EXTREME LEARNING MACHINE BASED FORECASTING OF PHOTOVOLTAIC POWER OUTPUT

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Overview

The economics of Photovoltaics will play an important role in the future electricity grid. In Germany, the PV capacity has reached more than 30GW. Policy makers need to understand the supply side economics of PV to formulate effective policies. One of the main issues with integrating PV energy in the grid is the fact that PV power plants are not dispatchable. The amount of solar power produced by a plant is difficult to predict and hence poses a problem with grid integration. Reliability of PV can only be increased if the uncertainty in PV electricity supply is reduced. Estimation of PV output is one of the ways to achieve this. In the key findings of the technology roadmap for PV (2008), IEA states that- "As PV matures into a mainstream technology, grid integration and management and energy storage become key issues." It is essential to estimate the amount of electricity produced by a PV plant for economic and technical reasons. The novelty of the paper lies in the application of a new algorithm to PV forecasting [1]. Forecasting of PV output power is done using a non-linear estimation method known as Extreme Learning Machine (ELM) that is used for estimating the parameters of generalized single layer feed forward neural networks.

Methods

The linear estimation methods suffer from the problem of under-estimation and over-estimation. For example, Ordinary Least Squares(OLS) is the Maximum Likelihood Estimator(MLE) of the mean of normal distribution. Hence, using OLS regression for estimating the profile of a time series will lead to estimation based on mean of the data. Non-Linear methods can be used to overcome this problem. Neural Networks are widely used for estimation of nonlinear systems. However, traditional learning methods suffer from non-convexity and over-fitting. Extreme Learning Machine(ELM)[1] is a state of the art algorithm for training the generalized single layer feed forward neural networks. It overcomes the problem of non-convexity and hence give a globally optimum solution to the non-linear estimation problem. This paper compares the performance of ELM with Support Vector Machine(SVM) [2] and Ordinary Least Squares (OLS) for short term profile forecasting of photovoltaic power output.

Results

A non-linear model is proposed for the PV output. The model is implemented for PV output time series taken from Tennet TSO in Germany[3]. PV output show auto-correlation and depend on external factors like weather conditions. Multi-Scale Seasonality is also one of the most important characteristics of PV output. For example, PV output show intra-day seasonality (high at noon and zero during night) and monthly seasonality(high during summer). Estimation of the model is done using ELM and LSSVM(LSSVM is Least Square Support Vector Machine and is used due to its computational simplicity). A comparision of the results of ELM, LSSVM and OLS is presented with respect to computational time and Mean Absolute Percentage Error(MAPE).

Conclusion

In this paper, a non-linear estimation method is applied for the PV output prediction. A model is proposed for PV output power and implemented using ELM. Future work include applying the SVM and ELM to forecasting using user defined constraints. Also, other application areas like load forecasting and and Hourly Price Forward Curves(HPFC) should be investigated.

References

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