# INTRODUCTON

Power system planning is an integral part of Electrical Engineering. One of its stages  
and the most important module include electrical load forecast to adequately satisfy  
the loads for a foreseen future. As the demand of electricity grow rapidly, the planning for power system is very important and helps utility companies in their operation and management of the supply of electricity to their customers. It also helps power generating and distribution companies to increase in efficiency and revenues of power generated. [1] It helps them to plan on their capacity and operations in order to reliable supply their consumers with the required energy.

The most important part of load forecasting is planning for the future in terms of the size, location and type of the future generating plant. By understanding and determining of regions with high or growing demand, the utilities will most likely generate the power near the load. This help minimizes the transmission and distribution infrastructures as well as the associated losses.

In this paper, different AI algorithms will be used to predict short-term, medium-term and long-term load to produce a result as accurate as possible

**OBJECTIVES OF THE STUDY**

The objective of this study is to utilize the strength of Artificial Intelligence in forecasting hour-to-daily, weekly-to-monthly and monthly-to-yearly electrical load to be consumed by people living in a geographical area. The use of machine learning algorithms provides an option for the distribution substations to further serve their consumers by producing standardized power which  
will be sufficient for them on hourly and daily basis.

**RESEARCH PROBLEM STATEMENT**

Ghana’s electrical power company faces economical and technical challenges in terms  
of power planning and distribution of adequate power to meet the needs of consumers.  
Previously, traditional approaches such as usage of genetic algorithms were used to  
forecast the load, but as the power is consumed in a non-linear format, these algorithms  
are not able to capture the trend. Human labor is also utilized to simulate and predict  
the power that will be consumed in a particular city.  
With the advent of Artificial Intelligence and machine learning, this problem can be  
solved with much more precision.

**SCOPE OF WORK**

The scope of this thesis covers an electrical load forecasting technique that makes use of various load forecasting factors such as weather, time, special events, type of consumer and others to predict load for short-term, medium-term and long-term planning with a well design android and mobile application interfaces. The performance of using either a deep learning approach by making use of Artificial Neural Networks (ANN) or machine learning approach is measured in two metrics. These metrics are: mean average percentage error (MAPE) and root mean squared error (RMSE). This error checking measures provides a good indication on how the artificial intelligence model is performing after been trained. The goal of this metrics will be to approach zero, as better performance comes the less error.

This thesis also covers the entire process of training the AI model to deploying it to  
production for use by the distribution substations. The production environments will  
cover mobile and web applications. Thus, the scope of this work goes beyond training  
the AI model, but also covers other technologies utilizing mobile and web application  
frameworks

**THESIS OUTLINE**

As the focus of this thesis is not dedicated only to the electrical engineering aspect, but also and more importantly on the application of artificial intelligence, the content will cover both areas.  
The content of this thesis will be spread across five chapters. The next chapter which is Chapter two covers the Literature review, where the details of relevant theory, review of past or reported work will be addressed. The chapter is concluded with a brief introduction of the proposed work or solution.  
Chapter three covers the research methodology which entails how the problem will be analyzed, the procedures and methods that will be taken, and the equipment that will be used. Block diagram and a break-down of each block will be explained in detail. Analysis of the results from the work will be done in chapter four. Many approaches for solving the load forecasting problem using artificial intelligence will be compared and deliberated on why a model performs better than the other. Model testing and deployment activities will be explained in this chapter. In chapter five, conclusion is written and a summary of main study and work will be presented. Directions for future research will be laid out.

# **LITERATURE REVIEW**

OVERVIEW

The subject of electrical load forecasting has become increasingly important in our daily life as electricity distribution companies faces a lot of challenges to predict the actual future load behavior of their consumers in other to produce it to meet their demand and to prevent future loses. Electrical load forecasting is the prediction of electrical power required to meet the short-term, medium-term and long-term demand. A lot of effort and research has been done in previous years to provide the best method to accurately predict the future load demands.

[2] The accuracy of load forecasted curves directly affects the reliability and profitability of power system operation and has a direct impact on the choice of generating equipment configuration and their modes of operation. Distribution companies are charged with the option or what kind of plant or generator to be used when there is an increase or decrease in one or two of the driven forces that affect their predictions.

In this regard, the main challenge is how to manage the system when there is an increase or decrease in the variables that affect the prediction of future loads.

**FACTORS AFFECTING LOAD FORECASTING**

[3] Electricity demand pattern has a lot of challenges due to the effect of various factors including time, social, economic, and environmental factors which form various complex variation patterns. Social factors and environmental factors are big form of randomness found in load predictions.

Environmental factors such as weather affect load prediction because different regions in the country have different weather conditions which makes it difficult for load forecasters to produce accurate results. Most forecasting operators use manual methods that rely on wide range of contributing factors on upcoming events and dataset but relying on this method cannot produce a reliable output. Some of the weather parameters that affect the output curve includes humidity, temperature, rainfall etc. [4] The electricity consumption rate increases whilst the temperature increase and vice versa and also when rainfall increases or decreases the average daily electricity consumption rate lag for one to two days then increase or decrease and affect short term and, medium term planning.

When the pricing and demand of electricity changes, the outcome of the prediction also changes and affect the planning of distribution companies. [5] special events such as Christmas, Eidul-Adhar, Eidul-Fitr, Easter and many more also introduce randomness or noise into the output curve. Time factors such as, hour of the day (day or night), day of the week, time of the year (season) also has effect on load prediction.

In this regard there is no specific method of forecasting the load that can be used for all utilities.

This is because the driven forces are constantly changing in the environment. During holidays or sport activities the influence fluctuation of the load curve at the customers end will be totally different from that during high on weekdays and working days.

**TYPES OF LOAD FORECASTING**

Electrical load forecasting has been categorized into three namely: Short Term Load Forecasting (STLF), Medium Term Load Forecasting (MTLF) and, Long Term Load Forecasting (LTLF) [6].

Short Term Load Forecasting methods are used for hour-by-hour prediction. Medium Term Load Forecasting methods are used for a day to a week prediction, whiles Long Term Load Forecasting methods are used for months to year prediction. In this way some driven factors can be ineffectively ignored to produce accurate results. Example GDP could be effective in LTLF and be ineffective in STLF. On the other hand, TV programs could be effective in STLF and ineffective in LTLF. Short-term forecasts are used to schedule power generation and transmission. Medium-term forecasts are used to schedule the fuel purchases. Long-term forecasts are used to develop the power supply and delivery system (generation units transmission system, and distribution system).

**Short-Term Forecasting** at load level needs to account for large number of behavioral  
variations and is a non-linear problem. Handling the forecast problem can be approached in two ways. one is the traditional methods such as temporal series methods  
and regression analysis methods, which are simple and high require computing speed,  
but they cannot simulate the complex and variable load. Another is the Artificial  
Intelligence methods, utilizing machine learning and deep learning. This approach  
proved better in recent years and are more suited for short-term forecasting.

**Medium-Term forecasting** is mostly for week to months prediction and help generation and distribution companies to plan for their fuel and generators. Some of the factors affecting this method includes events, addition of new loads, demand patterns of large facilities and maintenance requirements of large consumers. This type usually uses hourly loads to predict the peak load of days, weeks, and months. The analysis of this method is similar to that of short-term but its sensitivity is more than that of medium-term load forecasting.

**Long Term Forecasting and, Medium Term Forecasting**

**[7]** the first step in making a proper forecast to determine the factors that will affect the load patterns and finding the relation among the factors. The factors that affect long term forecasting includes time, factors, historical load, weather factors, population growth, energy supply etc.

Long-term load forecasting has been approached in three many ways such as time series methods, econometric methods, and End-Use approaches has been proven to produce better results in recent years.

**ALGORITHMS USED IN LOAD FORECASTING**

[8] Load forecasting can be categorized into qualitative and quantitative in terms of their **mathematical degree.** The qualitative techniques can be sub classified into Traditional technique, Modified-Traditional technique and Soft-Computing technique.

**Traditional technique** is one of the imperative topics to determine future load demands for the development of the infrastructure, trends and catalog of the country. Regression Method, Multiple Regression Method, and Exponential Smoothing Method.

**Modified traditional techniques**: the traditional techniques are improved to auto update the previous infrastructure depending on the varying environmental conditions. Some of the improved forms of traditional techniques are adaptive load forecasting, time series and support vector machine-based techniques.

**Soft-Computing techniques:** It is an approach that is beyond human mind to train the computer to reason and learn in an environment of unpredictable and inaccuracy. It is developed using tools to aid computer-based intelligent systems to replicate the capability of the human mind to utilize the methods of reasoning that are in exact rather than precise. Soft computing forms an  
assortment of order which includes fuzzy logic (FL), neural networks (NNs), evolutionary algorithms (EAs) etc.

Artificial Neural Networks (ANN) in power industries has been growing in acceptance.  
ANN is primarily developed to mimic basic biological systems to learn by example,  
like humans do. In general, ANNs are mathematical techniques composed of basic  
computing processing elements known as neurons, in conjunction with layers which are  
responsible for transferring the weights and biases across neurons.

[9] A neural-network based approach for short term load forecasting of electrical power was proposed and the performance and the efficiency of the proposed algorithm was practically examined using two consecutive years hourly load data. The algorithm yields average relative error of 3.61% and root mean square error of 3.85%.

In [10] a method to select influence factors and simulate the nonlinear relationship is brought forward using CBR-ANN model. The average relative error was reduced to 0.0313 which performs better than the previous approach but the method fails to ascertain how many cases to select and how to process the selected cases

[11,12,13] The artificial neural networks (ANN or simply NN) has been a widely used of electric load forecasting technique based on the non-linear characteristic. However, the defects of artificial neural network are, it is difficult to determine existing network and also has slow convergence. And also takes longer time when the dataset set is non-linear.

Time series algorithms has been proven to be effective in recent years and predicting short term and medium-term. Time series algorithm to forecast short term and long-term load using quarter-hour loads. The Torus performed well using daily, weekly, yearly and special days such as holidays for the prediction but fails to consider weather factors which are key factors in determining future short-term loads [14].

[15] Three regression model the linear, the polynomial and the exponential power was proposed using the Jordanian power system. Results showed that the performance of the linear and polynomial models perform was close, when applied to hourly load of different years. The exponential model performed close to the linear model but is too complex. The output curve forecasted indicates that, the exponential model performed lesser than linear and polynomial regression methods. The peak load error forecasted using the exponential model reaches 9.2% which is almost double the error of the other models. The average incurred error in peak load forecasting using linear model was 5.3%, which is better than the exponential model.

Support vector machines (SVM) for regression is a powerful nonlinear method that can be used for load forecasting. SVM is a powerful supervised learning algorithm in machine learning that has been utilized in pattern recognition and classification issues, now extended for regression problems. In [16] SVM algorithm was implemented using RStudio software package to forecast a daily record peak load consumption with a corresponding temperature and relative humidity for three consecutive years. The model performed well in both short-term and long term.

[17] A novel method was proposed based on SVM using similar day’s load data as the training data for power load forecasting. Authors quantify the dataset by grouping weather features with similar days and find the correlation between them. The train data was derived based on the relationship between the two datasets. This does not only improve on the efficiency of the model but also reduce the training time which is more important for load forecasting. the simulation indicates that grouping dataset into similar days perform faster and has higher precision than other methods.

[18,19] indicates that, SVM perform well when in medium and short term load forecasting.

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Method