural network where the output were predicted for a resolution of 10minutes [42]. The model had a potential to capture a dynamics of non linear, it was concluded that the no. of neuron in hidden layer directly impact the performance of ANN model. Also the over fitting problem is caused due to too many hidden neurons.

Load forecasting for holiday using fuzzy linear regression method gives good accuracy with average max. Percentage error is 3.5% [17]. Along with fuzzy logic and neural network chaos is integrated for load forecasting in [18].An inference system developed by using a fuzzy inference system and regression method used a large amount of historitical data to forecast load error [19]. By slight modification of back propagation method a neuron expert system crated. And it used for medium term load forecasting [20]. A data mining approach using support vector machine regression algorithm was used to provide a short term prediction of short term power [22]. That is advantage of this approach was that the error was aggregated because the previously used value was predicted. Two layer feed forward neural network model was used to predict short term wind power with ten minute resolution. It was observed that the model estimate a wind speed with the better accuracy [23]. The validity of autoregressive (AR) model, kalman filter, and neural network was investigated for the very short term power forecasting using wind energy based on the time series data. Simulation result enabled the authors to coin the following hypothesis "If wind speed data are always available we have the ability to forecast and estimate sequences of second's scale power output from wind speed only. The theoretical and mathematical back ground related to application in neural network in wind power generation" is mentioned in [24]. Autoregressive artificial neural network forecasts the wind speed with batter precision compared to the persistent artificial neural network. Also the wind speed is assumed to be function of previous wind speed and local time.

ANN multilayer Perceptron was applied to obtain prediction using a meteorological data from several stations at canary iyeland, Spain [21].

A review paper on current method and advances in forecasting of wind power generation was reviewed in [25]. According to a paper researchers have used the physical, statistical and hybrid methods for wind forecasting and prediction. Error measures used in various techniques were Buyers, MSE (Means Square error), and RMSE (Root mean Square error, SDE (Standard Deviation of error) and Skilled score. For statistical approach methods auto regressive moving average model (ARMA) and auto regressive integrated moving average model (ARIMA) were used for learning ANN, Fuzzy systems, and support vector machine are applied. Bayesian is used for autoregressive model for forecasting [26]. Researched simulated grid side and wind turbine side parameters. It was observed that the DFIG system offers good contribution to grid voltage support in case of short circuits. DFIG seemed to be reliable and stable when it was connected to grid side with proper converter control systems.



[Fig1: concept for forecasting technique] [44].

Modelling and simulation of 2MW PMSG wind energy conversion system. Investigation of Self excited Induction generator for wind turbine applications is done in [27].validity of autoregressive model kalman filter and neural network is confirmed by forecasting the short term generating power in [44]. In this paper time series analysis is performed considering the wind speed in the order of 1-30sec. for investigation purpose

The concept of forecasting is shown in fig.1. based on the simulation results, the authors were able to hypothesise that, one can estimate sequences seconds scale power output if time series data of wind speed is available.

A Review of various forecasting models is presented in paper [46]. The paper discussed the research involved in forecasting model associated with wind speed and power. The method implemented by reasercher includes Physical, statistical and hybrid model on different time scales. Also the factors which affect the predictive results were discussed in paper. It is observed that almost 80% errors can be described by Numerical Weather prediction (NWP). The Spatio-Temporal correction of account more than 20% of the errors for a 2hour predictions. Due to the phase error in the meteorological forecast prediction, error produced for the tool like Wind power prediction tool (WPPT).

Current wind power prediction technologies were evaluated by s.saroha [47]. There are three different ways in which the wind data can be utilized for wind power forecasting which include statistical model, physical model and hybrid model. A factor affecting for wind power forecasting includes Atmospheric characteristic, topographical characteristic, wind power characteristic, behaviour indices, other stochastic uncertainty, and geographical conditions. Input data pre-processing has been done either using kalman filter or wavelet transform or using unsupervised learning algorithm. Even few papers used self organizing maps, Bayesian clustering bi-dynamics (BCD) and seasonal exponential adjustment. Researcher have worked on various wind power estimation technique like Feed forward neural network (FFN), radial bases function neural network, and support vector machine. It is concluded that multi step ahead prediction with high level of accuracy is complex and tedious as compare to single step ahead prediction enhance there is a scope of research in multi step ahead perdition.

An artificial neural network base approach with 3 layer feed forward ANN model was used to forecast short term wind power for Portugal as described in [48]. The forecasting accuracy was evaluated using Mean absolute percentage error (MAPE) and Standard deviation error (SDE) criterion.

Wind power forecasting using ANN was done in [49]. Data for this work was obtained from ALIAS, Belgium for about 13months.to train the neural network the back propagation was used in combination of gradient decent algorithm and gauss Newton iteration.

$$F = mse = \frac{1}{N}\sum_{i=1}^{N}(e_i)^2 = \frac{1}{N}\sum_{i=1}^{N}(t_i - a_i)^2$$

Wind power forecasting model based on NARX is more accurate and reliable as compared to NAR model.

Modelling and simulation of grid connected wind power generation using doubling fed induction generator implemented using MATLAB is shown in [28]. Using diode and thyristor in power conversion it is observed that the system is scaled to high voltage for high power applications. The Problem with the system is that the output current is non sinusoidal. To improve power quality passive filter, active filter, or other topologies are used at the output of the phase controlled inverter. Squirrel cage induction generator with reduced converter power rating for standalone energy system with variable speed is proposed in [29]. The system can operate with nonlinear and unbalanced load. A squirrel cage induction generator can also be withstand against the variation of external forces up to 5-7% when air gust and sudden variation over a turbine shaft. This also a major factor to used SQIG in wind turbine system. A model for variable speed cage induction generator is a technique which uses any one of the phases of machine as excitation winding and the other two are the power winding this is termed as the two series connected and one isolated (TSCAOI) phase winding. This implementation of TSCAOI power generation is simple, low cost and does not required output filtering for grid integration. A closed loop control strategy is expected to identify the limitation of this novel cage induction generator. A paper focusing on various wind turbine model which were using PSIM software and MATLAB Simulink Toolbox. Variation calculation of torque and speed were performed [30].The performance comparison of wind power system was done for SCIG, DFIG, and DFIG in single sided grid connection systems [31]. For a small turbine system and induction drive was modelled and simulated. This model is represented as fluxes of state variable. It estimates a magnetic flux and electromagnetic torque. It shows good design and operation [32]. Security and stability are integrated part of the distributed generations. The micro grid solution is proposed to handle the same and is simulated using MATLAB Simulink Tool Box. The fluctuation of load and other distributed generation is considered in future work. The energy storage device of the micro grid is concluded to energy storage model. An open source library for simulation of wind power plans was presented in open source library for the simulation of wind power plants [43]. The library is named Modelica Library wind Power Plants. In the said Paper the library structures control strategy of pitch angle and angular velocity of wind turbine.

3. WIND POWER CALCULATION

Theoretical Power calculation for wind turbine system is mentioned in [51], a turbine affects wind force in form of push and due to that it rotate. This push base principle is mentioned in old generation wind turbine system. And in new generation base turbine system a Lift and Drag force create, and due to these two component resultant force on blade start to displace and rotate turbine [52].

A total kinetic energy contained in wind is given as,

$$P = ½mv^2$$

Where, m = rate of air flow

v= Wind speed or wind velocity,

Now for this we can give a rate of change of air is proportional to the area swept air and air density so this kinetic energy is given as,

$$P = ½A\rho v^3$$

Where ρ = Air Density and

A= Area of passing

These equation is used to know about the wind energy absorb by any system, because to we need to know about actual power available in air.

Here in general case a air density is consider as $\rho = 1.225\ kg/m^3$**.**

ρ is actually not constant but we consider as general value.

A betz-limit describe a maximum limit of maximum power extracted by turbine.

$$P = ½\ \rho\ A\ V\infty^3\ [16/27]$$

So here, 16/27≈ 0.5925 is the max. Possible efficiency of system.

This shows the maximum energy to push back by wind Force = Change in movement

$$P = Cp\ \rho\ a\ V\infty^2$$

Where Cp, is Power co-efficient is defined as,

$$Cp\ (\lambda, \beta = C1(\frac{C2}{\lambda 1} - C2\beta - C4\ )e^{-\frac{C5}{\lambda 1}} + C6\lambda 1$$

Here, λ = Tip Speed Ratio (TSR).

$$\lambda = \frac{\omega D}{2v}$$

And (ω) is Angular frequency,

$$\omega = 2\pi f$$

And λ_1 = Internal Tip Speed Ratio.

$$\lambda 1 = \frac{1}{\frac{1}{\lambda + 0.089} - \frac{0.035}{\beta^3 + 1}}$$

And β= Pitch angle.

$$P = Pw\ \times Cp\ (\lambda, \beta)$$

This power deliver to main shaft of turbine and that power is deliver to the gear box mechanism, here considered a gear mechanism is design on based of lumped model. Gear box is a mechanical part which increases the rotation ratio from low to high. This system can assume all rotating mass can be treated as one concentrated mass.

This power and high rotation delivered to the generator system. Here for generation an Induction Generator were used. And squirrel cage induction generator were used because it has characteristic to works as generator above synchronous speed.[50]

For induction generator value of Stator Voltage (V_1), No. of Pole (P) , System Frequency (f) in Hz, Stator and Rotor Resistance (R_1 & R_2) , stator and rotor reactance (X_1 , X_2) , and Mutual Reactance (X_m), Parameters of squirrel cage generator are found by,

$$\text{Slip (s)} = \frac{\omega s - \omega m}{\omega s}$$

Where, ω_s = Synchronous speed.

ω_m = Actual rotating speed.

Here,

$$\omega s = \frac{120 \times f}{P}$$

A stator current is given as,

$$I1 = \frac{V1}{Zin}$$

Here a Generator has a two different type of winding so voltage and current also vary so it gives as,

For Delta Connected system,

Line Voltage, $Vll = V1$

Line Current $I1 = \sqrt{3}\ \times I1$

And For Star Connected system,

Line voltage $Vll = \sqrt{3}\ \times V1$

Line Current $I1 = I1$

In that a Impedance given as,

$$Zin = R1 + j\ X1 + \frac{j\ Xm\ (\frac{R2}{s} + jX2)}{\frac{R2}{s} + j\ (X2 + Xm)}$$

For this generator a power across gap is also given as,

$$Pgap = \frac{3I2^2R2}{s}$$

Rotor Current (I_2),

$$I2 = \frac{j\ Xm}{\frac{R2}{s} + j\ (X2 + Xm)} I1$$

And

Toru Produce by Generator is given as,

$$\tau = \frac{Pgap}{\omega s}$$

A Squirrel Cage Induction generator is basically a machine so it need some power to tart at a initial condition.

Real and reactive power of generator given as,

$P\ elec. = 3 \times V \times Re\ \{I\}$

$Q\ elec. = -3 \times V \times Im\ \{I\}$.

A value of above all parameter is comes negative. So it indicates that Induction motor works as a induction generator [53].

And that total capacitance required is given as,

$$C = \frac{1}{2 \times \pi \times Xc}$$

This gives a capacitance value per phase for a generator at variable output.

In induction generator for create constant generation a few amount of reactive power is also required. In general the reactive power absorb from supply source, or from connected grid. This is also considering a small drawback parameter of induction generator. Because if generator absorb a large amount of reactive power than system will unbalance. But here in this system a generator feed reactive power by placing a Capacitor bank.

Matlab/ Simulink simulation platform is adopted for building the asynchronous wind turbine and micro grid model in [45]. Asynchronous wind turbine was used a storage unit and connected to the port of wind turbine to study the effect of energy storage device in micro grid. That smoothen the power fluctuation.

4.REFERENCES

[1] Gera, R. K., et al. "Renewable energy scenario in India: Opportunities and challenges." *Indian Journal of Electrical and Biomedical Engineering* 1.1 (2013): 10-16.

[2] Bunnoon, Pituk, Kusumal Chalermyanont, and Chusak Limsakul. "A Computing Model of Artificial Intelligent Approaches to Mid-term Load Forecasting: a state-of-the-art-survey for the researcher." *International Journal of Engineering and Technology* 2.1 (2010): 94

[3] Metaxiotis, K., et al. "Artificial intelligence in short term electric load forecasting: a state-of-the-art survey for the researcher." *Energy Conversion and Management* 44.9 (2003): 1525-1534.

[4] Senjyu, Tomonobu, et al. "One-hour-ahead load forecasting using neural network." *Power Systems, IEEE Transactions on* 17.1 (2002): 113-118.

[5] Wang, Zhiyong, and Yijia Cao. "Mutual information and non-fixed ANNs for daily peak load forecasting." *Power Systems Conference and Exposition, 2006. PSCE'06. 2006 IEEE PES*. IEEE, 2006.

[6] Dai, Wenjin, and Ping Wang. "Application of pattern recognition and artificial neural network to load forecasting in electric power system." *Natural Computation, 2007. ICNC 2007. Third International Conference on*. Vol. 1. IEEE, 2007.

[7] Mori, Hiroyuki, and Eitaro Kurata. "Graphical modeling for selecting input variables of short-term load forecasting." *Power Tech, 2007 IEEE Lausanne*. IEEE, 2007.

[8] Adepoju, G. A., S. O. A. Ogunjuyigbe, and K. O. Alawode. "Application of neural network to load forecasting in Nigerian electrical power system." *The Pacific Journal of Science and Technology* 8.1 (2007): 68-72.

[9] Hayati, Mohsen, and Yazdan Shirvany. "Artificial neural network approach for short term load forecasting for Illam region." *Performance Evaluation* 48 (2007): 10741.

[10] Salama, H. A., et al. "Short-term load forecasting investigations of Egyptian electrical network using ANNs." *Universities Power Engineering Conference, 2007. UPEC 2007. 42nd International*. IEEE, 2007.

[11] Seetha, Hari. "Short term electric load prediction using Fuzzy BP." *CIT. Journal of Computing and Information Technology* 15.3 (2007): 267-282.

[12] Kung, Chih-hsien, et al. "An adaptive power system load forecasting scheme using a genetic algorithm embedded neural network." *Instrumentation and Measurement Technology Conference, 1998. IMTC/98. Conference Proceedings. IEEE*. Vol. 1. IEEE, 1998.

[13] Lai, L. L., et al. "Object-oriented genetic algorithm based artificial neural network for load forecasting." *Simulated Evolution and Learning*. Springer Berlin Heidelberg, 1998. 462-469.

[14] Pandian, S. Chenthur, et al. "Fuzzy approach for short term load forecasting." *Electric Power Systems Research* 76.6 (2006): 541-548.

[15] Lu, Jian-Chang, Dong-Xiao Niu, and Zheng-Wan Jia. "A study of short-term load forecasting based on ARIMA-ANN." *Machine Learning and Cybernetics, 2004. Proceedings of 2004 International Conference on*. Vol. 5. IEEE, 2004.

[16] Filik, Ummuhan Basaran, and Mehmet Kurban. "A new approach for the short-term load forecasting with autoregressive and artificial neural network models." *International Journal of Computational Intelligence Research* 3.1 (2007): 66-71.

[17] Song, Kyung-Bin, et al. "Short-term load forecasting for the holidays using fuzzy linear regression method." *Power Systems, IEEE Transactions on* 20.1 (2005): 96-101.

[18] Liao, Gwo-Ching, and Ta-Peng Tsao. "Application of a fuzzy neural network combined with a chaos genetic algorithm and simulated annealing to short-term load forecasting." *Evolutionary Computation, IEEE Transactions on* 10.3 (2006): 330-340.

[19] Liang, R-H., and C-C. Cheng. "Combined regression-fuzzy approach for short-term load forecasting." *Generation, Transmission and Distribution, IEE Proceedings-*. Vol. 147. No. 4. IET, 2000.

[20] Chandrashekara, Adiga S., T. Ananthapadmanabha, and A. D. Kulkarni. "A neuro-expert system for planning and load forecasting of distribution systems." *International Journal of Electrical Power & Energy Systems* 21.5 (1999): 309-314.

[21] Hernandez-Travieso, Jose G., Carlos M. Travieso, and Jesus B. Alonso. "Wind speed modelling for the estimation of the wind energy generation." *Bio-inspired Intelligence (IWOBI), 2014 International Work Conference on*. IEEE, 2014.

[22] Kusiak, Andrew, Haiyang Zheng, and Zhe Song. "Short-term prediction of wind farm power: a

IJCSC 0973-7391 Volume 7 • Issue 2 March 2016 - Sept 2016 pp. 1- 7 available online at www.csjournalss.com

data mining approach." *Energy Conversion, IEEE Transactions on* 24.1 (2009): 125-136.

[23] Kumar, A. Senthil, Tomas Cermak, and Stanislav Misak. "Short-term wind power plant predicting with Artificial Neural Network." *Electric Power Engineering (EPE), 2015 16th International Scientific Conference on*. IEEE, 2015.

[24] Mishra, Alok Kumar, and L. Ramesh. "Application of neural networks in wind power (generation) prediction." *Sustainable Power Generation and Supply, 2009. SUPERGEN'09. International Conference on*. IEEE, 2009.

[25] Foley, Aoife M., et al. "Current methods and advances in forecasting of wind power generation." *Renewable Energy* 37.1 (2012): 1-8.

[26] Miranda, Marcos S., and Rod W. Dunn. "One-hour-ahead wind speed prediction using a Bayesian methodology." *Power Engineering Society General Meeting, 2006. IEEE*. IEEE, 2006.

[27] Koley, Indrajit, et al. "Matlab Modeling and Simulation of Grid Connected Wind Power Generation Using Doubly Fed Induction Generator." *International Journal of Computational Engineering Research (IJCER) ISSN (e)*: 2250-3005.

[28] Muljadi, Eduard, et al. "Investigation of self-excited induction generators for wind turbine applications." *Industry Applications Conference, 1999. Thirty-Fourth IAS Annual Meeting. Conference Record of the 1999 IEEE*. Vol. 1. IEEE, 1999.

[29] Trapp, J. G., et al. "Variable speed wind turbine using the squirrel cage induction generator with reduced converter power rating for stand-alone energy systems." *Industry Applications (INDUSCON), 2012 10th IEEE/IAS International Conference on*. IEEE, 2012.

[30] Joshi, Siddharth, et al. "Wind energy-a brief survey with wind turbine simulations." *International Journal of Computer Communication and Information System (IJCCIS)* 2.1 (2010): 228-232.

[31] Tapia, Arantxa, et al. "Modeling and control of a wind turbine driven doubly fed induction generator." *Energy Conversion, IEEE Transactions on* 18.2 (2003): 194-204.

[32] Tamas, Levente, and Zoltan Szekely. "Modeling and simulation of an induction drive with application to a small wind turbine generator." *Automation, Quality and Testing, Robotics, 2008. AQTR 2008. IEEE International Conference on*. Vol. 3. IEEE, 2008.

[33] Nogay, H. Selcuk, Tahir Cetin Akinci, and Marija Eidukeviciute. "Application of artificial neural networks for short term wind speed forecasting in Mardin, Turkey." *Journal of Energy in Southern Africa* 23.4 (2012): 3.

[34] Gomes, Pedro, and Rui Castro. "Wind speed and wind power forecasting using statistical models: Autoregressive moving average (ARMA) and artificial neural networks (ANN)." *International Journal of Sustainable Energy Development* 1.1/2 (2012).

[35] Luebbers, Raymond J., William A. Foose, and Gregory Reyner. "Comparison of GTD propagation model wide-band path loss simulation with measurements." *Antennas and Propagation, IEEE Transactions on* 37.4 (1989): 499-505.

[36] Holttinen, H., T. S. Nielsen, and G. Giebel. "Wind energy in the liberalised market–forecast errors in a day-ahead market compared to a more flexible market mechanism." *Proceeding, International Symposium on Distributed Generation: Power System and Market Aspects, Stockholm*. 2002.

[37] Enders, Craig K., and Davood Tofighi. "Centering predictor variables in cross-sectional multilevel models: a new look at an old issue." *Psychological methods* 12.2 (2007): 121.

[38] Sideratos, George, and Nikos D. Hatziargyriou. "An advanced statistical method for wind power forecasting." *Power Systems, IEEE Transactions on* 22.1 (2007): 258-265.

[39] Giebel, Gregor, et al. "State-of-the-art Methods and software tools for short-term prediction of wind energy production." *EWEC 2003 (European Wind Energy Conference and exhibition)*. 2003.

[40] SVENSSON, MORGAN. "Short-term wind power forecasting using artificial neural networks."

[41] http://in.mathworks.com/help/nnet/gs/neural-network-time-series-prediction-and-modeling.html

[42] Kumar, A. Senthil, Tomas Cermak, and Stanislav Misak. "Short-term wind power plant predicting with Artificial Neural Network." *Electric Power Engineering (EPE), 2015 16th International Scientific Conference on*. IEEE, 2015.

[43] Eberhart, Philip, et al. "Open Source Library for the Simulation of Wind Power Plants." *Proceedings of the 11th International Modelica Conference*. Vol. 2.

[44] Yona, Atsushi, et al. "Very short-term generating power forecasting for wind power generators based on time series analysis." (2013).

[45] Shao, Wen, et al. "Modeling and simulation of the asynchronous wind turbine." *Innovative Smart Grid Technologies-Asia (ISGT Asia), 2012 IEEE*. IEEE, 2012.

[46] Wang, Xiaochen, Peng Guo, and Xiaobin Huang. "A review of wind power forecasting models." *Energy procedia* 12 (2011): 770-778.

[47] SAROHA, SUMIT, and SK AGGARWAL. "A Review and Evaluation of Current Wind Power Prediction Technologies."

[48] Catalão, J. P. S., H. M. I. Pousinho, and V. M. F. Mendes. "An artificial neural network approach for short-term wind power forecasting in Portugal." *Intelligent System Applications to Power Systems, 2009. ISAP'09. 15th International Conference on*. IEEE, 2009.

[49] Kariniotakis, G. N., G. S. Stavrakakis, and E. F. Nogaret. "Wind power forecasting using advanced neural networks models." *Energy conversion, ieee transactions on* 11.4 (1996): 762-767.

[50] http://people.ucalgary.ca/~aknigh/electrical_machines/induction/operation/generating.html

[51] Eberhart, Philip, et al. "Open Source Library for the Simulation of Wind Power Plants." *Proceedings of the 11th International Modelica Conference*. Vol. 2.

[52] Non-Conventional Sources of Energy by Mr.G.D.Rai (B.sc. ,B.E. (Mechanical),M.E. (Hons). ,MSESI, MISTE.; Dept. of Mechanical Engineering, Samrat Ashok Technological Institute; Vidisha (M.P.).

[53] http://www.allaboutcircuits.com/textbook/alternating-current/chpt-11/true-reactive-and-apparent-power/