UNIVERSITI TEKNIKAL MALAYSIA MELAKA

MODELLING AND FORECASTING STUDENT'S RESIDENTIAL AREA ELECTRICITY DEMAND USING STATISTICAL ANALYSIS

This report is submitted in accordance with the requirement of Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electrical Engineering Technology (Industrial Automation & Robotics) with Honours

by

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SESI PENGAJIAN: **2016/2017 Semester 1**

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This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Engineering Technology (Industrial Automation & Robotics) (Hons.). The member of the supervisory is as follow:

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ABSTRAK

Satu pendekatan baru ramalan permintaan beban elektrik dalam jangka masa pendek. Dalam ramalan beban tertentu, biasanya ia dibuat dengan membina model maklumat relatif seperti iklim dan data permintaan beban sebelumnya. Ramalan permintaan beban adalah satu proses pusat dan penting untuk merancang operasi berkala dan kemudahan yang besar dalam sektor elektrik. Corak permintaan adalah sangat kompleks kerana pembatalan kawal selia pasaran tenaga. Oleh itu, dalam mencari model ramalan yang sesuai untuk permintaan elektrik tertentu bukan satu tugas yang mudah. Walaupun banyak kaedah ramalan yang telah dihasilkan, tidak boleh umum untuk semua corak permintaan. Oleh itu, kertas kerja ini membentangkan mengenai pemodelan dan ramalan permintaan elektrik di kawasan kediaman pelajar dengan menggunakan analisis statistik. Analisis statistik boleh digunakan sebagai panduan untuk membina permintaan elektrik dan memilih model yang terbaik. Beberapa analisis statistik yang terlibat untuk mengkaji ciri-ciri beban dan ketepatan ramalan seperti purata bergerak dan plot kebarangkalian bunyi beban. Data beban sebenar dari meter kilowatt digunakan setiap hari sebagai kajian kes. Beberapa keputusan yang dihasilkan sebagai panduan ramalan masa depan untuk projek ini. Model terbaik yang dipilih ialah ARIMA model. Model ARIMA yang terbaik dipilih berdasarkan nilai AIC yang terendah iaitu untuk SU1 ialah ARIMA (1,1,1), SU2 ialah ARIMA (1,3,4), SU3 ialah ARIMA (1,1,4), SU4 ialah ARIMA (1,1,4) dan akhir sekali untuk SU5 iaitu ARIMA (3,1,3).

ABSTRACT

A present a new approach for short-term electricity load demand forecasting. In particular load forecasting is usually made by constructing models on relative information such as climate and previous load demand data. Electricity demand forecasting is a central and integral process for planning periodical operations and facility expansion in the electricity sector. Demand pattern is almost very complex due to the deregulation of energy markets. Therefore, finding an appropriate forecasting model for a specific electricity demand is not an easy task. Although many forecasting methods were developed, none can be generalized for all demand patterns. Therefore, this paper presents a modelling and forecasting student's residential area electricity demand using statistical analysis. Statistical analysis can be used as a guide to construct electricity demand and select the best models. Several statistical analysis are involved to study the load features and forecasting precision such as moving average and probability plots of load noise. Real daily load data from kilowatt meter are used as a case study. Some results are reported to guide forecasting future needs of this research. The best model was selected is ARIMA model. The best model of ARIMA was chosen by the lowest AIC which is for SU1 is ARIMA (1, 1, 1), for SU2 is ARIMA (1, 3, 4), for SU3 is ARIMA (1, 1, 4), for SU4 is ARIMA (1, 1, 4) and lastly for SU5 is ARIMA (3, 1, 3).

DEDICATIONS

A special appreciation, I dedicate this thesis to my family especially my mother Siti Eshah Binti Awang, my late father Said Bin Awang, my brother Mohd Annuar and all that involved in my thesis.

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CHAPTER 1
INTRODUCTION

1.0 Introduction

Electricity demand is a derived demand which it is consumption is used as an input in other processes giving utility. The demand for electricity just like any other good depends on income and price and other factor as well. The electricity demand analysis contributes significantly to policy implementation especially on energy planning. Then, there have a method of forecasting demand which is to counting the electricity used by users. The method to use is statistical analysis. Accurate forecasts lead to saving in operation and maintenance cost, increase the reliabilities of power supplies and delivery system and correct decision for future development. Electricity demand is assessed by accumulating the consumption periodically, it almost considered for hourly, daily, weekly, monthly, and yearly periods. Electricity demand forecasts is concern with the predicted of hourly, daily, weekly and annual value of the systems demand and peaks demand.

Forecast have three categorized which is short term load forecasts, medium term load forecasts and long term load forecasts depends on the time horizon. For a short-term forecasting is use to scheduled the generation and transmission of the electricity demand. Electricity demand pattern is affect by several factors including social, time, economical, and environment factors which is the pattern will form many complex variations. Social (such as behaviour) and environmental factors are big sources of randomness (noise) found on the load pattern. Diversity and complexity in demand pattern have been leading to developing complicated statistical analysis methods. The literature is enriched with statistical methods having many attempted to find the best or good estimation of load forecasting. First method included the time-

series such as Box–Jenkins ARIMA, ARMA, transfer function (dynamic regression), regression model, expert systems, exponential smoothing, neural networks, support vector machine and Fuzzy logic.

The purpose of the project is to find or search the best model in order to modelling and forecasting student's residential area electricity demand using statistical analysis. The best method that has been selected is using ARIMA. The ARIMA models and their versions have achieved a considerable success for electricity demand. Then, by using the model for forecast the future demand for student's residential area, ARIMA model can be use when the time series was stationary without missing the data. They can be further hybridized with artificial intelligence techniques. However, the complexity of demand pattern depends on its base period which it is changes from fairly smooth curve (annually based) to most noisy and cyclic complex curve (hourly based) since the effect of environmental factors increases. Combined forecasting was also introduced based on a few linear combination of various result from different forecasting methods.

1.1 Problem Statement

Electricity consumption play an important roles in our daily life especially in student's residential area. The major objective when creating electricity regulators of the electricity market is to reduce electricity costs through competition. There have a few factors that contribute highly electricity demand in student's residential area including social, economical sector, time and environment factors which is the pattern will formed a various complex variations. Social (such as behaviour) and environmental factors are big sources of randomness (noise) found on the load pattern. Weather also have a many impact or effect on the economy sector. The one of the mostly sensitively is the electrical market because the power demand is depends to weather

variable, especially the air temperatures. The electric demand showed a various trends due to socio-economic factor, then to daily and monthly seasonal effect has been taken into account to isolated the weather influenced on electric load. Mostly, economic activity is exposes to weather change so the expected revenue may be seriously affect by a departure from 'usual' weather. The energy sectors is one of the mostly sensitive to weather, particular electricity production, stated that electricity cannot be store. Then, due to development in the economy sector, it can cause the highly electricity uses. This facts implies that produce the electric must be immediately consumed, so the best model to predicted the future load consumptions is needed.

Then, other problem is the electricity load included the end-use light, fans and the other electrical appliance. As for cooling as an end-use has not been thoroughly investigate due to the limited amounts of electricity measurement include this end-use. However, these methods also can be apply when such measurement becomes available. The load predicted methods can be estimated the expect maximum load, load profile and yearly energy load demand, which is all divided into electricity purpose for a planning area. For instance, the people all over the world are using increased and variety number of electric appliances which is most of them are environmentally related, that increases the cyclic noise on the demand pattern.

1.2 Objectives

This paper is a study on modelling and forecasting student's residential area electricity demand by using statistical analysis. The data was collected from kilowatt meter in student's residential area every day to complete this project. The objective of this project are as follow:

1. To study the model of electricity demand for student's residential area.
2. To select the best model using statistical analysis.
3. To use the best model to forecasts the future electrical demand.

1.3 Project Scope

In this project, the electricity consumptions is a model as a major functions of the price of electricity, the number of households, real personal incomes, the weather or temperature as a function of heated and cooled days. Electricity forecast are divided in the three categorized which is short-term load forecast, medium-term load forecast and long-term load forecast. The short-term load forecasting are useful in daily operation of a utilities company where as long-term load forecasting are needed for strategic planning. The first thing to focus is to study the electricity demand in student's residential area. The data was collected at five different selected houses from five different building at student's residential area which is started from SRI UTAMA 1 (SU1) until SRI UTAMA 5 (SU5). After completing the data collection, the next step or process of this project is to modelling the electricity load demand in student's residential area.

The next step or process to focus is selected the best model. The good or best model will be selected by using statistical analysis. This project used or forecast the short-term load demand. Short-term load demand relationship shows that weather effects are the main determinates of electricity demand. We developed a short term modelling and forecasting student's residential area electricity demand by using statistical analysis method. A largest variety of statistical and artificial intelligences technique has develops for a short-term load forecast. These approached is based on search the historical data for day within one, two or three year with the same characteristic to the forecasting days. Same characteristic included weather, the date and days of the weeks. The load demand of a similarly day is consider as a forecasting. Instead of a

single similarly day loads, the forecasting can be a linear combination that can be included a several similar days. The trends coefficient can be uses for similarly day in the previously year. The time series method is based on the assumptions that data have an internal structures such as autocorrelations, seasonal variation and trend.

The best method or the best model that used is by using ARIMA method. ARIMA modelling is use by more univariated framework as a sophisticate benchmark for evaluate alternative proposal. The ARIMA model and their versions have achieved a considerable success for electricity demand. In general, ARIMA models also can use when the time series is stationary without missing the data. They can be further hybridized with artificial intelligence techniques. Lastly, after the best model was selected, load demand will be forecasting for the future electricity.

CHAPTER 2
LITERATURE REVIEW

2.0 Introduction

In chapter two, literature review contains the current knowledge included substantive findings, as well as the theoretical contribution to a particular subject or topic. This chapter consists of explanation of load demand where is this load demand consists of the three types of load forecasts which is short-term load demand, medium-term load demand and long-term load demand. This project used the short-term load demand to forecasting the future load demand. Then, it also consists of statistical review for load demand by using statistical analysis. The best model to forecasting the future load demand is by using ARIMA model.

2.1 Load Demand

Load demand forecast is a process of predict the future electric load demand. Load demand forecast is very important for the electrical industries in the sector of economy. It has more application include the infrastructure development, energy purchase and generation, contract evaluate, and load switching. A larger varieties of mathematical method has be develops for load forecast. According to (Dudhia J., et al, 2002) the accurate model for electrical power load forecast are important to the operation and planning of a utilities in the company. Load forecast helped electrical utilities to make important decision included decision on purchase and generate electrical power system, load switch, and infrastructure developments. According to (Akhwanzada S.A., 2012) the electricity are considers the mostly new and the mostly very efficiently form of the secondary energy. It is playing an important or major

roles in the social and economic developments of a countries and consequently in the standard of living of peoples. The issues of present and future power supplies of electricity is of equal interest to politicians, public and scientific community. Load forecasts are very important for energies supplier, the finance institution and other parts in the electric energy transmission, generate, distribute and markets. The load forecasts can divide into three categorized which is short-term forecasts, medium-term forecasts and long-term forecasts. Short term forecasting which is usually from one week to one month, medium forecasting which is usually from a month to a year and long term forecasting which is it is longer than a years. The forecasting for different time horizon is very important for a differently operation with a utilities company. The nature of this forecasting is very different as well. For an example, the particular regions, it is possibly to predicted the next day load demand with the accuracies of approximately 1- 3%.

Based on (Bunn D.W., 1982) the load forecasts helping the electrical utilities to make an very important decisions included decision on purchase and generate the electrical power supply, infrastructure development and load switched. Electrical-supplies planning required the efficient managements of existing power supply system and optimization of the decision concerned of additional capacities. The demand predicted is a very important aspects in the developments of any model for electrical planning. According to (Chow et al, 1996) the short-term load forecast is requires for the controlling and schedule of power systems. The focus and attention vary from minute to a few hours ahead. The prediction are require as input to schedule the algorithm for the generate and transmit of electricity load. The load forecasting is helping to determine which is the device to operated in a given time so to minimized the cost and secures load demand even when local failure may occurred on the systems.

The load demand is broadly influence by seasonal effect, meteorological condition and special event. Then, the weather relate variation is certainly critically in predicted the electric demand for the lead time beyond a days ahead. According to (Dudhia J., et al, 2002) the short term load forecast can helping to estimated the load flowing and to makes a decision that can

prevented from overload. Time implementation of such decision leads to the improvements of network reliabilities and to reduce that occurrence of equipments failure and blackout. Load forecast is a very importance for contract evaluation and evaluation of various sophisticate financials product on the energy price which is offer by the markets. Then, in the deregulate economies, the decision on a capital expenditure based on long term forecast also more likely important than in a non-deregulate economies when the rate increase can be justify by capitals expenditures project.

Mostly the forecasts method used a statistical technique or artificial intelligences algorithm such as neural networks, regression, expert system and fuzzy logic. Two of the method, called end-use and econometrical approaches is mostly use for medium and long term forecasts. There have a variously of method, which is included the so-called various regressions model, similarly day approached, neural networks, time series, statistical learning algorithm, expert systems and fuzzy logic have been develop for a short-term forecasts. In this project, in term to determine the best model is by using ARIMA method which is this method can forecast the future load demand. Besides that, the future load demand is always influence by variously non-energy factors such as economic growing, the use of technological advance, population growth and energy price (Tan C.S., et al, 2013).

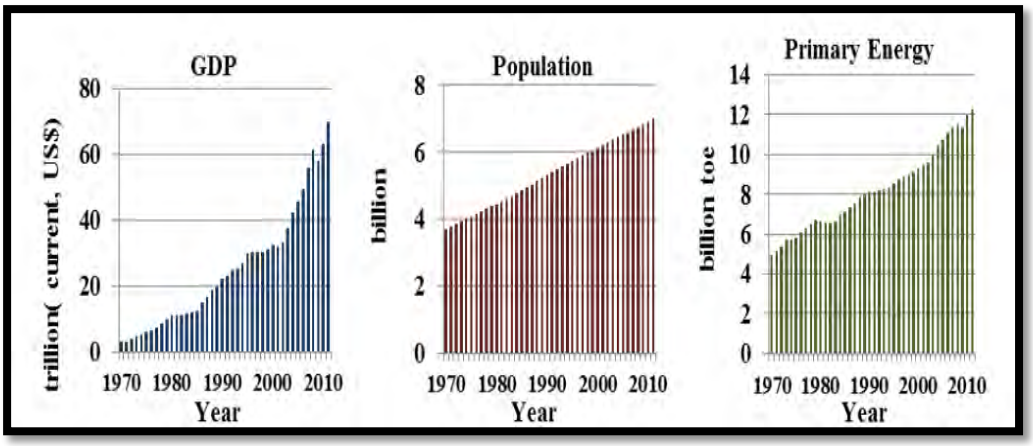

Figure 2.1: Correlation between economic activity, population, and energy demand between 1970 until 2010 (source: *electricity energy outlook in Malaysia*, Tan C.S, et al, 2013)

2.2 Type of Load Forecasting

2.2.1 Short-Term Load Forecasting (STLF)

For this project, a short term is chosen which is it takes 50 days to record the data. According to (F. D. Galiana, 1987) a discuss about the states of the arts in short term load forecasts (STLF) which is the predict of the systems load demand over the intervals range from half an hours to one week. These project reviews the mostly important roles of short-term load forecasts in the online schedule and security function of an Energy Management System (EMS). Then, it is to discuss about the nature of the load demand and the differentiation of factor influence it behaviours. A details classification of the type of load modelling and forecasts technique is present. Whenever it is appropriates, the classification is accompany by the recommendation and by reference to the literature which is to support or expanded the discussions. The project also presented a long or length discussions of practical aspect for the development and usages of short term load forecasts model and package. The bibliography offered as a representative selection of the principals publication in the short term load forecasts area.

Based on (Galiana F.D., 1987) which is concern with the area of short term load forecast in power system operations. Throughout (Galiana F.D., 1987), use the term ‘short’ to implies predicted time of the order of hour. The