Key Concepts and Methods in Point and Probabilistic Forecasting of Electricity Price

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Abstract

Italy, as a developed country and a member of the European Union, is undertaking the process commonly referred to as the energy transition. This involves the rapid integration of high percentages of renewable energy generation into the electric system. Unlike traditional thermoelectric generation from fossil fuels, renewables lack flexibility and thus require greater care and optimization to be made both energy-efficient and financially viable. Unfortunately, this evolution is taking place during a particularly challenging period: Europe has to deal with an unstable geopolitical framework. After the Russian aggression to Ukraine, a tariff war on gas prices together with and intense wave of speculation have resulted in historically unprecedented commodity prices. Certain segments of industry have faced serious difficulties, particularly electric utility companies, which had to incur over-indebtedness to ensure supplies. In order to control financial risks, forecasting the movement of future electricity prices becomes critical for electric operators. While long-term market outcomes remain difficult to predict, short-term electricity price trends can be analyzed and understood. This understanding means—if not the generation of precise numerical predictions (point forecasting)— at least the modelling of stochastic price behavior (probabilistic forecasting). This thesis consists of three self-contained chapters that explore the problem of Electricity Price Forecasting (EPF), progressing from introductory aspects to the latest trends.
In Chapter 1, we present a comprehensive introduction. We start with an

outline of the energy sector on European and Italian scales. We place particular emphasis on the recent crises affecting the EU, which have become a serious concern and have dramatically conditioned electricity markets in recent years. After that, we present some intuitions about the fundamentals of EPF and an anticipation of the main results.
In Chapter 2, we present a case study on short-term EPF in the Italian electricity. This part has two main objectives: exposing which factors a forecaster should take into account when developing a statistical model, and clarifying the difference between point and probabilistic forecasting. We present a series of univariate regression analyses that illustrate the differences between models belonging to different classes (linear/nonlinear, parametric/ nonparametric) and across different inputs. After that, we conduct both point and probabilistic multivariate regression analyses, with detailed evaluation of the results. The key to success lies in choosing the right predictors, which proves more critical than the choice of statistical forecasting algorithm.
The final research Chapter 3 addresses one of the most current areas of research in EPF: Model Averaging (MA). This involves combining forecasts from multiple, diverse models to enhance prediction accuracy and robustness. The concept is introduced with point forecasts and extended to the contemporary topic of MA for probabilistic models. Various aggregation schemes are evaluated for different classes of models, and the advantages of this approach are demonstrated: a reduction of roughly 10% in the error metrics can be achieved. Specifically, while point forecasting can benefit from a nearly indiscriminate aggregation of models, probabilistic forecasting requires a more cautious and deliberate analysis.
The concluding Chapter offers broader reflections and summarizes the lessons learned from the EPF problem. Finally, we outline the potential directions for future development of this work.