PREDICTION OF ENERGY CONSUMPTION IN MALAYSIA USING STATISTICAL METHOD

By

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APPROVAL

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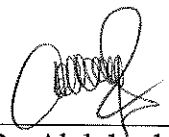

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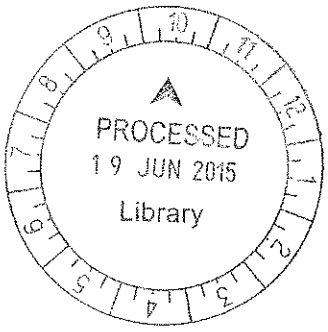

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DECLARATION

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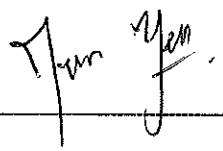
Signature: 

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ABSTRACT

The goal for this paper is to forecast the electricity consumption of Malaysia from 2014 to 2035 and also determine the factors that affect the electricity consumption. Linear regression analysis, Fourier Series and Singular Value Decomposition are being used to achieve the objective. From the results, it shows that gross domestic product and population have high impact on the electricity consumption of Malaysia. Two different approaches have been used where forecasting models are constructed using data from 1980 until 2012 and 2005 until 2012. Results show that in year 2035, the electricity consumption of Malaysia is going to increase to 762890 GWh with an increment of 7 to 11 percent annually. It also shows that models were constructed using data from 1980 to 2012 give better results. It is hope that this paper will become an important reference for the policy maker to come out with a plan to ensure enough supply of electricity for the country.

ACKNOWLEDGEMENTS

I will not be able to finish this project in time without the guidance and support from different sides which involved directly and indirectly to the completion of this project. I would like to thank Faculty of Science, Technology, Engineering and Mathematics (FOSTEM), INTI International University for giving me opportunity to finish my research during my studies.

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DEDICATION

To all staffs of BMEGI INTI International University

To Dr Abdulwehab, who is always supportive during this project

To my family members that give me full support and encouragements in any situations

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LIST OF ABBREVIATION

AI	Artificial Intelligence
ANN	Artificial Neural Network
ARIMA	Autoregressive Integrated Moving Average
CEB	National Electricity Board
FDI	Foreign Direct Investment
GDP	Gross Domestic Product
GM	Grey Model
GWh	Giga Watt hour
KeTTHA	Ministry of Energy, Green Technology and Water
Mtoe	Mega Ton of Oil Equivalent
NEB	National Electricity Board
PE	Processing Element
PSO	Particle Swarm Optimization
RE	Renewable Energy
RMSE	Root Mean Square Error
SEDA	Sustainable Energy Development Authority Malaysia
SVD	Singular Value Decomposition
TNB	Tenaga National Berhad
TWh	Tera Watt hour

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1 INTRODUCTION

1.1 Background

In the published paper by International Energy Agency, the world energy consumption shoots up to 8918 Mtoe which is 190% more than the energy consumption in 1973, 4674Mtoe. As shown in figure 1-1, in year 2011, electricity has become 2nd major energy being consumed. The role of electricity in country development caused electricity to become the major energy for a nation.

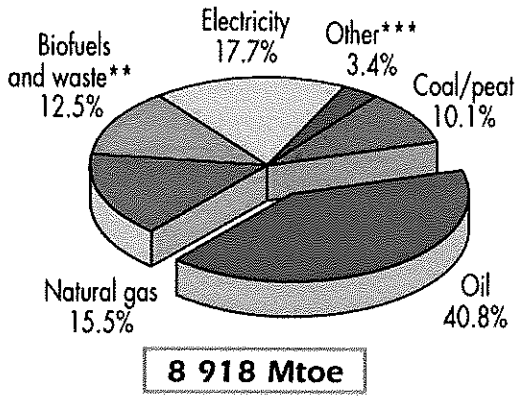

Figure 1-1 Distribution of energy consumption in 2011

(Energy Commission, 2014)

From the chart in figure 1-1, it can be seen that electricity is the 2nd major consumption in the world which occupied 17.7%. Pao (2009) stated that energy is the foundation of economic development and it is one of the vital infra-structural inputs in socioeconomic development. Therefore, electricity consumption forecasting for a nation is crucial to understand the future energy consumption so that the government can plan for the future needs.

There are few studies that have been done by researchers to predict the electricity demand of Malaysia. Ga and Li (2008) predicted that by year 2020, the electricity consumption of Malaysia will reach 116 mega ton of oil equivalent (Mtoe) while Keong (2005) also concluded that the electricity consumption of Malaysia to have a growth rate of 8.87% based on 8.1 annual growth rate in year 2005. It is expect that

the electricity consumption of Malaysia will increase more than Keong's prediction with the direction of world that is heading towards green technology in recent years. One of the main green products is hybrid vehicles. With increasing popularity of hybrid vehicles, demand of electricity is expected to increase as they are powered by electricity.

There are two different types of prediction method being used by researchers which are the statistical method and machine learning (AI) techniques. Both of the techniques are having their own difficulties. As stated by Zhao, Wang et al. (2014), the limitation for statistical method is because of the non-linearity in different model where they have limitation of linear assumption where AI method usually suffer from complicated model that is made up of different parameters. In this paper, 3 different types of statistical methods will be used to determine the energy consumption of Malaysia until year 2035 which are Fourier Series, Singular Value Decomposition model, and linear regression analysis.

The usage of electricity is varying due to various factors such as population, gross domestic product (GDP) and others. It is said that the demand of electricity is also depending on different seasons as monsoon season will have a high electricity demand because community will turn on lights to light up the environment at noon or in the morning. By looking at the electricity demand of Malaysia from 2010 until 2012 which is provided by Energy Commission, it can be seen that the electricity demand of Malaysia is increasing but not in a linear form. Therefore, there is a need of using different types of models to study the behaviour of energy consumption of Malaysia.

Table 1-1 Electricity consumption of Malaysia from 2009-2011

Year	**Electricity consumption (GWh)**	**Percentage of increment (%)**
2012	116660.5	8.62
2011	107403.1	2.69
2010	104588.6	-

Since all energy is hard to store, therefore electricity is being generated and use immediately without being reserved. This explains that the accuracy of electricity

consumption prediction is very important. A over estimation of electric demand will caused the nation to waste huge amount of money which can be used at other crucial development of the country. Other than that, it will also cause lots of time to be wasted at the construction of the plant. An underestimation will slow down the economy of the nation because of shortage of electricity. One of the examples of the underestimation of electricity demand happened in 2004 where China had a lack of electricity supply due to shortage of installed capacity. (Zhao, Wang et al., 2014).

1.2 Problem Statements

From studies, it is understood that 42.6% of the Malaysia power plants are coal fired and this caused high carbon footprint. This opposed the will of the nation to transfer to a low carbon emission country as coal creates lots of carbon dioxide, CO_2 when it is burned. This is also opposing the world idea of creating a greener earth.

Statistics shows that Malaysia is one of the countries with highest CO_2 emission in the world with 7.9% compounded average growth rate during 1990-2006. Until year 2020, the emission of greenhouse gases from Malaysia is expected to rise from 189 million tonnes to 382 million tonnes.

In Budget Malaysia 2015, Prime Minister of Malaysia, Datuk Seri Najib Tun Razak stated that all the subsidiaries will be reduced to help the nation to reduce the nation deficit from 3.5% to 3.0% by year 2015. Therefore, the electricity prediction for a nation is very crucial as the government can plan the expenses that are being used to build power plants to suit nation's needs and use the extra one for other sectors.

Other than that, up to 90% of Malaysia electric generation are generated using non-renewable energy which are coal and gas. At the fast rate of non-renewable energy depleting, electricity forecast is important so that the government can plan for better technology for generation such as renewable energy which is tide, wind and even nuclear in future so that Malaysia will have a continuous supply of electricity.

The result of this paper is very important as this will be an important reference for Malaysia government to come out with a long term energy policies where this can help to reduce the rate of depletion of the non-renewable resources in the country and also continuous supply of electricity to the nation.

1.3 Objectives of the Research

This project consists of 4 major objectives as listed:

- To understand the trend of electricity consumption for Malaysia until year 2035
- To develop statistical models to predict electricity consumption of Malaysia
- To study factors that affect the electricity consumption of Malaysia
- To give a clue for related authorities and Malaysia government on the increment of power generation facilities due to demand of nation from 2014 until 2035

1.4 Scope of the Research

There are several types of energy such as biomass, thermal, wind, gas and others which are available for study. In this paper, the only energy consumption which will be study is electrical energy.

There are lots of ways which are being used to carry out energy forecasting. But in this study, only three types of statistical methods which are Fourier Series, Singular Value Decomposition model (SVD), and linear regression model will be used to investigate the electricity consumption of Malaysia.

Throughout the studies, it is understood that there are lots of factors that will affect the electricity consumption of a nation such as season, fuel prices, political issues and others. In this paper, only 2 major factors are being considered in the prediction model which are gross domestic product (GDP) and population of Malaysia.

Researchers used different types of mathematical software such as Matlab and Microsoft Excel to build the mathematical model for energy prediction. In this paper, only Matlab software will be used to build statistical models and carry out electricity consumption forecasting.

1.5 Report Organization

The structure of the thesis is organized as follows into five chapters.

Chapter 1 gives the reader an overall view of the paper. It presents and discuss about the background electricity supply in Malaysia. Other than that, objectives, problem statement, scope of research in this thesis are also being stated in this chapter. In objectives, 4 major objectives for this research have been clearly described.

In Chapter 2, work done by researchers in Malaysia about electricity consumption forecasting in Malaysia will be discussed. Other research works which have been done by other researchers in forecasting electricity consumption using various prediction models will also be discussed.

In Chapter 3, methodology of this paper will be explained. In this chapter, flow charts will be presented to show the process for the whole research to be done. Other than that, the methods and approaches to the result of the research will also be shown. In this research, the modelling of 3 different mathematical models will be clearly shown.

In Chapter 4, discussion and result of this thesis been presented according to objectives of thesis. All the results which are obtained from the models will be compared with other papers to validate the accuracy of the results. Other than that, factors that caused the inaccuracy of the results will be discussed.

Chapter 5 summarize the successfulness of this project while discussing any future projects that can be carried out. Other than that, recommendations are also being discussed to give the next researchers ideas to increase the accuracy for their researchers.

2 LITERATURE REVIEW

2.1 Electricity in Malaysia

2.1.1 Governance and electricity service in Malaysia

In Malaysia, there are 4 major electricity suppliers which are Tenaga National Berhad (TNB), Sabah Electricity Sdn. BHD (SESB), Syarikat SESCO Berhad (SEB) and independent power producer (IPP). The flow of electricity supply in Peninsula Malaysia and East Malaysia is shown in figure 2-1 and 2-2 respectively.

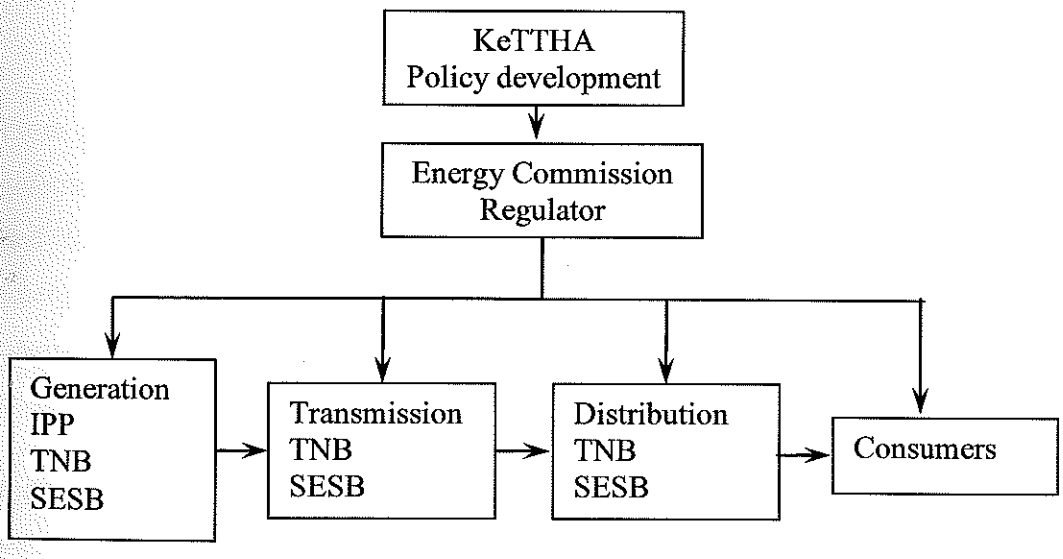

Figure 2-1 Governance and flow of electricity service for Peninsular Malaysia and Sabah

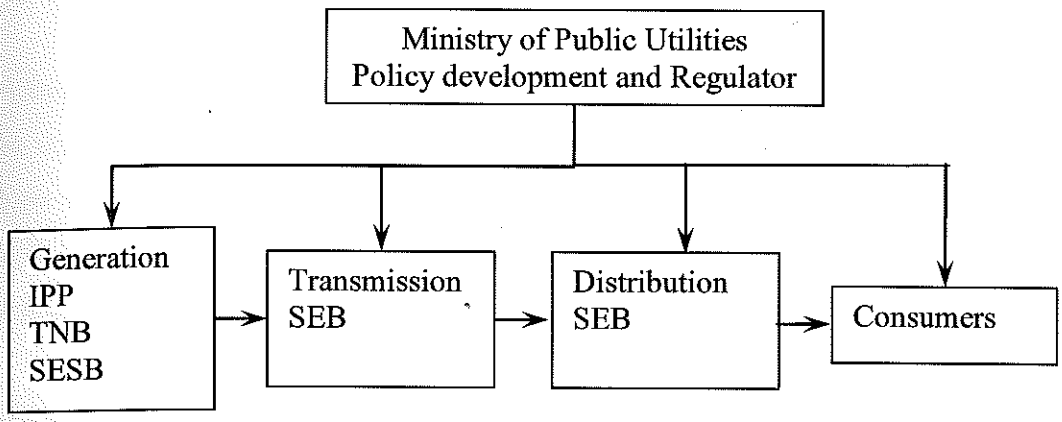

Figure 2-2 Governance and flow of electricity service for Sarawak

From figure 2-1, it can be seen that for Peninsular Malaysia and Sabah, electricity generation and supply is being monitored by Ministry of Energy, Green Technology and Water (KeTTHA). They are in charge of policy development and is assisted by Energy Commission for regulation. Under them are the three main electricity supplies components which are the generation, transmission and distribution followed by consumers.

Figure 2-3 shows the governance and flow of electricity service for Sarawak. It is be seen that the Ministry of Public Utilities is acts as the policy developer and regulator in Sarawak. In Sarawak, all the power generation is controlled by one company, SEB who owns Syarikat SECSO Berhad. Statistic shows that 33% of Sarawak does not have electricity supply because of poor regulation; therefore, it is proposed that a regulator should be introduced in Sarawak. (Energy Commission, 2014).

2.1.2 Power plants in Malaysia

According to Energy Commission, it is concluded that until year 2013, gas and coal are still the main fuel that is used to produce electricity where there are contributing 49.4% and 42.6% of power generation respectively. Until 2014, there are 30 different

types of plants operating in Malaysia generating a total capacity of 21060MW. Table 2-1 shows the types of plants in Malaysia and their capacity.

Although the nation is generating a total of 21060MW, but the power generation will be interrupted due to breakdown of power plants. Other than that, power plants also have their own lifetime. Table 2-2 shows some of the big power plants in Malaysia with their expiry date. A full list of power plants with expiry date can be view at the Appendix A.

Table 2-1 Capacity of different plants in Malaysia

No	Type	Fuel	Capacity (MW)
1.	Conventional Thermal	Coal	7056
2.	Combined Cycle Gas Turbine (CCGT)	Gas	9200
3.	Conventional Thermal	Gas	564
4.	Open Cycle Gas Turbine (OCGT)	Gas	2340.4
5.	Hydroelectric	Hydro	1899.1
6.	(Total Capacity (MW)		21060

Table 2-2 Big capacity power plant with expiry date (Energy Commission, 2014)

No	Power Plant	Fuel	Capacity (MW)	Expiry month and Year
1.	S.J. Jambatan Connaught	Gas	478	Aug 2014
2.	YTL Power Generation	Gas	1170	Sept 2015
3.	(Paka & P. Gudang)S.J. Sultan Ismail, Paka	Gas	1029	Aug 2017
4.	Segari Energy Ventures Sdn.Bhd	Gas	1303	June 2027
5.	Kapar Energy Ventures Sdn Bhd	Coal	1486	July 2029
6.	TNB Janamanjung Sdn. Bhd	Thermal	2100	Dec 2033
7.	Jimah Energy Ventures Sdn. Bhd	Thermal	1400	Aug 2037

From table 3, it can be seen that most of the power plants are using gas as fuel. The total capacity being generated in 2014 dropped by 478MW because of the retirement of S.J. Jambatan Connaught power plant. However, the service of a CCGT unit was extended for 4 years 4 months which is until 31st of December 2018. This is due to high electricity demand at the central region of Peninsular Malaysia. With this, Malaysia is generating only 20882MW of electricity in 2014 as there is no new power plant being completed in year 2014. In year 2015, 2 new power plants will be introduced which are TNB Janamanjung (Unit 4) and CBPS Redevelopment. These 2

plants are predicted to increase the power generation in Malaysia by 1394.7 MW as they are generating 1010MW and 384.7MW respectively. The commercial operation date for the Janamanjung plant will be on 31st of March 2015 while for CBPS plant; it will be on 1st of September 2015. Table 2-3 shows some of future generation projects until 2022. A complete list of projects can be viewed at the Appendix B.

Table 2-3 Future generation project (Energy Commission, 2014)

No	Projects	Fuel	Capacity (MW)	Commercial Operation Date
1.	TNB Janamanjung (Unit 4)	Coal	1010.00	31st March 2015
2.	CBPS Redevelopment	Gas	384.70	1st September 2015
3.	TNB Prai	Gas	1071.43	1st January 2016
4.	Tg. Bin Energy	Coal	1000.00	1st March 2016
5.	Tekai	Hydro	156.00	Dec 2020
6.	Telom	Hydro	132.00	Dec 2022

2.1.3 Energy policy of Malaysia

The first energy policy in Malaysia is being introduced by the Central Electricity Board (CED) or known as National Electricity Board (NEB) in year 1949. This policy had been used to create a more environmental-friendly energy development path. The first energy policy which brought a huge impact is the Petroleum Development Act 1974 which gives PETRONAS the exclusive rights to explore, develop and produce petroleum resources in Malaysia. (Oh, Pang et al., 2010)

In year 1979, the National Energy Policy was been introduced. This policy has 3 major objectives which are

1. Supply: To ensure the provision of adequate, secure, and cost-effective energy supplies through developing indigenous non- renewable and non-renewable energy resources using least cost options and diversification of supply sources both from within and outside Malaysia.

2. Utilization: To provide electricity supply to as many citizens as possible

3. Environmental: To minimize the negative impact to the environment due to urbanization (Jalal and Bodger, 2009).

Knowing that the rate of depletion for the oil reserve in Malaysia was too rapid, the Government came out with Four- Fuel Diversification Strategy Policy in year 1980. 4 different fuels which are oil, natural gas, coal and hydro have been introduced. This policy also accelerated the transition of oil as main energy source to natural gas which is a cleaner and cheaper source of energy (Tan, Maragatham et al., 2013).

Until 2001, Malaysia government started to realise the importance of Renewable Energy. Therefore, Five – Fuel Diversification Strategy 2001 was introduced. In this policy, Renewable Energy is included as the fifth fuel in energy supply mix. This is an important policy as this represents the starting of renewable energy in Malaysia. Under this policy, the government targeted that by 2010, renewable energy will contribute 5% of total energy mix under 8th Malaysia Plan (Oh, Pang et al., 2010).

Table 2-4 Energy policies in Malaysia (Saad, Barimani et al., 2014)

No	Policy name and year	Description of energy Policy
1.	Petroleum Development Act 1974	Vested the exclusive right to explore, develop and produce petroleum in Malaysia
2.	National Petroleum Policy 1975	To regulate downstream oil and gas industry via the Petroleum Act
3.	National Energy Policy 1979	Based on three objectives: Supply, Utilisation and Environmental
4.	National Depletion Policy 1980	To prolong lifespan of Malaysia's oil reserves for the future
5.	Four- Fuel Diversification Strategy 1981	To balance utilization of oil, gas, hydro and coal
6.	Renewable energy Policies	Description of Renewable energy Policy
7.	Five-Fuel Diversification Strategy 2001	Renewable energy included as fifth fuel in energy supply mix
8.	National Biofuel Policy 2006	Promote the demand for palm oil
9.	National Renewable Energy Policy and Action Plan 2010	Enhance the utilisation of indigenous renewable energy resources

2.1.4 Renewable energy (RE)

Renewable Energy (RE) is defined as electricity generated or produced from renewable resources as stated in the Law of Malaysia under act 725; while renewable resources means the recurring and non-depleting indigenous resources or technology as set out in the first column of the Schedule of the Renewable Act 2011.

As mentioned before, renewable energy is being introduced in 2001 under the 8th Malaysia Plan (2001-2005). In these 5 years, Malaysia government targeted to generate 5% of total electricity generated by the nation but at the end, only 0.3% was achieved. Therefore, renewable energy is further emphasized in the 9th Malaysia Plan. Government started to pay more attention in renewable energy from 9th Malaysia Plan.

Knowing that energy is very important issue to the nation, the government decided to set up a new ministry, Ministry of Energy, Green Technology and Water which separated the Ministry of Energy from Ministry of Communications and Multimedia. Other than that, in April 2009, the Prime Minister Datuk Seri Najib Tun Razak also launched the new National Green Technology Policy. This policy has 4 main objectives,

1. To attain energy independence and promote efficient utilization
2. To conserve the environment
3. To increase the national economic growth using technology
4. To improve quality life for all (Oh, Pang et al., 2010).

Basically, renewable energy sources in Malaysia can be divided into 3 main groups which are biomass, hydro and solar. Figure 2-3 shows the renewable energy sources in Malaysia. Since Malaysia is one of the countries that produce lots of palm oil products, palm oil has been added into the biomass category recent years as most of the waste from palm oil production such as kernel, fruit bunch can be used to generate electricity.

It is said that the renewable energy source is very limited as the nation is still very dependent on non-renewable energy source which are oil and coal. Therefore, the Energy Commission only expecting 3% of power generated in the country will be generated using renewable energy source in 2024. Figure 2-4 shows the prediction of different types of resources used to generate electricity until year 2024.

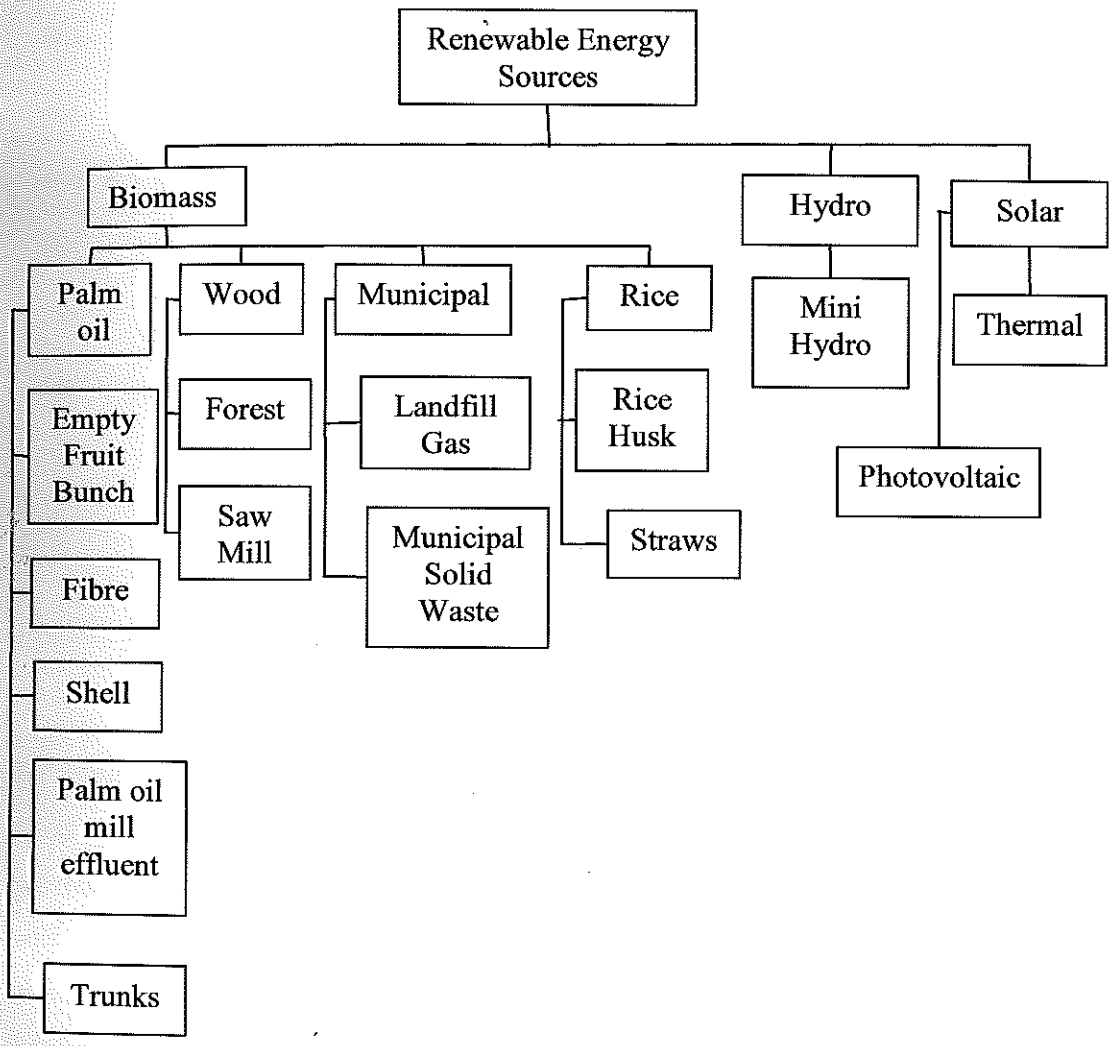

Figure 2-3 Renewable energy sources in Malaysia

(Jalal and Bodger, 2009)

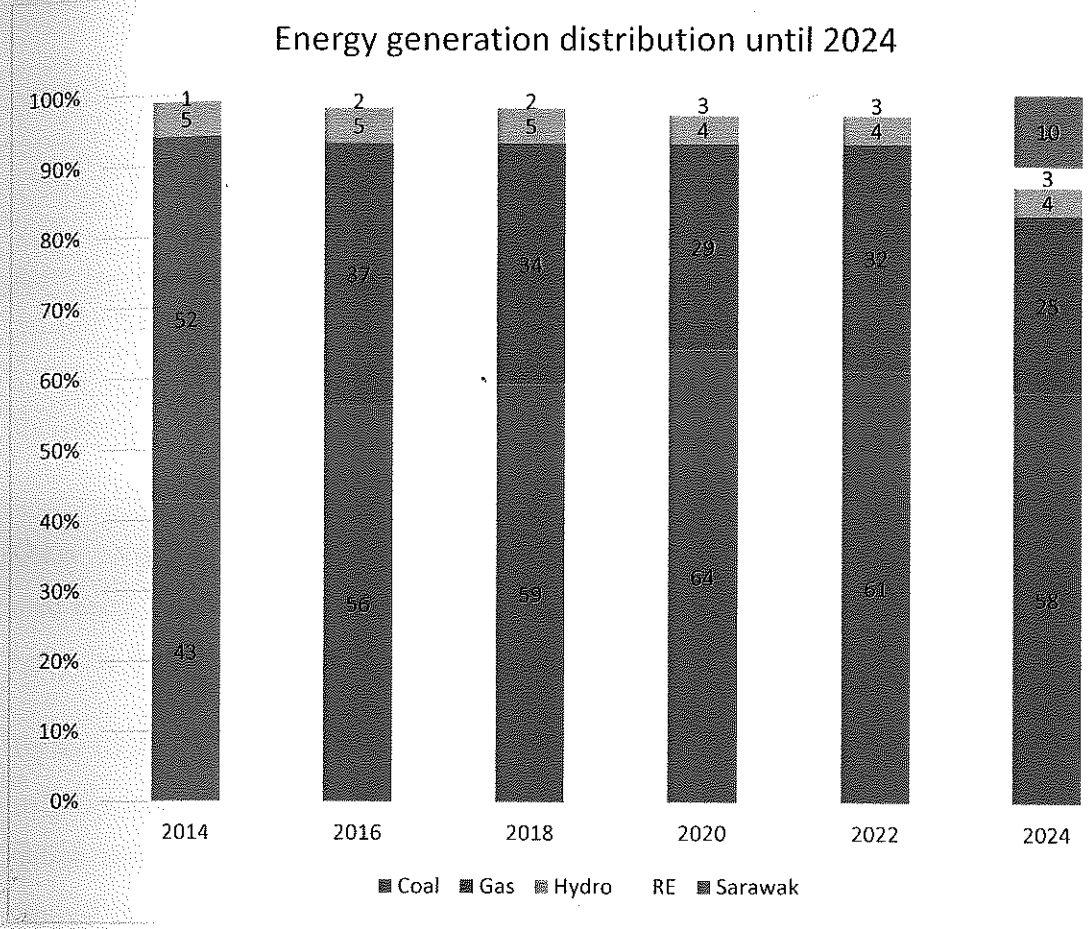

Figure 2-4 Different resources used for power generation until 2024

(Energy Commission, 2014)

To make sure that the citizen does not waste electricity and also to fund for the development of renewable energy in Malaysia, renewable energy fund has been introduced by government. Before January 2014, those citizens that used 300kWh will have to pay 1% of their bills for the renewable energy fund. The rate has been increased to 1.6% since 1st of January 2014. Table 2-5 shows the comparison of tariff before and after 1st of January 2014.

Table 2-5 Comparison of tariff before and after 1st of January 2014

Current Tariff calculation		
1.	First 200 kWh (1-200 kWh) per month : (200*21.80)/100	= RM 43.60
2.	Next 100 kWh (201-300k Wh) per month : (100 * 33.40)/100	= RM 33.40
3.	Next 100kWh (301-400kWh) per month: (50*40.0)/100	= RM 20.00
Estimated Current Bill (Effective 1 June 2011)		= RM 97.00
New Tariff Calculation (Effective 1 January 2014)		
1.	First 200 kWh (1-200 kWh) per month : (200*21.80)/100	= RM 43.60
2.	Next 100 kWh (201-300k Wh) per month : (100 * 33.40)/100	= RM 33.40
3.	Next 100kWh (301-400kWh) pèr month: (50*51.60)/100	= RM 25.80
Estimated Current Bill (Effective 1 Jan 2014)		= RM 102.80

Other than that, Sustainable Energy Development Authority Malaysia (SEDA) had also been formed. Every month, 1% of the electricity revenue will be channel to this body for the development of renewable energy.

By understanding that coal is non-renewable fuel, Malaysia government has come out with the idea of construction nuclear reactor plant in 2009. The idea is included in the nation energy policy and in December 2010, government announced that 2 units of nuclear reactor will be built to replace some of the coal fired plant. But the nuclear disaster that happened at Fukushima Daiichi on 11 March 2011 caused the government to rethink about this idea. Finally in 2013, the government announced that the planning of building a nuclear reactor will be postponed until further notice.

2.1.5 Feed-in Tariff

The Feed- in Tariff is first introduced by Sustainable Energy Development Authority Malaysia (SEDA) in 1st of December 2011. Before the launching of feed-in tariff system, Malaysia cabinet came out with Renewable Energy Act 2011 under Act 725.

Under Part I of the act, Feed-in Tariff means special tariff payable to feed-in approval holders in consideration for renewable energy generated and sold to a distribution licensee. Under part II of this act, it is stated that,

"There is hereby established a feed-in tariff system to provide for:

(a) The connection to supply line connection points for the distribution of renewable energy generated by renewable energy installations which are owned by feed-in approval holders;

(b) The priority of purchase and distribution by distribution licensees for renewable energy generated and sold by feed-in approval holders; and

(c) The feed-in tariff to be paid by distribution licensees to feed-in approval holders for such renewable energy. "Renewable Energy Act 2011, Part II, 3.(1)"

Basically, this means that citizens or companies can generate their own electricity at their places and sell back to authorities for a specific price. Figure 2-5 shows the concept of feed-in tariff for normal houses,

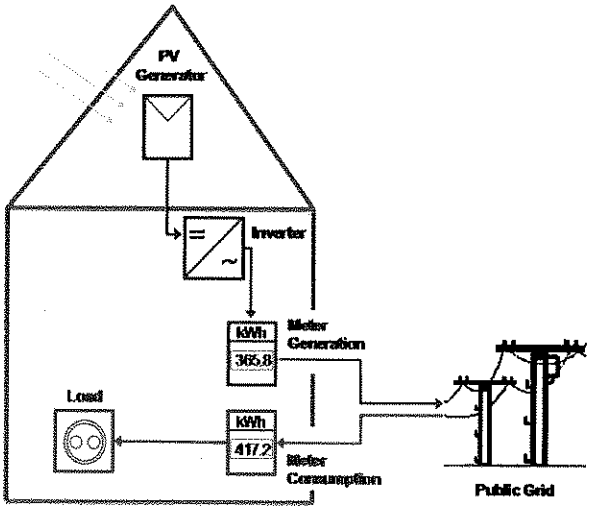

Figure 2-5 Household feed-in tariff

(SEDA Malaysia, 2011)

From figure 2-5, it can be seen that the house is equipped with PV generator that generate electricity by solar energy. Two different meters will be installed in the house. One is to record the electricity that is supply to the grid and one is to record the electricity being used.

Under the Feed- in Approval and Feed-in Tariff Rules 2011, individuals that aged 21 years old and above can apply to for this programme. For Malaysian, everyone can generate up to 30MW of power as stated in the Renewable Energy Act 2011 but for