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ENERGY PRICING OPTIMIZATION BY USING NEURAL NETWORK (NN) FOR DEMAND SIDE TARIFF STRATEGY; PENINSULAR MALAYSIA CASE STUDY

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A report submitted in partial fulfillment of the requirement for the degree of Bachelor of Electrical Engineering (Industrial Power)

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JUNE 2016

I declare that this report entitle "Energy pricing optimization by using Neural Network (NN) for demand site tariff strategy; peninsular Malaysia case study" is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree

Signature : ....

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Date : 31 MAY 2016

To my beloved parents and family

Abu Hanipah Abdul Ghani

Zainon Mohd Zain

Siti Juriawati

Mohd Redzwan

Umi Kalsom

Mohd Ariff

Mohd Amir Mukmin

Mohammad Imran

"Thank you for your patience and support"

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In the name of Allah S.W.T, Most Gracious Most Merciful. Praise to Allah for his willingness I had succeeded to finish my Final Year Project report entitled “ Energy pricing optimization by using Neural Network (NN) for demand side tariff strategy; peninsular Malaysia case study”.

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ABSTRACT

In regards to Malaysia environment, the demand of electricity is affected and rapidly rising as the population of human being is increasing and industries that fast developed. Due to this constrain, Tenaga Nasional Berhad (TNB) has introduced Enhance Time of Use (ETOU) tariff in planning to replace Time of Use (TOU) tariff for demand side benefits. Unsuitable tariff with load profile will give the big impact to demand side pricing. The objectives of this project are to model the equation of TOU and ETOU for optimum industrial demand-site tariff selection, analyze the best potential energy profile for ETOU tariff via Neural Network (NN) and compare the cost saving for optimal load profile with TOU and ETOU tariff. The demand side pricing optimization will be conduct via forecasting the energy profile for suitable tariff selection that correlate to the peninsular Malaysia energy scenario. Neural Networks method will be implement in order to validate the proposed model. Energy profiles of industry sector will be used as case study environment in order to determine the demand side pricing patent. It is hoped that, the result of this project will benefit the energy authority and consumers of the electricity energy in the future action respectively.

Berdasarkan persekitaran Malaysia, permintaan elektrik semakin terjejas dan meningkat dengan pesat kerana penduduk yang semakin bertambah dan industri yang cepat membangun. Oleh kerana kekangan ini, Tenaga Nasional Berhad (TNB) telah memperkenalkan Meningkatkan Masa Penggunaan (ETOU) tarif dalam perancangan untuk menggantikan Masa Penggunaan (TTP) tarif bagi faedah berasaskan permintaan. Tarif yang tidak sesuai dengan profil beban akan memberi impak yang besar untuk harga berasaskan permintaan. Objektif projek ini adalah untuk memodelkan persamaan untuk mengoptimumkan pemilihan tarif bagi sektor industri di antara TTP dan ETOU berasaskan permintaan, dan untuk menganalisis potensi profil tenaga melalui Rangkaian Neural (RN) untuk harga kuasa ETOU kemudian bandingkan jumlah harga tenaga profil beban yang telah dioptimumkan dengan menggunakan TTP dan ETOU tarif. Pengoptimuman harga berasaskan permintaan akan dijalankan melalui ramalan profil tenaga untuk pemilihan tarif yang sesuai yang dikaitkan dengan senario tenaga Malaysia Semenanjung. Kaedah Rangkaian Neural adalah topik penyelidikan yang paling popular yang telah dilakukan sejak sedekad yang lalu. Kaedah ini akan dilaksanakan bagi mengesahkan model yang dicadangkan. Profil beban sektor industri akan digunakan sebagai persekitaran kajian kes untuk menentukan paten permintaan harga sampingan. Adalah diharapkan, hasil daripada projek ini akan memberi manfaat kepada pihak berkuasa tenaga dan pengguna tenaga elektrik masing-masing dalam untuk tindakan masa depan.

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INTRODUCTION

1.0 Motivation

According to the Malaymail Online in Figure 1.1, Malaysia Prime Minister stated that the electricity pricing need to be increased due to cost of fossil fuel rising [1]. TNB introduced new strategy in order to help consumers with new electricity pricing. Consistent with RMK-10 policies to bring green energy in Malaysia, new energy policy for industrial, commercial, residential and transport has been introduced to enhanced energy efficiency [2].Low price for off-peak electricity consumption are offered for Thermal Energy Storage (TES) while Firm Standby charged purposed to promote Energy Efficiency (EE), Green Technology and Demand Side Management (DSM), are prefered for co-generators side respectively [3].


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MALAYSIA

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Figure 1.1: Malaymail online currency of electricity pricing in Malaysia

In global context, electricity tariff varies widely for every country and may vary slightly from zone to zone within a certain country. These differences are occurred due to many reasons. The power generation pricing depends largely on the market price and types of the government policy and industry regulation, fossil fuel, local weather patterns and even government subsidies [4]. In Malaysia, Tenaga Nasional Berhad (TNB) is the authority company that can buy and sell energy to other parties. This company accountable for generation, transmission and distribution sector [5]. TNB introduce tariff rates that called as “Domestic Consumer” means a consumer occupying a private dwelling, which is not used as a boarding house, hotel or used for the purpose of carrying out any form of trade, business, services or professional activities. These tariffs are classified into two sections which are commercial and industrial tariff based on demand side characteristic. Three types of tariffs are introduced for commercial which are tariff B, C1 and C2 while eight types of tariffs for industrial usage which are D, DS, E1, E1S, E2, E2S, E3 and E3S [6].

The TOU stand for Time-of-Use tariff was introduced from TNB electricity pricing systems in year of 2009. TOU system is a price that fluctuates based on the time of day or week. The electricity pricing systems consists of two period’s zones which is peak time and off peak time zones simultaneously. The electricity price is stationary in a moderately long period in a day. Since the commercial and industrial sectors electricity consumption has grown steadily during this time, renewable electricity pricing was introduced as Enhance Time of Use (ETOU) in 2015. This tariff will conduct the system by using three periods of time which is peak, medium peak and off peak time zones [7]. These tariffs provide lots of benefits for demand side as the currently utilizing electricity during mid-peak or off-peak time zone whereby the rates are cheaper compared to peak period. The tariffs help consumers by shifting usage of electricity to the time of the day when rates are cheaper hence reducing monthly bill [6].

1.1 Problem Statement

In regards to Malaysia environment, the demand of electricity is affected and rapidly rising as the population of human being is increasing and industries that fast developed. According to [1], due to the high cost of fuel, although knowing that the prices of basic goods and services will increase after raising electricity tariff, government had no other choice. Refer to the changes of generation fuel mix in Figure 1.2, it is obviously shown the big shuffle in 2011 due to supply deficiencies. Due to this constraint, power generation companies loss multi-million in gas fired plants and forced the companies to change to expensive distillates to sustain the electricity supply. By switching to the distillates, the companies need to sustain additional cost due to expensive fuel and higher logistic charges that can harmful to the gas turbine operation. These Natural gas deficiencies lead to an increase the coal and oil concurrently [8].

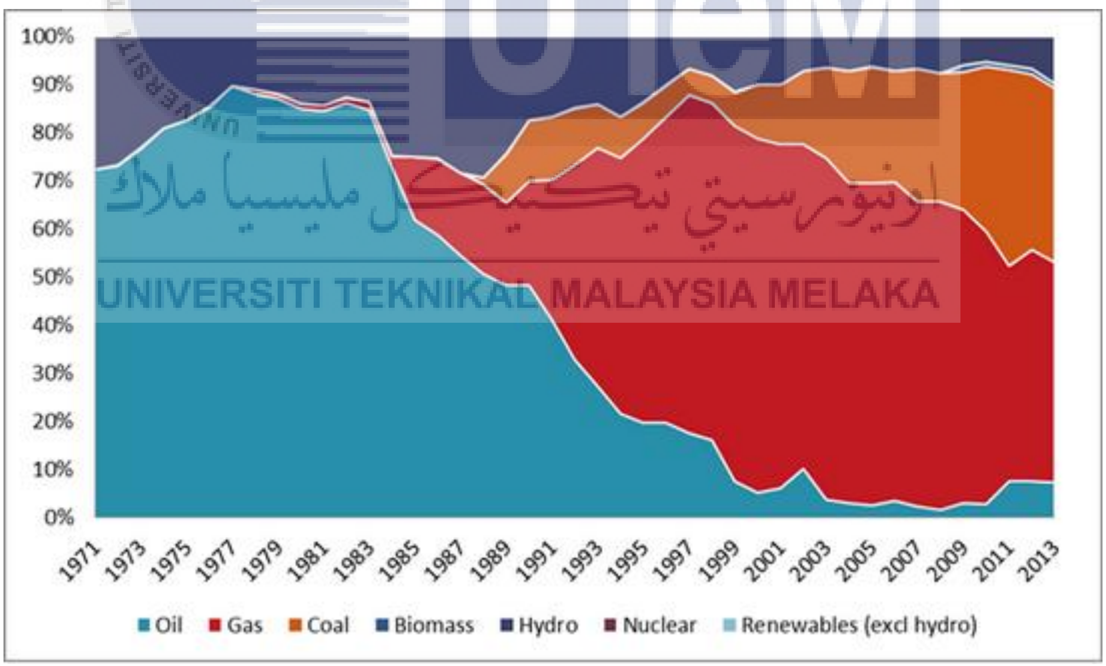

Figure 1.2: Malaysia power mix evolution from 1971 until 2013

From 2014, Malaysian government has performed Incentive Based Regulation (IBR) as reform in the Malaysian Electricity Supply Industry (MESI). In order to accommodate the higher costs of domestic LNG, piped gas and coal, the electricity tariff had to be increased. In 2013, 45% of electricity was generated from natural gas; so that electricity industry in Malaysia facing a supply security problem due to expensive of LNG, declining gas production and high gas subsidies [8].

In the face of dramatic changes, electric companies need to examine associated business models and a host of potential strategies to solve equations for disruptions [9]. Nowadays, on site demand still not has any sign to configure the best tariff for their electricity charge. TNB was introduced many scheme in order to give some option for the commercial consumer but many of them do not understand what is the best option that they should go. Unsuitable tariff with load profile will give the big impact to consumer especially in electric energy cost, energy consumer and unstable price increase in product production especially in industrial sector. Therefore new energy optimization method to configure the suitable TNB tariff with energy profile for demand side management is proposed.

1.2 Objective

The objectives of this research are:

1. To model the equation of TOU and ETOU tariff for optimum industrial demand side tariff selection.
2. To analyze the best potential energy profile for ETOU tariff via Neural Network.
3. To compare the cost saving of optimal load profile with TOU and ETOU TNB tariff.

1.3 Scope

Studies on the innovation of energy priced optimization for demand site tariff selection by using Neural Network. Energy profile of industrial sector is used for tested in order to choose the best tariff. Microsoft Excel and MATLAB software are used for observed, validated and analyzed the system.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

Electricity industries all over the world have been using load profiles for many years to offer information for system planning, forecasting and demand side development. To provide utility companies with good marketing strategies and upgraded efficiency in operating the current facilities, the determination of customer load profile is very important [10]. In many nations, consumers now have the activeness to choose their electricity tariff. Detailed knowledge on load consumption will enable customers to select suitable tariff for different type of usage.

2.1 Theory

This topic emphasizes about the energy pricing optimization by using Neural Network (NN) for demand site tariff strategy for peninsular Malaysia case study.

2.1.1 Malaysia Electricity

Electrical industry began from the tin mining in 1990 through the private generation companies such as Malacca Electric Light Co. Ltd. (1913), Hutten Bach Ltd. (1916), Perak River Hydro Electric Co. Ltd. (1926) and Kinta Electric Distribution Co. Ltd. (1928). In 1949, the electricity to peninsular Malaysia are provided via CEB stands for Central Electricity Board then the central was renamed as National Electricity Board (NEB) in 1965, then introduced as corporatization of NEB in July 1990 and keep changed as Tenaga Nasional Berhad (TNB). Due to the rising demand, privatization was the best alternative since the government was unable to build power generation in a short time. In 1992, TNB was privatized and listed on the Malaysian Stock Exchange. Through licenses awarded by government to Build, Operate and Own (BOO) the power generation in year 1993, the Independent Power Producer (IPP) introduced to assist TNB to overcome the electricity issue and enlarge electrical energy generation sector [11]. Figure 2.1 shown one of the largest IPP electrical generation network in Malaysia which collaborated with TNB [12].

Figure 2.1: Powertek Energy Sdn Bhd

Nevertheless, TNB are the only one sector that control transmission and distribution operation. As preparation to face the new challenge of electricity supply liberalization, Energy Commission (EC) was developed in 2001as a new regulator in Malaysia [11]. On 1 January 2002, the Commission became fully functioning and takes over all the duties of the Department of Electricity and Gas Supply which was dissolved at the same time. The EC of Malaysia is a statutory body responsible for controlling the energy sector especially the piped gas supply and electricity supply industries in Peninsular Malaysia and Sabah. The EC confirms that the supply of electricity and piped gas to consumers is safe, reliable, secure, and at reasonable prices [13].

2.1.2 Energy Tariff

Over the past 25 years, due to the economic changes, the electric utility industry has experienced a drastic transformation in its cost structure. This is due to power mix evolution, environmental aspect and supply of electric power. These factors have led to the rising in electricity industry. Demand Side Management (DSM) have been implemented to keep balance with demand and to contain the growth of demand [14]. DSM provided benefits to both grid utilities and consumers for domestic and commercial sectors [15].

The Imbalance Cost Pass-Through (ICPT) mechanism in Figure 2.2 is one of the DSM benefit, it act as benchmark which can help the TNB to reflect changes due to fluctuation in fuel and generation cost in the electricity tariff every six months. This mechanism approved by the Government and implemented by Suruhanjaya Tenaga (ST) since 1st January 2014 as part of a wider regulatory reform called the Incentive Based Regulation (IBR) [16].

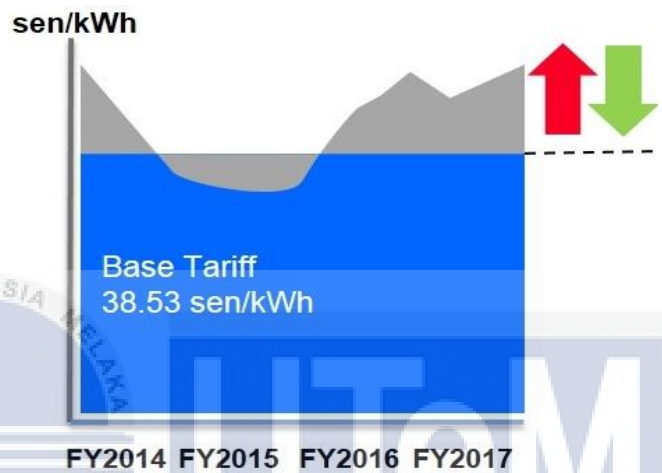

Figure 2.2: ICPT for year 2014 until 2017

DSM also includes conservation programs, incentives to purchase energy efficient equipment and appliances, and innovative pricing such as time-of-use (TOU) rates. TOU rates are the practical application of marginal cost pricing. Based on the used currently by many utilities, and which set the price of electricity based primarily on the average cost of production, TOU rates set the price closer to the true marginal cost compared to flat rates. TOU help consumer in controlling the energy usage since it has two difference rates of electricity pricing. Even though these rates are designed for specific customer classes, there are two customers within the class will enjoy reduction in electricity bills while others stick with actual price rates. The customer's bill will change depends on their pattern of electricity consumption throughout the day or season of the year [14]. In Malaysia, electricity has been designed by single set price for every kilowatt per hour and all electricity tariff pricing are based on TNB. Table 2.1 shows the time zone for TOU rates [16].

Table 2.1: TOU time zones

Zone	Time Range
Off Peak	10:30PM – 07:00AM
Peak	08:00AM – 10:00PM

2.1.2.1 Commercial Consumer Tariffs

Commercial Consumer" is defined as a consumer occupying or operating. Table 1 show three types of tariff category introduced from TNB which is type B for low voltage, type C1 for medium voltage general and type C2 for medium voltage peak or off peak. Table 2.2 shows three types of industrial tariff introduced by TNB [16].

Table 2.2: Category and rates of TNB commercial tariff

TARIFF CATEGORY	CURRENT RATES(1 JAN 2014)
TARIFF B – LOW VOLTAGE COMMERCIAL TARIFF	
For the first 200 kWh (1 -200 kWh) per month	43.5 sen/kWh
For the next kWh (201 kWh onwards) per month	50.9 sen/kWh
The minimum monthly charge is RM7.20	
TARIFF C1 – MEDIUM VOLTAGE GENERAL COMMERCIAL TARIFF	
For each kilowatt of maximum demand per month	30.3 RM/kW
For all kWh	36.5 sen/kWh
The minimum monthly charge is RM600.00	
TARIFF C2 – MEDIUM VOLTAGE PEAK/OFF-PEAK COMMERCIAL TARIFF	
For each kilowatt of maximum demand per month during the peak period	45.1 RM/kW
For all kWh during the peak period	36.5 sen/kWh
For all kWh during the off-peak period	22.4 sen/kWh
The minimum monthly charge is RM600.00	

2.1.2.2 Industrial Consumer Tariffs

Industrial Consumer" means a consumer engaging in the conversion of raw material or components to finished product. The aim for this program is specially introduced from TNB for consumers that contribute spend millions of ringgit as on their monthly electricity consumption. Table 2.3 shows eight types of industrial tariff introduced by TNB [16].

Table 2.3: Category and rates for TNB industrial tariff

TARIFF CATEGORY	CURRENT RATE (1 JAN 2014)
TARIFF D – LOW VOLTAGE INDUSTRIAL TARIFF	
For the first 200 kWh (1 -200 kWh) per month	38.00 sen/kWh
For the next kWh (201 kWh onwards) per month	44.10 sen/kWh
The minimum monthly charge is RM7.20	
TARIFF DS – SPECIAL INDUSTRIAL TARIFF (FOR CONSUMERS WHO QUALIFY ONLY)	
For all kWh	42.70 sen/kWh
The minimum monthly charge is RM7.20	
TARIFF E1 – MEDIUM VOLTAGE GENERAL INDUSTRIAL TARIFF	
For each kilowatt of maximum demand per month	29.60 RM/kW
For all kWh	33.70 sen/kWh
The minimum monthly charge is RM600.00	
TARIFF E1S – SPECIAL INDUSTRIAL TARIFF (FOR CONSUMERS WHO QUALIFY ONLY)	
For each kilowatt of maximum demand per month	23.70 RM/kWh
For all kWh	33.60 sen/kWh
The minimum monthly charge is RM600.00	
TARIFF E2 – MEDIUM VOLTAGE PEAK/OFF-PEAK INDUSTRIAL TARIFF	
For each kilowatt of maximum demand per month during the peak period	37.00 RM/kW
For all kWh during the peak period	35.50 sen/kWh
For all kWh during the off-peak period	21.90 sen/kWh
The minimum monthly charge is RM600.00	
TARIFF E2S – SPECIAL INDUSTRIAL TARIFF (FOR CONSUMERS WHO QUALIFY ONLY)	
For each kilowatt of maximum demand per month during the peak period	32.90 RM/kW
For all kWh during the peak period	33.60 sen/kWh
For all kWh during the off-peak period	19.10 sen/kWh
The minimum monthly charge is RM600.00	
TARIFF E3 – HIGH VOLTAGE PEAK/OFF-PEAK INDUSTRIAL TARIFF	
For each kilowatt of maximum demand per month during the peak period	35.50 RM/kW
For all kWh during the peak period	33.70 sen/kWh
For all kWh during the off-peak period	20.20 sen/kWh
The minimum monthly charge is RM600.00	
TARIFF E3S – SPECIAL INDUSTRIAL TARIFF (FOR CONSUMERS WHO QUALIFY ONLY)	
For each kilowatt of maximum demand per month during the peak period	29.00 RM/kW
For all kWh during the peak period	31.70 sen/kWh
For all kWh during the off-peak period	17.50 sen/kWh
The minimum monthly charge is RM600.00	

2.1.2.3 Enhance Time of Use (ETOU) Tariffs

Regarding to the Malaysia environment, new tariff strategy introduced from TNB which is Enhance Time of Use (ETOU). The main benefits for demand side from ETOU are three different energy rates. Currently utilizing electricity during mid-peak or off-peak time zone whereby the rates are cheaper compared to peak period. This tariff help customer to use energy efficiently by switched the usage of electricity to time of the day when rates are cheaper hence reducing monthly bills. Table 2.4 shows the time zone for ETOU rates [17].

Table 2.4: ETOU time zones

Zone	**Time Range**
Off Peak	10:00PM – 08:00AM
Medium Peak	08:30AM – 11:00AM
	12:30PM – 02:00PM
	05:30PM – 09:30PM
Peak	11:30AM – 12:00PM
	02:30PM – 05:00PM

Table 2.5 show the tariff category and energy pricing for ETOU tariff

Tariff Category	**Current rated**
Tariff C1- normal customer	
For each kWh for maximum demand/ month during the peak period	34.00 RM/kwh
For each kWh for maximum demand/ month during the medium peak period	28.80RM/kWh
For all kWh during peak period	47.30 sen/kWh
For all kWh during medium peak period	34.80 sen/kWh
For all kWh during off peak period	28.10 sen/kWh
Tariff C2- normal customer	
For each kWh for maximum demand/ month during the peak period	48.40 RM/kwh
For each kWh for maximum demand/ month during the medium peak period	42.60 RM/kwh

For all kWh during peak period	47.90 sen/kWh
For all kWh during medium peak period	31.60 sen/kWh
For all kWh during off peak period	22.40 sen/kWh
Tariff E1- normal customer MV	
For each kWh for maximum demand/ month during the peak period	35.50 RM/kwh
For each kWh for maximum demand/ month during the medium peak period	29.60 RM/kwh
For all kWh during peak period	43.80 sen/kWh
For all kWh during medium peak period	33.20 sen/kWh
For all kWh during off peak period	22.50 sen/kWh
Tariff E1s- special MV	
For each kWh for maximum demand/ month during the peak period	35.50 RM/kwh
For each kWh for maximum demand/ month during the medium peak period	29.60 RM/kwh
For all kWh during peak period	43.80 sen/kWh
For all kWh during medium peak period	33.20 sen/kWh
For all kWh during off peak period	22.50 sen/kWh
Tariff E2- normal customer MV	
For each kWh for maximum demand/ month during the peak period	40.00 RM/kwh
For each kWh for maximum demand/ month during the medium peak period	36.00 RM/kwh
For all kWh during peak period	42.80 sen/kWh
For all kWh during medium peak period	32.00 sen/kWh
For all kWh during off peak period	21.90 sen/kWh
Tariff E2s- special customer MV	
For each kWh for maximum demand/ month during the peak period	40.00 RM/kwh
For each kWh for maximum demand/ month during the medium peak period	36.00 RM/kwh
For all kWh during peak period	42.80 sen/kWh
For all kWh during medium peak period	32.00 sen/kWh
For all kWh during off peak period	21.90 sen/kWh
Tariff E3- normal customer HV	
For each kWh for maximum demand/ month during the peak period	38.30 RM/kwh
For each kWh for maximum demand/ month during the medium peak period	35.00 RM/kwh

For all kWh during peak period	39.00 sen/kWh
For all kWh during medium peak period	31.00 sen/kWh
For all kWh during off peak period	20.20 sen/kWh
Tariff E3s- special customer HV	
For each kWh for maximum demand/ month during the peak period	38.30 RM/kwh
For each kWh for maximum demand/ month during the medium peak period	35.00 RM/kwh
For all kWh during peak period	39.00 sen/kWh
For all kWh during medium peak period	31.00 sen/kWh
For all kWh during off peak period	20.20 sen/kWh

2.2 Related Previous Work In Demand Site Energy Pricing

2.2.1 US & European Time of use (TOU) Strategy

In [14], the author focus on how to qualify the effect of moving New York Dairy Farms from flat rates to time of use rates. By estimating the electricity consumption at peak and off-peak periods, some judgment can be made regarding the possibility of reducing electric bills by shifting energy use to off-peak periods. One easy way to analyze the effects of time-of-use rates would be to apply the different rates to simulate load curves using the spline estimates. This research was analyzed by assuming the total electricity consumption for a farm located in New York is the same as a similar farm located in Wisconsin or Minnesota. The method that can combine the conditional demand equations was used to predict the annual farm electricity consumption. Some problems was founded after data tested which is to predict the shape during predicting the level of the load curve. Due to the empirical results, the cubic spline regression model is useful for estimating the impact of demographic characteristics on the shape of the load curve for residential customers. The combination of the shape and load curve is very important to estimate the electric bills under time-of-use electric service. After the observation, compared to the flat rate, farms that are located under TOU billing realize reductions in their electricity bills. TOU rates are an effective ways in inducing customers to switch shift demand.

TOU tariff is efficient electricity pricing system since consumer can plan to use energy efficiently. This pricing system helped customer in reducing electricity bill by consume electricity energy during off-peak periods. However, this electricity pricing is not fair for some sector that only active during daylight or every second such as school, residential, hospital and so on due to unexpected energy usage.

2.2.2 Real Time Pricing (RTP) with Time-of-Use TOU Strategy

In [18], by using the same objective in [14] which is to control the energy cost for demand side, the author focuses on how to prove the effectiveness of numerical method which is beneficial for customers due to price volatility risk of RTP for England electricity market. There is two categories need to be analyzed in this case which are customers' risk decision basis and customers' risk decision model. There are three aspects under customers' risk decision basis need to be considered. The first aspect is RTP implementation process, this process helped consumers to purchase the suitable hedge contract, then the optimal load hedge rates with the goal of maximizing utilities of purchasing electricity was decided by using CVaR method. Next is RTP-related hedge contracts, three types of hedge contract are used which are Time-of-Use hedge contract, flat rate hedge contract and price cap hedge contract. For contract pricing aspect, Monte-Carlo simulation method is used. Under Customers' risk decision model, there is two category customers can be considered. The first category is customers' decision process, this part will help customers control the risk to acceptable extend such as balance expected return and risk of electricity purchasing. Next category is to check customer's conditional risk value of electricity purchasing for not exceeds expected electricity charge. After analyzed numerical method for customers' risk decision basis and customers' risk decision model, the effectiveness of this method are proven since it can gives details when customers face different risk from three types of contract. By comparing the optimal solutions of different contracts, the optimal hedging strategy and the contract choice can be obtained.

Based on the research, it is shown that RTP with TOU tariff is very effective due to the current environment. However, these RTP systems are a little bit hard to some sectors for expecting their electricity cost due to the fast price changing. This system will make customer electricity bill unstable and customers should make detail observation for tariff selection. Nevertheless, it is different with electrical industry in Malaysia that uses a fix electricity pricing systems for specific times.

2.2.3 Demand Side Management for Electricity Pricing Policy

2.2.3.1 Demand side outlook for load profile shifting

In [19], the author focus to the some features of electricity markets from the outlook of the demand-side and how consumers of electricity can take part in providing of power system security. According to the economic characteristic of the demand for electricity, even though the price of electrical energy fluctuates more rapidly, consumers would be willing to pay to avoid being disconnected. To avoid small increase in electricity cost, consumers will not decrease their production drastically especially in industrial sector. However, there is some support tools helped consumers to reduce electricity consume. The first tool is price forecasting, this technique helped consumers to forecasting prices to plan production. Next tools are production optimization which is the ability to store electrical energy, heat, or an intermediate product and has admission to a forecast of electricity prices. This could help consumers to improve its production schedule for usage during lower electricity prices.

Figure 2.3 show the price for 12-h periods. In order to diminish the electricity cost, the industrial plant fully operated during first four hour since the electricity pricing only around 25$/MWh compared with last five periods electricity pricing that around 50% higher than fourth period.

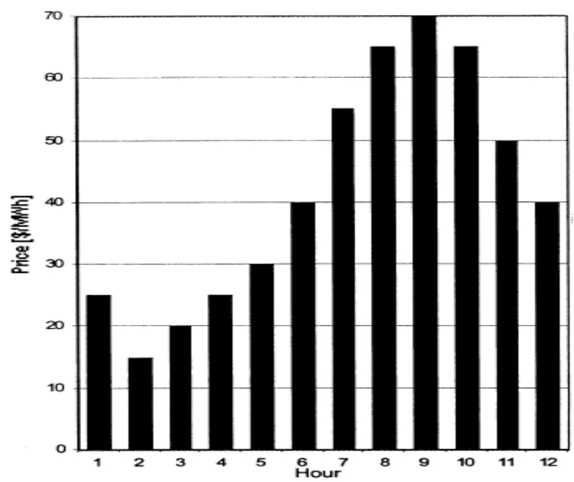

Figure 2.3: Price profile for the 12 hour period in industrial plant.

Electricity is the main essential part nowadays. Consumer will not easily negotiate to shut down their electricity source due to the high electricity pricing. The details step in energy shifting for demand side management is very important to guide the customer to control energy usage. Support tools such as price forecasting and production optimization is a brilliant idea for reduction of electricity usage.

2.2.3.2 Optimal Load response to TOU power price for DSM in Denmark

According to [22], the author analyzed a load optimization method to TOU power price for DSM in order to save the energy cost as much as possible. The author believes this method could reduce the energy cost such stated in [19] as production optimization is one of the ways to control energy consumption. Three typical different kinds of loads in Denmark which are residential, industrial, and commercial load are chosen as study cases. Three processes were used in order to analyze how consumers may shift their loads to achieve the minimum energy costs. Process one is mathematical model which is to calculate the energy cost paid by the customer in a day for before and after rescheduling the load by referring to the load profile and spot price of each hour. Next process is assumption which is the analysis of load shifting according to TOU power price by the customers. Last process is optimization method which is the process to find the minimum value of energy cost, Sequential quadratic programming method were used to represent the nonlinear programming methods. Optimal load response of typical load in west Denmark to TOU price for demand side management is shown in Figure 2.4. The customers shift some of the load from the high price periods to the low price periods to achieve the minimum energy cost in all day. The Saving Cost Percentage (SCP) in Figure 2.5 shown that the energy cost decrease up to 9.6% with optimal load response to TOU power price for different loads. Simulation results shown the optimal load response to TOU power price for demand side management generates different load profiles when the pek electricity consumption is reduced and the off peak electricity consumption is increased significantly.

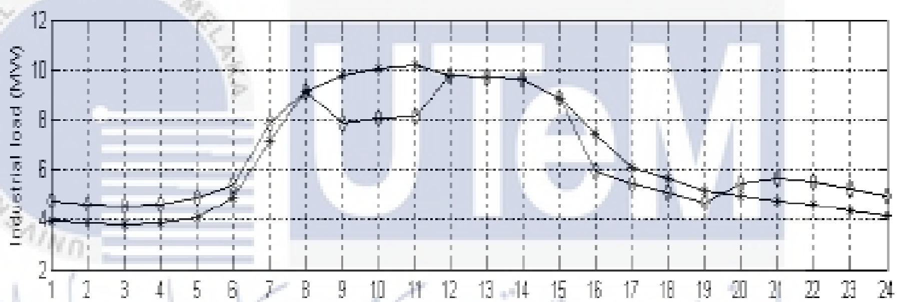

Figure 2.4: original load and optimal load for industrial sector

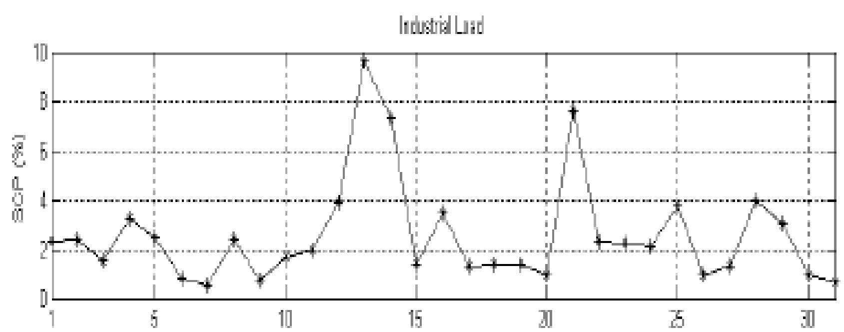

Figure 2.5: The SCP of industrial load at January, 2007

TOU power prices in Denmark consist of three zones pricing such as ETOU tariff in Malaysia. This research give a big opportunity for industry demand side management especially ETOU tariff users to optimize their load profile in order to save the energy cost as much as possible by load shifting system.

2.2.4 Computing Algorithm Implementation in Energy Pricing

2.2.4.1 Optimization Technique with Particle Swarm Optimization and Genetic Algorithm

According to [21], the author focus on how to propose a particle swarm optimization (PSO) approach to support electricity producers for multiperiod optimal contract allocation. PSO performance was evaluated by comparing it with a genetic algorithm-based approach. In order to analyzed the electricity producers for multiperiod optimal contract allocation, PSO are used since the systems are conducted with linear and nonlinear contract characteristics, which makes the decision even more complex. There is four stages was considered in these research which is sport contract, forward contract, option contract and optimization problem. To help electricity producer in fid the best solution, PSO was used. To prove the effectiveness, a comparison between the PSO and GA algorithm is provided. In order to analyze the PSO and GA performance, load profile data in Figure 2.6 was used. PSO used eight parameters to find the best solution compared to GA that only used five parameters. Based on the standard deviation results, it is shown that PSO is more forceful than GA. Figure 2.7 shown PSO finds a better solution by using a smaller number of iterations. The graph show PSO is faster than GA and could finds better solutions in terms of mean fitness value.

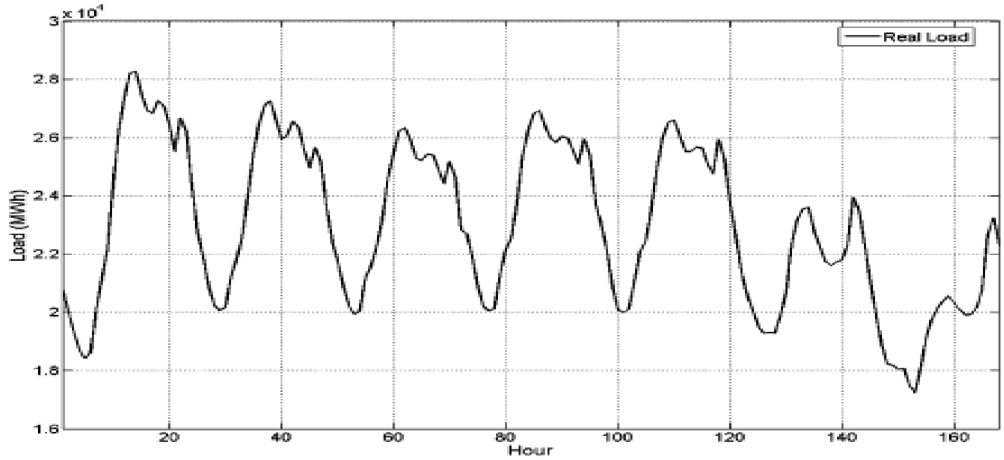

Figure 2.6: the load profile data

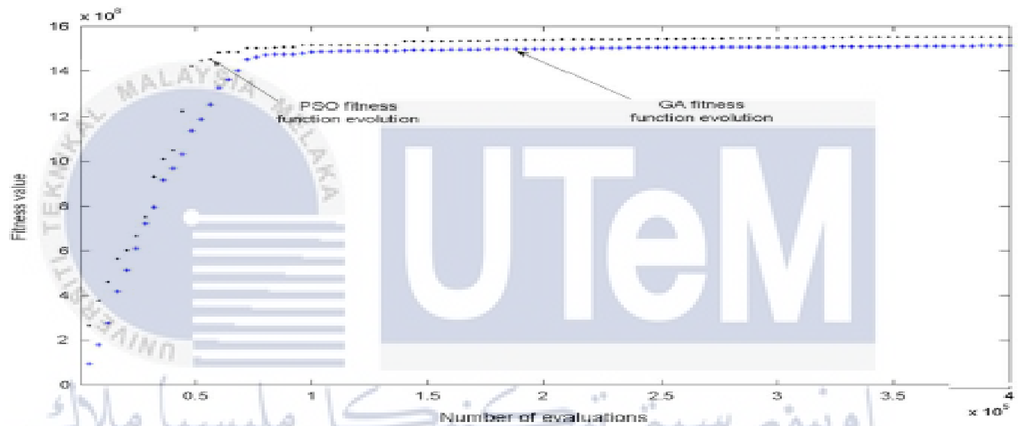

Figure 2.7: evolution of PSO and GA fitness function

Based on the research, it is shown that PSO is an effective method to approach to support electricity producers for multiperiod optimal contract allocation. Even though PSO is faster than GA, the GA results are more accurate than PSO. The PSO effectiveness was shown based on the smaller number of iterations compared to GA. However, the comparison between PSO and GA in this journal is more to the period analysis which is to test the performance in terms of strength and division time only.

2.2.4.2 Forecasting by using Neural Network

According to [20], the author focuses on how to investigate the self-organizing maps (SOM) neural networks can be used to forecast load demand. SOM software consists of five steps to follow in order to complete the analysis which are data organization, data training, data testing, data forecasting and MAPE calculation. Data organization is finished by setting the input data. Load demand value in hourly is used for testing and it was divided into8 main groups by hourly. All the input data are divided into two groups which are for training and testing. The data training are conducted by normalized the data structure. A 'var', 'range', 'log', or 'logistic' are four types of normalization. The 'var' data input will normalize the variance variable to unity and the means to zero then 'range' will scale the variable values between zero and one. Meanwhile, 'log' is a logarithmic transformation and the 'logistics' scales all possible values between zero and one. Next, the maps are tested by associate the most similar times formed by the tested period. These parts will produce the most suitable time by obtained the pattern. The actual and load demand curves are obtained by the software after forecast data operation. Then the percentage errors are calculated in order to form the accuracy of the results. After performing all the testing operation for industry model, the performance of SOM method gives better results due to a low index error which is low than 3%. This research shown NN could give a better performance since it is faster and more accurate compared with [21].

SOM is the outstanding method to make a selection. This Neural Network is very suitable for forecast load demand since it can perform analysis with lots of input data such as load profile. By perform the results in pattern form; it will be easier for consumer to get clear information.

2.3 Summary

In order to analyzed the electricity pricing systems for demand side benefits, great deals of research have been conducted to improve the effectiveness of energy pricing selections. Since the electricity pricing in Malaysia are fix, RTP systems are not used. However, the method to choose customers' risk decision basis and customers' risk decision model can be implemented in Malaysia environment for customers' tariff selection. The implemented will be easier since Enhance Time of Use ETOU tariff system in Malaysia is quite similar with TOU tariff in England and Denmark electricity market which is used three different prices for peak, medium and off peak time zones. By controlling the energy usage the reduction in electricity bill occurred. This pricing system is more effective compared to the previous pricing tariff that only consider two different prices for peak and off peak time. The controlling in energy usage is limited in two time zones only.

Regarding to increasing of electricity, demand side management faces the big impact in terms of electricity billing. Even though some electrical tools were provided to help demand side management it is still costing due to the installation cost and maintenance. In order to help demand side choose the best tariff selection by using load profile, there is two computational algorithm techniques had been implemented which is Neural Network and Genetic algorithm.

Based on the observation for Genetic algorithm technique, the technique is suitable for analyzed a systems with various parameters but it is more to period analysis. The algorithm method is suitable to test the performance in terms of strength and division time only. Since the main input is the load profile data and consists of many types of tariff, Neural Network is the most suitable platform in order to choose the best tariff for industry. The analysis of load pattern data can be unraveling easily with NN technique based on the graphical result accordingly.

In this project, the demand side pricing optimization will be conducted via industrial load profile analysis for tariff selection that correlated to the Malaysia energy scenario. Neural Network technique will be implement in order to analyze the proposed model. Chapter 3 will be discussed details on the methodology of this project while Chapter 4 presents the results of the finding respectively.

CHAPTER 3

METHODOLOGY

3.0 Overview

This chapter clarifies the overall steps that been taken during the research to fulfill the objectives. Thus the actions taken will ensure the research is well organized and lead to project succeeds. The energy profile will be taken from the data logger at industry sector while the rating for tariff has been referred from the Tenaga Nasional Malaysia (TNB).

3.1 Formulation of nonlinear Formula

In order to analyze the performance of TOU and ETOU tariff on industrial energy profile, conventional method were used by using Microsoft Excel. Meanwhile, for ETOU tariff optimization, method of Neural Network is chosen.

The energy profile given is for one day data that records for every minute within 24 hours. In order to observe the data, the average energy profiles for every 30 minutes are calculated since maximum demand is considered in 30 minutes.

$$Average\ power, Pave = \frac{Total\ power\ in\ 30\ minutes}{30} \qquad (3.1)$$

Based on the average power data, graph average power versus time are designed to identify the maximum demand. Tariff E2 for industrial are used for calculating the cost since the industry sector is under tariff E2. Table 3.1 show the TOU and ETOU pricing rate for tariff E2.

Table 3.1: TOU and ETOU pricing rate for tariff E2

Tariff	Off peak rate (sen/kWh)	Medium peak rate (sen/kWh)	Peak time rate (sen/kWh)	Max demand peak rate (RM/kWh)	Max demand medium peak (RM/kWh)
TOU	21.90	-	35.50	37.00	-
ETOU	21.90	32.00	42.80	40.00	36.00

3.2 Normal TOU & ETOU Calculation

In this research, the total cost for TOU and ETOU rates are calculated manually based on the average energy profile data.

3.2.1 TOU Rates

Steps:

1. Based on average energy profile data, the total power for peak time (P_{TP}), and off peak time (P_{TOP}), are calculated.
2. The maximum demand (P_{MD}) is identified.
3. The total cost for 24 hour energy profile data are calculated:

$$T_{TC} = (P_{TP} \times R_{TP}) + (P_{TOP} \times R_{TOP}) + (P_{MD} \times R_{TMD}) \quad (3.2)$$

Where: $\mathbf{T_{TC}}$ = Total cost using conventional method for TOU rates

$\mathbf{R_{TP}}$ = TOU rates during peak time

$\mathbf{R_{TOP}}$ = TOU rates during off peak time

$\mathbf{R_{TMD}}$ = TOU rates during maximum demand

3.2.2 ETOU Rates

Steps:

1. Based on average energy profile data, the total power for peak time (P_{EP}), medium peak time (P_{EMP}) and off peak time (P_{EOP}) are calculated.
2. The maximum demand is identified.
3. The total cost for 24 hour energy profile data are calculated:

$$\boldsymbol{T_{EC}} = (P_{EP} \times R_{EP}) + (P_{EMP} \times R_{EMP}) + (P_{EOP} \times R_{EOP}) + (P_{MD} \times R_{EMD}) \quad (3.3)$$

Where: $\mathbf{T_{EC}}$ = Total cost using conventional method for ETOU rates

$\mathbf{R_{EP}}$ = ETOU rates during peak time

$\mathbf{R_{EMP}}$ = ETOU rates during medium peak time

$\mathbf{R_{EOP}}$ = ETOU rates during off peak time

$\mathbf{R_{MMD}}$ = ETOU rates during medium peak maximum demand

3.3 Implementation of Formulation Model for Peninsular Malaysia Load Demand

Flow chart in Figure 3.1 and Figure 3.2 below shows the formulation process using Microsoft Excel based on the average energy profile data.

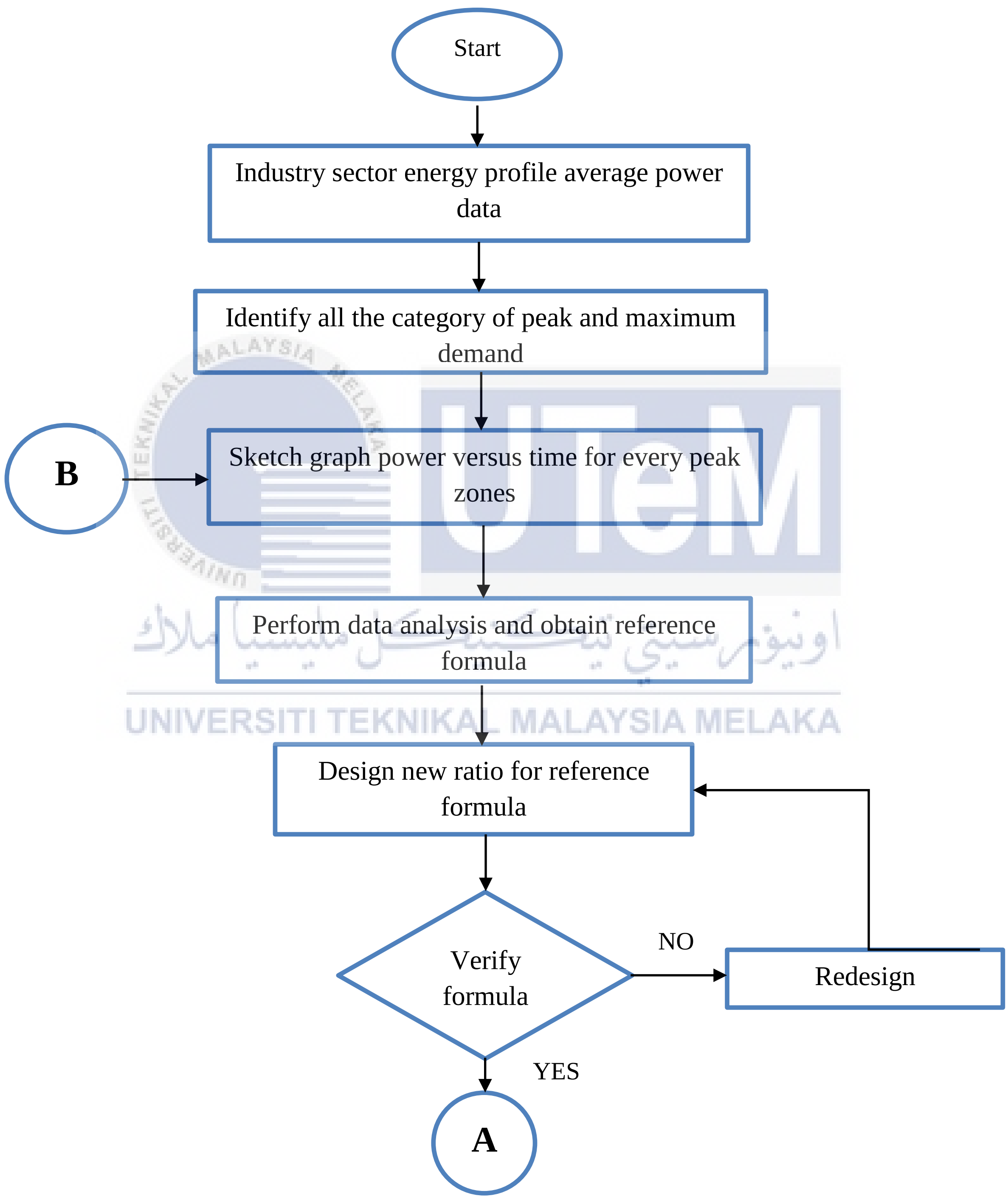

Figure 3.1: First stages formulation process

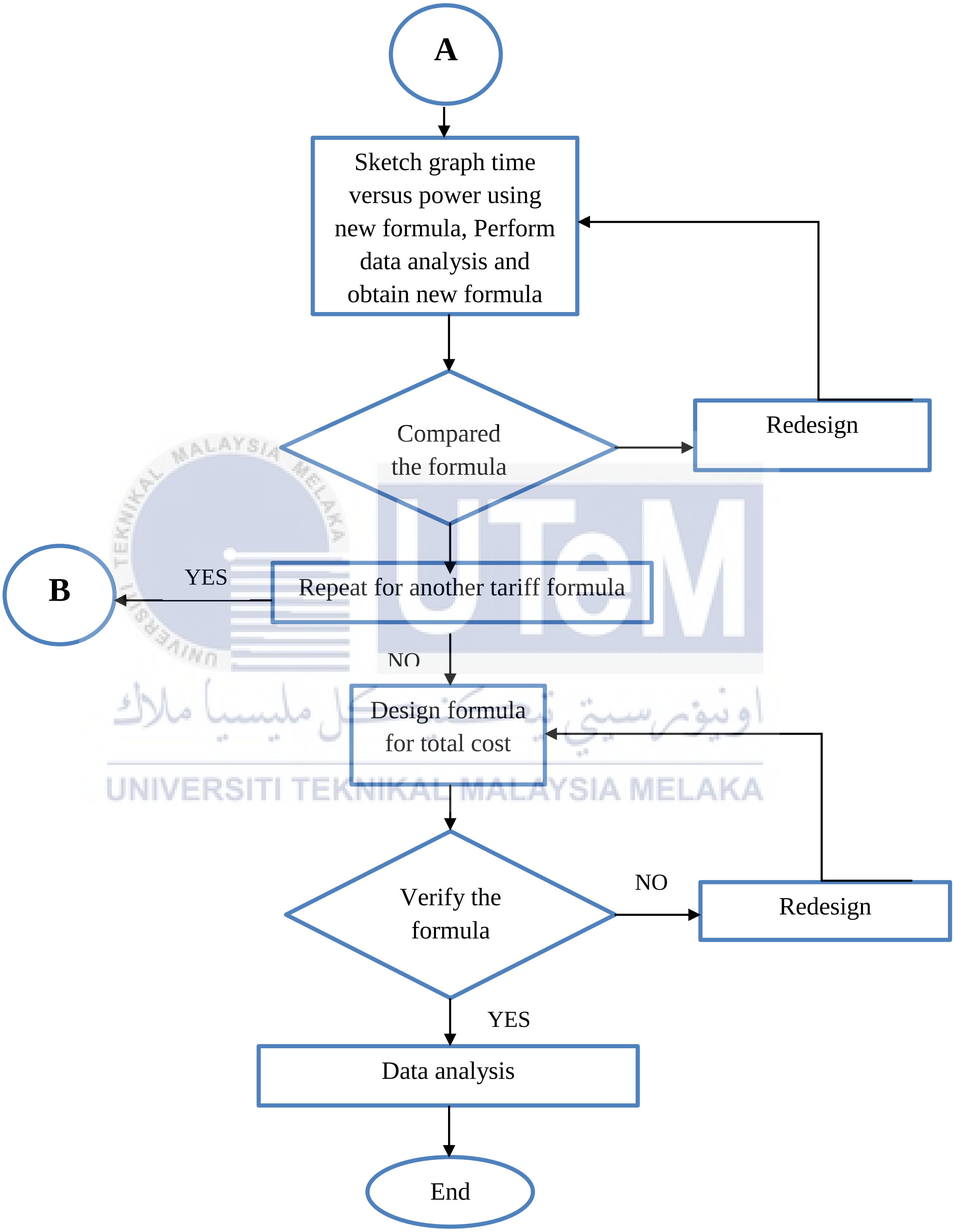

Figure 3.2: Second stages formulation process

3.3.1 Formulation of TOU Tariff

By using TOU rates, the formula are designed based on the following steps.

1. Based on the average energy profile data, range for peak time, off peak time and maximum demand are identified.

   Maximum demand cost, C_{TMD}:

   $$C_{TMD} = P_{MD} \times R_{TMD} \quad ; (RM) \tag{3.4}$$

2. The graphs for average energy profile versus time for every peak are plotted.
3. The reference formula was obtained from the graph by performing regression and data analysis process.
4. Remodeling the reference formula by substitute the total peak cost and rated peak value to find new peak and off peak ratio.

   Total off peak cost, Y_{TOP}:

   $$Y_{TOP} = P_{TOP} \times R_{TOP} \quad ; (RM) \tag{3.5}$$

   Total peak cost, Y_{TP}:

   $$Y_{TP} = P_{TP} \times R_{TP} \quad ; (RM) \tag{3.6}$$

5. The formulas for total cost for every peak are designed by using new ratio values.
6. Verify the total formula cost for peak and off peak by plotting new graph time versus power by using total cost for every peak formula.
7. Perform data analysis and regression in order to get the formula from the graph.
8. Compared the ratio value with the calculated ratio value from (4).

9. The total cost for TOU tariff, T_T is:

$$T_T = C_{TOP} + C_{TP} + C_{MD} \; ; (RM) \tag{3.7}$$

Where; C_{MD} = total electricity cost for maximum demand

C_{TOP} = total electricity cost for off peak time

C_{TP} = total electricity cost for peak time

10. The T_T formula is tested with conventional method by substitute all the TOU ratio, S and TOU tariff rates, R_T values then compared with formula value.
11. The results of T_T by using all TOU tariff types are tabulated and the graph TOU cost versus tariff are plotted and observed.

3.3.2 Formulation of ETOU Tariff

By using ETOU rates, the formula are designed based on the following steps.

1. Based on the average energy profile data, range for peak time, medium peak time, and off peak time and maximum demand are identified.

   Maximum demand cost, C_{EMD}:

$$C_{EMD} = P_{MD} \times R_{EMD} \; ; (\mathrm{RM}) \tag{3.8}$$

2. The graphs for average energy profile versus time for every peak are plotted.
3. The reference formula was obtained from the graph by performing regression and data analysis process.
4. Remodeling the reference formula by substitute the Y as total peak cost and R_E as ETOU rated value to find new peak, medium peak and off peak ratios.

   Total off peak cost, Y_{EOP}:

$$Y_{EOP} = P_{EOP} \times R_{EOP} \quad ; (RM) \tag{3.9}$$

   Total medium peak cost, Y_{EMP}:

$$Y_{EMP} = P_{EMP} \times R_{EMP} \quad ; (RM) \tag{3.10}$$

   Total peak cost, Y_{EP}:

$$Y_{EP} = P_{EP} \times R_{EP} \quad ; (RM) \tag{3.11}$$

5. The formulas for total cost for every peak are designed by using new ratio values.
6. Verify the total formula cost for peak, medium peak and off peak by plotting new graph time versus power by using total cost for every peak formula.
7. Perform data analysis and regression in order to get the formula from the graph.
8. Compared the ratio values with the calculated ratio values from (4).
9. The total cost for ETOU tariff, T_E is:

$$T_E = C_{EOP} + C_{EMP} + C_{EP} + C_{EMD} \ ;(RM) \tag{3.12}$$

Where; C_{ED} = total electricity cost for maximum demand
C_{EOP} = total electricity cost for off peak time
C_{EMP} = total electricity cost for medium peak time
C_{EP} = total electricity cost for peak time

10. The T_E formula is tested with conventional method by substitute all the ratio, Q and tariff rates, R values and compared with formula value.
11. The results of T_E by using all ETOU tariff types are tabulated and the graph cost versus tariff are plotted and observed.
12. To observed TOU and ETOU tariff, graph tariff versus cost TOU and ETOU are performed and analyzed the results.

3.4 Optimizations of ETOU Tariff

There is three process involved in order to optimize the energy profile with ETOU tariff. The mathematical models were designed to analyze how consumer may shift their load to achieve the minimum energy cost. The method of Neural Network is espoused as optimization method.

3.4.1 Mathematical model

The total energy cost, EC paid by the customer in a day may be calculated with the following equation

$$EC = \sum_{t=1}^{48} R(t)L(t) \quad (3.13)$$

Where; R(t) = ETOU rate of each hour

L(t) = Load of each 30 minutes ($0 < t \leq 48$)

Since the ETOU tariff is fix for every day, the consumer may reschedule their loads usage in order to save energy cost. Then the reschedule energy cost, EC_R could be written as

$$EC_R = \sum_{t=1}^{48} R(t)L_R(t) \quad (3.14)$$

Where; EC_R = Energy cost of that day under reschedule load

$L_R(t)$ = Reschedule load of each 30 minutes ($0 < t \leq 48$)

The objective of consumer is to reach the minimum energy cost by load shifting. The optimization objective function could be chosen as

$$min(EC_R) = \min[\sum_{t=1}^{48} R(t)L_R(t)] \quad (3.15)$$

3.4.2 Optimization Method Energy Cost Forecasting Using Neural Network

The consumers may try to find the minimum value of objective function under the assumptions mentioned. This kind of problem is an optimization problem under constrains, mathematically. Sequential quadratic programming method represents the state of the art in nonlinear programming methods [10]. This method make a lot of iterations in order to find the optimization results under the following constrains:

1) Energy Profile

The total energy consumption in a day for original load and rescheduled load will kept the same. The consumers may only change some of their loads from the high price periods to the low price periods. But the total consumption may be not changed due to the similar behaviors in their daily life or production. However, if the reschedule load exceed about less than 5% from original load it will be accepted [22]. The assumptions could be written as

$$\sum_{t=1}^{48} L_R(t) \geq \sum_{t=1}^{48} L(t) \tag{3.16}$$

Only some of the loads could be shift according to the ETOU tariff by the consumers. Some of loads are fixed, that means the customer consumes the power no matter how much the price is. It may be assumed that 20% of the total load is the flexible load and could be shifted according to the ETOU tariff price by the consumers.

2) Regression

The regression, R^2 result of new energy profile should more than 0.65 respectively [23].

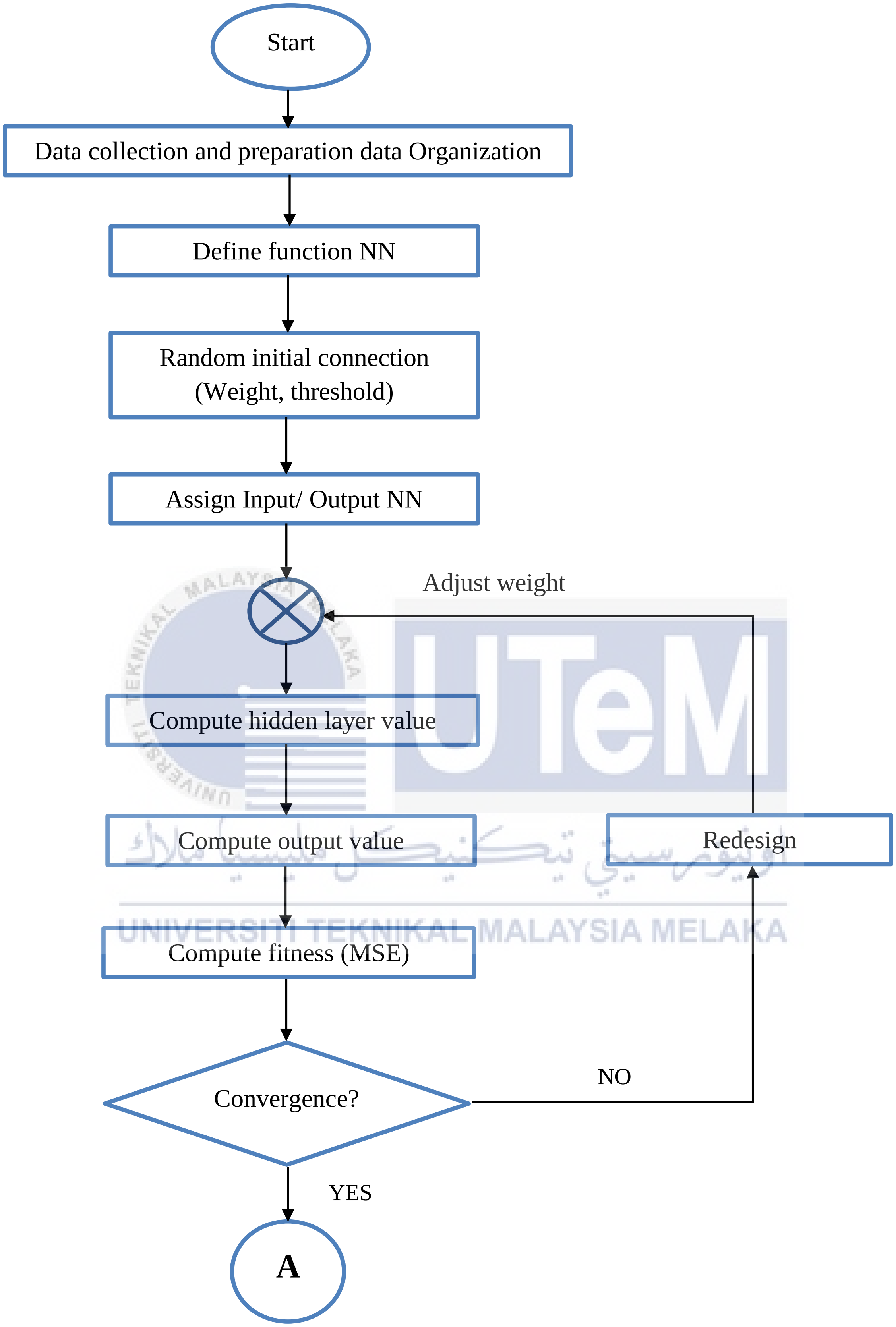

Figure 3.3: First stages optimization process

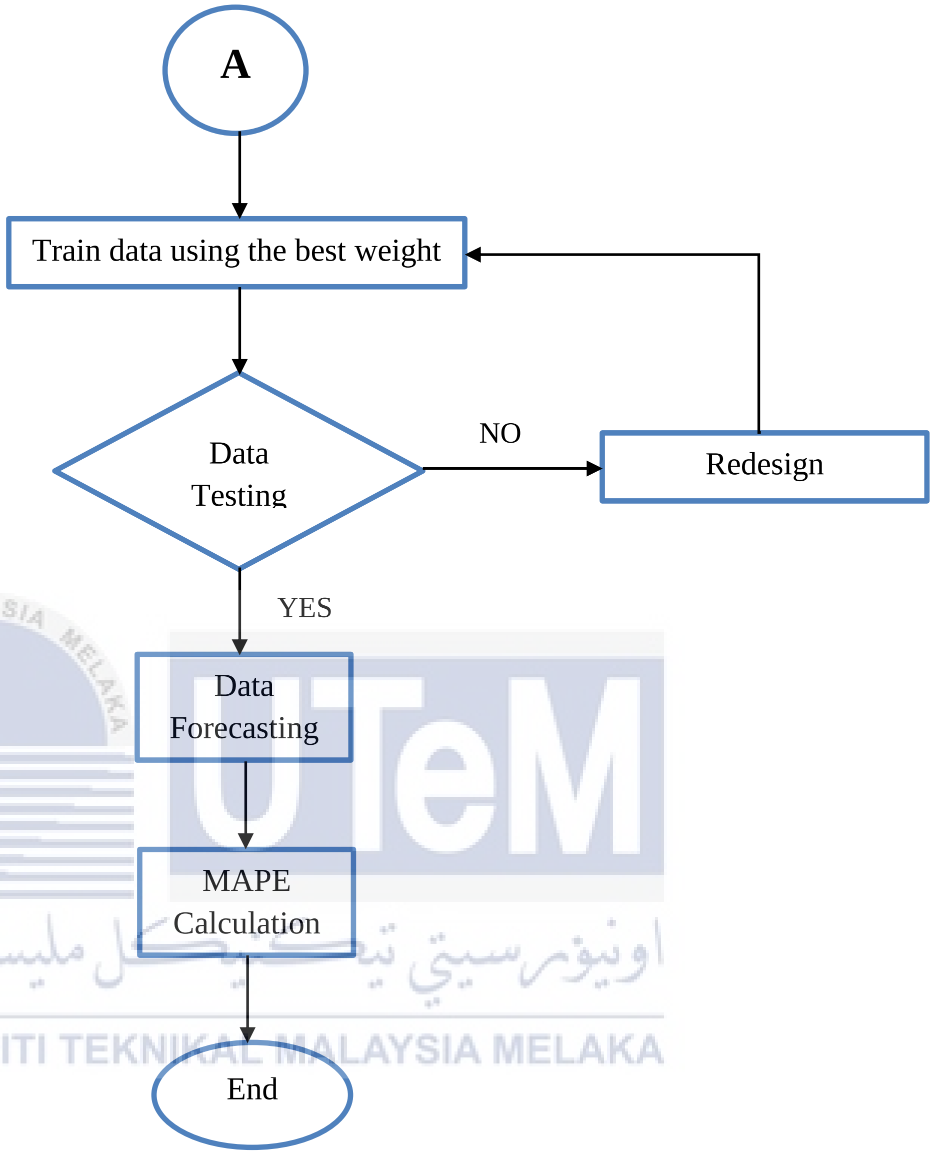

Figure 3.4: Second stages optimization process

Flow chart in Figure 3.3 and 3.4 shows the optimization process using NN based on the average energy profile data of Industry sector with ETOU tariff.

3.4.3 The Application of NN for Load Forecasting

The NN consist of three process to produce the output as follows:

1) Training

The certain cells of the map contain a linear combination of the vectors in the database. It is shown that the content of each cell does not resemble the content of its neighbours. After training, the new map show how the cells are arranged so that each one is similar to its neighbours. Also, the whole input space is covered.

2) Association

The image in the top center shows a data vector. At the time of forecasting, only the known data is used as input to find the cell in the trained map that best matches it.

3) Forecasting

The information stored in the best matching cell is split into the part that was used to match the input and the part that is used to produce a forecast.

3.4.4 NN data organization

The previous energy profile data is used as input data. The data include daily energy profile value in minutes in January, 2016. 28 data sets are divided into 2 main groups which are x_LoadProfile and y_EnergyCost. An x_LoadProfile are industry energy profile for 14 data set for working days. Meanwhile, y_EnergyCost is for total energy cost per day with ETOU tariff for 14 data set for working days.

3.4.5 NN for training

For training the data structure must be normalized. The normalization is copied to the map structure during the trained NN. The data input and output will normalize and scale the variable values between negative one to positive one. The optimum number of neurons must be considered during normalization. The data are normalized by using following formula

$$x_n = \left[x_j - \left(\frac{x_{max}+x_{min}}{2}\right)\right] \div \left(\frac{x_{max}-x_{min}}{2}\right) \quad (3.17)$$

Where; Xn = Normalized data

Xj = Actual data

Xmax = Maximum value in actual data

Xmin = Minimum value in actual data

3.4.6 NN for testing

After training, the maps are tested with testing data of energy profile and energy cost. This method is to associate the energy profile and tariff. This will obtained the pattern for the most suitable load shifting.

3.4.7 Forecasting load data

After testing, all the load data will be forecast. The curve of energy cost forecasting and actual curve is obtained by the software.

3.4.8 Percentage error calculation

To express the accuracy of the results, the percentage error is calculated using mean absolute percentage error (MAPE) based on actual cost data and forecast result. The equation of MAPE is:

$$MAPE\ (\%) = \left(\frac{1}{N}\right)\left[\frac{Y_t - X_t}{X_t}\right] \times 100\% \quad (3.18)$$

Where: Y_T = forecasted cost

X_T = real cost

3.5 Data analysis

The actual data and optimization data will be observed in three category which is total energy cost, maximum demand per day and energy profile per day before and after load shifting.

For deduction of total energy cost observed via this formula

$$SCP = [\frac{EC - EC_R}{EC}] \times 100\% \quad (3.19)$$

Where; SCP = saving cost percentage

EC = energy cost of that day

EC_R = energy cost of that day under reschedule load

3.6 Summary

In order to optimize the energy cost, Neural Network technique will implement to observe and analyze the industrial load profile for demand side management. Hopefully this method could achieve the entire stated objective.

CHAPTER 4

RESULTS

4.0 Overview

There is three parts of results were obtained. First are the results performed two methods for calculating electricity cost by using industrial TNB tariff of TOU and ETOU rates. The one day energy profile of industrial sector for January, 25 2016 and E2 tariff pricing are used in this category. These results will be obtained via normal calculation and formulation by Microsoft Excel. Second parts is the optimization of the energy cost with ETOU tariff for demand side benefits, 14 days energy profile of Industrial sector are used in this part. The E2 tariff pricing also used for this category since the industrial sector is under this rate. This result was obtained by using Neural Network (NN) method via Mat-lab software. The last part is the comparison of energy cost for actual energy profile and optimizes energy profile with TOU and ETOU tariff. The main purpose of this research is for demand side usage to find the best TNB tariff selection between TOU and ETOU based on their energy profile pattern. The main consideration during the execution of this technique is to achieve minimum electricity cost.

4.1 Industrial Load Profile and TNB Tariff

To verify the effectiveness of TOU and ETOU tariff based on industrial sector energy profile, one days energy profiles were used as shown in Table 4.1 respectively. The non-linear formulas were created by using Microsoft Excel and were verified with conventional method. Thus, the results are recorded and tabulated.

Table 4.1: Average power of energy profile of industry sector on January, 25 2016 for every 30 minutes

Time	Power in kilowatt (kW)	Time	Power in kilowatt (kW)
12:30 AM	2760	**12:30 PM**	2900
1:00 AM	2890	**1:00 PM**	2740
1:30 AM	2690	**1:30 PM**	2660
2:00 AM	2770	**2:00 PM**	2910
2:30 AM	3030	**2:30 PM**	3200
3:00 AM	3090	**3:00 PM**	3330
3:30 AM	2950	**3:30 PM**	3320
4:00 AM	2840	**4:00 PM**	3210
4:30 AM	2810	**4:30 PM**	3090
5:00 AM	2690	**5:00 PM**	2950
5:30 AM	2730	**5:30 PM**	2930
6:00 AM	2480	**6:00 PM**	2780
6:30 AM	2580	**6:30 PM**	2780
7:00 AM	2630	**7:00 PM**	2630
7:30 AM	2660	**7:30 PM**	2720
8:00 AM	2440	**8:00 PM**	2490
8:30 AM	2580	**8:30 PM**	2540
9:00 AM	2640	**9:00 PM**	2880
9:30 AM	2820	**9:30 PM**	2900
10:00 AM	2850	**10:00 PM**	2880
10:30 AM	3050	**10:30 PM**	2760
11:00 AM	3110	**11:00 PM**	2640
11:30 AM	3000	**11:30 PM**	2740
12:00 PM	2740	**12:00 AM**	2650

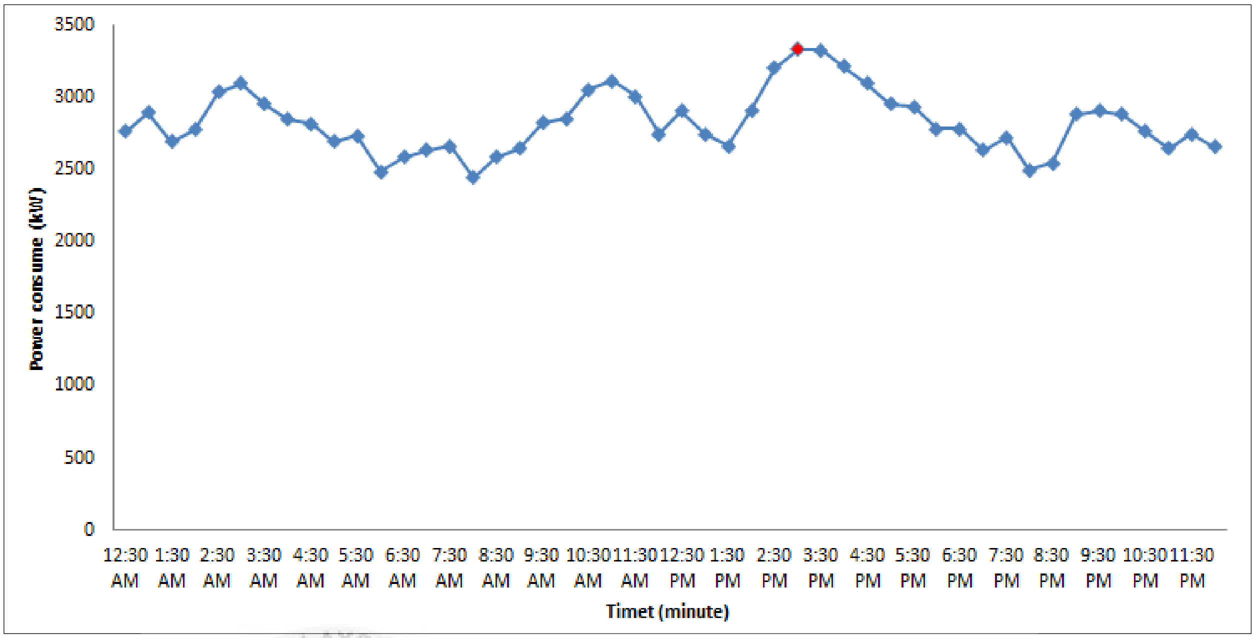

Figure 4.1: Energy profile in every 30 minutes for 24 hours from 12:30AM until 12:00AM

Figure 4.1 shows the waveform of energy profile which is having different power consumes during every time zone. The energy pattern represent for January, 25 2016 (Thursday-Working day) shown that the energy was fully consumed during peak time zones. The Red dot on the figure shows the max power consumes 3330kW that will be considered as maximum demand. The position of maximum demand is at 3:00PM which is in the peak time zone for both TOU and ETOU tariff.

4.2 Normal Calculation Results

Based on conventional method, the total energy costs for TOU and ETOU tariff can be calculated by using formula (3.2) and (3.3).

Table 4.2: The total average power for every peaks value of TOU and ETOU tariff

Energy	TOU	ETOU
Total off peak power, (kW)	52390	57710
Total medium peak power, (kW)	-	52910
Total peak power, (kW)	83070	24840
Total maximum demand power, (kW)	3330	3330

Based on the Table 4.2, it is represent the total average power consumes for every peak of energy profile.

Table 4.3: TOU and ETOU electricity cost for conventional method

Tariff	TOU cost, T_{TC} (RM)	ETOU cost, T_{EC} (RM)
E2	164173.26	173401.21

Table 4.3 shows the electricity cost by using the E2 rate of TOU and ETOU tariff. The calculations were used normal method which is manually calculated. The results ware included Maximum Demand cost for daily basis comparison.

4.3 Tariff Formulation

4.3.1 TOU Tariff

Based on the Table 4.1, graph time versus average power usage for every peak time of TOU time zones was plotted. The data analysis and regression are formed to get the reference formula for correlation between time and power of the energy profile.

Reference formula from graph time versus average power usage (refer Appendix A for graph from figure 7.1 and 7.2) for every peak times;

Reference formula from the graph for off peak time, Y_{TOP} with regression, R^2:

$$Y_{TOP} = \underbrace{2820.4}_{\text{Off peak ratio, } S_{OP\,(OLD)}} \times e^{(-0.002)(R_{TOP}/100)};\ \ R^2 = 0.061 \tag{4.1}$$

Reference formula from the graph for peak time, Y_{TP} with regression, R^2:

$$Y_{TP} = \underbrace{2842.6}_{\text{Peak ratio, } S_{P\,(OLD)}} \times e^{(0.0003)(R_{TP}/100)};\ \ R^2 = 0.0009 \tag{4.2}$$

Since the equations from the graph are not 100% accurate, the formula was remodeled by finding new ratio, S values for every peak. Use formula (3.5) and (3.6) to find total cost for every peak.

Off peak ratio, S_{op}:

$$Y_{TOP} = 52390\ kW \times 0.2190$$
$$Y_{TOP} = RM11473.41$$

Substitute in the formula (4.1):

$$RM11473.41 = S_{OP} \times e^{(-0.002)(21.90/100)}$$
$$S_{OP} = 11478.44 \tag{4.3}$$

The formula for S_{op} is:

$$S_{OP} = \left[P_{TOP} \times \left(\frac{R_{TOP}}{100}\right)\right] / e^{\left[-0.002 \times \left(\frac{R_{TOP}}{100}\right)\right]} \quad (4.4)$$

Verify S_{OP} formula by substitute R_{TOP} value and compared with (4.3):

$$S_{OP} = \left[52390 \times \left(\frac{21.90}{100}\right)\right] / e^{\left[-0.002 \times \left(\frac{21.90}{100}\right)\right]}$$

$$S_{OP} = 11478.44 \quad (4.5)$$

Peak ratio, S_P:

$$Y_{TP} = 83070\ kW \times 0.3550$$

$$Y_{TP} = RM29489.85$$

Substitute in the formula (4.2):

$$RM29489.85 = S_P \times e^{(0.0003)(35.50/100)}$$

$$S_P = 29486.7 \quad (4.6)$$

The formula for S_P is:

$$S_P = \left[P_{TP} \times \left(\frac{R_{TP}}{100}\right)\right] / e^{\left[0.0003 \times \left(\frac{R_{TP}}{100}\right)\right]} \quad (4.7)$$

Verify S_P formula by substitute P_{TP} and R_{TP} value and compared with (4.6):

$$S_P = \left[83070 \times \left(\frac{36.50}{100}\right)\right] / e^{\left[0.0003 \times \left(\frac{35.50}{100}\right)\right]}$$

$$S_P = 29486.7 \quad (4.8)$$

Based on the new ratio, S the total cost formula for every peak is obtained as:

Total cost off peak time for TOU rates, C_{TOP}:

$$C_{TOP} = S_{OP} \times e^{(-0.002)(R_{TOP}/100)}\ ; (RM) \quad (4.9)$$

Total cost peak time for TOU rates, C_{TP}:

$$C_{TP} = S_P \times e^{(0.0003)(R_{TP}/100)} \quad ;(RM) \tag{4.10}$$

By using formula C_{TOP} and C_{TP}, new graph time versus power is plotted to verify the formula by performing data analysis. (Refer Appendix B for graph from figure 7.3 and 7.4)

Formula from the graph:

Off peak data,

$$C_{TOP} = \underbrace{11478}_{\text{Value } S_{OP} \text{ from the graph}} \times e^{(-0.002x)} \quad ; R^2 = 1 \tag{4.11}$$

Peak data,

$$C_{EP} = \underbrace{29487}_{\text{Value } S_{P} \text{ from the graph}} \times e^{(0.0003x)} \quad ; R^2 = 1 \tag{4.12}$$

Since the value of calculated ratio (4.5) and (4.8) are quite similar with value of ratio from the graph (4.11) and (4.12) with regression is greater than 0.75, the equations are considered succeed.

From equation (3.7), the total cost formula for TOU tariff is obtained as:

The total cost in RM for TOU tariff, T_T is:

$$T_T = \left[S_{OP} \times e^{(-0.002)\left(\frac{R_{TOP}}{100}\right)}\right] + \left[S_P \times e^{(0.0003)\left(\frac{R_{TP}}{100}\right)}\right] + [P_{MD} \times R_{TMD}] \tag{4.13}$$

Table 4.4: Electricity cost of TOU tariff for formulation method

Tariff	**Peak Ratio, S_P**	**Off Peak Ratio, S_{OP}**	**Cost, T_T (RM)**
E2	29486.71	11478.44	164173.26

Table 4.4 shows the electricity cost of TOU tariff rates by using formula. The TOU costs by using formula are the same with TOU cost by using normal method in Table 4.4 which is RM164,173.26.

4.3.2 ETOU tariff

Based on the Table 4.1, graph time versus average power usage for every peak time of ETOU time zones was plotted (refer appendix C for graph from figure 7.5 until 7.7). The data analysis and regression are formed to get the reference formula for correlation between time and power of the energy profile.

Reference formula from graph time versus power usage for every peak times;

Reference formula for off peak time, Y_{EOP} with regression, R^2:

$$Y_{EOP} = \underbrace{2881.8}_{\text{Off peak ratio, } Q_{OP\ (OLD)}} \times e^{(-0.004)(R_{EOP}/100)};\ \ R^2 = 0.2194 \tag{4.14}$$

Reference formula for medium peak time, Y_{EMP} with regression, R^2:

$$Y_{EMP} = \underbrace{2831}_{\text{Medium peak ratio, } Q_{MP\ (OLD)}} \times e^{(-0.002)(R_{EMP}/100)};\ \ R^2 = 0.0287 \tag{4.15}$$

Reference formula for peak time, Y_{EP} with regression, R^2:

$$Y_{EP} = \underbrace{3018.8}_{\text{Peak ratio, } Q_{P\ (OLD)}} \times e^{(0.0058)(R_{EP}/100)};\ \ R^2 = 0.0463 \tag{4.16}$$

Since the equations from the graph are not 100% accurate, the formula was remodeled by finding new ratio, Q values for every peak. Use formula (3.9), (3.10) and (3.11) to find total cost for every peak.

Off peak ratio, Q_{OP}:

$$Y_{EOP} = 57710\ kW \times 0.2190$$

$$Y_{EOP} = RM12638.49$$

Substitute in the formula (4.14):

$$RM12638.49 = Q_{OP} \times e^{(-0.004)(21.90/100)}$$

$$Q_{OP} = 12649.57 \tag{4.17}$$

The formula for Q_{OP} is:

$$Q_{OP} = \left[P_{EOP} \times \left(\frac{R_{EOP}}{100}\right)\right] / e^{\left[-0.004\times\left(\frac{R_{EOP}}{100}\right)\right]} \tag{4.18}$$

Verify Q_{OP} formula by substitute P_{EOP} and R_{EOP} value and compare with (4.17):

$$Q_{OP} = \left[57710 \times \left(\frac{28.10}{100}\right)\right] / e^{\left[-0.004\times\left(\frac{21.90}{100}\right)\right]}$$

$$Q_{OP} = 12649.57 \tag{4.19}$$

Medium peak ratio, Q_{MP}:

$$Y_{EMP} = 52910\ kW \times 0.32$$

$$Y_{EMP} = RM16931.20$$

Substitute in the formula (4.15):

$$RM16931.20 = Q_{MP} \times e^{(-0.002)(32/100)}$$

$$Q_{MP} = 16942.04 \tag{4.20}$$

The formula for Q_{MP} is:

$$Q_{MP} = \left[P_{EMP} \times \left(\frac{R_{EMP}}{100}\right)\right] / e^{\left[-0.002\times\left(\frac{R_{EMP}}{100}\right)\right]} \tag{4.21}$$

Verify Q_{MP} formula by substitute P_{EMP} and R_{EMP} value and compared with (4.20):

$$Q_{MP} = \left[52910 \times \left(\frac{32}{100}\right)\right] / e^{\left[-0.002 \times \left(\frac{32}{100}\right)\right]}$$

$$Q_{MP} = 16942.04 \tag{4.22}$$

Peak ratio, Q_P:

$$Y_{EP} = 24840\ kW \times 0.4280$$

$$Y_{EP} = RM10631.52$$

Substitute in the formula (4.16):

$$RM10631.52 = Q_P \times e^{(0.0058)(42.80/100)}$$

$$Q_P = 10605.16 \tag{4.23}$$

The formula for Q_P is:

$$Q_P = \left[P_{EP} \times \left(\frac{R_{EP}}{100}\right)\right] / e^{\left[0.0058 \times \left(\frac{R_{EP}}{100}\right)\right]} \tag{4.24}$$

Verify Q_P formula by substitute P_{EP} and R_{EP} value and compared with (4.23):

$$Q_P = \left[24840 \times \left(\frac{42.80}{100}\right)\right] / e^{\left[0.0058 \times \left(\frac{42.80}{100}\right)\right]}$$

$$Q_{OP} = 10605.16 \tag{4.25}$$

Based on the new ratio, Q the total cost formula for every peak is obtained as:

Total cost off peak time for ETOU rates, C_{EOP}:

$$C_{EOP} = Q_{OP} \times e^{(-0.004)(R_{EOP}/100)}\ ; (RM) \tag{4.26}$$

Total cost medium peak time for ETOU rates, C_{EMP}:

$$C_{EMP} = Q_{MP} \times e^{(-0.002)(R_{EMP}/100)}\ ;\ (RM) \tag{4.27}$$

Total cost peak time for ETOU rates, C_{EP}:

$$C_{EP} = Q_P \times e^{(0.0058)(R_{EP}/100)} \quad (RM) \tag{4.28}$$

By using formula C_{EOP}, C_{EMP} and C_{EP}, new graph time versus power is plotted to verify the formula by performing data analysis. (Refer appendix D for graph from figure 7.8 until 7.10)

Formula from the graph:

Off peak data,

$$C_{EOP} = \underbrace{12649.57}_{\text{Value } Q_{OP} \text{ from the graph}} \times e^{(-0.004x)} \;;\; R^2 = 1 \tag{4.29}$$

Medium peak data,

$$C_{EMP} = \underbrace{16942}_{\text{Value } Q_{MP} \text{ from the graph}} \times e^{(-0.002x)} \;;\; R^2 = 1 \tag{4.30}$$

Peak data,

$$C_{EP} = \underbrace{10605}_{\text{Value } Q_{P} \text{ from the graph}} \times e^{(0.0058x)} \;;\; R^2 = 1 \tag{4.31}$$

Since the value of calculated ratio (36), (39) and (42) are quite similar with the ratio value from the graph (4.29), (4.30), and (4.31) with regression is greater than 0.75 the equations are considered succeed.

From equation (12), the total cost formula for ETOU tariff is obtained as:

The total cost in RM for ETOU tariff, T_E is:

$$T_E = \left[Q_{OP} \times e^{(-0.004)\left(\frac{R_{EOP}}{100}\right)}\right] + \left[Q_{MP} \times e^{(-0.002)\left(\frac{R_{EMP}}{100}\right)}\right] + \left[Q_P \times e^{(0.0058)\left(\frac{R_{EP}}{100}\right)}\right] + [P_{MD} \times R_{MMD}] \tag{4.32}$$

Table 4.5: Electricity cost of ETOU tariff for formulation method

Tariff	Peak Ratio, Q_P	Medium Peak Ratio, Q_{MP}	Off Peak Ratio, Q_{OP}	ETOU Cost, T_E (RM)
E2	10605.16	16942.04	12649.57	173401.21

Table 4.5 shows the electricity cost of ETOU tariff rates by using formula. The ETOU costs by using formula are the same with ETOU cost by using normal method in Table 4.4 which is RM 173401.21 with the maximum demand in high peak region.

Table 4.6: Electricity cost of TOU and ETOU tariff

Tariff	TOU cost, T_T (RM)	ETOU cost, T_E (RM)
E2	164,173.26	173,401.21

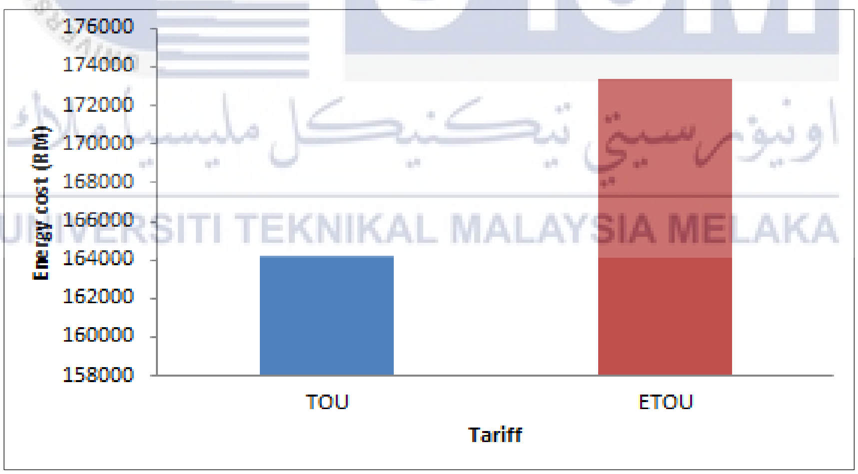

Figure 4.2: Graph energy cost of TOU and ETOU tariff

Figure 4.2 show the electricity cost for industry energy profile on January,25 2015 with TOU and ETOU tariff. Refer to the graph, it is shown that electricity cost for TOU tariff are much lower than ETOU tariff which is RM164,173.26 compared to RM173,401.21 for ETOU tariff. Since the saving energy cost is about 5.32% (RM9,227.95 per day), TOU tariff are the more suitable tariff for energy profile Industrial sector.

4.4 Optimization of energy profile based on ETOU tariff

In order to optimize the energy cost by using industry energy profile, 48 data set of energy profile and energy cost for 14 days are used. The data set is from 8/2/2016-12/2/2016, 15/2/2016-19/2/2016 and 22/2/2016-25/2/2016.

4.4.1 Input and output data

Refer Appendix E Table 7.1 until 7.3 shows the actual energy profile for every 30 minutes in 24 hours from 12.30AM until 12.00AM, this data will be set as input data for data training and data testing.

Refer appendix F, Table 7.4 until 7.6 show the actual energy cost for every 30 minutes. The energy cost was calculated by using ETOU tariff under E2 category, this data will be set as output data for data training and data testing.

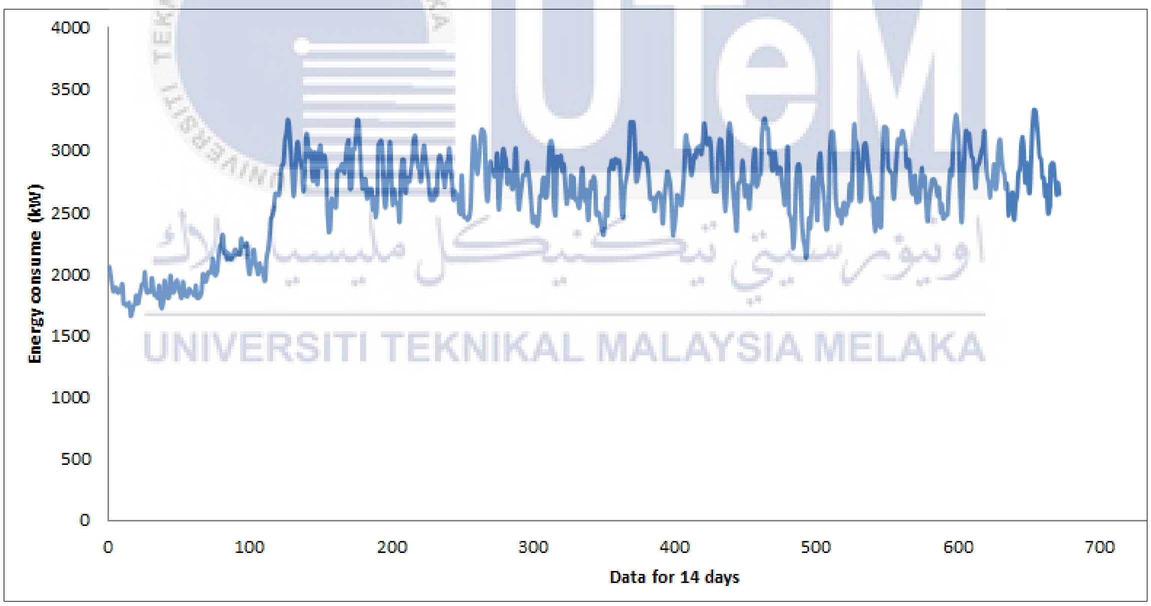

Figure 4.3: The energy pattern of Industrial sector for 14 days (working day)

Figure 4.3 shown the pattern of energy consumed in industrial sector for 14 days (working day). The waveform showed those energy usages for every working day are just the same which is fully consumed during daylight and only 50% operate at night.

4.4.2 Normalization of Input and output data

By using formula (3.17), the input and output data are normalized via Mat-Lab software. Refer Appendix G, Table 7.7 until 7.9 show the normalized input data for actual energy profile in every 30 minutes, this data will be used for data training and data testing in NN. The data is named as x_LoadProfile in Mat-Lab Software.

Refer Appendix H, Table 7.10 until 7.12 show the normalized output data for energy cost in every 30 minutes, this data will be used for data training and data testing in NN. The data is named as y_EnergyCost in Mat-Lab Software.

4.4.3 Training and Testing Data Selection

In order to select the testing data, the max demand of January 2016 were obtained. Since the maximum demand are in January, 25 2016, which is 3330kW the one day data testing are choose. The Data training will be used data from another day.

4.4.4 Results from simulation of NN

Table 4.7 show the minimum energy cost after optimization process.

Table 4.7**:** Minimum energy cost by load shifting

Time	**Energy cost, EC_R (RM)**	**Time**	**Energy cost, EC_R (RM)**
12:30 AM	774.91	**12:30 PM**	876.62
1:00 AM	869.35	**1:00 PM**	760.40
1:30 AM	724.18	**1:30 PM**	702.48
2:00 AM	782.16	**2:00 PM**	883.89
2:30 AM	971.17	**2:30 PM**	1094.57
3:00 AM	1014.77	**3:00 PM**	1188.46
3:30 AM	912.99	**3:30 PM**	1181.26
4:00 AM	833.00	**4:00 PM**	1101.81
4:30 AM	811.20	**4:30 PM**	1014.77
5:00 AM	724.18	**5:00 PM**	912.99
5:30 AM	753.15	**5:30 PM**	898.44
6:00 AM	572.92	**6:00 PM**	789.42
6:30 AM	644.74	**6:30 PM**	789.42
7:00 AM	680.80	**7:00 PM**	680.80
7:30 AM	702.48	**7:30 PM**	745.91
8:00 AM	544.32	**8:00 PM**	580.09
8:30 AM	644.74	**8:30 PM**	615.96
9:00 AM	688.02	**9:00 PM**	862.08
9:30 AM	818.47	**9:30 PM**	876.62
10:00 AM	840.27	**10:00 PM**	862.08
10:30 AM	985.71	**10:30 PM**	774.91
11:00 AM	1029.30	**11:00 PM**	688.02
11:30 AM	949.35	**11:30 PM**	760.40
12:00 PM	760.40	**12:00 AM**	695.25

From minimum energy cost by load shifting in Table 4.7, the new energy profile after shifting can be obtained by using formula number (3.14).

Table 4.8: Minimum energy profile after load shifting

Time	New shifting load, L_R (kW)	Time	New shifting load, L_R (kW)
12:30 AM	3538	**12:30 PM**	2739
1:00 AM	3970	**1:00 PM**	2376
1:30 AM	3307	**1:30 PM**	2195
2:00 AM	3572	**2:00 PM**	2762
2:30 AM	4435	**2:30 PM**	2557
3:00 AM	4634	**3:00 PM**	2777
3:30 AM	4169	**3:30 PM**	2760
4:00 AM	3804	**4:00 PM**	2574
4:30 AM	3704	**4:30 PM**	2371
5:00 AM	3307	**5:00 PM**	2133
5:30 AM	3439	**5:30 PM**	2808
6:00 AM	2616	**6:00 PM**	2467
6:30 AM	2944	**6:30 PM**	2467
7:00 AM	3109	**7:00 PM**	2128
7:30 AM	3208	**7:30 PM**	2331
8:00 AM	2485	**8:00 PM**	1813
8:30 AM	2015	**8:30 PM**	1925
9:00 AM	2150	**9:00 PM**	2694
9:30 AM	2558	**9:30 PM**	2739
10:00 AM	2626	**10:00 PM**	3936
10:30 AM	3080	**10:30 PM**	3538
11:00 AM	3217	**11:00 PM**	3142
11:30 AM	2218	**11:30 PM**	3472
12:00 PM	1777	**12:00 AM**	3175

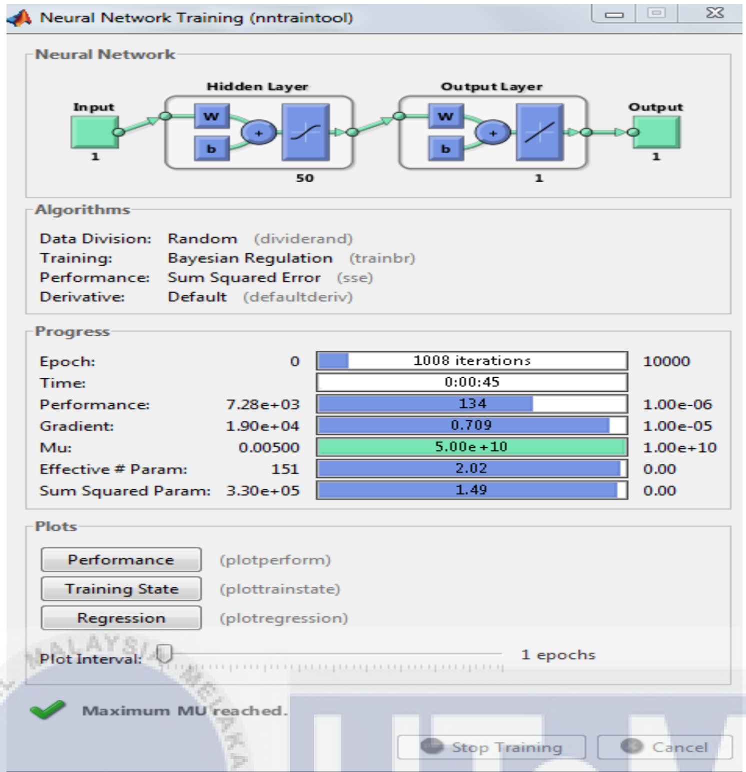

Figure 4.4: Neural Network training tool with 50 hidden layer

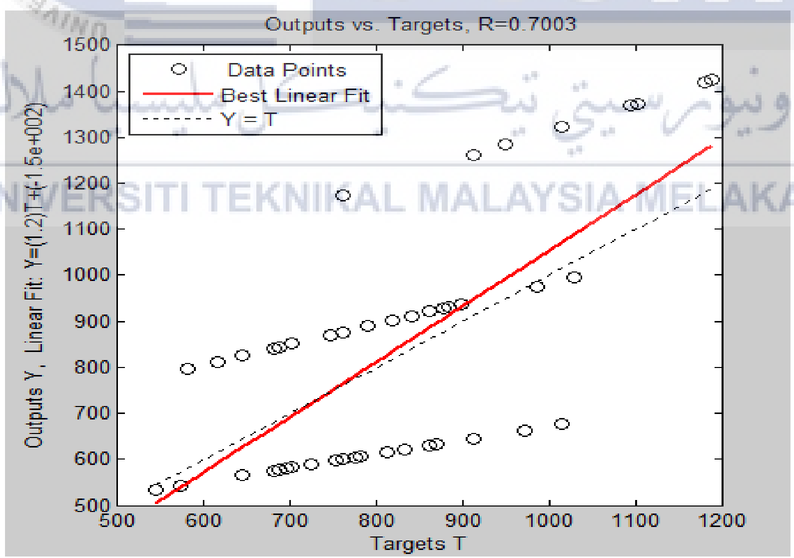

Figure 4.5: the regression graph for energy cost optimization

Figure 4.4 shows the training process via neural network for load forecasting. The 50 hidden layers were used for nonlinear data in order to produce one linear output layer. Meanwhile, Figure 4.5 shows the regression, R^2 of output versus target with best linear fit of 0.7003.

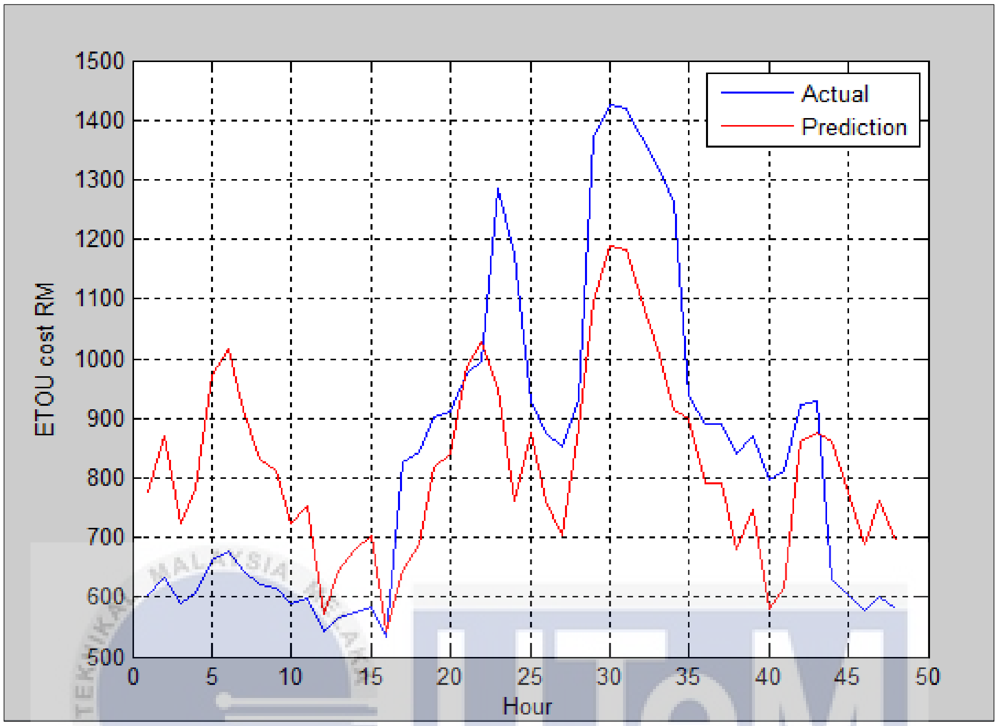

Figure 4.6: The energy cost pattern for actual data and prediction data

The best prediction of minimum energy cost pattern was produced in Figure 4.6. The blue line refers to actual energy cost with ETOU tariff while the red line show the new energy cost after optimization. The graph prediction graph showed a various changing pattern in order to reach the minimum energy cost.

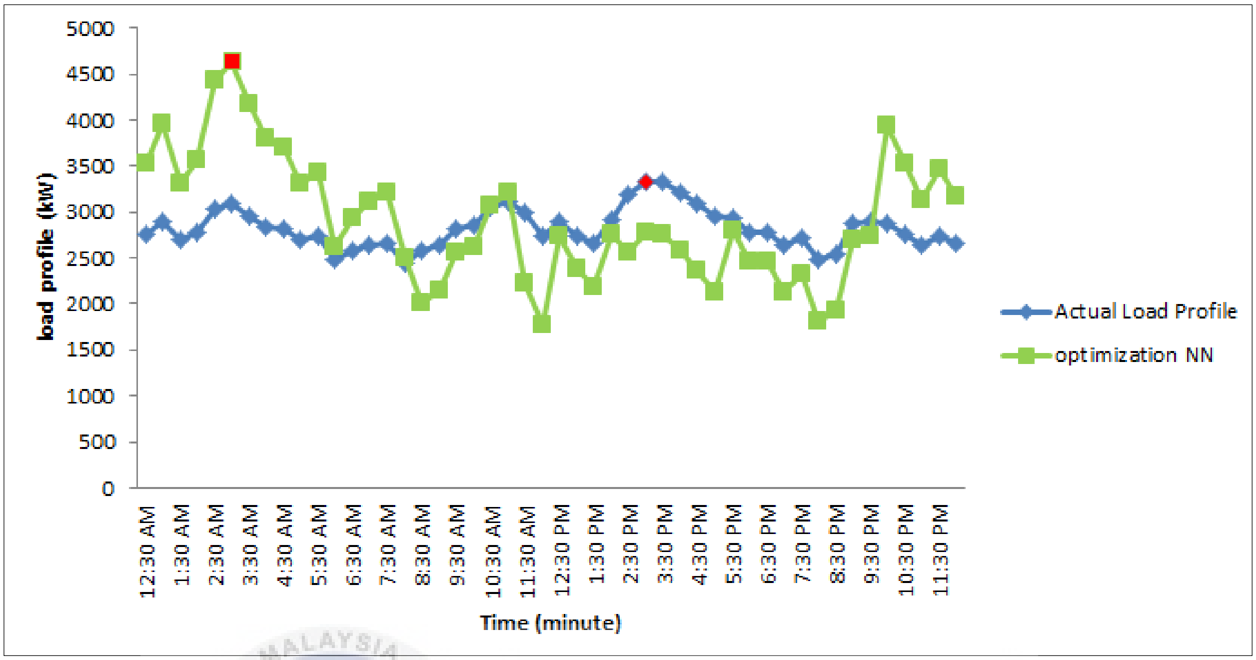

Figure 4.7: The energy profile pattern for actual data and optimization data for January,25 2016

The optimal load respons of typical industrial load to ETOU power price for demand side management are shown in Figure 4.7. The customer shifts some of the loads from the high price period to the low price period in order to achieve minimum energy cost in the day. The load is reduce about 10% at the price peak (about 3:00PM) and 15% reduce at mid peak (about 11:30AM). Meanwhile the load is increased about 20% at the price low peak (about 3:00AM) and 15% increased at low peak (about 10:00PM). The position of maximum demand also shifted from peak region to off peak region. As already informed by TNB, if the maximum demand was in off peak region, the maximum charged will not considered in billing. It is indicated that the peak electricity consumption is reduced and the off peak electricity consumption is increased significantly, which have good effect on the power system normal operation.

Table 4.8: the comparison between actual energy profile and optimization energy profile pattern for January, 25 2016

Type	Actual Energy Cost, (RM)	Optimization of Energy Cost, (RM)	Saving per day, (%)
Total Energy cost	173,401.21	39,369.52	77.30%
Total Load per day (kW)	135460	139737	3.06%
Maximum demand (kW)	3330	4635	28.16%
Maximum demand position	Peak region (3:00 PM)	Off peak region (3:00 AM)	-

Refer to table 4.8 due to the load shifting, the total load per day was exceed about 3.06%. Refer to the formula in (3.16), since the total energy consumption in a day for rescheduled load did not less than original load the result considered achieved. The maximum demand for optimal load response also increased about 28.16% but the position is changed from peak region to off peak region. However, the energy cost decrease up to 77.30% (RM134,031.69 per day) due to optimal load response to ETOU power price for industry energy profile. The big saving was achieved since the maximum demand in off peak position is not considered in billing.

Table 4.9: The comparison of energy cost by using optimization energy profile

Tariff	Actual Energy Cost, (RM)	Optimization Energy Cost, (RM)	Saving per day, (%)
TOU	164,173.26	40,486.32	75.34%
ETOU	173,401.21	39,369.52	77.30%

Table 4.9 shown that the minimum energy cost is achieved since the energy cost for new energy profile by using both TOU and ETOU tariff is decreased up to 75.34% and 77.30% compared with actual energy profile in Table 4.6.

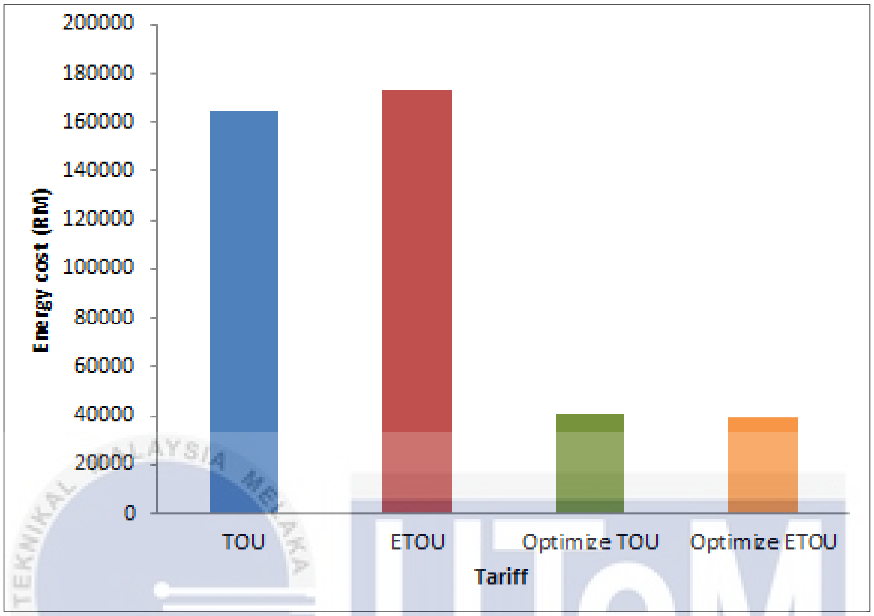

Figure 4.8: Graph energy cost for actual and shifted energy profile with TOU and ETOU tariff

Figure 4.8 show the electricity cost for actual and shifted energy profile with TOU and ETOU tariff. Refer to the graph, it is shown that after the energy shifting, the ETOU tariff offer the minimum energy cost compared with others. The energy cost was decreased up to 77.3% (RM134,031.69 per day) compared with the old energy profile while using ETOU tariff. Meanwhile, the energy cost decreased up to 75.34% (RM123,686.94) if compared with old energy profile while using TOU tariff pricing. The ETOU tariff is fully effective when the energy cost saving by using new energy profile is decreased about 2.77% (RM1,116.8 per day) compared with TOU tariff. From the observation it was shown that the tariff selection and optimum energy costing is very important for demand side management.

4.3 Summary

In this chapter, the results are obtained by testing the electricity cost formula with normal calculation in Table 4.3 for the purpose of tariff selection between TOU and ETOU rates. The results show the capability of this technique to choose the suitable tariff based on the energy profile of demand side for industrial tariff. The following evaluation can be drawn from results achieved. Based on the overall tariffs observations from industry energy profile, the best tariff achieved is TOU tariff with the lowest electricity cost which is RM164,173.26.The summarization of results is shown in Figure 4.2 respectively. Meanwhile, for load optimization with ETOU power pricing, it shown that the saving energy cost is decreased up to 77.3%. Moreover, with the new energy profile, ETOU tariff offer the minimum energy cost with saving of 2.77% compared with TOU tariff. When more load are flexible loads and could be shift according to the ETOU power price by the customer, the more energy cost saving could be achieved.

CHAPTER 5

CONCLUSSION & RECOMMENDATION

5.1 Conclusion

In order to configure the effectiveness of TOU and ETOU tariff for industrial demand side. The industry energy profile on January, 25 2015 has been used. From final result, the TOU tariff is more suitable for sector which fully operation during high peak time such as Industrial sector since the energy saving is 5.32% lower than ETOU tariff. However, referring to Appendix I, if the customer maximum demand is in medium peak, the ETOU tariff could give the more saving in electricity cost compared with TOU tariff pricing [17]. It was shown that the energy profile pattern could give big impact to energy cost for demand side tariff selection.

Since the ETOU energy pricing is fix for the next day, consumer may shift their loads from high price period to low price period in this day in order to minimize their energy cost. This research represents a load optimization method to ETOU tariff pricing for demand side management in order to save the customer' energy cost as much as possible. Optimal load responses of industrial load in Industrial sector are studied. The energy cost decrease up to 77.3% due to optima load response to ETOU tariff. Meanwhile, the energy cost decreased up to 76.02% if compared with TOU tariff pricing. The ETOU tariff is fully effective when the energy cost saving by using new energy profile is decreased about 2.77% compared with TOU tariff which mean ETOU tariff offer the minimum energy cost. When more load are the flexible load and could be shifted according to the ETOU power price by the customer, the more energy cost saving could be achieved.

Simulation results shown that the optimal load response to ETOU tariff for demand side management generates different energy profile. The peak electricity consumption is reduce and the off peak electricity consumption is increased significantly. This kind of load pattern may also have a significant effect on the power system normal operation.

5.2 Recommendation

In order to get more convincing solution, further development can be suggested:

1. To consider the various sector of energy profile (industry, commercial and residence) in analyzing the effect of TOU and ETOU tariff to energy costing for demand side management.
2. To implement the combination of Genetic Algorithm (GA) and NN for load optimization and forecasting.

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APPENDIX A: Graph Correlation of Energy Profile for TOU tariff

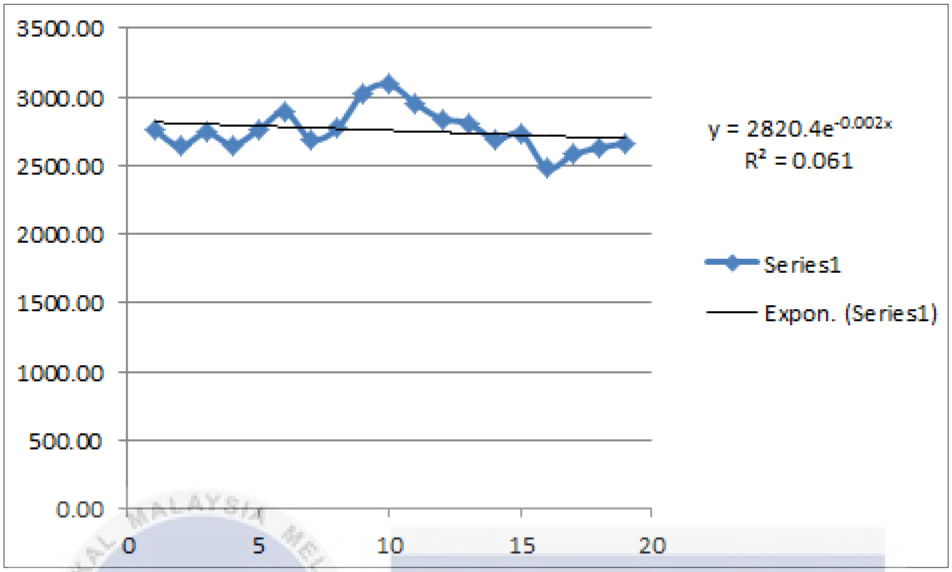

Figure 7.1: Graph correlation between energy profile and time for TOU off peak time zone

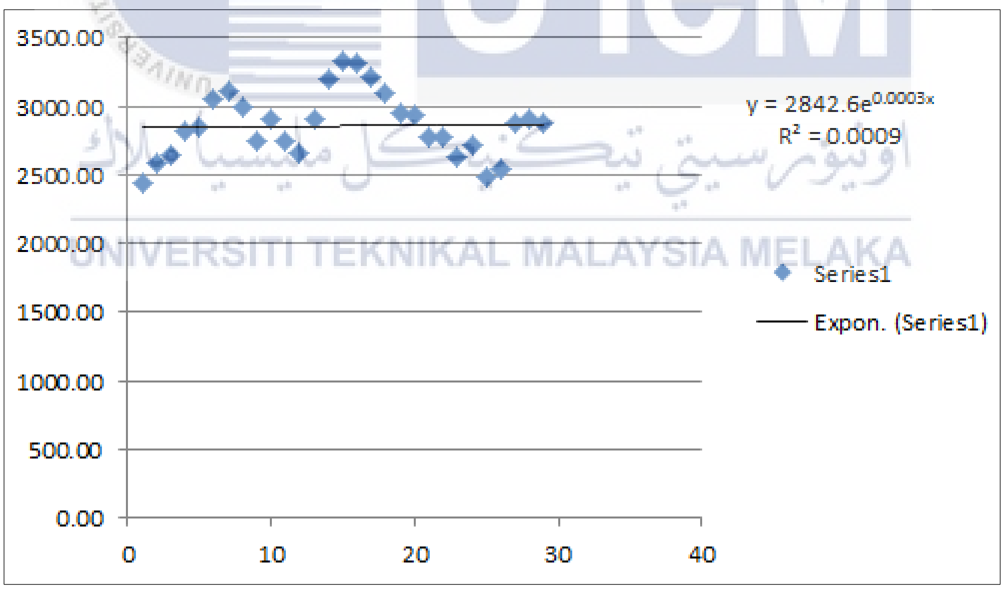

Figure 7.2: Graph correlation between energy profile and time for TOU off peak time zone

APPENDIX B : New Graph Correlation of Energy Profile for TOU tariff

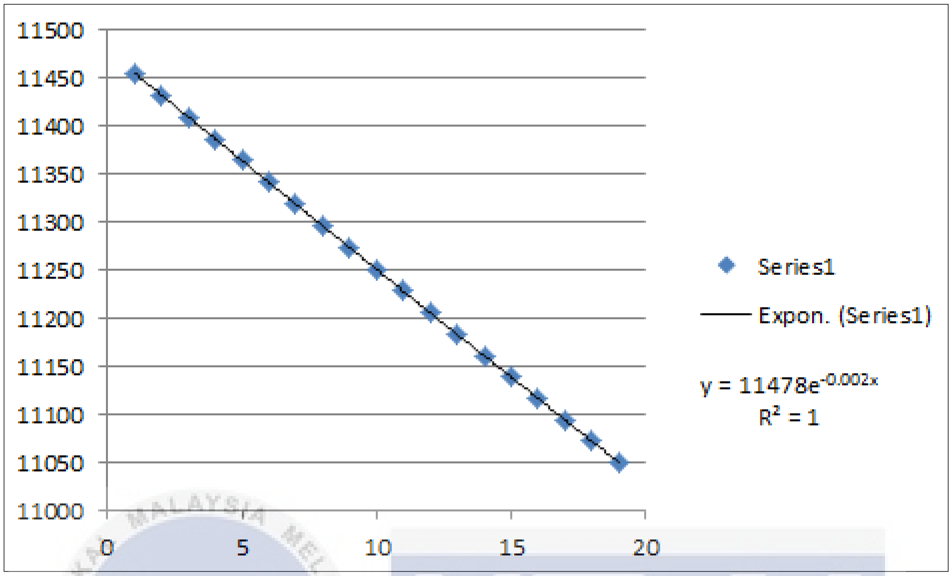

Figure 7.3: New graph correlation between energy profile and time for TOU off peak time zone

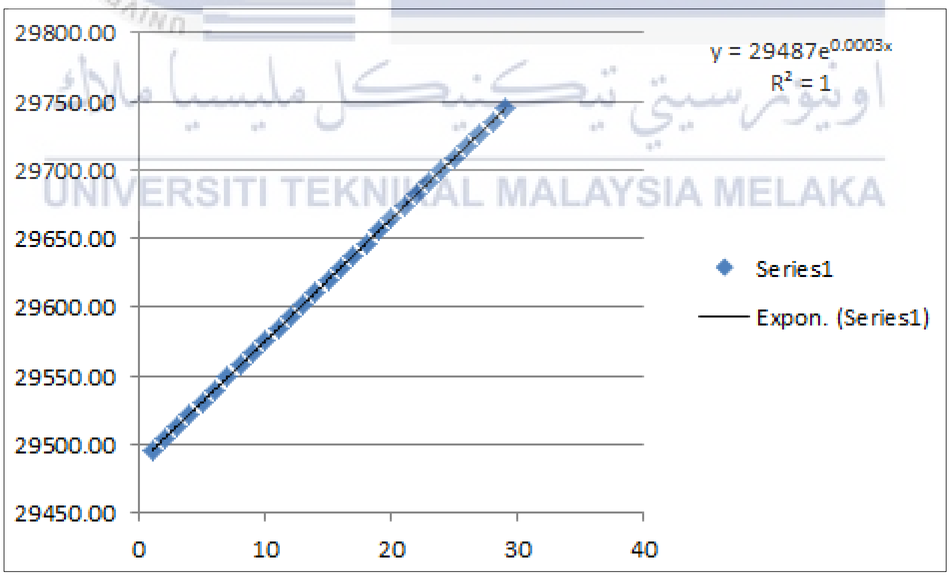

Figure 7.4: New graph correlation between energy profile and time for TOU peak time zone

APPENDIX C: Graph Correlation of Energy Profile for ETOU tariff

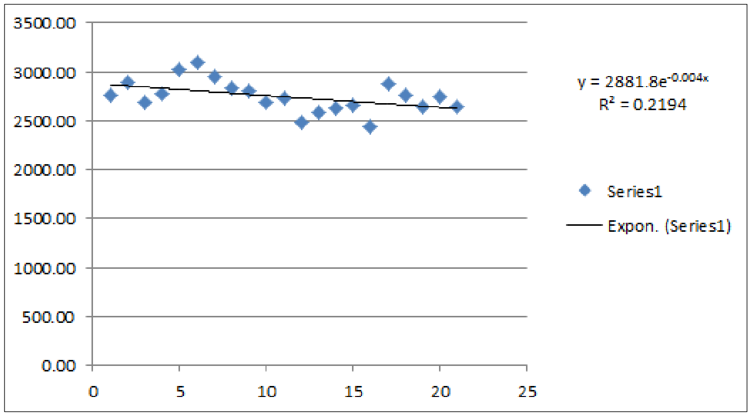

Figure 7.5: Graph correlation between energy profile and time for ETOU off peak time zone

Figure 7.6: Graph correlation between energy profile and time for ETOU medium peak zone

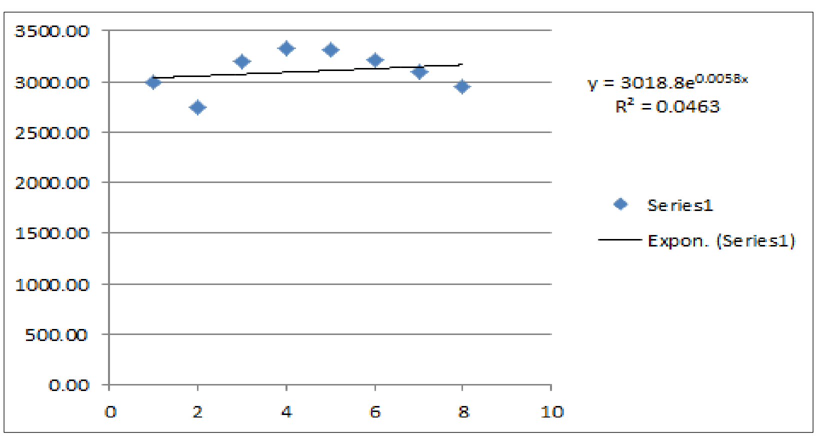

Figure 7.7: Graph correlation between energy profile and time for ETOU peak time zone

APPENDIX D: New Graph Correlation of Energy Profile for ETOU tariff

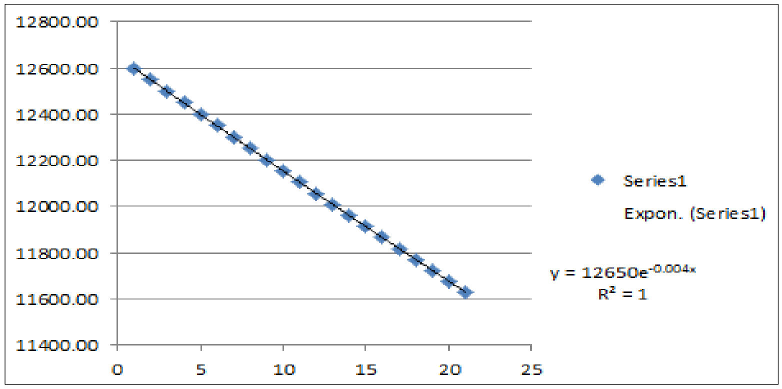

Figure 7.8: New graph correlation between energy profile and time for ETOU off peak time

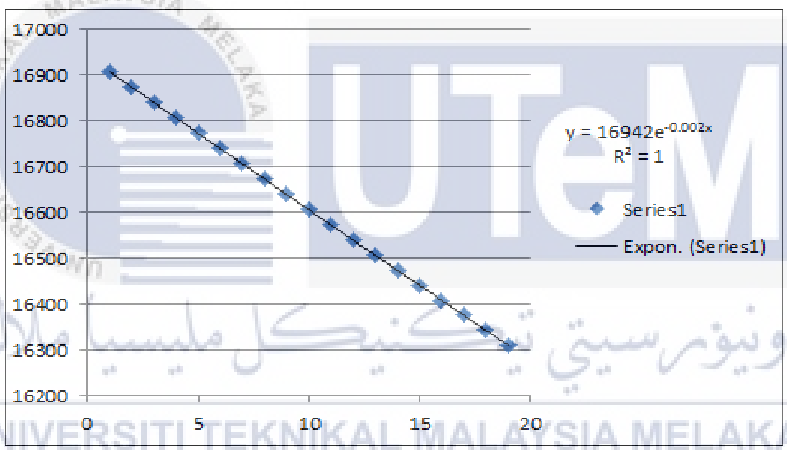

Figure 7.9: New graph correlation between energy profile and time for ETOU medium time

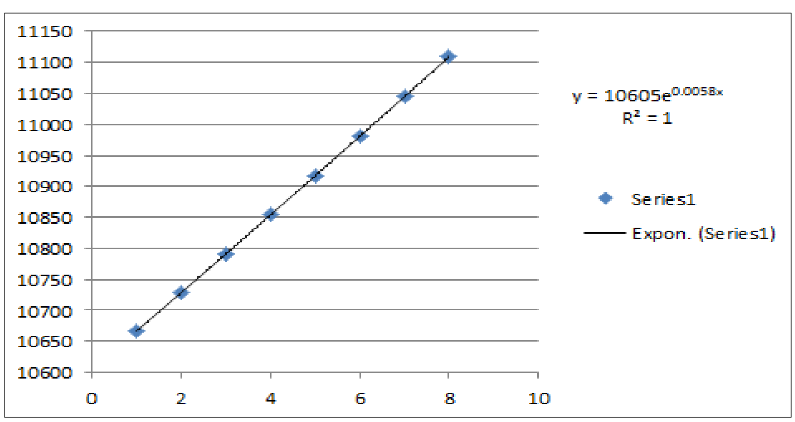

Figure 7.10: New graph correlation between energy profile and time for ETOU peak time zone

APPENDIX E : Industrial Energy Profile

Table 7.1: Actual average energy profile in (kW) for February, 8 2016 until February, 12 2016

No/Time	8/2/2016	9/2/2016	10/2/2016	11/2/2016	12/2/2016
1	2060	1950	2220	2760	3080
2	1990	1860	2250	2990	2960
3	1900	1850	2080	2800	2640
4	1860	1810	2000	2730	2540
5	1890	1940	2090	2980	2720
6	1890	1830	2120	3040	2820
7	1850	1850	2200	2870	3070
8	1860	1820	2080	2920	2840
9	1860	1880	2050	2960	2560
10	1920	1870	2000	2880	2690
11	1760	1850	2090	2480	2580
12	1760	1850	2030	2340	2580
13	1740	1830	2050	2360	2550
14	1760	1910	1990	2610	2430
15	1770	1810	1950	2600	2810
16	1660	1810	2130	2560	2930
17	1690	1820	2190	2540	2920
18	1740	1860	2300	2840	2660
19	1760	2000	2450	2850	2780
20	1830	1990	2470	2840	2760
21	1760	1940	2540	2890	2750
22	1810	1990	2650	2890	2850
23	1870	2020	2650	2820	2920
24	1920	2010	2640	2970	3080
25	1920	2050	2640	3040	3120

26	2020	2130	2810	3080	2950
27	1870	2010	2880	2690	2870
28	1850	1990	2900	2710	2840
29	1870	2020	3080	3010	2750
30	1860	2130	3140	3010	2930
31	1970	2230	3250	3100	3040
32	1870	2230	3170	3250	2970
33	1830	2320	2990	3240	2880
34	1840	2170	2810	3030	2790
35	1810	2190	2630	2770	2680
36	1910	2120	2730	2690	2600
37	1750	2170	2980	2770	2630
38	1720	2130	3070	2770	2600
39	1770	2120	2980	2610	2690
40	1950	2140	2910	2690	2640
41	1840	2180	2860	2680	2860
42	1810	2200	2670	2690	2960
43	1810	2160	2860	2520	2930
44	1990	2180	3130	2620	2870
45	1890	2160	3060	2460	2760
46	1850	2290	2950	2530	2710
47	1900	2230	3000	3040	2900
48	1940	2230	2820	3060	2840

Table 7.2: Actual average energy profile in (kW) for February, 15 2016 until February, 19 2016

No/Time	15/2/2016	16/2/2016	17/2/2016	18/2/2016	19/2/2016
1	3020	2780	2590	2610	3080
2	2860	2530	2680	2510	2940
3	2740	2610	2440	2620	2650
4	2600	2710	2570	2640	2510
5	2670	2800	2750	2660	2650
6	2630	2800	2690	2640	3010
7	2640	2810	2790	2570	3220
8	2500	2910	2750	2410	3140
9	2490	2830	2480	2620	2780
10	2800	2730	2500	2720	2600
11	2480	2570	2490	2830	2470
12	2460	2420	2410	2790	2360
13	2460	2470	2360	2730	2730
14	2440	2450	2320	2560	2740
15	2460	2390	2460	2320	2770
16	2540	2440	2620	2370	2920
17	2840	2630	2480	2470	2840
18	3110	2630	2850	2640	2630
19	3080	2770	2870	2620	2720
20	2870	2780	2920	2590	2710
21	2810	2620	2850	2560	2530
22	2910	2630	2930	2680	2710
23	3080	2830	2930	2860	2740
24	3170	3050	2900	3120	2960
25	3160	3080	2920	3060	3010
26	3120	3000	2750	3020	2710
27	2700	2540	2480	2900	2730

28	2590	2480	2460	2800	2800
29	2780	2950	2690	2850	2810
30	2910	2940	2770	2960	3120
31	2850	2880	2830	2940	3240
32	2840	2960	2950	3020	3260
33	2790	2830	3230	3010	3180
34	2820	2890	3220	3040	3180
35	2970	2720	3230	2970	2980
36	2530	2570	3080	3070	3000
37	2710	2640	2750	3220	2840
38	2830	2640	2780	3130	2870
39	3010	2800	2870	3050	2990
40	2960	2620	2980	3080	2890
41	2910	2780	2970	3100	2810
42	2730	2600	2930	3020	2860
43	2840	2610	2940	2760	2860
44	2820	2570	2940	2670	2750
45	2730	2540	2900	2670	2660
46	2690	2750	2770	2670	2560
47	2830	2860	2610	2970	2700
48	3020	2680	2620	3090	3030

Table 7.3: Actual average energy profile in (kW) for February, 22 2016 until February, 25 2016

No/Time	22/2/2016	23/2/2016	24/2/2016	25/2/2016
1	2490	3050	2790	2760
2	2470	2930	2580	2890
3	2380	2590	2430	2690
4	2210	2600	2580	2770
5	2330	2870	2680	3030
6	2720	3040	2760	3090
7	2870	3060	2770	2950
8	2890	2970	2750	2840
9	2780	2840	2690	2810
10	2440	2780	2630	2690
11	2290	2600	2700	2730
12	2230	2620	2500	2480
13	2130	2420	2570	2580
14	2210	2350	2450	2630
15	2450	2560	2460	2660
16	2370	2610	2490	2440
17	2550	2400	2480	2580
18	2780	2380	2710	2640
19	2690	2870	2850	2820
20	2650	3190	2800	2850
21	2440	3190	3080	3050
22	2900	3170	3220	3110
23	2980	2870	3290	3000
24	2770	2840	3220	2740
25	2700	2820	3050	2900
26	2560	2810	2680	2740
27	2370	2610	2420	2660

28	2360	2740	2720	2910
29	2500	2940	2980	3200
30	3000	3090	3160	3330
31	3150	3050	3090	3320
32	3150	3070	3140	3210
33	2990	3160	3030	3090
34	2610	3100	2950	2950
35	2510	3050	2940	2930
36	2470	2870	2780	2780
37	2520	2930	2700	2780
38	2410	2920	2870	2630
39	2530	2750	2890	2720
40	2580	2660	2940	2490
41	2480	2650	3000	2540
42	2540	2800	3040	2880
43	2570	2580	3160	2900
44	2730	2590	2940	2880
45	2600	2590	2790	2760
46	2900	2780	2740	2640
47	3210	2860	2620	2740
48	3090	2710	2730	2650

APPENDIX F : Industrial Energy Cost

Table 7.4: Actual energy cost, EC in (RM) for February, 8 2016 until February, 12 2016

No/Time	8/2/2016	9/2/2016	10/2/2016	11/2/2016	12/2/2016
1	451.14	427.05	486.18	604.44	674.52
2	435.81	407.34	492.75	654.81	648.24
3	416.10	405.15	455.52	613.20	578.16
4	407.34	396.39	438.00	597.87	556.26
5	413.91	424.86	457.71	652.62	595.68
6	413.91	400.77	464.28	665.76	617.58
7	405.15	405.15	481.80	628.53	672.33
8	407.34	398.58	455.52	639.48	621.96
9	407.34	411.72	448.95	648.24	560.64
10	420.48	409.53	438.00	630.72	589.11
11	385.44	405.15	457.71	543.12	565.02
12	385.44	405.15	444.57	512.46	565.02
13	381.06	400.77	448.95	516.84	558.45
14	385.44	418.29	435.81	571.59	532.17
15	387.63	396.39	427.05	569.40	615.39
16	363.54	396.39	466.47	560.64	641.67
17	540.80	582.40	700.80	812.80	934.40
18	556.80	595.20	736.00	908.80	851.20
19	563.20	640.00	784.00	912.00	889.60
20	585.60	636.80	790.40	908.80	883.20
21	563.20	620.80	812.80	924.80	880.00
22	579.20	636.80	848.00	924.80	912.00
23	800.36	864.56	1134.20	1206.96	1249.76
24	821.76	860.28	1129.92	1271.16	1318.24
25	614.40	656.00	844.80	972.80	998.40

26	646.40	681.60	899.20	985.60	944.00
27	598.40	643.20	921.60	860.80	918.40
28	592.00	636.80	928.00	867.20	908.80
29	800.36	864.56	1318.24	1288.28	1177.00
30	796.08	911.64	1343.92	1288.28	1254.04
31	843.16	954.44	1391.00	1326.80	1301.12
32	800.36	954.44	1356.76	1391.00	1271.16
33	783.24	992.96	1279.72	1386.72	1232.64
34	787.52	928.76	1202.68	1296.84	1194.12
35	579.20	700.80	841.60	886.40	857.60
36	611.20	678.40	873.60	860.80	832.00
37	560.00	694.40	953.60	886.40	841.60
38	550.40	681.60	982.40	886.40	832.00
39	566.40	678.40	953.60	835.20	860.80
40	624.00	684.80	931.20	860.80	844.80
41	588.80	697.60	915.20	857.60	915.20
42	579.20	704.00	854.40	860.80	947.20
43	579.20	691.20	915.20	806.40	937.60
44	435.81	477.42	685.47	573.78	628.53
45	413.91	473.04	670.14	538.74	604.44
46	405.15	501.51	646.05	554.07	593.49
47	416.10	488.37	657.00	665.76	635.10
48	424.86	488.37	617.58	670.14	621.96

Table 7.5: Actual energy cost, EC in (RM) for February, 15 2016 until February, 19 2016

No/Time	15/2/2016	16/2/2016	17/2/2016	18/2/2016	19/2/2016
1	661.38	608.82	567.21	571.59	674.52
2	626.34	554.07	586.92	549.69	643.86
3	600.06	571.59	534.36	573.78	580.35
4	569.40	593.49	562.83	578.16	549.69
5	584.73	613.20	602.25	582.54	580.35
6	575.97	613.20	589.11	578.16	659.19
7	578.16	615.39	611.01	562.83	705.18
8	547.50	637.29	602.25	527.79	687.66
9	545.31	619.77	543.12	573.78	608.82
10	613.20	597.87	547.50	595.68	569.40
11	543.12	562.83	545.31	619.77	540.93
12	538.74	529.98	527.79	611.01	516.84
13	538.74	540.93	516.84	597.87	597.87
14	534.36	536.55	508.08	560.64	600.06
15	538.74	523.41	538.74	508.08	606.63
16	556.26	534.36	573.78	519.03	639.48
17	908.80	841.60	793.60	790.40	908.80
18	995.20	841.60	912.00	844.80	841.60
19	985.60	886.40	918.40	838.40	870.40
20	918.40	889.60	934.40	828.80	867.20
21	899.20	838.40	912.00	819.20	809.60
22	931.20	841.60	937.60	857.60	867.20
23	1318.24	1211.24	1254.04	1224.08	1172.72
24	1356.76	1305.40	1241.20	1335.36	1266.88
25	1011.20	985.60	934.40	979.20	963.20
26	998.40	960.00	880.00	966.40	867.20
27	864.00	812.80	793.60	928.00	873.60
28	828.80	793.60	787.20	896.00	896.00

29	1189.84	1262.60	1151.32	1219.80	1202.68
30	1245.48	1258.32	1185.56	1266.88	1335.36
31	1219.80	1232.64	1211.24	1258.32	1386.72
32	1215.52	1266.88	1262.60	1292.56	1395.28
33	1194.12	1211.24	1382.44	1288.28	1361.04
34	1206.96	1236.92	1378.16	1301.12	1361.04
35	950.40	870.40	1033.60	950.40	953.60
36	809.60	822.40	985.60	982.40	960.00
37	867.20	844.80	880.00	1030.40	908.80
38	905.60	844.80	889.60	1001.60	918.40
39	963.20	896.00	918.40	976.00	956.80
40	947.20	838.40	953.60	985.60	924.80
41	931.20	889.60	950.40	992.00	899.20
42	873.60	832.00	937.60	966.40	915.20
43	908.80	835.20	940.80	883.20	915.20
44	617.58	562.83	643.86	584.73	602.25
45	597.87	556.26	635.10	584.73	582.54
46	589.11	602.25	606.63	584.73	560.64
47	619.77	626.34	571.59	650.43	591.30
48	661.38	586.92	573.78	676.71	663.57

Table 7.6: Actual energy cost, EC (RM) for February, 22 2016 until February, 25 2016

No/Time	22/2/2016	23/2/2016	24/2/2016	25/2/2016
1	545.31	667.95	611.01	604.44
2	540.93	641.67	565.02	632.91
3	521.22	567.21	532.17	589.11
4	483.99	569.40	565.02	606.63
5	510.27	628.53	586.92	663.57
6	595.68	665.76	604.44	676.71
7	628.53	670.14	606.63	646.05
8	632.91	650.43	602.25	621.96
9	608.82	621.96	589.11	615.39
10	534.36	608.82	575.97	589.11
11	501.51	569.40	591.30	597.87
12	488.37	573.78	547.50	543.12
13	466.47	529.98	562.83	565.02
14	483.99	514.65	536.55	575.97
15	536.55	560.64	538.74	582.54
16	519.03	571.59	545.31	534.36
17	816.00	768.00	793.60	825.60
18	889.60	761.60	867.20	844.80
19	860.80	918.40	912.00	902.40
20	848.00	1020.80	896.00	912.00
21	780.80	1020.80	985.60	976.00
22	928.00	1014.40	1030.40	995.20
23	1275.44	1228.36	1408.12	1284.00
24	1185.56	1215.52	1378.16	1172.72
25	864.00	902.40	976.00	928.00
26	819.20	899.20	857.60	876.80
27	758.40	835.20	774.40	851.20
28	755.20	876.80	870.40	931.20

29	1070.00	1258.32	1275.44	1369.60
30	1284.00	1322.52	1352.48	1425.24
31	1348.20	1305.40	1322.52	1420.96
32	1348.20	1313.96	1343.92	1373.88
33	1279.72	1352.48	1296.84	1322.52
34	1117.08	1326.80	1262.60	1262.60
35	803.20	976.00	940.80	937.60
36	790.40	918.40	889.60	889.60
37	806.40	937.60	864.00	889.60
38	771.20	934.40	918.40	841.60
39	809.60	880.00	924.80	870.40
40	825.60	851.20	940.80	796.80
41	793.60	848.00	960.00	812.80
42	812.80	896.00	972.80	921.60
43	822.40	825.60	1011.20	928.00
44	597.87	567.21	643.86	630.72
45	569.40	567.21	611.01	604.44
46	635.10	608.82	600.06	578.16
47	702.99	626.34	573.78	600.06
48	676.71	593.49	597.87	580.35

APPENDIX G : Normalization Data of Energy Profile

Table 7.7: Normalized input data for actual average energy profile from February, 8 2016 until February, 12 2016

No/Time	8/2/2016	9/2/2016	10/2/2016	11/2/2016	12/2/2016
1	1.0000	-0.4510	-0.5846	-0.0769	0.8841
2	0.6500	-0.8039	-0.5385	0.4286	0.5362
3	0.2000	-0.8431	-0.8000	0.0110	-0.3913
4	0.0000	-1.0000	-0.9231	-0.1429	-0.6812
5	0.1500	-0.4902	-0.7846	0.4066	-0.1594
6	0.1500	-0.9216	-0.7385	0.5385	0.1304
7	-0.0500	-0.8431	-0.6154	0.1648	0.8551
8	0.0000	-0.9608	-0.8000	0.2747	0.1884
9	0.0000	-0.7255	-0.8462	0.3626	-0.6232
10	0.3000	-0.7647	-0.9231	0.1868	-0.2464
11	-0.5000	-0.8431	-0.7846	-0.6923	-0.5652
12	-0.5000	-0.8431	-0.8769	-1.0000	-0.5652
13	-0.6000	-0.9216	-0.8462	-0.9560	-0.6522
14	-0.5000	-0.6078	-0.9385	-0.4066	-1.0000
15	-0.4500	-1.0000	-1.0000	-0.4286	0.1014
16	-1.0000	-1.0000	-0.7231	-0.5165	0.4493
17	-0.8500	-0.9608	-0.6308	-0.5604	0.4203
18	-0.6000	-0.8039	-0.4615	0.0989	-0.3333
19	-0.5000	-0.2549	-0.2308	0.1209	0.0145
20	-0.1500	-0.2941	-0.2000	0.0989	-0.0435
21	-0.5000	-0.4902	-0.0923	0.2088	-0.0725
22	-0.2500	-0.2941	0.0769	0.2088	0.2174
23	0.0500	-0.1765	0.0769	0.0549	0.4203
24	0.3000	-0.2157	0.0615	0.3846	0.8841

25	0.3000	-0.0588	0.0615	0.5385	1.0000
26	0.8000	0.2549	0.3231	0.6264	0.5072
27	0.0500	-0.2157	0.4308	-0.2308	0.2754
28	-0.0500	-0.2941	0.4615	-0.1868	0.1884
29	0.0500	-0.1765	0.7385	0.4725	-0.0725
30	0.0000	0.2549	0.8308	0.4725	0.4493
31	0.5500	0.6471	1.0000	0.6703	0.7681
32	0.0500	0.6471	0.8769	1.0000	0.5652
33	-0.1500	1.0000	0.6000	0.9780	0.3043
34	-0.1000	0.4118	0.3231	0.5165	0.0435
35	-0.2500	0.4902	0.0462	-0.0549	-0.2754
36	0.2500	0.2157	0.2000	-0.2308	-0.5072
37	-0.5500	0.4118	0.5846	-0.0549	-0.4203
38	-0.7000	0.2549	0.7231	-0.0549	-0.5072
39	-0.4500	0.2157	0.5846	-0.4066	-0.2464
40	0.4500	0.2941	0.4769	-0.2308	-0.3913
41	-0.1000	0.4510	0.4000	-0.2527	0.2464
42	-0.2500	0.5294	0.1077	-0.2308	0.5362
43	-0.2500	0.3725	0.4000	-0.6044	0.4493
44	0.6500	0.4510	0.8154	-0.3846	0.2754
45	0.1500	0.3725	0.7077	-0.7363	-0.0435
46	-0.0500	0.8824	0.5385	-0.5824	-0.1884
47	0.2000	0.6471	0.6154	0.5385	0.3623
48	0.4000	0.6471	0.3385	0.5824	0.1884

Table 7.8: Normalized input data for actual average energy profile from February, 15 2016 until February, 19 2016

No/Time	15/2/2016	16/2/2016	17/2/2016	18/2/2016	19/2/2016
1	0.5890	0.1304	-0.4066	-0.3556	0.6000
2	0.1507	-0.5942	-0.2088	-0.5778	0.2889
3	-0.1781	-0.3623	-0.7363	-0.3333	-0.3556
4	-0.5616	-0.0725	-0.4505	-0.2889	-0.6667
5	-0.3699	0.1884	-0.0549	-0.2444	-0.3556
6	-0.4795	0.1884	-0.1868	-0.2889	0.4444
7	-0.4521	0.2174	0.0330	-0.4444	0.9111
8	-0.8356	0.5072	-0.0549	-0.8000	0.7333
9	-0.8630	0.2754	-0.6484	-0.3333	-0.0667
10	-0.0137	-0.0145	-0.6044	-0.1111	-0.4667
11	-0.8904	-0.4783	-0.6264	0.1333	-0.7556
12	-0.9452	-0.9130	-0.8022	0.0444	-1.0000
13	-0.9452	-0.7681	-0.9121	-0.0889	-0.1778
14	-1.0000	-0.8261	-1.0000	-0.4667	-0.1556
15	-0.9452	-1.0000	-0.6923	-1.0000	-0.0889
16	-0.7260	-0.8551	-0.3407	-0.8889	0.2444
17	0.0959	-0.3043	-0.6484	-0.6667	0.0667
18	0.8356	-0.3043	0.1648	-0.2889	-0.4000
19	0.7534	0.1014	0.2088	-0.3333	-0.2000
20	0.1781	0.1304	0.3187	-0.4000	-0.2222
21	0.0137	-0.3333	0.1648	-0.4667	-0.6222
22	0.2877	-0.3043	0.3407	-0.2000	-0.2222
23	0.7534	0.2754	0.3407	0.2000	-0.1556
24	1.0000	0.9130	0.2747	0.7778	0.3333
25	0.9726	1.0000	0.3187	0.6444	0.4444
26	0.8630	0.7681	-0.0549	0.5556	-0.2222
27	-0.2877	-0.5652	-0.6484	0.2889	-0.1778

28	-0.5890	-0.7391	-0.6923	0.0667	-0.0222
29	-0.0685	0.6232	-0.1868	0.1778	0.0000
30	0.2877	0.5942	-0.0110	0.4222	0.6889
31	0.1233	0.4203	0.1209	0.3778	0.9556
32	0.0959	0.6522	0.3846	0.5556	1.0000
33	-0.0411	0.2754	1.0000	0.5333	0.8222
34	0.0411	0.4493	0.9780	0.6000	0.8222
35	0.4521	-0.0435	1.0000	0.4444	0.3778
36	-0.7534	-0.4783	0.6703	0.6667	0.4222
37	-0.2603	-0.2754	-0.0549	1.0000	0.0667
38	0.0685	-0.2754	0.0110	0.8000	0.1333
39	0.5616	0.1884	0.2088	0.6222	0.4000
40	0.4247	-0.3333	0.4505	0.6889	0.1778
41	0.2877	0.1304	0.4286	0.7333	0.0000
42	-0.2055	-0.3913	0.3407	0.5556	0.1111
43	0.0959	-0.3623	0.3626	-0.0222	0.1111
44	0.0411	-0.4783	0.3626	-0.2222	-0.1333
45	-0.2055	-0.5652	0.2747	-0.2222	-0.3333
46	-0.3151	0.0435	-0.0110	-0.2222	-0.5556
47	0.0685	0.3623	-0.3626	0.4444	-0.2444
48	0.5890	-0.1594	-0.3407	0.7111	0.4889

Table 7.9: Normalized input data for actual average energy profile from February, 22 2016 until February, 25 2016

No/Time	22/2/2016	23/2/2016	24/2/2016	25/2/2016
1	-0.3333	0.6667	-0.1494	-0.2809
2	-0.3704	0.3810	-0.6322	0.0112
3	-0.5370	-0.4286	-0.9770	-0.4382
4	-0.8519	-0.4048	-0.6322	-0.2584
5	-0.6296	0.2381	-0.4023	0.3258
6	0.0926	0.6429	-0.2184	0.4607
7	0.3704	0.6905	-0.1954	0.1461
8	0.4074	0.4762	-0.2414	-0.1011
9	0.2037	0.1667	-0.3793	-0.1685
10	-0.4259	0.0238	-0.5172	-0.4382
11	-0.7037	-0.4048	-0.3563	-0.3483
12	-0.8148	-0.3571	-0.8161	-0.9101
13	-1.0000	-0.8333	-0.6552	-0.6854
14	-0.8519	-1.0000	-0.9310	-0.5730
15	-0.4074	-0.5000	-0.9080	-0.5056
16	-0.5556	-0.3810	-0.8391	-1.0000
17	-0.2222	-0.8810	-0.8621	-0.6854
18	0.2037	-0.9286	-0.3333	-0.5506
19	0.0370	0.2381	-0.0115	-0.1461
20	-0.0370	1.0000	-0.1264	-0.0787
21	-0.4259	1.0000	0.5172	0.3708
22	0.4259	0.9524	0.8391	0.5056
23	0.5741	0.2381	1.0000	0.2584
24	0.1852	0.1667	0.8391	-0.3258
25	0.0556	0.1190	0.4483	0.0337
26	-0.2037	0.0952	-0.4023	-0.3258
27	-0.5556	-0.3810	-1.0000	-0.5056

28	-0.5741	-0.0714	-0.3103	0.0562
29	-0.3148	0.4048	0.2874	0.7079
30	0.6111	0.7619	0.7011	1.0000
31	0.8889	0.6667	0.5402	0.9775
32	0.8889	0.7143	0.6552	0.7303
33	0.5926	0.9286	0.4023	0.4607
34	-0.1111	0.7857	0.2184	0.1461
35	-0.2963	0.6667	0.1954	0.1011
36	-0.3704	0.2381	-0.1724	-0.2360
37	-0.2778	0.3810	-0.3563	-0.2360
38	-0.4815	0.3571	0.0345	-0.5730
39	-0.2593	-0.0476	0.0805	-0.3708
40	-0.1667	-0.2619	0.1954	-0.8876
41	-0.3519	-0.2857	0.3333	-0.7753
42	-0.2407	0.0714	0.4253	-0.0112
43	-0.1852	-0.4524	0.7011	0.0337
44	0.1111	-0.4286	0.1954	-0.0112
45	-0.1296	-0.4286	-0.1494	-0.2809
46	0.4259	0.0238	-0.2644	-0.5506
47	1.0000	0.2143	-0.5402	-0.3258
48	0.7778	-0.1429	-0.2874	-0.5281

APPENDIX H : Normalization Data of Energy Cost

Table 7.10: Normalized output data for actual energy cost from February, 8 2016 until February, 12 2016

No/Time	8/2/2016	9/2/2016	10/2/2016	11/2/2016	12/2/2016
1	-0.6347	-0.8972	-0.8773	-0.7906	-0.6378
2	-0.6986	-0.9633	-0.8637	-0.6759	-0.7047
3	-0.7808	-0.9706	-0.9409	-0.7707	-0.8830
4	-0.8174	-1.0000	-0.9773	-0.8056	-0.9387
5	-0.7900	-0.9046	-0.9364	-0.6809	-0.8384
6	-0.7900	-0.9853	-0.9228	-0.6510	-0.7827
7	-0.8265	-0.9706	-0.8864	-0.7358	-0.6434
8	-0.8174	-0.9927	-0.9409	-0.7108	-0.7715
9	-0.8174	-0.9486	-0.9546	-0.6909	-0.9276
10	-0.7626	-0.9559	-0.9773	-0.7308	-0.8551
11	-0.9087	-0.9706	-0.9364	-0.9302	-0.9164
12	-0.9087	-0.9706	-0.9636	-1.0000	-0.9164
13	-0.9269	-0.9853	-0.9546	-0.9900	-0.9331
14	-0.9087	-0.9266	-0.9818	-0.8654	-1.0000
15	-0.8995	-1.0000	-1.0000	-0.8704	-0.7883
16	-1.0000	-1.0000	-0.9182	-0.8903	-0.7214
17	-0.2608	-0.3764	-0.4320	-0.3163	0.0234
18	-0.1941	-0.3335	-0.3590	-0.0977	-0.1883
19	-0.1674	-0.1833	-0.2594	-0.0904	-0.0906
20	-0.0740	-0.1940	-0.2461	-0.0977	-0.1069
21	-0.1674	-0.2477	-0.1996	-0.0613	-0.1150
22	-0.1007	-0.1940	-0.1266	-0.0613	-0.0336
23	0.8215	0.5695	0.4672	0.5810	0.8258
24	0.9108	0.5552	0.4583	0.7272	1.0000

25	0.0461	-0.1297	-0.1333	0.0480	0.1862
26	0.1795	-0.0438	-0.0204	0.0771	0.0478
27	-0.0206	-0.1726	0.0261	-0.2070	-0.0173
28	-0.0473	-0.1940	0.0394	-0.1924	-0.0417
29	0.8215	0.5695	0.8490	0.7662	0.6406
30	0.8037	0.7274	0.9023	0.7662	0.8367
31	1.0000	0.8709	1.0000	0.8538	0.9564
32	0.8215	0.8709	0.9290	1.0000	0.8802
33	0.7501	1.0000	0.7691	0.9903	0.7822
34	0.7680	0.7848	0.6093	0.7856	0.6842
35	-0.1007	0.0205	-0.1399	-0.1487	-0.1720
36	0.0327	-0.0546	-0.0735	-0.2070	-0.2371
37	-0.1808	-0.0009	0.0925	-0.1487	-0.2127
38	-0.2208	-0.0438	0.1522	-0.1487	-0.2371
39	-0.1541	-0.0546	0.0925	-0.2653	-0.1639
40	0.0861	-0.0331	0.0460	-0.2070	-0.2046
41	-0.0607	0.0098	0.0128	-0.2143	-0.0255
42	-0.1007	0.0313	-0.1133	-0.2070	0.0560
43	-0.1007	-0.0116	0.0128	-0.3308	0.0315
44	-0.6986	-0.7283	-0.4638	-0.8604	-0.7548
45	-0.7900	-0.7430	-0.4956	-0.9402	-0.8161
46	-0.8265	-0.6476	-0.5456	-0.9053	-0.8440
47	-0.7808	-0.6916	-0.5229	-0.6510	-0.7381
48	-0.7443	-0.6916	-0.6047	-0.6410	-0.7715

Table 7.11: Normalized output data for actual energy cost from February, 15 2016 until February, 19 2016

No/Time	15/2/2016	16/2/2016	17/2/2016	18/2/2016	19/2/2016
1	-0.6911	-0.7816	-0.8647	-0.8465	-0.6410
2	-0.7763	-0.9216	-0.8197	-0.8994	-0.7108
3	-0.8402	-0.8768	-0.9399	-0.8412	-0.8554
4	-0.9148	-0.8208	-0.8748	-0.8306	-0.9252
5	-0.8775	-0.7704	-0.7846	-0.8200	-0.8554
6	-0.8988	-0.7704	-0.8147	-0.8306	-0.6759
7	-0.8935	-0.7648	-0.7646	-0.8676	-0.5712
8	-0.9680	-0.7087	-0.7846	-0.9523	-0.6111
9	-0.9734	-0.7536	-0.9198	-0.8412	-0.7906
10	-0.8083	-0.8096	-0.9098	-0.7882	-0.8803
11	-0.9787	-0.8992	-0.9148	-0.7300	-0.9452
12	-0.9893	-0.9832	-0.9549	-0.7512	-1.0000
13	-0.9893	-0.9552	-0.9800	-0.7829	-0.8155
14	-1.0000	-0.9664	-1.0000	-0.8729	-0.8105
15	-0.9893	-1.0000	-0.9299	-1.0000	-0.7956
16	-0.9467	-0.9720	-0.8497	-0.9735	-0.7208
17	-0.0894	-0.1862	-0.3469	-0.3175	-0.1076
18	0.1207	-0.1862	-0.0761	-0.1860	-0.2606
19	0.0974	-0.0716	-0.0614	-0.2014	-0.1950
20	-0.0661	-0.0634	-0.0248	-0.2246	-0.2023
21	-0.1127	-0.1944	-0.0761	-0.2478	-0.3335
22	-0.0349	-0.1862	-0.0175	-0.1550	-0.2023
23	0.9063	0.7592	0.7063	0.7310	0.4933
24	1.0000	1.0000	0.6769	1.0000	0.7077
25	0.1596	0.1821	-0.0248	0.1390	0.0163
26	0.1285	0.1166	-0.1493	0.1080	-0.2023
27	-0.1983	-0.2599	-0.3469	0.0152	-0.1877

28	-0.2839	-0.3090	-0.3615	-0.0622	-0.1367
29	0.5941	0.8905	0.4713	0.7206	0.5615
30	0.7294	0.8796	0.5497	0.8344	0.8636
31	0.6669	0.8139	0.6084	0.8138	0.9805
32	0.6565	0.9015	0.7259	0.8965	1.0000
33	0.6045	0.7592	1.0000	0.8862	0.9220
34	0.6357	0.8249	0.9902	0.9172	0.9220
35	0.0118	-0.1125	0.2021	0.0693	-0.0056
36	-0.3306	-0.2353	0.0923	0.1467	0.0090
37	-0.1906	-0.1780	-0.1493	0.2627	-0.1076
38	-0.0972	-0.1780	-0.1273	0.1931	-0.0857
39	0.0429	-0.0471	-0.0614	0.1312	0.0017
40	0.0040	-0.1944	0.0191	0.1544	-0.0712
41	-0.0349	-0.0634	0.0118	0.1699	-0.1295
42	-0.1750	-0.2108	-0.0175	0.1080	-0.0930
43	-0.0894	-0.2026	-0.0102	-0.0931	-0.0930
44	-0.7976	-0.8992	-0.6894	-0.8147	-0.8055
45	-0.8455	-0.9160	-0.7095	-0.8147	-0.8504
46	-0.8669	-0.7984	-0.7746	-0.8147	-0.9003
47	-0.7923	-0.7367	-0.8547	-0.6559	-0.8305
48	-0.6911	-0.8376	-0.8497	-0.5923	-0.6659

Table 7.12: Normalized output data for actual energy cost from February, 22 2016 until February, 25 2016

No/Time	22/2/2016	23/2/2016	24/2/2016	25/2/2016
1	-0.8212	-0.6341	-0.8200	-0.8427
2	-0.8311	-0.6968	-0.9250	-0.7788
3	-0.8758	-0.8745	-1.0000	-0.8771
4	-0.9603	-0.8693	-0.9250	-0.8378
5	-0.9006	-0.7282	-0.8750	-0.7099
6	-0.7069	-0.6393	-0.8350	-0.6804
7	-0.6324	-0.6288	-0.8300	-0.7493
8	-0.6225	-0.6759	-0.8400	-0.8033
9	-0.6771	-0.7438	-0.8700	-0.8181
10	-0.8460	-0.7752	-0.9000	-0.8771
11	-0.9205	-0.8693	-0.8650	-0.8574
12	-0.9503	-0.8588	-0.9650	-0.9803
13	-1.0000	-0.9634	-0.9300	-0.9312
14	-0.9603	-1.0000	-0.9900	-0.9066
15	-0.8410	-0.8902	-0.9850	-0.8918
16	-0.8808	-0.8641	-0.9700	-1.0000
17	-0.2072	-0.3952	-0.4031	-0.3462
18	-0.0402	-0.4105	-0.2350	-0.3031
19	-0.1056	-0.0362	-0.1328	-0.1738
20	-0.1346	0.2082	-0.1693	-0.1522
21	-0.2870	0.2082	0.0353	-0.0085
22	0.0469	0.1930	0.1376	0.0346
23	0.8350	0.7037	1.0000	0.6829
24	0.6311	0.6731	0.9316	0.4331
25	-0.0983	-0.0744	0.0134	-0.1163
26	-0.1999	-0.0820	-0.2570	-0.2312
27	-0.3378	-0.2348	-0.4469	-0.2887

28	-0.3451	-0.1355	-0.2277	-0.1091
29	0.3690	0.7752	0.6971	0.8751
30	0.8544	0.9285	0.8730	1.0000
31	1.0000	0.8876	0.8046	0.9904
32	1.0000	0.9080	0.8534	0.8847
33	0.8447	1.0000	0.7459	0.7694
34	0.4758	0.9387	0.6677	0.6349
35	-0.2362	0.1013	-0.0670	-0.0947
36	-0.2652	-0.0362	-0.1839	-0.2025
37	-0.2289	0.0096	-0.2424	-0.2025
38	-0.3088	0.0020	-0.1181	-0.3103
39	-0.2217	-0.1279	-0.1035	-0.2456
40	-0.1854	-0.1966	-0.0670	-0.4108
41	-0.2580	-0.2043	-0.0232	-0.3749
42	-0.2144	-0.0897	0.0061	-0.1307
43	-0.1927	-0.2577	0.0937	-0.1163
44	-0.7019	-0.8745	-0.7450	-0.7837
45	-0.7665	-0.8745	-0.8200	-0.8427
46	-0.6175	-0.7752	-0.8450	-0.9017
47	-0.4635	-0.7334	-0.9050	-0.8525
48	-0.5231	-0.8118	-0.8500	-0.8968

APPENDIX I: ETOU tariff With Industrial Load Profile

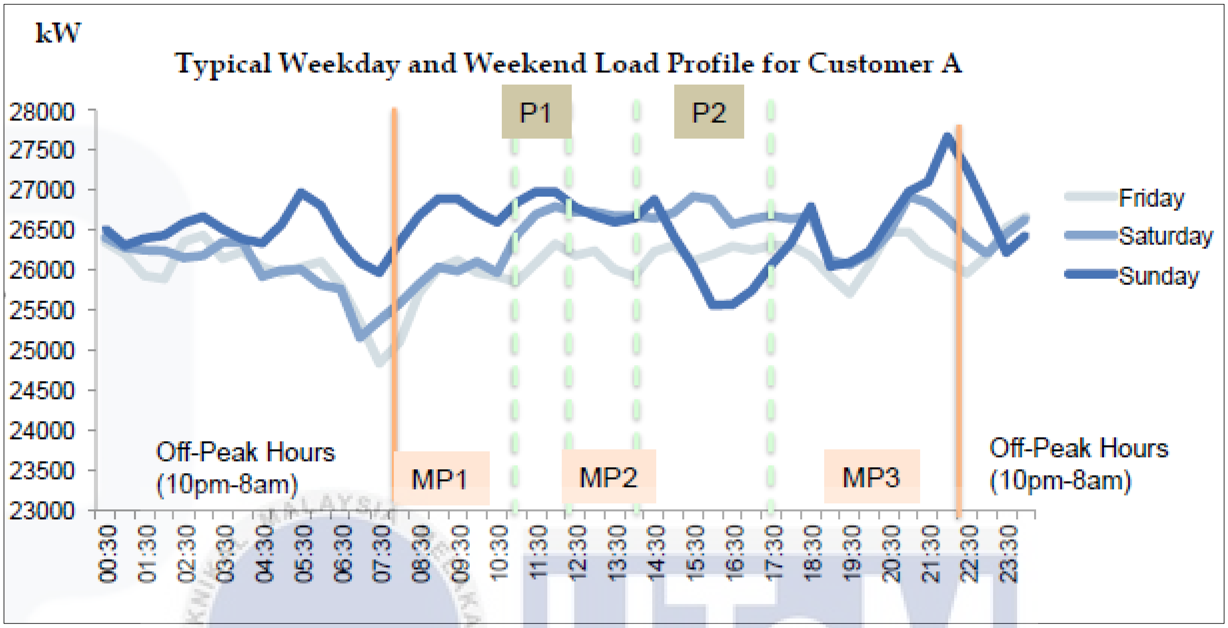

Figure 7.11: The industry load profile with max demand in medium peak region

Table 7.13 : The energy cost saving for TOU and ETOU tariff

Tariff	Energy Cost, (RM)	Saving (RM)
TOU	6,444,212.00	-
ETOU	6,383,308.00	109,749.30