Abstract

Poland, as a member of the European Union, is subject to European regulations on energy markets, especially in the context of the growing share of renewable energy sources and the functioning of the CO2 emissions trading system. This is reflected not only in several national legal regulations, but also has an impact on the methods and analytical tools used in this area.

The dissertation focuses on the issue of forecasting demand for electricity and natural gas in the short term. The initial part of the work concerns the current state of knowledge on forecasting demand for electricity and natural gas, considering the specificity of the Polish market and the methods and prediction models used. Forecasting in this context is a multidimensional problem, covering both technical and economic aspects, which have a direct impact on trade and optimal resource management. Then, the details of the organization of the Polish electricity market are discussed, including the mechanisms of trading on the wholesale market, the role of transmission system operators and energy sellers, as well as key regulations influencing demand forecasting.

The next part of the work discusses the functioning of the natural gas market, including the analogy to the electricity market in terms of demand forecasting methods. The main factors influencing the nominal demand for natural gas are also indicated.

A review of contemporary methods of forecasting electricity demand is presented next, from classic statistical models, such as linear and autoregressive models, to advanced machine learning techniques, such as neural networks or decision trees. Particular attention is paid to methods used in short-term forecasts, which are necessary to minimize operating costs. Challenges related to including meteorological variables and seasonality in forecasts are discussed.

Then, the focus is on the data aggregation method, building predictive models and selecting predictive variables, which are the foundation of effective forecasts. Data aggregation plays a key role in eliminating noise and improving the quality of available information, which allows for a better understanding of behavior related to energy consumption. In turn, building predictive models based on methods such as neural networks or regression trees allows for the use of complex patterns in historical data to better predict future demand. Selecting appropriate predictive variables, such as temperature, insolation or peak consumption hours, improves the quality of forecasts, minimizing the prediction error. The paper continues with a discussion of current trends in the energy sector, including photovoltaic sources, heat pumps and other factors influencing demand. Challenges related to aggregating customer data and explanatory variables, as well as building forecasting models, were also analyzed. The impact of these factors on forecast accuracy was assessed, and metrics used to assess model performance were presented.

Next, the challenges related to forecasting electricity demand and production from PV micro-generation were discussed, considering the accuracy of meteorological forecasts, the selection of predictive variables and the impact of forecast errors on the operating costs of the trading company. Forecasting electricity demand is becoming increasingly complicated due to the increasing variability of generation from renewable energy sources and dynamically

changing meteorological conditions. The accuracy of forecasting energy demand and micro-generation, from photovoltaic installations, is a key element in managing modern power systems. The above aspect causes variability of the examined time series (net demand profile) correlated with the intensity of solar radiation. Therefore, an attempt was made to separate the aggregated data on net demand, the components of gross demand and the generation of photovoltaic micro-installations. Then, the specified time courses were subjected to a correlation study with explanatory variables.

The research results were presented, paying particular attention to the accuracy of forecasting methods and models, the identification of key variables influencing demand, and the effectiveness of the methods used. The conclusions resulting from the analysis of the impact of meteorological variables on the forecasting of demand and energy production from photovoltaics were also discussed. The focus was on possible directions for improving current forecasting models. Attention was drawn to areas in which further research efforts should be focused, such as the integration of additional meteorological data, better adaptation of models to changing market conditions, and the introduction of more advanced artificial intelligence techniques, such as deep neural networks or hybrid methods, which can improve the quality of forecasts in the context of variability of RES generation.

In conclusion, the novelty aspects introduced in the research were highlighted, such as improving the efficiency of short-term forecasts, optimizing the selection of predictive variables and using new data aggregation methods, which can find practical application both at the level of system operators and energy market participants. In the context of comparing different models, an important aspect is the assessment of costs resulting from inaccurate forecasts, which can lead to the destabilization of the energy system and generate additional operating costs. The introduction of appropriate variables, such as meteorological variables and historical data, is crucial for obtaining precise forecasts. The variability of PV generation in short periods is a challenge for network operators, who must balance the system based on uncertain forecasts of solar radiation intensity. The quality of available meteorological forecasts, which are crucial for accurate prediction of both energy demand and RES generation, was analyzed. Small deviations in temperature or solar radiation forecasts can lead to significant errors in energy forecasts. Economic consequences resulting from forecasting errors are presented. Forecast inaccuracies may lead to suboptimal management of energy reserves, the need to launch expensive power reserves or penalties imposed on trading companies in the form of additional costs for drawing energy than was contracted, e.g. on the stock exchange. Accurate forecasting of demand and generation from RES is therefore not only a technical challenge, but also a key element in managing costs and stability of the power system.

The final part of the work contains a summary of the obtained results and the resulting directions for further work in this field.