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REVIEW OF METHODOLOGIES USED IN ELECTRICITY SUPPLY AND DEMAND FORECASTING

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ABSTRACT – European countries began liberalizing their electricity markets to increase competition and reduce prices for consumers [1]. In a liberalized electricity market, electricity is treated as a tradable commodity like any other product. Since then, electricity markets have been subject to the same economic principles of supply and demand as other markets, with prices rising when demand outstrips supply and falling when supply exceeds demand. A variety of methods and ideas have been tried for electricity forecasting in generation, demand, and price domains over the last few decades, with varying degrees of success. Over time. Researchers have applied methodologies from time series analysis, ARIMA models to machine learning and deep learning techniques. The evolution of these techniques have improved cost reductions in the industry. The purpose of this review is to illustrate the evolution of employed methodology, the complexity of applied solutions, and the opportunities and challenges that forecasting tools offer or may encounter.

Keywords: Energy forecasting; Electricity Supply; Electricity Demand; Energy supply chain

1. INTRODUCTION

Electricity industry's distinctive and particular traits cause generation, consumption, and price dynamics that are seldom seen in any other market, demonstrating seasonality at the daily, weekly, and annual levels, as well as rapid, fleeting, and typically unexpected spikes. The intermittency of electricity generation from renewable sources has created market complexities and this has led to more emphasis on efficiency-driven interventions in the market [2]. Rather than investigating day ahead electricity prices, practitioners started to research on intraday electricity prices and volumes. Intraday forecasts of electricity volumes and prices can be used to balance the deviations caused by differences in day-ahead supply contract positions and the actual demand [3]. The importance of forecast accuracy has drastically increased as it directly impacts cost reductions. Over time, electricity price and load forecasting has improved with advancements in the available technologies and accurate data. However, the development in this area is not steady or unambiguous [4]. We reviewed these changes over time in methodologies used to forecast electricity price and load domains. This paper contains the analysis of an extensive bibliometric study of the Scopus database.

2. MATERIALS AND METHODS

We found 17 review papers on Scopus which contain literature review, systematic literature review, comprehensive review and review papers. The first step of the analysis we conducted was defining the

keyword structure (KS). Defining KS is the most crucial step in a systematic review as it defines the direction that the study takes [5]. The structure of the KS includes three levels; electricity, forecasting, and the market structure based on time. The forecasting domain consists of supply chain concepts of the industry which include price and imbalance. The market structure consists of the two markets; intraday market and day ahead market. Then, the search result is narrowed down to journal publications that are published in English. Further, the search results are filtered based on the subject area. From initial results, inclusion keywords were used to recognize the most relevant studies to review. Studies that contain title or author keywords representing the identified words from both the forecasting contexts and electricity supply chain domain were selected in the first phase of selection.

The Inclusion keywords were searched from the abstracts. After filtering, 705 papers were selected by carefully going through their abstracts individually. A thorough bibliometric analysis was conducted on the selected papers by carefully going through each paper.

3. RESULTS AND DISCUSSION

Among selected studies, 53% were published after 2018. *Energies*, *Applied Energy*, and *IEEE Transactions on Power Systems* are the journals which has the highest publications relevant to this scope. Wrocław University of Science and Technology, Xi'an Jiaotong University, University of Oxford are the universities in which most of these studies were conducted. Researchers based in Europe and Asia have mostly conducted studies on this domain. We analyzed the methodologies used over time using author keywords.

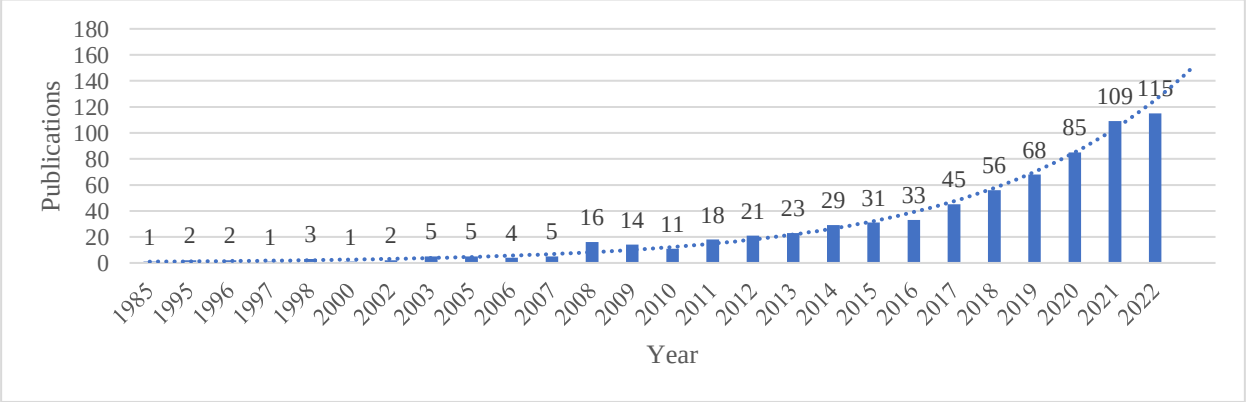

Figure 1. Number of publications over the years

The keyword analysis clearly shows that artificial neural network and machine learning are the two key techniques used in this domain. From this bibliographic analysis, we identified that, artificial intelligence and deep learning algorithms are increasingly used in the electricity industry for forecasting since they can analyze large amounts of data and identify patterns that may be missed by traditional statistical methods. Also, these techniques consists the ability to model complex nonlinear relationships between input variables and forecast targets. With the introduction of the smart grid technology researchers were able to access more accurate and reliable data for forecasting electricity demand and supply. Additionally, Internet of Things (IOT) is being used to collect real-time data from sensors installed in the electricity grid, which can help in predicting demand and supply with more accuracy, specifically in the intraday market. These advanced forecasting models help to minimize forecast errors by considering many factors that affect energy demand and supply, including weather patterns, energy consumption patterns, and energy generation.

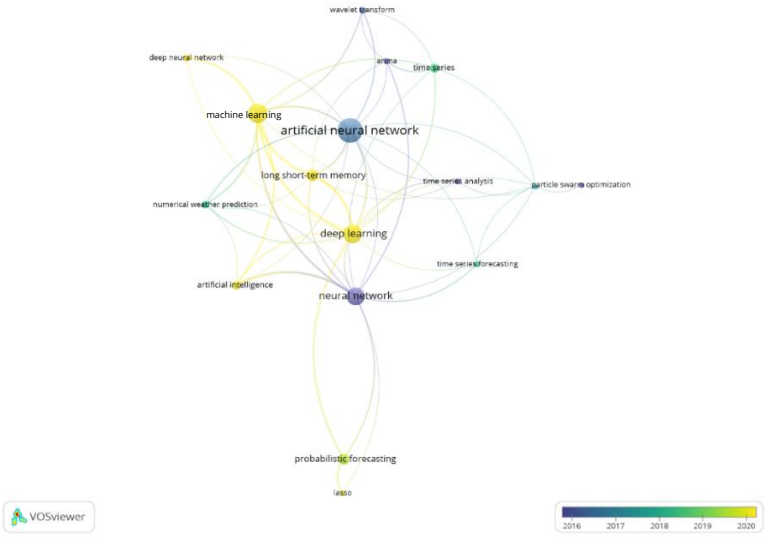

Figure 2. Research clusters in methodologies

4. CONCLUSION

Over the last few decades more efficient forecasting techniques such as deep learning and artificial intelligence have emerged as prominent solutions to reduce forecast error. Overall, these techniques have proven to be effective tools for electricity forecasting, enabling accurate predictions of power demand, prices, and renewable energy output. These advancements in electricity forecasting have led to more accurate and reliable predictions of demand and supply, which can assist utility providers to better plan and manage their resources, reduce costs, and improve grid stability.

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