Short-Term Electric Power Demand Forecasting Using the Weighted Coeficients of the Partial Autocorrelation Function

ABSTRACT

Forecasting the short-term demand for electricity in the National Power System, especially over the next 24 hours, is essential for ensuring its safe operation and, consequently, for the continuity of electricity supplies. The indicated process is one of the strategic competences of each power system operator. In view of legislative, technological, cyber, climate and social changes, it is adapted and improved to them, which indicates the need to modify the existing forecasting methods and search for new solutions.

The subject of the research carried out in the doctoral dissertation was short-term forecasting of electricity demand in the National Power System for each hour of the day, with particular emphasis on the first six hours of the day. The issues of dynamics of changes in the amount of electricity demand in particular hours of the day in 2009-2018, taking into account public holidays and non-standard days, were analyzed in particular. The means of covering the demand for electricity in the power system were analyzed and the issue under consideration was placed in the context of econometrics and statistics. In this context, the review of the methods of analyzing and forecasting short-term power demand used for power distribution and transmission systems was essential.

The main objective of the research carried out in the doctoral dissertation was to develop a new autoregressive method for forecasting electricity demand, characterized by at least acceptable forecast quality, with particular emphasis on the first six hours of the day as well as public holidays and non-standard days. This method is aimed at improving the efficiency of forecasting and will be a means of supporting the forecasting process for all hours of the day in situations of disruptions in obtaining data for forecasting models using external data other than data on the historical values of the analyzed parameter.

Appropriate research methodology based on weighted coefficients of the partial autocorrelation function was used to solve the research problem and achieve the assumed goals. A mathematical model was developed for short-term forecasting of electricity demand in the National Power System using only historical data reflecting hourly power demand values. The model was implemented in MS Excel®, and the values of the coefficients of the partial autocorrelation function were calculated in the STATISTICA® package, in accordance with the adopted theoretical assumptions. A set of validation tests for the proposed method was also prepared. The developed method was tested on the National Power System as well as on the systems of Sweden and France. Moreover, it was compared to eighty selected forecasting models from the group of autoregressive methods, using the historical data of the national system.

The analysis of the forecast results obtained primarily included the assessment of the acceptability and effectiveness of the method, broken down into the first six hours of the day and the remaining eighteen hours of the day, as well as for public holidays and

non-standard days. The most important conclusions from the conducted research were formulated as follows:

- the results of the analysis positively verified the admissibility and effectiveness of the obtained forecasts of short-term electricity demand, taking into account the specificity of the forecasting process used by the Polish Transmission System Operator and in the analyzed foreign systems;
- the developed method, thanks to the use of a hybrid connection with the forecasting results obtained by the national Transmission System Operator, allows to increase the overall forecasting efficiency, which has been validated for the ten-year analysis period;
- application of the developed method, compared to the selected set of eighty selected prognostic models using the autoregressive approach, allows to obtain (on selected types of days) forecasts that are more effective than the low-cost naive method; the developed method is at the same time more effective than the advanced and recognized ARIMA method;
- the developed method based on the weighted coefficients of the partial autocorrelation function allows to obtain greater efficiency than most of the selected autoregressive models subjected to comparative analysis, while maintaining the lowest time-consuming while meeting the assumed admissibility criterion;
- the proposed method is flexible and is not dedicated only to the nature of the load waveforms of the power system in Poland.

It should be emphasized that the research conducted in the doctoral dissertation, the developed method and the obtained results are of an application nature, especially in the context of the dynamic development of prosumer energy, disruptions in telecommunications continuity and cyber threats, both in relation to electricity demand and other parameters describing the operation of the National Power System in the short term.