Abstract

The electricity sector is undergoing enormous changes, including alterations in the generation mix, more involved customers, new gadgets and technologies, and never-before-seen business models. These factors raised complexity and uncertainty, bringing new opportunities and challenges. In addition, the electricity network is being equipped with precision information acquisition equipment to measure and collect the data with higher resolution than what was previously available. On the one hand, internet development and extensive data gathering devices have successfully reduced the cost of data collection. On the other hand, large-volume data with a complex structure- big data- necessitate the development of the data analytics approaches.

In the last decade, data analytics studies have covered a wide range of fields across the entire value chain in the electricity sector, from production and transmission to the electricity market, distribution, and load consumption.

Due to the significance of the electricity market in the value chain of the electricity sector, in the first chapter, this thesis work provides a comprehensive review of the data analytics-related works to classify the more common applications (e.g., prediction, Demand Side Management, analysis the Merit Order Effect, market simulation) and approaches in the electricity market context.

This present thesis applies different data analytics approaches to assess the Italian electricity market, which is one of the distinctive electricity markets in Europe with a zonal market mechanism, volatile electricity price, and a considerable amount of wind and solar generation in different zones. In this regard, chapter 2 briefly introduces the market and provides a statistical summary of the market-related variables.

Electricity price is a crucial factor in each electricity market. In this regard, forecasting electricity price is critical for the market participants to maximize their profits. The more accurate the prediction is, the lower the market risk is. In chapter 3, the most important electricity price prediction methods are introduced. Then, in chapter 4, the introduced methods with different structures have been utilized to forecast the Italian wholesale electricity prices. Considering different time horizons (hourly, daily, and weekly), their performances have been compared through several performance metrics.

Chapter 5 assesses the impact of increasing wind and solar power generation on zonal market prices in the Italian electricity market, employing a multivariate regression model. A significant aspect to consider in the discussion is that additional

wind and solar generation changes the inter-zonal export and import flows. In the first and second steps of the model, the impact of additional wind and solar generation that distribute across zonal borders is calculated separately based on the empirical approach. Then, the Merit Order Effect of the intermittent RESs is quantified in every six geographical zones of the Italian day-ahead market. The results generated by the multivariate regression model reveal that increasing wind and solar generation decrease the daily zonal electricity price. Therefore, the Merit Order Effect in each zonal market is confirmed. These findings also suggest that the Italian electricity market operator can reduce National Single Price by accelerating wind and solar generation development. Moreover, these come up with principal knowledge advantageous for decision-makers and market planners to predict the future market structure.

The Global spread of the COVID-19 pandemic caused disruptions in the whole energy sector. The power system and electricity market were no exception. To have a detailed quantitative representation of the effects of the pandemic on the Italian electricity system, chapter 6 provides a definition of pandemic and a list of short/mid/long term possible dangers that threaten the electricity network in the pandemic period. Then, by defining various metrics, the influence of the recognized pandemic-related threats on the power system is evaluated quantitatively. Finally, by comparing the assessment results, the relevant reactions and preparation strategies in case of pandemic persistence or resurgence, both at the planning and operational stage, are proposed.