POWER FLOW FORECASTING WITH LOW PREDICTION ERROR

Boris BIZJAK[1]

Introduction

Predicting the future has been a great motivation for the human mind for centuries. Today's prediction methods are based on time series theory. Time series harbor a wealth of information. With proper mathematical and statistical processing, they give us prediction models. With forecasting models, we can predict the future. The goal is to make the forecast with as low error as possible.

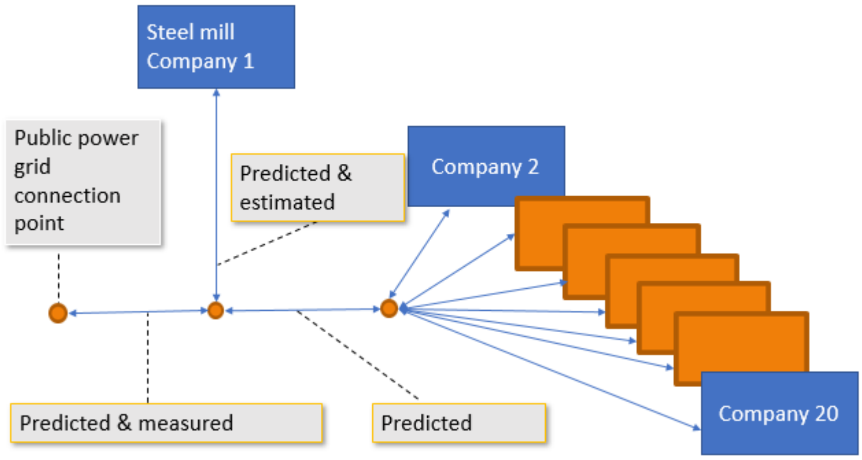

Figure 1: Block diagram of industrial complex and branches with forecasted power flows.

The motivation is to predict as low error as possible the amount of energy we need in the next few days, which can be useful in reducing the cost of electricity. Secondly, the question is why would we produce more energy than we need and thus pollute the environment? We present power flow forecasts for three branches of one energy node at the entrance of a large industrial complex. The Root-Mean-Square Error (RMSE) is a measure of the quality of the different forecasting models for the same time series. The classic prediction model for the described case reaches RMSE = 3389. Power flow forecasting model with low prediction error reaches RMSE = 2584, in other words, we have improved the forecast model by over 30%. The prediction step is 1 hour or 15 min. The results can be represented by a forecast error for the next hour on with 6% error and the next 48 hours with 12% error.

Methodology of Work

The methodology of the work is based on time series theory, statistics and machine learning. The forecasting methodology is supported by a database and visualization is performed through a secure Web server. The work process is basically classical: first, based on the characteristics of the time series of the measured electricity consumption, we choose the appropriate forecasting methodology. The methodology chosen returns a prediction model, but with indeterminate parameters. The parameters of the prediction model are then calculated by the program before each prediction. Up to this point the methodology is completely usually.

In order to achieve low prediction error, classical work procedures need to be modified. Simplified, for each time series at branch, it is necessary to determine what is the useful signal and what is the noise. The prediction is then made only for the useful signal, because the noise interferes with the forecast. After the prediction is completed, the noise is again added to the useful signal. That’s how we get power flow forecasting with low prediction error. In this way, the basic measuring time series of the measured

[1] University of Maribor, FERI, Koroška cesta 46, Maribor, E-mail: boris.bizjak@um.si, tel. +386 41 327 348

energy was processed - it is the first input signal. In order to perform the described procedures, we used two different forecast model, which partially covers the dynamic property of consumption in each branch.

The second input time series is a planned production of the arc furnace in the company 1. For low prediction error, it is necessary to determine what information the predictor of the production of the arc furnace must contain. The predictor should be as simple as possible. A periodogram was used to optimize the content of the predictor. The result is a bit surprising: for a prediction with a low error it is only necessary to know the time interval from when and until the production in the furnace will run. So, the predictor only has a value of 0 or 1.

Results

The solution itself is folded from standard software modules that are purchased on the market. The smartness of our application is the way we used and modify standard modules. Such application solutions require close cooperation with the technical staff of the client who lives and works in such an industrial complex, only in this way can we understand what information the time series contains.

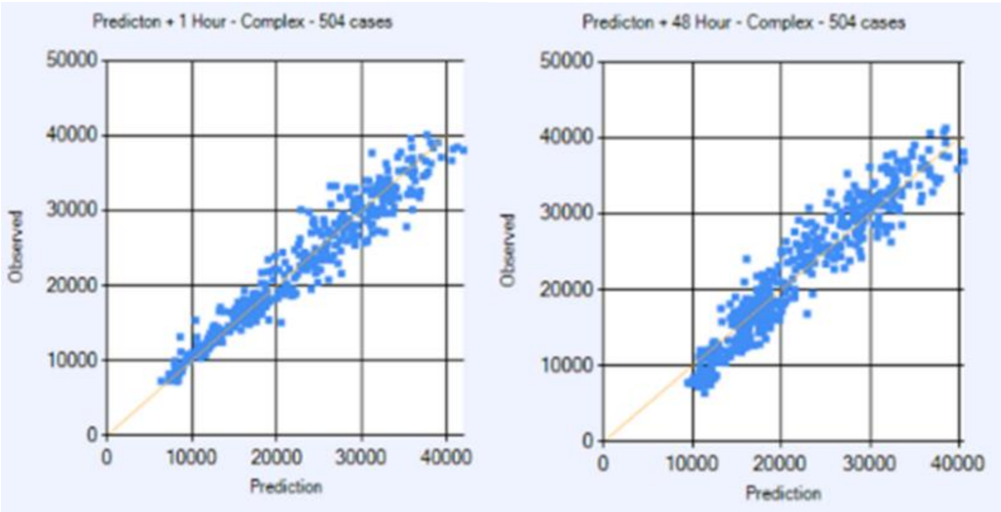

Figure 2: Power flow prediction with low error for next 48 hours at public grid connection point.

Branch A represents prediction of the power flow from the public grid, the total energy consumption and has the result: for the next 24 hours: $R^2_{24} = 0.93$ $MAPE_{24} = 9.9\%$; for the next 48 hours: $R^2_{48} = 0.91$ $MAPE_{48} = 12.3\%$ $RMSE_{48} = 2584$ (Figure 2).

Branch B represents power flow prediction to the company 1, the largest consumer of power, with a typical coefficient of determination $R^2_{48} = 0.93$. Branch C represents a flow to all other businesses with $MAPE_{48} = 7\%$.

References

[1] Douglas C. Montgomery, George C. Runger, Applied Statistics and Probability for Engineers, Wiley, 2003.

[2] George E. P. Box Gwilym M. Jenkins Gregory C. Reinsel. Time series analysis, forecasting and control, 2014, Wiley.