ENERGY CONSUMPTION AND INTENSITY AT BUILDING CONSTRUCTION INDUSTRY

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DEDICATION

Thanks to My Beloved Family

My late father, Haji Apandi bin Haji Kasim

My mother, Hajjah Norsiah Binti Sakimin

My wife, Nurul Dalina Binti Mohd Ristak

My sister, Hulasah Binti Apandi and family

My brother, Khusni Bin Apandi and family

My sister, Anidah Binti Apandi and family

My sister, Hasmah Binti Apandi and family

My brother, Khalid Bin Apandi and family

My brother, Mohd Haris Bin Apandi and family

My brother, Mohd Zaki bin Apandi

And My family-in-laws

For taking care of me and always standing right behind of me,

Supporting me in whatever decisions I make,

May Allah S.W.T grant you a Jannah

ACKNOWLEDGMENT

بِسْمِ ٱللَّهِ ٱلرَّحْمَٰنِ ٱلرَّحِيمِ

All praises to Al-Mighty God, Allah SWT, for His blessing in giving me a chance and protection to complete this thesis succesfully Thank you Allah, for lending me this great achievement. *Syukur, Alhamdulillah*

My special and heartily to my family, especially my mother, Norsiah Binti Sakimin and my wife, Nurul Dalina Binti Mohd Ristak. To all the family and family in-law, thanks for giving me a motivation, advise and invaluable guideline

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I would like to convey my deepest appreciate and thanks to all my fellow friends who always help me by sharing their knowledge and also encourage me to complete this thesis. Finally, I would like to thank those who contributed directly or indirectly towards the success of this research project."

May the Al-Mighty God, Allah S.W.T, richly bless all of you.

ABSTRACT

Number of industries that used energy is increasing every year and one of it is construction industry. Construction industry is a major consumer of non-renewable resources and a massive producer of waste. Based on the research at develop country, 30 to 40% of natural resources were exploited by construction industry which are 50% of energy will be used for heating and cooling the building. The objective of this research is to know on how to control the energy consumption and intensity at construction industry. For this research, it will focus on the specification of the project site based on contract sum, location and environment of the project. The case study for this research was cover by several high-rise building construction industry. Selected data have been taken from the case study which are manpower of the contractor, energy used for each equipment, number of plant machinery to be used and work program of the project completion. All the data given have been analyst and the result have been tabulated based on their total floor area. Technically, construction can be divided into six stage which are initial construction stage, coordination stage, implementation stage, critical stage, testing and commissioning stage and handover stage. Based on the result, it can come out the six step on to overcome energy intensity in Building Construction Industry which are, to are conduct material or tool inspection before enter the site, conduct monthly inspection for all plant machinery, to upgrade temporary work system, to start stage 5 (which is Testing and Commissioning) early, to install the individual meter for every machinery and equipment and to install BAS system. At the end of the research, a new method to measure Energy Consumption Guideline for Building Construction Industry have been established. Two main components for this guideline are type of activity to be conduct and energy per floor area. As a result, stage 5 which are Testing and Commissioning Stage is the highest energy demand compare to others stage. The contractor needs to control the energy usage and make sure it not more than 1.2 kWh/sqft.

ABSTRAK

Bilangan industri yang menggunakan tenaga semakin meningkat setiap tahun dan salah satunya adalah industri pembinaan. Industri pembinaan adalah pengguna utama sumber tidak boleh diperbaharui dan pengeluar bahan buangan yang besar. Berdasarkan kajian di negara membangun, 30 hingga 40% sumber asli telah dieksploitasi oleh industri pembinaan yang mana 50% tenaga akan digunakan untuk memanaskan dan menyejukkan bangunan. Objektif kajian ini adalah untuk mengetahui cara mengawal penggunaan tenaga dan keamatan dalam industri pembinaan. Untuk penyelidikan ini, ia akan memberi tumpuan kepada spesifikasi tapak projek berdasarkan jumlah kontrak, lokasi dan persekitaran tapak projek. Kajian kes untuk penyelidikan ini diliputi oleh beberapa industri pembinaan bangunan pencakar langit. Data yang dipilih telah diambil daripada kajian kes iaitu tenaga kerja kontraktor, tenaga yang digunakan untuk setiap peralatan, bilangan jentera loji yang akan digunakan dan program kerja penyiapan projek. Semua data yang diberikan telah menjadi penganalisis dan hasilnya telah dijadualkan berdasarkan jumlah keluasan lantainya. Secara teknikal, pembinaan boleh dibahagikan kepada enam peringkat iaitu peringkat pembinaan awal, peringkat penyelarasan, peringkat pelaksanaan, peringkat kritikal, peringkat pengujian dan pentauliahan dan peringkat penyerahan. Berdasarkan keputusan tersebut, dapatlah keluar enam langkah untuk mengatasi intensiti tenaga dalam Industri Pembinaan Bangunan iaitu menjalankan pemeriksaan bahan atau alatan sebelum memasuki tapak, menjalankan pemeriksaan bulanan untuk semua jentera loji, menaik taraf sistem kerja sementara, memulakan peringkat 5 (iaitu Pengujian dan Pentauliahan) lebih awal, untuk memasang meter individu untuk setiap jentera dan peralatan dan untuk memasang sistem BAS. Pada akhir penyelidikan, kaedah baru untuk mengukur Garis Panduan Penggunaan Tenaga untuk Industri Pembinaan Bangunan telah diwujudkan. Dua komponen utama untuk garis panduan ini ialah jenis aktiviti yang akan dijalankan dan tenaga setiap keluasan lantai. Hasilnya, peringkat 5 iaitu Peringkat Pengujian dan Pentauliahan adalah permintaan tenaga tertinggi berbanding peringkat lain. Kontraktor perlu mengawal penggunaan tenaga dan memastikan ia tidak melebihi 1.2 kWj/sqft.

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INTRODUCTION

1.1 Background of Research

Nowadays, energy is a high demand from all industry. By referring to the Oxford Dictionary, energy can be described as the capacity of a physical system to perform work. However, it's important to keep in mind that just because energy exists, that doesn't mean it's necessarily available to do work. Energy cannot be created, nor destroyed, but it can change forms and is also related to mass.

One of the energies that normally being used in daily life is electrical energy. Types of energy can be categorized into two broad categories which is kinetic energy and potential energy. Kinetic energy is the energy of motion, observable as the movement of an object, particle or set of particles while potential energy can be described as the energy possessed by a body by virtue of its position relative to others, stresses within itself, electric charge and other factors. These are the two basic forms of energy. The different types of energy include thermal energy, radiant energy, chemical energy, nuclear energy, electrical energy, motion energy, sound energy, elastic energy and gravitational energy. Motion energy, thermal energy, sound energy, electrical energy and radiant energy is the example of kinetic energy, while chemical energy, nuclear energy, gravitational energy and elastic energy is the example of potential energy [1].

Resources of energy can be divided into two which area renewable and nonrenewable energy. Renewable resources are replenished naturally and over relatively short periods of time. The five major renewable energy resources are solar, wind, water, biomass and geothermal. Since the dawn of humanity people have used renewable sources of energy to survive, such as wood for cooking and heating, wind and water for milling grain and solar for lighting fires. A little more than 150 years ago people created from ancient fossilized remains of plants an animal. Nonrenewable energy like coal, nuclear, oil and natural gas are available in limited supplies. This is usually due to the long time it takes them to be replenished [2].

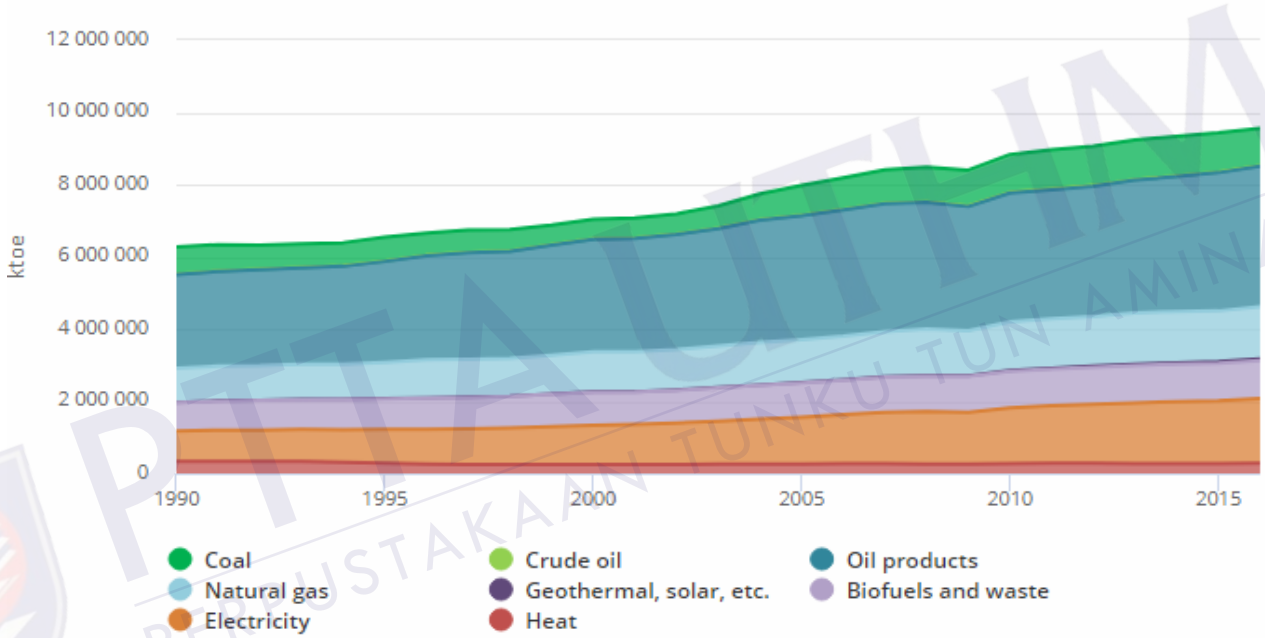

Figure 1. 1 : Total Final Consumption by source (World 1990 -2016) [3]

An agency called International Energy Agency (IEA) has come out with the data for final consumption energy as per mention in Figure 1. Based on the figure, it can assume that the most used energy in the world is oil and the lowest is crude oil. In 1990, data shown that total energy used for oil is 2,594,051 ktoe, following natural gas (944,576 ktoe), electricity energy (833,866 ktoe), biofuels and waster (795,2457 ktoe) coal (752,276 ktoe) heat (336,289 ktoe), Crude oil (11,273 ktoe) and the lowest is geothermal (3,414 ktoe). While in 2016, it has shown the total energy used for oil is 3,893,250 ktoe, following electricity energy which is 1,793,937 ktoe, natural gas (1,440,262 ktoe), biofuels and waster (1.050,877 ktoe) coal (1,035,502 ktoe) heat

(283,185 ktoe) geothermal (43,626 ktoe) and the lowest is Crude oil (14,683 ktoe). Based on the data, energy increase every year and rapidly increase form 2010 until now. In 2016, it shown that electricity rapidly increases and become the second highest of the consumption.

To manage the usage of energy usage in this century is not easy, even though most of the company have R&D team, still it can't make energy to work efficiently. Energy efficiency can be described as using less energy to provide the same service or to perform the same tank by eliminating energy waste. For example, a compact fluorescent bulb is more efficient than a traditional incandescent bulb as it uses much less electrical energy to produce the same amount of light. The phrase 'energy efficiency' is often used as a shorthand to describe any kind of energy-saving measure, though technically it should be distinguished from energy conservation, a broader term which can also include forgoing a service rather than changing the efficiency with which it is provided. Energy efficiency brings a variety of benefits such as reducing greenhouse gas emissions, reducing demand for energy imports, and lowering our costs on a household and economy-wide level. While renewable energy technologies also help accomplish these objectives, improving energy efficiency is the cheapest and often the most immediate way to reduce the use of fossil fuels. There are enormous opportunities for efficiency improvements in every sector of the economy, whether it is buildings, transportation, industry, or energy generation.[4].

ISO 5001 or also known as Energy Management System (EnMS) is the guideline to increase the energy efficiency and to implement the system that has been developed to be adopted differently at various sectors situation or condition. In addition to that, the problems in the current energy scenarios also triggered to the introduction of various green rating tools in Malaysia such as Green Building Index GBI and *penarafan Hijau*. These green rating tools in Malaysia are specifically focused on increasing the efficiency resources use such as energy, water and material, at the same time to reduce building impact on human health and environment through the building lifestyle, design, construction, operation and maintenance.

Number of industries that used energy is increasing every year. One of it is construction industry. The construction industry is the overall maze of large organization and smaller companies the facilitate building. The industry is combined of innumerable persons, firms, organization and corporation, which perform a group of intricately related, but very different activities in building. The industry is

responsible for the construction of all fixed facilities such as factories, ship piers, tunnel, pipelines, canals and sewerage treatment. Construction includes the building of everything from simple, light-frame sheds to massive dams. It includes such projects as intricate high-rise building, high speed reel (ECRL), new city development at Forest City, and new deep water terminal at Kuantan Port. This includes the majorities of the work which has been and is still doing to develop the surface of the earth to meet civilization needs.

The construction industry involves a tremendous number of skilled trades. It includes an array of highly trained workers who apply their training, knowledge and ability through hands-on activities in constructing the projects. Examples of trades are bricklayers, concrete finishers, ironworkers, painters, carpenters, welders, electrician, roofer and plumber. Within each of these categories are numerous tasks and functions that the worker performs. In addition, unskilled workers such as laborer, carpenter helper and the like provide direct aid and support to those in the skilled trades.

Construction and the need for correct application of construction technology are universal. Every country in the world, and every city, town, village or community needs construction, in one form or another. All nation's building are served by larger systems called infrastructure. There are the road, sewer, and water systems. For examples, the government builds for their people, and for even further development of new cities and villages. Although the needs are the same worldwide, the methods of applying the technology, and the actual construction methods, materials, techniques, skill levels, and so on vary widely.

Behind the actual construction projects stands an elaborate system of manufacturers who produces the systems, materials, modules, devices, clothing, tools, equipment and countless other items required by the construction industry. Builders must be able to purchase everything from the smallest item to the largest, most sophisticated, and often most expensive item or system that each project requires. Each year more than 5,000 new products and materials come on the market and are made available for use in projects. These are newly invented or developed, have undergone extensive testing, and are the products of a through manufacturing process. Others are improvements or modifications of existing materials. A constant process of research and development serves the construction industry. This process endeavors to make things better, faster, cheaper, more convenient, safer, more numerous, more

widely available, and of more colors and finishes. All this allow the industry to do its works in a more diverse and timely manner.

Construction can be divided into three stage which are pre-construction stage, net pay construction stage and completion and post completion stage. For pre-construction stage normally involve contract department and the director of the company. While for construction stage will be done by project team. For completion and post completion stage will lead by QA department and Manager before handover totally to client. The process that will involve of energy usage at construction industry is the second stage. At this stage, the process that involve are preparation and implementation process. All planning will be lead by project manager and will be control by project team. Quality Assessment System for Building Construction Work and Quality Assessment System in Construction or known as QLASSIC have been established by CDIB on 2006. Based on the analysis defect CIS 7 & QLASSIC Acceptable Score (2015 – 2018) [36] the acceptable QLASSIC scoring is 70 score and above for the high rise building project. Thus, the baseline of the QLASSIC score will be fall between 70 – 75. In this research, it follows CIDB requirement to make sure the project handover in good quality.

Based on the Occupational Safety and Health (Notification of Accident, Dangerous Occurrence, Occupational Poisoning and Occupational Disease) Regulation 2004, any accident happen at the construction project need to report to CIDB. If accident happen, the project to be stop until the further notice by authority and normally it will take 2 weeks for them to continent to work. It will affect on the LTI (Los Lost Time Injury) for that project become zero.

1.2 Problem Statement

Construction industry is a major consumer of non-renewable resources and a massive producer of waste. Based on the research at develop country, 30 to 40% of natural resources were exploited by construction industry which are 50% of energy will be used for heating and cooling the building. [37] This similar percentage is expected in the developing country such as Malaysia.

Malaysia is categorized as a developing country; a lot of projects are in progress and on planning to build it. A lot of electricity energy to be used to complete the entire project The developer team's attitude plays an important part toward creating sustainable living. Campaign had been going to educate and reminds all the team to control the usage of energy. Not only will it save the electrical bill, but also the environment impact.

However, the main problem is the developer or contractor don't have awareness on how to reduce or overcome the energy resources. For them, the progress to complete the project on time is more important than the environment impact after used a lot of energy in one time. These issue if not tackled strategically will further aggravate and exert challenges toward sustainable construction in the following way.

1.3 Objective

The objective of this project is to know the energy consumption and intensity at construction industry. The final result will be as a benchmarking for new developer or contractor to control and reduce energy waste during construction stage.

The objectives of this research are:

i. Categorized energy consumption data for building construction on each stage.
ii. Analyze energy consumption according to building construction stage.
iii. Propose building construction energy reduction measure.
iv. Established energy consumption guideline for building construction industry

1.4 Scope of Research

The location of the research is in Peninsular Malaysia, and all the project have completed on time. In this research, it will focus on the specification of the project site based on contract sum, location and surrounding environment of the project. The case study for this research will cover several high-rise building construction industries. The selection of the case study as per mention below:

1) All the project that has been selected have contract value for each construction project is around RM 300 million and onward
2) The construction period have is around 28 to 40 months, not more than 4 years completion date.
3) QLASSIC Scoring more than 70%, and
4) Have minimum 5 million hour without LTI (Lost Time Injury)

1.5 Significant of Research

This research will be a significant endeavor in promoting good environment in construction industry. This research will be benefitted to the construction company in management strategy, the costing project and environment surrounding, when the worker or project team knows on how to save energy in their daily work. By understanding the important of energy used, and how to control it before becomes waste energy, this research will provide recommendation on how to control the energy at construction in term of machinery and worker time.

The finding of this research will rebound to the benefit of construction industry that energy plays important role in our environment today. The greater awareness about energy efficiency, the more energy can save. The result can be easily found at their monthly bill.

Moreover, this research will be help to the construction industry on the awareness of energy usage and educate construction's company in deciding in whether to implement energy in their project work program or just to catch up the work progress without thinking of energy waste.

CHAPTER 2

LITERATURE REVIEW

2.1 Malaysia Energy Outlook

In Malaysia, there are many challenges and issue about energy supply and demand. Some challenges are energy security, fuel supply and pricing, renewable energy, energy efficiency and conservation, sensitivities of nuclear option and the restructuring of the electricity supply industry.

In 1979, National Energy Policy was introduced as a guide for Malaysia energy development. There are three main objectives which are supply objective, utilization objective and environment objective. Supply objective is to ensure adequate, secure and cost-effective supply of energy, while the utilization objective to promote efficient utilization of energy and discourage wasteful and non-productive patterns of energy consumption. Lastly, environmental objective is to ensure factors pertaining to environmental protection are not neglected in the production and utilization of energy [7].

In order to achieve the objective of the policy, various related polices have been made, such as National Depletion Policy in 1980, Four- Fuel Diversification Strategy Policy on 1981 and Five-Fuel Diversification Policy on 2001. All these policy initiatives were conscious efforts by the Government to diversify fuel resources for power generation to ensure sufficient and reliable power at affordable prices [8].

Under the Tenth Malaysia Plan (2011-2015), Feed-in Tariff is designed and targeted to achieve 985MW and 208MW by 2015 and 2020 respectively form various renewable energy resources. In addition, Malaysia, plan for an additional 6 GW of new generation capacity between 2015 and 2020 to meet increasing demand [9].

Table 2. 1: Electrical Energy Production in 2005, 2010 and 2030 [9]

Energy Source	Production Capacity (GWH)			Percentage of Production (%)		
	2005	2010	2030	2005	2010	2030
Coal	23,134	49,675	154,686	26.5	41.6	49.0
Oil	2,489	2,855	3,107	2.9	2.4	1.0
Natural Gas	55,899	55,700	139,025	64.0	46.6	44.0
Hydro	5,784	111,245	18,166	6.6	9.4	5.7
Total	87,306	119,475	315,984	100.0	100.0	100.0

By referring to table 2.1, the projections Malaysia electricity production will increase from 87,306GWh to 315,984GWh in 2005 and 2030 respectively with annual growth rate of 5.3%. However, the projection does not take into consideration of nuclear and renewable energy. Deployed of renewable energy and advances of renewable energy technology will increase feed-in Tariff implementation in Malaysia. Renewable energy will contribute the electricity production soon. Therefore, in order to ensure diversity of fuel sources, a balances fuel mix is important [10].

2.2 Energy Supply and Demand in Malaysia

Malaysia is on of the Southeast Asia's fast developing economies. Its economic has been principally based on manufacturing and resource extraction, although there are ongoing initiatives to expend services and higher value added activities. Malaysia is well capable wih convertional energy resources such as oil and gas as well as renewable energy soruces such as hydro, biomass and solar energy. Malaysia's domestic oil production occurs offshore, primarily near the Peninsular Malaysia [11].

In 2008, total final energy consumption in Malaysia was 44,901 ktoe. The industrial sectore was the biggers final energy user at 18, 556 ktoe, or 42.6% of total final energy consumption, folloed by the transport sector at 16,395 ktoe, or 36.9% the commercial and residential sector at 6,205 ktoe, or 13.8% and other sectors (agriculture, and non- energy) at 3, 162 ktoe.

The role energy plays in achieving the golas of sustainable development in Malaysia had been recognised many years ago. As a result, strategic planning and management of energy resources have been given high priority in Malaysia's development plans.

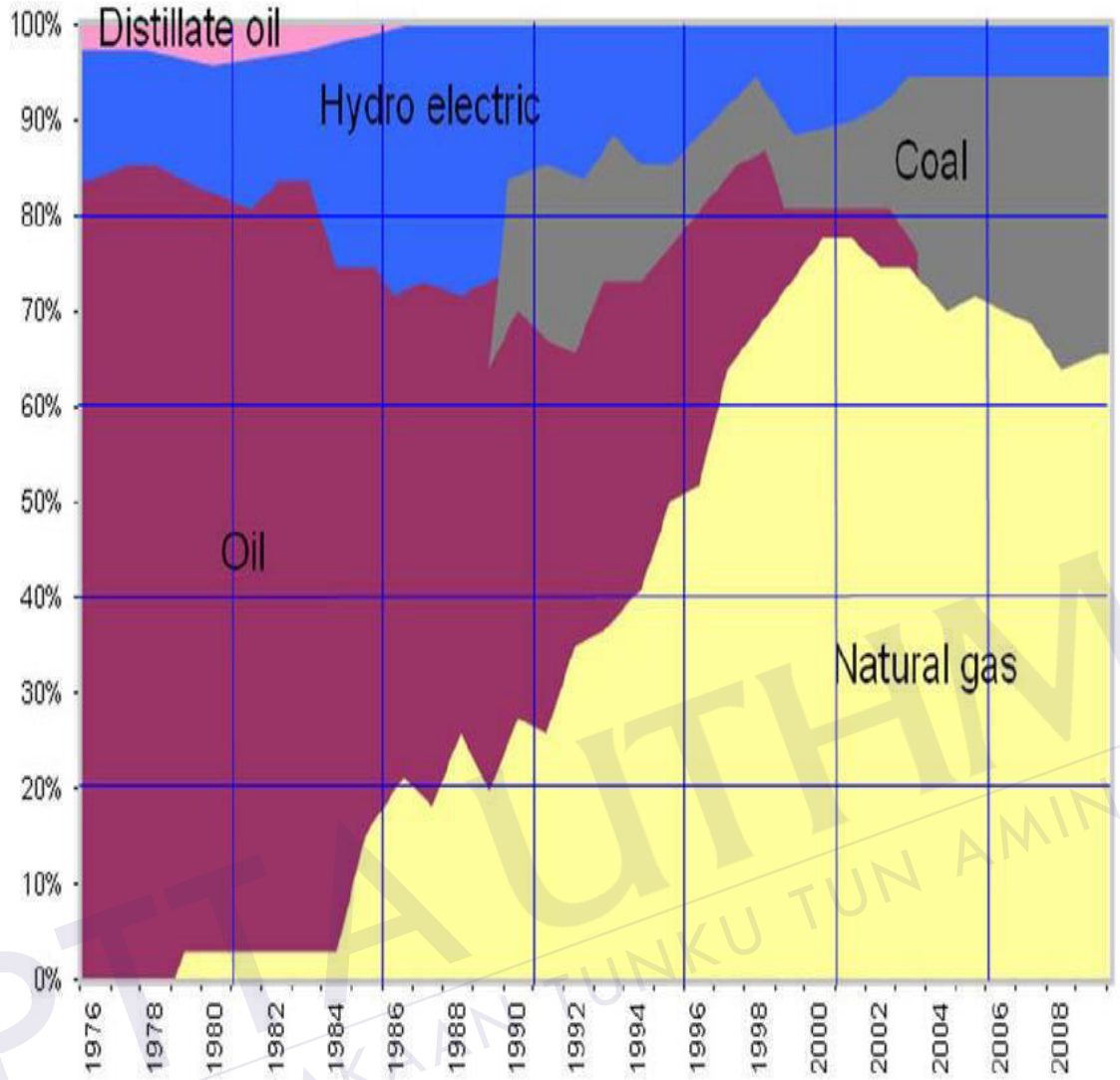

Figure 2. 1: The transformation of fuel mix structure in the power generation [12].

Figure 2.1 show the transformation of fuel mix structure in the Power Generation sector. It can see that in the end of 2008 power generation turn to natural gas and coal.

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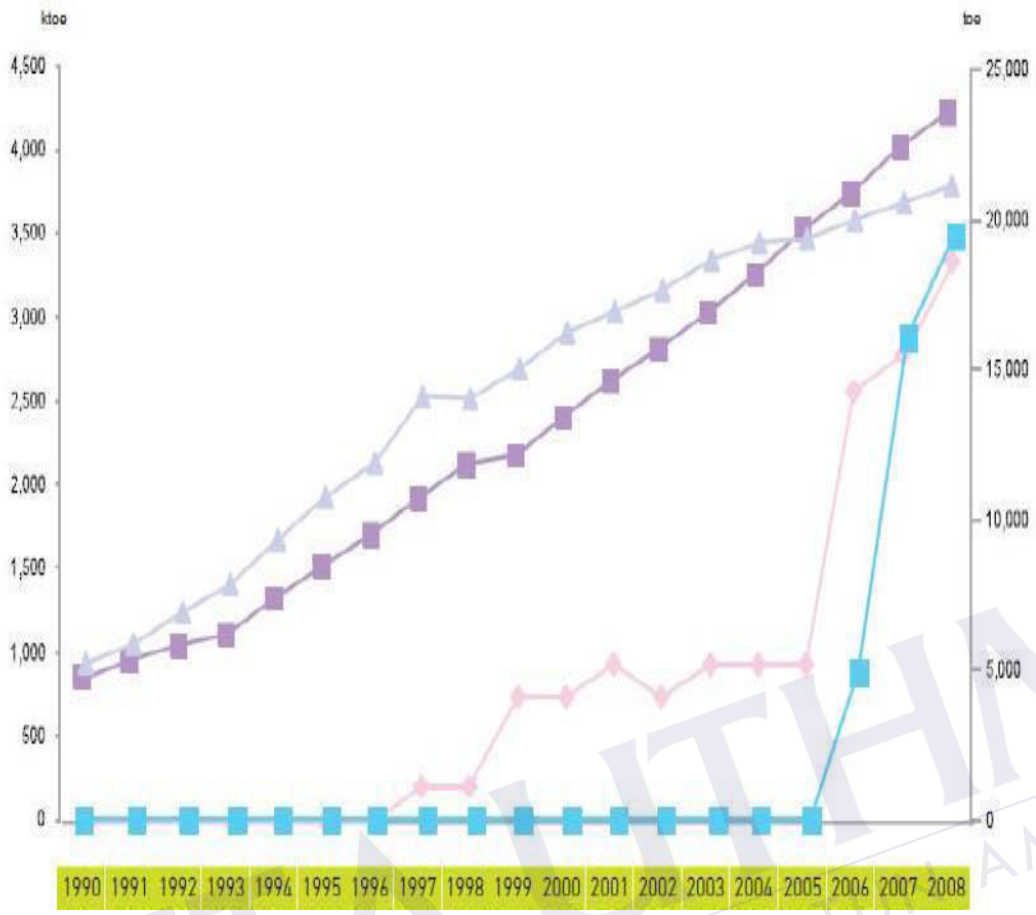

Figure 2. 2: Electricity consumption by sector [12].

Figure 2.2 show the industrial sector had been the higher electricity consumer until mid 2000's where the residential and commercial sector overtook the industrial sector as the highest electricity user. Start 1st June 2006, TNB has introduced specific Agriculture Tariff, before this, agriculture was under Commercial Tariff.

2.3 Energy Management Programs

The Malaysia's government is leading energy efficiency by example through the building of energy efficient and green building. The first energy efficient building that as built is the Low Energy Office (LEO), housing the Ministry of Energy, Green Technology and Water. Malaysia have established some program in order to make sure all the sectors are involve in this energy efficiency program. Figure 2.3 shows the program have been conduct and ongoing campaign [4,13].

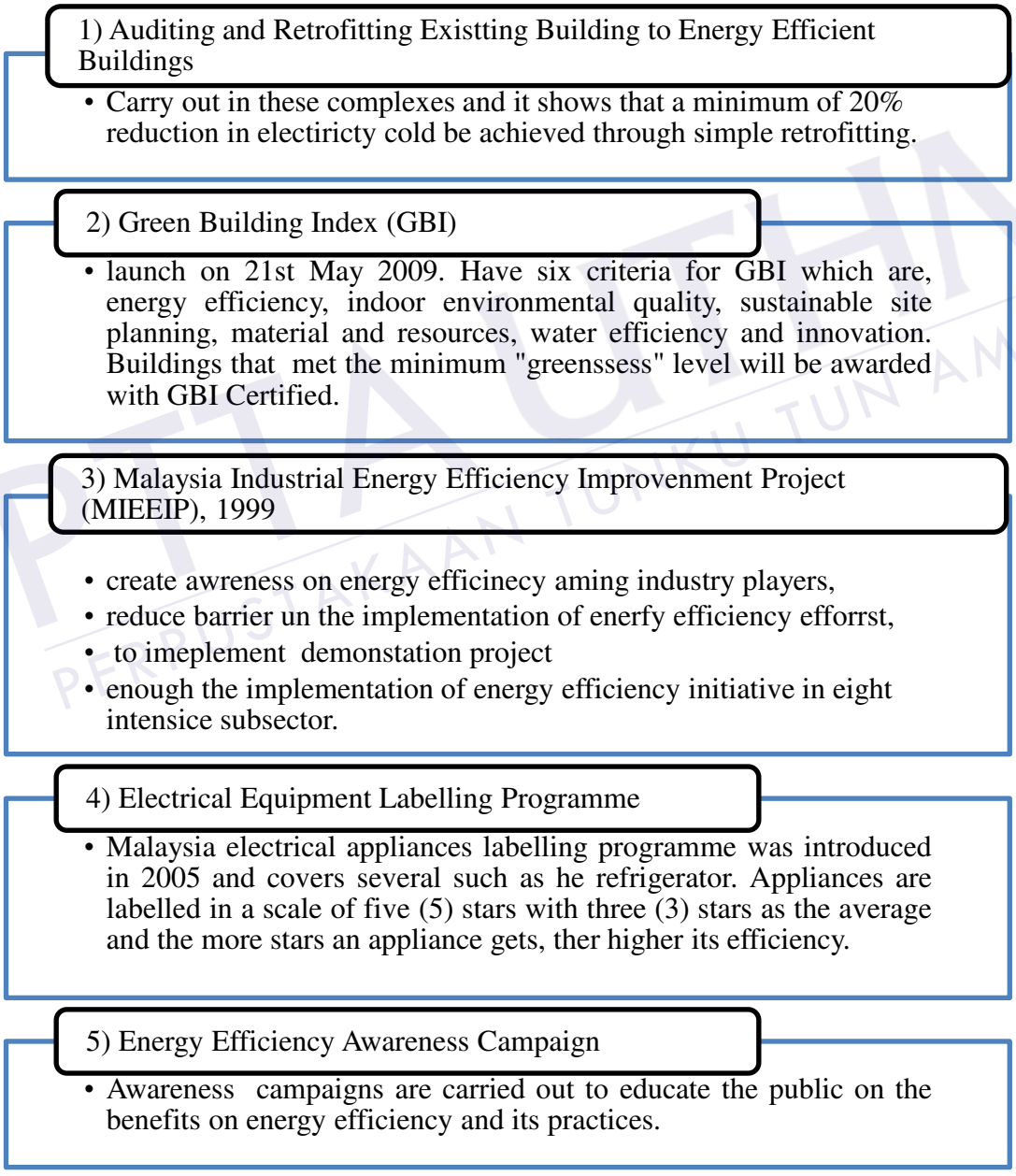

Figure 2. 3 : Energy program activity conducted by Malaysia's Government

2.4 Energy Efficiency Policy Frameworks and Institutional Setup

By referring Malaysia Industry Energy Improvement Project (MIEEIP), it has established policy framework and institutional setup in order to monitor the energy efficiency at Malaysia [14].

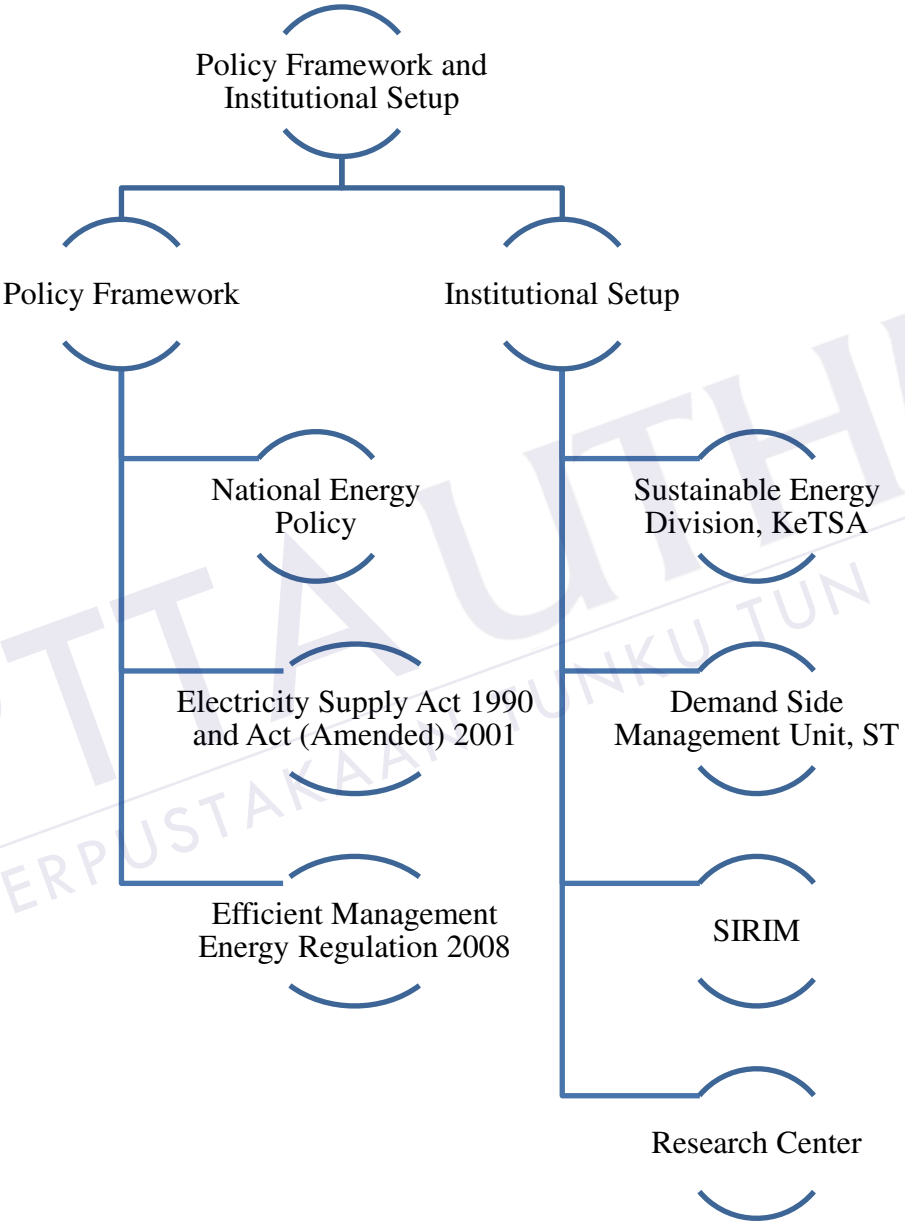

Figure 2. 4: Malaysia Energy Efficiency Policy Frameworks and Institutional

2.4.1 National Energy Policy

The National Energy Policies in Malaysia are formulated in 1979 by the Energy Section of EPU under the Prime Minister's Department. It is renewed every five years as part of the Five-Year Malaysia Plan. The aim of the National Energy Policy was to ensure an efficient, secure and environmentally sustainable supply if energy in the future. The National Energy Policy has identified three objective which are supply, utilization and environment. For supply objective, it to ensure adequate, secure and cost effective energy supply by developing and utilizing energy source. Utilization objective means to promote efficient utilization of energy and discourage waste full and non-productive pattern of energy consumption. Lastly, environmental objective is to minimize the negative environmental impact on the whole energy supply chain [15,16].

2.4.2 Electricity Supply Act 1990 and Supply Act (Amended) 2001

The main objective of the Act is to regulate the electricity supply industry. The act also has provision on efficient use of electricity. Section 23A, Section 23B and Section 23C has been use for electricity supply Act. [17].

1. Section 23A: The ministry may, from time to time, prescribe the standards, specifications, practices and measures to be adopted and any other matters in respect of the efficient use of electricity.
2. Section 23B: No person shall use or operate any installation unless the installation meets such requirements as may be prescribed in respect of the efficient use of electricity.
3. Section 23C: No person shall manufacture, import, sell or offer for sale or lease any equipment unless the equipment meets such requirement as may be prescribed in respect of the efficient use of electricity.

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