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# Powering the Future: Forecasting Household Electricity Consumption.

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***Abstract*— Accurately forecasting electricity consumption is very important to ensure efficient energy management and avoid resource wastage. In this study, we delve into the performance of previously trained models and discuss areas that can be improved for even more accurate forecasts. In our review of related research, we observe a predominant trend involving the use of artificial intelligence- based models, particularly Artificial Neural Networks (ANNs), in short- term electricity forecasting. These ANNs focus on accuracy metrics such as RMSE and MSE, have proven helpful at capturing intricate consumption patterns. Key input variables often include weather conditions, economic factors, historical consumption data and lifestyle indicators.**

**This study offers a comprehensive perspective on the evolving landscape of electricity demand forecasting and introduces a novel approach to address forecasting challenges with enhanced precision.**

***Keywords* – MSE (mean squared error), RMSE (root mean squared error)**

## I. INTRODUCTION

Electricity is a fundamental energy source with numerous advantages, including its convenience, controllability, adaptability, cost-effectiveness, cleanliness, and high efficiency. Modern society heavily relies on electricity, and accurate forecasting of electricity consumption is crucial for anticipating future power demand and calculating the variance between current and projected load. Precise power consumption forecasting is essential for effective energy supply planning, financial management, and efficient electricity resource management while also serving as a safeguard against costly errors. Within the domain of energy forecasting, Short-Term Load Forecasting (STLF) plays a central role. STLF involves predicting power demand in the coming hours, days, or even several days. Its primary goals encompass the effective scheduling of power generation, streamlined dispatch operations, and the overall safety of power plants. Accurate load forecasting is vital for optimizing the performance of the power system, enhancing its security, and facilitating the allocation of generation resources. STLF also plays a pivotal role in economic dispatch and contributes significantly to the reliability of the power system. The power system's dependability is highly sensitive to abrupt changes in load demand, with underestimations potentially leading to power shortages and overestimations resulting in unnecessary resource allocation.

A crucial element of this system centers on the integration of Kalman filtering, a methodology that combines data from inertial sensors and the Global Navigation Satellite System (GNSS), such as GPS. The primary goal is to enhance the accuracy of user location estimation, ensuring the precise positioning of augmented reality (AR) objects within the user's immediate surroundings.

Additionally, the paper highlights the limitations of existing navigation applications, particularly their inefficiency in guiding users through non-public areas. It emphasizes the need for specialized navigation applications tailored to the specific requirements of particular facilities. The ongoing research project aims to address this gap effectively.

Various approaches exist for short-term consumption prediction, broadly categorized into conventional algorithms and artificial intelligence (AI) algorithms. This research primarily centers on AI-based methods for short-term forecasting, as they tend to demonstrate superior performance compared to traditional statistical methods. Within the realm of AI models, the Artificial Neural Network (ANN) stands out as a particularly renowned choice for this purpose.

Artificial Neural Networks (ANNs) are employed to forecast future values by examining the intricate, nonlinear connections between past data and external factors. Through the utilization of input-output datasets and an appropriate learning mechanism, these networks acquire an understanding of the intricate relationships between input parameters and corresponding output predictions.

## II. LITERATURE REVIEW

Paper [1]; Electricity, with its manifold benefits including ease of use, controllability, adaptability, cost-effectiveness, environmental friendliness, and high energy efficiency, serves as a cornerstone of contemporary society. To secure a reliable energy supply, enable prudent financial planning, and ensure effective electricity resource management, accurate electricity consumption forecasting, particularly in the short term, is of paramount importance.

Short-term load forecasting (STLF) is focused on estimating power demand for the upcoming hours to a few days. Precise STLF is essential for maintaining the dependable, secure, and efficient operation of power plants and for facilitating effective system scheduling. Moreover, it plays a crucial part in upholding the safety of the electrical grid and enhancing the allocation of resources.

Weather variables, like temperature and humidity, and various types of loads significantly impact load forecasting. Combining historical load data and weather information is essential for precise predictions.

There are two main categories of forecasting methods: traditional statistical algorithms and AI-based algorithms. This paper emphasizes AI-based methods, particularly Artificial Neural Networks (ANNs), which tend to outperform classical statistical approaches.

In ANNs, nonlinear relationships between past values and external factors are learned from input-output data, making them effective for short-term load prediction. The paper provides an overview of ANN-based methods and evaluates them for easier comparison.

Electricity plays a vital role in contemporary society, thanks to its various benefits such as convenience, controllability, adaptability, cost-effectiveness, cleanliness, and high efficiency. Anticipating electricity consumption, especially in the short term, is essential for maintaining reliable energy supply, prudent financial planning, and the efficient management of electricity resources.

Short-term load forecasting (STLF) is focused on estimating power demand for the upcoming hours to a few days. Ensuring accuracy in STLF is critical for supporting the dependable, secure, and cost-effective operation of power plants and for facilitating effective system scheduling. Additionally, it plays a central role in upholding the safety of the electrical grid and optimizing resource allocation.

Paper [2]; Time series methods are commonly employed for forecasting, a task of great significance in our daily lives. Accurate forecasting of electrical load and energy consumption is crucial for the operation, planning, and design of power systems. Traditional forecasting techniques rely on precise numerical data, yet historical data is often limited to approximate or anecdotal information, rendering conventional methods less effective.

In the context of Ukraine, where not all consumers have automated power metering systems, data inaccuracies and uncertainties are prevalent, presenting a unique challenge. Traditional time series approaches are inadequate for predicting fuzzy sets that represent linguistic concepts. To address this limitation, Song and Chissom introduced the theory of fuzzy time series, providing a solution to this issue.

Paper [3]; Due to electricity's essential function in modern life, both residential and commercial consumption has been constantly rising worldwide. The cost of electricity has been shifting, and the amount of electricity produced frequently isn't enough to keep up with the rising demand. Numerous studies have attempted to predict future electrical energy consumption in an effort to solve these issues, aiding power suppliers in making informed planning decisions and encouraging energy saving.

Forecasting the load has been a long-standing challenge in the power industry. This study conducted a systematic review of 77 relevant academic journal articles published over a nine-year period (2010–2020) on electricity demand forecasting. The review focused on several key aspects:

1. Forecasting AlgorithmsAccording to the study, 28% of the top nine electricity forecasting models were based on artificial neural networks (ANN), which made up 90% of the models. In forecasting short-term electricity, ANN models were particularly prevalent.

2. Factors Affecting Electricity Consumption: The research considered factors such as weather, economic parameters, household lifestyle, historical energy consumption, and stock indices. Weather and economic parameters were found to be the most influential.

3. In the realm of electricity forecasting, the key metrics for assessing accuracy predominantly revolved around the root mean square error and the mean absolute percentage error, with RMSE being the more prevalent choice, accounting for 38% of its usage.

4. Regarding the forecasting period, the research delved into the time frame of forecasting activities, underscoring that artificial neural networks were predominantly applied for short-term electricity forecasting, owing to the intricate nature of energy consumption patterns.

To summarize, this review highlighted the predominance of artificial intelligence-based models, notably artificial neural networks, in tackling the task of electricity demand forecasting. The study emphasized the importance of considering weather and economic factors in the forecasting process. Additionally, it brought to light the existing challenges and promising avenues for future research in electricity load forecasting, both on local and global scales.

Paper [4]; This thesis is a fundamental element of the Data Science master's program at LTU, centering on the development of models for short-term electricity consumption prediction through the analysis of historical data. In response to the increasing demand for electricity, the necessity for precise forecasting is of utmost importance. The research investigates three unique time series forecasting models as part of its study.

1. An ensemble model combining Facebook Prophet and XGBoost.
2. A neural network harnessing deep learning techniques, specifically Recurrent Neural Network.
3. A model based on Convolutional Neural Network (CNN) architecture.

The research assesses and discusses the performance of these models while offering insights into potential enhancements. Notably, the models were trained using data spanning from 2014 to 2019 and their predictions were evaluated in light of the unique circumstances brought about by the COVID-19 pandemic in 2020, which had a substantial impact on electricity consumption due to office closures. The study also delves into the specific effects of the pandemic on these models.

The thesis establishes a structured research framework by adhering to the Cross Industry Standard Process for Data Mining (CRISP-DM) methodology.

Paper [5]; The paper employs a multi-layer neural network in conjunction with wavelet transform to construct a model for predicting power consumption. The primary goal is to establish a dependable forecasting model that can facilitate efficient power generation and diminish electricity wastage. The strategy entails the following key steps:

1. Wavelet transform is used to denoise the sample data, removing the volatility in the data on electricity use.

2. In the Multi-Layer LSTM model, a neural network architecture is employed, which is based on Long Short-Term Memory (LSTM) and comprises multiple layers. This methodology leverages the output of each layer as the input for the subsequent time step, effectively enhancing the network's depth.

3.Comparative Analysis: To assess the accuracy of predictions and the model's fitting, the study contrasts the experimental results with those obtained from conventional LSTM and bidirectional LSTM models.

The findings indicate that, particularly when utilized in combination, the multi-layer LSTM model plays a significant role. Predicting electricity consumption is essential for effective power demand management. Several techniques have been proposed, including LSTM-based models, support vector regression, and linear regression models. In this paper, the incorporation of a multi-layer LSTM and wavelet transform is aimed at further enhancing the accuracy of predictions, ultimately improving the outcomes of power consumption forecasting.

Paper [6];This research delves into the realm of Very Short-Term Load Forecasting (VSTLF), with a specific focus on its application within individual households. The study particularly emphasizes its relevance in the context of smart grids and automated demand response systems. The primary objective is to predict electricity consumption within short timeframes, ranging from a few minutes to an hour. The proposed methodology involves a comprehensive analysis of daily behavioral patterns, the incorporation of contextual data (including weather conditions, events, economic factors, and day types), and the formulation of a rule set for projecting daily behavior patterns. Furthermore, distinct forecasting models are established for each unique behavioral pattern to estimate electricity usage during specific hours of the day.

In the study, which is centered on individual households in Taiwan, the approach demonstrated superior performance when compared to alternative methods. It achieved an average Mean Absolute Percentage Error (MAPE) of 3.23% for individual household load forecasting and 2.44% for aggregate load prediction with a 30-minute lead time. The research underscores the critical significance of precise load forecasting in the effective management of energy grids, particularly in light of the potential consequences of even minor forecasting errors on operational costs.

Load forecasting is typically categorized into several distinct time frames, including Very Short-Term, Short-Term, Medium-Term, and Long-Term, based on the duration of the projections. Over the years, a plethora of approaches has been introduced, incorporating statistical methods, artificial intelligence, machine learning, and pattern-based techniques. However, it is noteworthy that, in comparison to other forecasting categories, the existing literature on Very Short-Term Load Forecasting (VSTLF) remains somewhat limited.

The essay highlights the growing significance of VSTLF, particularly within the realm of smart grids and demand response applications. This growing significance is attributed to advancements in metering infrastructure and the establishment of two-way communication channels between energy providers and consumers. The essay emphasizes the critical need to comprehend household energy consumption patterns and recognizes the influence of contextual factors in achieving accurate forecasts. While a significant portion of research concentrates on calculating load forecasts for broader regions, the essay acknowledges the added complexity and reduced accuracy in predicting energy consumption for individual households, primarily due to the absence of error offset mechanisms.

The end of the research demonstrates the proposed methodology and how it was applied to actual load data from specific Taiwanese houses. After giving experimental data that show the strategy's effectiveness, the paper concludes with a summary of the findings.

Paper [7]; This paper specifically explores Very Short Term Load Forecasting within the context of smart grids and demand response systems, with a particular emphasis on individual households. The objective here is to predict electricity consumption within a time frame ranging from minutes to an hour. The proposed methodology entails a comprehensive examination of daily behavior patterns while considering contextual factors such as weather conditions, events, economic variables, and the specific day of the week. To predict power consumption patterns for these distinct behavior profiles, predictive models are established for each category, enabling the estimation of electricity usage during various time intervals.

The study, primarily focused on Taiwanese households, demonstrated superior performance when compared to alternative methods. It achieved a notable level of precision, with a Mean Absolute Percentage Error (MAPE) of 3.23% for individual household load forecasting and 2.44% for predicting aggregate load 30 minutes ahead. This level of accuracy proves to be instrumental in efficiently managing the power grid and reducing operational costs.

The sophisticated metering infrastructure and two-way connection with houses are highlighted in the report as reasons for the growing significance of VSTLF in smart grids. It is essential to comprehend consumption patterns and context elements in each family. While most studies concentrate on regional load forecasting, it is difficult to anticipate individual household loads because there is no error offset.

In the research's conclusion, the unique methodology is described, its feasibility is demonstrated using real household data, and it is emphasized how crucial VSTLF is to the advancement of smart grids and demand response technologies.

## III. CONCLUSION

Predicting future energy demands is a crucial aspect of decision-making within the energy sector, where precise estimates of electricity consumption are of utmost importance. Short-term load forecasting relies on mathematical models and a wide array of input variables. Given the intricate nature of the problem, the selection of model structure and parameters is contingent upon the currently available information.

The research paper conducts a thorough examination of various models, with a particular focus on those based on Artificial Neural Networks (ANNs). An extensive review of pertinent literature reveals a clear shift towards the adoption of neural networks, which have exhibited promising outcomes in the realm of Short-Term Load Forecasting (STLF). Furthermore, there is a growing trend in the utilization of hybrid forecasting techniques, often incorporating methods such as wavelet transformations and evolving algorithms, to enhance the accuracy of ANNs.

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