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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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FOR DEMAND SITE TARIFF STRATEGY; PENINSULAR MALAYSIA CASE
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**A report submitted in partial fulfillment of the requirement for the degree of
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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

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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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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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CHAPTER 1

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 preferred for co-generators side respectively [3].

The image shows a screenshot of a news article on the Malaymail Online website. The article is titled "Government 'no option' but to raise power rates, PM says" and is dated Friday, May 16, 2014, at 06:45 PM GMT+8. The author is Syed Jaymal Zahid. The article features a large photo of Prime Minister Najib Razak speaking at a podium. To the left of the main article, there is a section titled "ICYMI" with a smaller photo of a man in a police uniform and a caption: "Seven caught in RM1.5m Bukit Aman fraud, claims IGP". To the right of the main article, there is a "MOST VIEWED" section with a list of related articles, including "At meeting with Maria Chin, Ambiga, NGO leaders, Obama says US backs their 'work'", "After meeting US president, Ambiga says Obama 'well aware' of Malaysia's issues", "Don't let Malays end up powerless like 'Red Indians', Zahid says", "Dr M: Malaysia will be like Singapore if Pakatan takes power", and "11pc of Malaysians are IS sympathisers, Pew Research poll shows".

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].

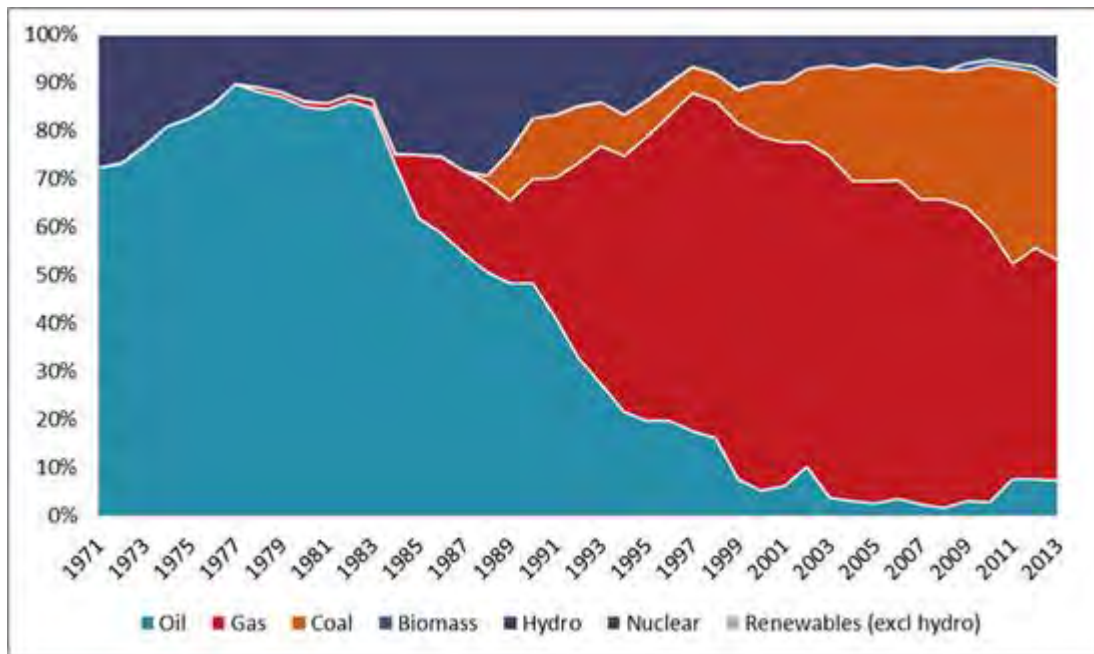


Figure 1.2: Malaysia power mix evolution from 1971 until 2013

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 2001 as 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].

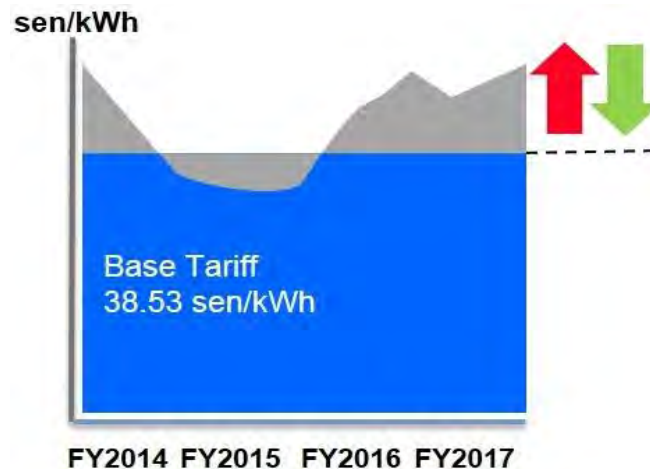


Figure 2.2: ICPT for year 2014 until 2017

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