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An Analysis of Different Techniques Electricity Marketing Clearing Price Prediction Using Machine Learning- A Review

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***Abstract*—In this Review paper discuss on an analysis of various machine learning techniques for predicting electricity market clearing prices. Electricity market clearing prices are important for market participants as they determine the price of electricity at which the market is cleared. Accurate prediction of these prices is essential for energy traders, producers, and consumers to make informed decisions about energy production, consumption, and trading. In this study, different machine learning models such as linear regression, decision trees, random forests, artificial neural networks, and support vector machines are evaluated for their effectiveness in predicting electricity market clearing prices. The data used for analysis is obtained from the ISO New England electricity market, and various statistical measures such as mean absolute error, root mean squared error, and coefficient of determination are used to compare the performance of the different models.**

***Keywords*— Electricity Marketing; Machine Learning; Clearing Price Prediction.**

I. INTRODUCTION

In the modern world, electricity is a basic need. In many respects, our everyday lives would be impossible without the usage of electricity in some form or another. The last century's rapid in dustrialisation has led to spectacular increases in power use and, consequently, electrical energy production.

The advent of bulk generation of electrical energy required that the electrical energy be transmitted to load centers via elaborate networks of transmission lines. At the load centers, electrical energy is then distributed by a complex web of distribution networks. This basic configuration of generation, transmission and distribution is still in use all over the world.

A part of the electrical energy is lost during its transmission. This puts a physical limit as to the distances of generation centers from the load centers. That is why electrical systems have evolved mainly within their own geographical jurisdiction. Although by employing a different technique, called DC transmission, it became feasible to transport electrical energy over longer distance; electrical systems predominantly remained bound to their geographical jurisdiction.

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I.1History of Electricity Market

On July 24, 1879, P.W. Fleury & Co. held the first public demonstration of electric lighting in Calcutta (now Kolkata). The Indian Electric Co. was incorporated in London on January 15, 1897, and Kilburn & Co., acting as agents, obtained the Calcutta electric lighting license on January 7, 1897. About a month after its original name was chosen, the corporation changed its name to the Calcutta Electric Supply Corporation. It wasn't until 1970 that the company's headquarters were moved from London to Calcutta. After the success of bringing power to Calcutta, it was expanded to neighboring Bombay (now Mumbai). Crawford Market saw the first demonstration of electric lights in Mumbai in 1882, and in 1905 the Bombay Electric Supply & Tramways Company (BEST) built a generating station to power the city's tram system.

On August 5, 1905, in Bangalore, India, an electric street light was turned on for the first time in Asia. On February 3, 1925, the first electric train in the nation made the trip from Bombay's Victoria Terminus to Kurla over the Harbour Line. In 1947, the Government Engineering College in Jabalpur became the first institution in India to

set up a high-voltage laboratory. [21] Cochin International Airport in India became the first airport in the world to be powered entirely by solar energy when a new solar facility was opened on August 18.

Grid management was first used in India on a regional scale in the 1960s. Five regional grids— the Northern, Eastern, Western, North Eastern, and Southern Grids—cover the whole Indian subcontinent by connecting the grids of individual states. The goal of establishing these regional linkages was to facilitate the transportation of power surpluses between states within each area. A national grid was first considered by the Indian government in the 1990s. Asynchronous high-voltage direct current (HVDC) back-to-back lines first linked regional grids, allowing for some limited interchange of regulated power. High capacity synchronous lines were later implemented on the connections.

II. LITERATURE SURVEY

Sajawal ur Rehman Khan, et. al. (2023)- In this research study, The main objective of the efficient and effective electric-load prediction for big data is successfully achieved using our proposed ECNN and ESVM forecasting models. Furthermore, our proposed forecasting models helped decrease computational complexity of the forecasting model by eliminating less-important features using modern feature-selection and extraction methods. The numbers of layers of our proposed ECNN are increased and the hyper parameters of the proposed techniques ECNN and ESVM are dynamically adjusted. Simulation results of our proposed techniques are compared with conventional CNN and SVM techniques using four performance error estimators, The performance metrics proved that our proposed ECNN and ESVM electric-load forecasting models have the lowest error rates. Due to the growing worldwide interest in reliable and sustainable energy supply, incorporating more renewable and alternative energy sources reduces stress on existing electric transmission systems. The proposed schemes should be helpful in finding the exact power generation from distributed sources and power consumption that helps in smooth working of the smart grid. The same infrastructure can be implemented for industrial power-management systems and will also be effective for smart agriculture systems [01].

Jiahui Wu, et. al. (2022) - The electricity market will tend to be diverse and competitive to realize Carbon Neutrality goals under Energy Internet. Moreover, bidding strategies and methods are essential for the stable and benign operation of the electricity market. With the development of artificial intelligence and computer simulation technology, multi-agent simulation has gradually become a significant method for electricity market bidding. Among them, Multi-Agent Reinforcement Learning (MARL) can help agents adapt to changing environments. In contrast, Multi-Agent Transfer Learning (MATL) can help agents learn from not only the target task but also other similar tasks [02].

Dakhaz Mustafa Abdullah, et.al. (2021) – In this research work presented, we present three LSTM-based hybrid architectures for the EPF. This study puts emphasis on the influence of feature selection methods in the proposed hybrid models. In particular, we compare the prediction performance of the two-step feature selection, the autoencoder, and two-stage feature selection models based on the empirical study on the Nord Pool day-ahead system price. In addition, we employ a SHAP method to evaluate the importance and impact of the features on predicting this price. The main findings are the following: (1) We conclude that the different feature selection methods will lead to different feature selections. As input, diverse features will have a comparably significant impact on the performance of LSTM-based predictive models. (2) Compared to CNN-LSTM and ConvLSTM, LSTM-LSTM is a better autoencoder structure for EPF. (3) The two-stage models can improve the forecasting accuracy of two-step models to some extent. The superior feature selection from the RFE-SVR model [03].

Haq, M. R., & Ni, Z, et.al (2019) - Forecasting electricity demand is crucial today to further reduce the cost of the energy market for the day ahead. Utility operators can benefit from load forecasting for effective administration of a demand response programmed. Utility managers can create appropriate operational plans for generating units with the aid of more accurate and efficient forecasting of the power load demand. But resolving the load forecasting issue is a difficult undertaking given that the current load, various exogenous external elements (such as weather variables, social variables, working day or holiday), time of day, and season of the year all have an impact on the current load [04].

Ahmad, A.., et.al (2019) - In SGs, DALF is an essential task because its accuracy has a direct impact on the planning schedules of utilities that strongly affects the energy trade market. Moreover, high volatility in the history load curves makes DALF in SGs relatively more challenging when compared to load forecast for longer duration. Taking into account DALF influencing factors such as exogenous variables and meteorological variables, As a hybrid ANN-based DALF model for SGs, we have presented A supervised ANN with many models for forecasting, using MARA for training. The proposed model significantly reduced the execution time and enhanced the forecast accuracy by distinctly carrying local normalization and local training. Additionally, the forecast technique can capture non-linearities in load-time series thanks to the sigmoid activation function and MARA. The forecast accuracy was also increased by integrating the optimization module with the forecast approach (based on the adjustments we suggested) [05].

Potapov, V., et.al (2018) - As can be seen from the data shown in Figure 4 and 5, the technique used gives an average error of 3.0 ... 3.3% for a period of 1 year. Thus, the considered methodology can be used by the subject of

the electricity market without large material costs and is based on general statistical methods and methods of structural models. At the same time, the subject of electricity market should have retrospective data on the electricity loads in the interval not less than one year, as well as the average temperature of the ambient air and the average temperature of the wind speed. The presented methodology for forecasting power consumption can be used by the subjects of the electricity market. At the same time, it may be necessary to create empirically an educational sample taking into account the specific energy consumption. In our case, LLC "Omsk Energy Retail Company" accounts for 75% of the total electricity consumption for consumption of legal entities and 25% for individuals. At the same time, the type of day should be taken into account, since the social phenomena can influence the specifics of electricity consumption, as mentioned above, and this fact should also be taken into account when developing the procedure for predicting of the electricity loads [06].

Mukhopadhyay, et.al (2017) - Fuzzy modeling is robust in incorporating the weather parameter namely the temperature and relative humidity in the load forecasting model. A simple but effective way to model these parameters in the domain of fuzzy to obtain realistic value of the forecasted load when compared to the actual load has been introduced and discussed. From the forecasted value of the load, optimizing the dispatch of the generation resources, controlling the export or import of the control area to remain within the interchange limit predetermined by a different set of study of the Available Transfer Capability of the area and also to economically exchange energy at the market can be achieved, thus resulting in overall economy, efficiency and reliability [07].

Ko, C. N, et.al (2019, February) an integrated prediction approach was proposed for short-term load forecasting. The proposed RBFNN is based on the combination of SVR and DEKF methods. After the initial parameters and structures of the RBFNN using SVR method, the DEKF is used to tune the parameters of RBFNNs to obtain an optimal model. After that, the best RBFNN is used to predict short-term load. Three separate real-load scenarios using various real-load data obtained from the Tai power Company were used to test the suggested methodology for multi-day load forecasting. DEKFe RBFNN and GRD-RBFNN models have been used to compare the performance of the suggested model. Comparison results demonstrate that the proposed SVR DEKF RBFNN model outcomes the existed prediction models on forecasting accuracy, robustness, and stability [08].

III. NATURAL MONOPOLY AND REGULATION

Generation, transmission and distribution of electrical energy require huge capital investment for operation, maintenance and expansion. This type of investment was achieved by awarding monopoly over the entire geographical jurisdiction. In some places, crown corporations were established and given monopoly of generation, transmission and distribution of electrical energy within pre-specified geographical boundaries. A single entity used to run and control all aspects of generation, transmission and distribution within a geographical jurisdiction. The single entity could set its own rate sometimes with the approval from a regulatory body. A natural monopoly guaranteed a decent return on the huge investment that a single entity or a crown corporation would typically make. However, regulation became part of the electricity industry all over the world. Its chief objective was to protect the consumer, from the inevitable consequences of a monopoly industry.

Although closely regulated, the electricity market is nonetheless a naturally monopolistic sector of the economy. Figure 1 depicts its vertically integrated structure. When it came to vertically integrated electric systems, there were often only a few large businesses operating them back in the 1970s. Each corporation was an independent system. Combined, they controlled more than 90 percent of the total electric market in their country. In a vertically integrated system, local consumers have no other choice for electricity service but the local provider. In a natural monopoly (regulated) electric market, electricity price is high and services are usually limited.

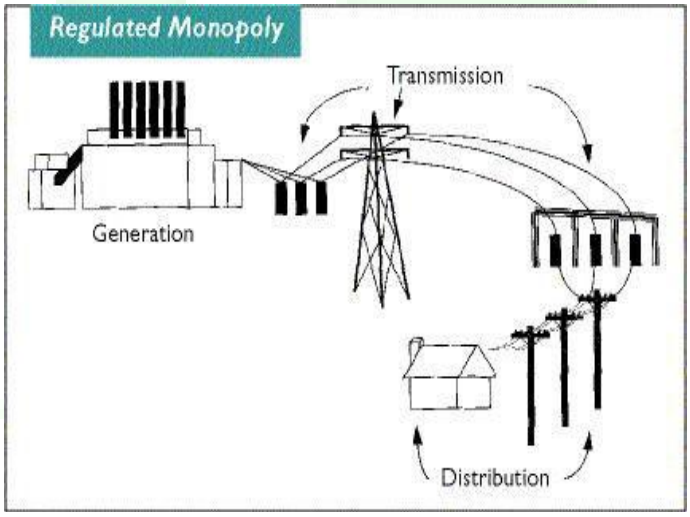

Fig .1 Regulated Electric Market

Figure 2 is a typical electricity bill from BC Hydro. As BC Hydro is the only electricity provider in British Columbia, it owns and operates generation, transmission and distribution. Therefore, the bill is presented as a package based on days of usage and total amount of electricity consumed. There is no need to separate the bill on each part of generation, transmission or distribution.

IV. ELECTRICITY MARKET CLEARING PRICE

By definition, a market clearing price is the price at which there is neither a shortage nor an excess, or when the

market is balanced. It is a slang term that laypeople use to refer to the equilibrium pricing. The equilibrium price in a market is the point where the supply and demand curves meet.

Figure 3 displays the MCP for California's statewide power market. In Figure 3 the MCP is $200 per MWh, and the demand is 30,000 MW at that price The market clearing price (MCP) is the resulting equilibrium price. Once the electric market clearing price has been determined, the energy delivery contract for that hour will be awarded to the provider whose offering price is lower than or equal to the electric MCP price. They will be compensated at the clearing price for the electrical market, not at the amount they originally provided.. That is done in order to maintain market fairness and prevent market manipulation.

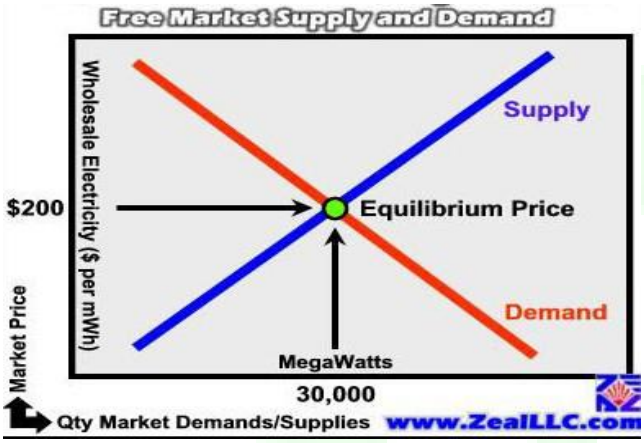

Fig 3: Electric Market Clearing Price

In Ontario deregulated electric market, for those consumers paying wholesale price from a 24- hour operation wholesale electricity market, Every five minutes, the wholesale price is decided. Finding out the initial electricity demand is the first step in the process of determining the clearing price on the electricity market. Each day, the IESO issues forecasted electricity demand throughout the following day and up to the month ahead. This forecasted electricity demand also includes an energy reserve of approximately 1400 MW above what will actually be consumed. This additional 1400 MW is kept in reserve for use in case of emergencies. The forecasted electricity demand is continually updated as new information comes in such as changes in weather. Less than two percent usually separates the IESO's forecasted electricity demand for the day ahead from the actual demand figures.

V. CONCLUSION

In this survey paper discuss survey of different techniques for electricity marketing clearing price prediction using machine learning techniques highlights the potential of these methods to improve the accuracy of price forecasts in the electricity market. The study found that machine learning models, such as Support Vector Machines, Random Forest, and Gradient Boosting, can achieve high prediction accuracy and outperform traditional statistical models, such as ARIMA, in certain scenarios. Additionally, the study found that the selection of appropriate input features, data preprocessing techniques, and model hyper parameters can significantly impact the accuracy of the prediction model.

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