Scenario Planning To Forecast Future Energy In Malaysia

By

ABDUL AZIZ BIN NORDIN (9743)

Dissertation report submitted in partial fulfillment of the requirements for the

Bachelor of Engineering (Hons) Petroleum Engineering

January 2011

Universiti Teknologi PETRONAS
Bandar Seri Iskandar
31750 Tronoh
Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

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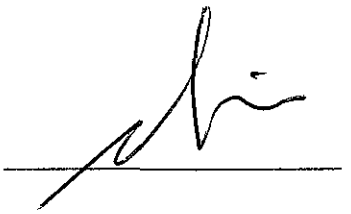


(Mr. Elias B Abllah)

Universiti Teknologi PETRONAS

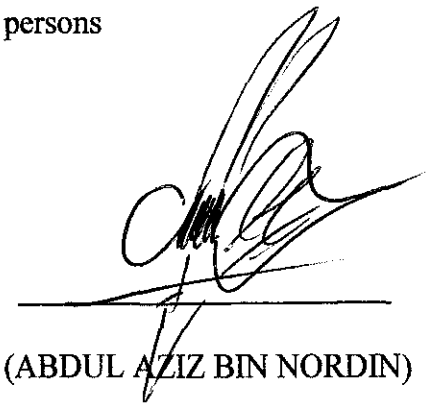
Bandar Seri Iskandar

31750 Tronoh

Perak Darul Ridzuan

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own concept as specified in the references and acknowledgement, and that the original work contained herein have not been undertaken or done by unspecified sources or persons



(ABDUL AZIZ BIN NORDIN)

ABSTRACT

Nowadays, we face the problem regarding the depletion of oil and gas but at the same time, final energy consumption grew at a fast rate of 5.6 percent between 2000 and 2005 to reach 38.9 Mtoe in 2005. A substantial portion of the energy consumed was from oil (63 percent) which was mainly utilized in the transport and industrial sectors. Natural gas consumption also increased in a rapid manner to fuel electricity demand. The share of natural gas in total installed electricity generation capacity remains high at 70 percent in 2005, but has fallen slightly from 77 percent in 2000.

Malaysia is endowed with conventional energy resources such as oil and gas as well as renewable like hydro, biomass and solar energy. At 2005 production levels, proven oil reserves are expected to last another 19 years while natural gas reserves are expected to last for about 33 years. Taking into account the growing energy consumption and domestic energy supply constraints, Malaysia has set sustainable development and diversification of energy sources, as the economy's main energy policy goals. The Five-Fuel Strategy recognises renewable energy resources as the economy's fifth fuel after oil, coal, natural gas and hydro. The introduction of biodiesel for the transport sector in 2005 is one of the positive steps that the government has undertaken to achieve sustainable energy development through diversification of fuel sources.

We need to do something to overcome the problem of depletion of oil and gas that affect the energy supply in the future. One of the way is by doing the scenario planning. There are lots of method that can be used to create scenario planning. Two of them are Business As Usual (BAU) and Green Future (GF). In this project, I will used this two method for energy scenario planning in Malaysia.

TABLE OF CONTENTS

CHAPTER 1: INTRODUCTION

1.1 PROJECT BACKGROUND

Malaysia is made up of Peninsular Malaysia and the states of Sabah and Sarawak on the island of Borneo. Today about 80% of the total 23.3 million people live in Peninsular Malaysia, the hub of the country's economic activities. Like many other developing countries, energy has been the prime contributor towards the rapid growth of Malaysia's economy. Rural–urban migration, higher living standards and increased income per capita have also spurred an ever-increasing demand for energy. Stable and abundant supply of energy resources in Malaysia epitomizes how blessed Malaysia is with these natural assets.

In terms of energy equivalent, Malaysia has gas reserves, which are four times the size of its crude oil reserves. Natural gas reserves off the east coast of Peninsular Malaysia are dedicated for domestic consumption while those in Sarawak are allocated as revenue earner in the form of liquefied natural gas (LNG) exports. The locked-in demand created through the construction of gas-fired power plants and the conversion of oil-fired thermal power stations to gas firing also created the necessary scale to justify the increase of natural gas production and development of the Trans-Peninsular gas pipeline.

Based on past energy patterns, growth in energy demand concentrated in Peninsular Malaysia, implying uneven demand trends between Peninsular Malaysia on one hand and Sabah and Sarawak on the other. Sales of electricity in Peninsular Malaysia recorded a doubledigit average annual growth rate for the past ten years, in tandem with the rapid rate of industrialization. Over the last two decades, pragmatic energy policies have facilitated a more environment-friendly energy development path. For instance, the four-fuel strategy adopted has accelerated the transition of oil substitution.

As a result natural gas has made dramatic inroads as the preferred fuel in the electricity industry, rising from 1.2% of the total fuel mix in 1980 to 71.1% in 1999. While the general energy policy thrust for the next ten years remains unchanged, concerted efforts will be made to usher the

energy sector development on a greener path. The Government has set a target that 5% of electricity generated should be from renewable energy by 2005. The challenge here would be to give renewable energy the necessary lift to greater heights in the next five years. Efforts to promote energy efficiency, which is considered a unique domestic energy resource, will also be intensified. Although opportunities for the application of sustainable energy options abound, the energy sector must also rise to the challenge of ensuring adequate, reliable and cost-effective supply of energy whilst contributing towards socio-economic welfare, industrialization and export earnings.

1.2 PROBLEM STATEMENT

Problem Identification

Malaysia's primary energy demand is projected to grow at 3.5 percent per year from 56 Mtoe in 2002 to 147 Mtoe in 2030; mainly due to the increase in demand for coal, oil and gas; with coal demand accounting for the highest growth rate at 9.7 percent per year through 2030. Indigenous oil reserves are projected to be depleted within the outlook period, thus shifting the economy to a net energy importer. Net import dependency will reach 32 percent in 2030 from a net export position of 57 percent in 2002.

Significant of Project:

- To forecast the demand of primary energy in the future;
- To forecast the production of oil and gas in Malaysia in the future;
- To do the scenario planning for energy demand and supply in Malaysia.

1.3 OBJECTIVE AND SCOPE OF STUDY

This project focuses on methodology to estimate the future oil supply in Malaysia.

1.4 RELEVANCY OF PROJECT

Basically we do not know what will be happen to Malaysia's future energy supply and demand in the next 10 years or more than that. It is already known and aware to us about how important the energy supply and demand in affecting our country in many aspects. So, it is very important to do the calculations to every single thing that could affect our country development, economy and politic.

1.5 FEASIBILITY OF PROJECT

This project is feasible within the time given to accomplish the Final Year Project course according to the schedule from Gantt-chart. The project begins with collecting materials such as books, journals and technical papers specifically on how to do the scenario planning.

CHAPTER 2: LITERATURE REVIEW

2.1 PRIMARY ENERGY IN MALAYSIA (BY 2009)

2.1.1 DEMAND OF PRIMARY ENERGY IN MALAYSIA (BY 2009)

Over the last decade, the economy grew at an average rate of 4.9 % p.a. Malaysia is a net energy exporter, with 13.7 percent of export earnings in 2009 derived from crude oil, liquefied natural gas (LNG) and petroleum products. During the period from 2000 –2008, energy consumption per capita increased at an average rate of 3.14 % p.a. In 2008, final use of commercial energy was 44.9 Mtoe, comprising of 54.5 23.9 % natural gas, 17.8 % electricity and 3.8 % coal and coke. The transport sector consumed 36.5 %, industrial sector at 42.6 % and the sector at 13.8%. Final energy demand is projected to grow at 3.4 % p.a. reaching 92.9 Mtoe the 2008 level. Electricity consumption per capita now is about 3,412 kWh per year, significantly developing countries, but still below the average in developed countries. This is projected to more than double to reach 7,571 kWh/person in 2030.

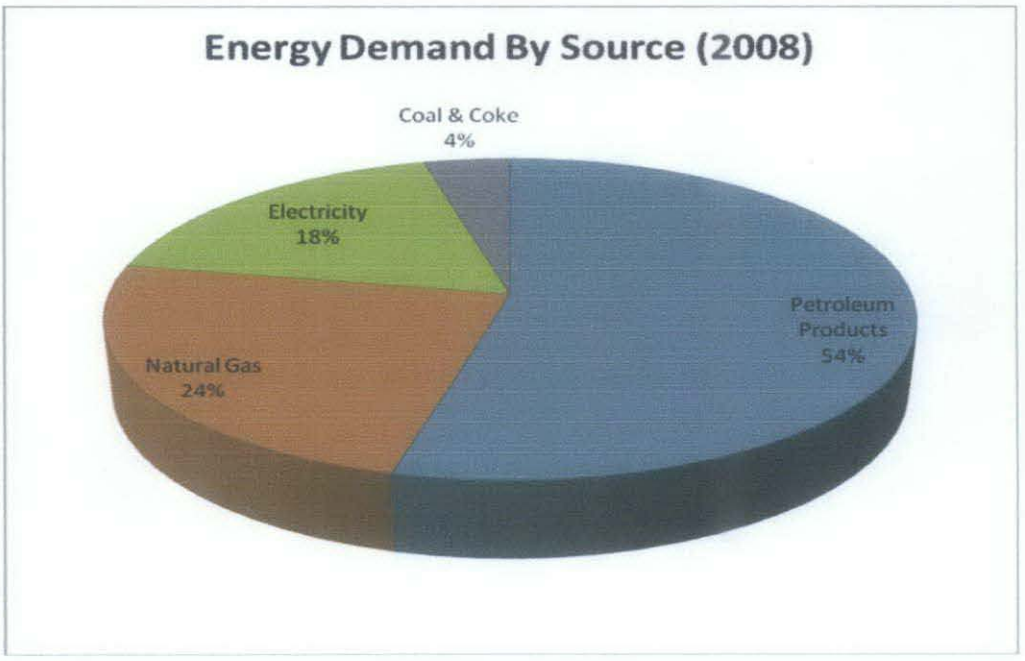


Figure 1 (Source – [3])

2.1.2 SUPPLY OF PRIMARY ENERGY IN MALAYSIA (BY 2009)

In 2008, our total primary energy supply stood at 75.5 Mtoe, contributed by crude oil and petroleum products (38.2 %), natural gas (43.4 %), coal and coke (15.3 %), and hydro (3.1 %). We currently imports about 20 million tonnesof coal annually, mostly from Indonesia, Australia and South Africa. Malaysia also imports about 110 mmscfd of natural gas from Indonesia and 290 mmsfd from the Malaysia-Thailand Joint Development Area via cross-border pipelines to meet the domestic demand for gas. In 2009, the total installed generation capacity of the three main utilities and IPPs was 24,006 MW, comprising of 21,817 MW in the Peninsula and 2,189 MW in East Malaysia. About 57.6% of our electricity generation comes from natural gas, 38.8% coal, 3.3% hydro, and 0.3% from oil and renewable.

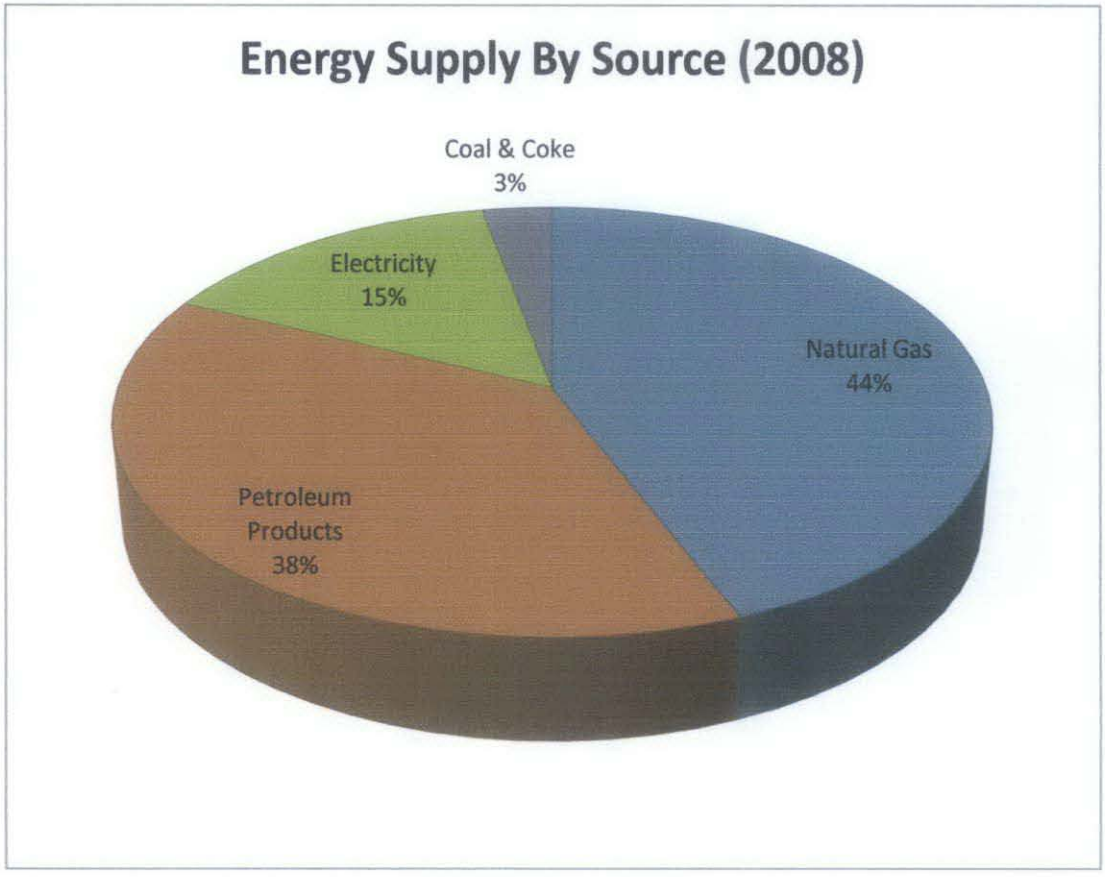


Figure 2 (Source – [3])

2.2 OIL SUPPLY AND DEMAND

2.2.1 OIL SUPPLY

Everyone knows the oil supply can't last forever, but no one has a very good estimate when it will end. Saudi Arabia has the largest amount of oil, but they aren't willing to tell the world exactly how much they think they have or when it may be depleted. Other countries have almost completely depleted their oil reserves such as the US and some other developed countries. Mexico announced in 2004 that their largest oil field and the second fastest producing field in the world, Cantarell Field, have begun a steep decline in production. In 2002 Cantarell produced 2.1 million barrels a day. By 2008 it is predicting to only produce 1 million a day. The largest oil field is Ghawar field in Saudi Arabia. According to the Saudi Government the field has 75-83 billion barrels of oil and should be able to increase production in the future. The field considered to be second largest is Kuwait's Burgan Field at 66-72 billion barrels. In 2005 it was announced to Burgan field will begin decreasing production and is estimated to have a lifespan of 30-40 years.

One different oil source is not an oil field as much as a tar pit. Canada's Athabasca Oil Sands have been estimated to hold 1.6 trillion barrels of crude oil. While this sounds like a wonderful supply of oil the extraction process is very expensive and difficult. Someday this process will certainly be refined and if oil prices continue to increase the Athabasca Oil Sands will become a huge supplier of gasoline to North America.

2.2.2 OIL DEMAND

Oil demand and price are set to grow steadily over the next 25 years despite environmental policies, essentially dooming climate change goals, the International Energy Agency (IEA) forecast on Tuesday. Slightly more than a third of the new demand would come from China's appetite for energy. Even under climate change pledges made under the Copenhagen Accord last year, fossil fuels will still account for more than half the increase in total energy demand, with oil to remain the dominant fuel, the IEA said in its World Energy Outlook report.

The broad failure of the Copenhagen summit on the climate would cost the world $1 trillion in extra investments needed by 2030 to avoid irreparable damage to the climate, raising the total investment needed to $11.6 trillion, the IEA estimated. It forecast demand for oil to rise by 18 percent between 2009 and 2035, driven by developing countries, with nearly half the increase accounted for by China alone. Global demand for oil would total 99 million barrels per day in 2035, or 15 million barrels per day more than in 2009, and all of the increase would come from outside the Organization for Economic Cooperation and Development (OECD) area of advanced economies. Demand for natural gas should increase by 44 percent to 4.5 trillion cubic meters, also largely driven by demand from China. The IEA, the energy monitoring and strategy arm of the OECD, concluded that this "rising demand for fossil fuels would continue to drive up energy-related carbon dioxide emissions through the projection period. Such a trend would make it all but impossible to achieve the two degree C goal...".

The Copenhagen Accord sets a non-binding target of a two degrees C increase in the global average temperature from pre-industrial changes, a level scientists believe is needed in order to prevent the most damaging climate change. The IEA said government commitments made at Copenhagen "fall short" of what is needed to get to the two degree C target, and the forecast increases in energy consumption would likely result in an increase of 3.5 degrees C. In particular, the IEA noted that increasing demand would force oil companies to unconventional sources, such as oil sands and shale, which are not only costly and will drive up prices, but which also generally emit more greenhouse gases. However, the IEA said that the commitment last year

by Group of 20 industrialized and emerging market countries to rationalize and phase out inefficient fossil fuel subsidies "has the potential to, at least partly, balance the disappointment at Copenhagen."

The IEA said such measures would be a "crucial pillar" to meeting climate goals along with carbon pricing and abatement measures in developed economies. In addition to the modest nature of the Copenhagen pledges making it less likely climate change goals with be achieved, the delay is causing the price of achieving them to increase. The IEA estimated meeting climate change goals would shave 1.9 percent off global GDP in 2030, more than double its estimate last year of 0.9 percent. The IEA report also emphasized the rising importance of developing countries in the energy market, expecting for them to account for 93 percent of the growth in energy demand over the next quarter century under Copenhagen pledges. China alone is expected to account for 36 percent of the projected growth. China's energy consumption more than doubled from 2000 to 2008 to overtake that of the United States, and the agency believes that prospects for future growth remain strong as its per-capita consumption level remains at only one-third the average for industrialized nations. The IEA said China could bring about a "golden age for gas" with demand forecast to grow by an average of six percent per year, or a fifth in the overall increase in demand. Chinese demand for gas could grow even faster if Beijing restrains use of coal for environmental reasons, it noted. OPEC is also projected to thrive despite Copenhagen climate policies, increasing its share of global oil output to more than half. Saudi Arabia is expected to reclaim the title of top producer from Russia with its output rising to 14.6 million barrels per day in 2035 from 9.6 million last year.

2.3 OIL IN MALAYSIA

2.3.1 OIL PRODUCTION IN MALAYSIA

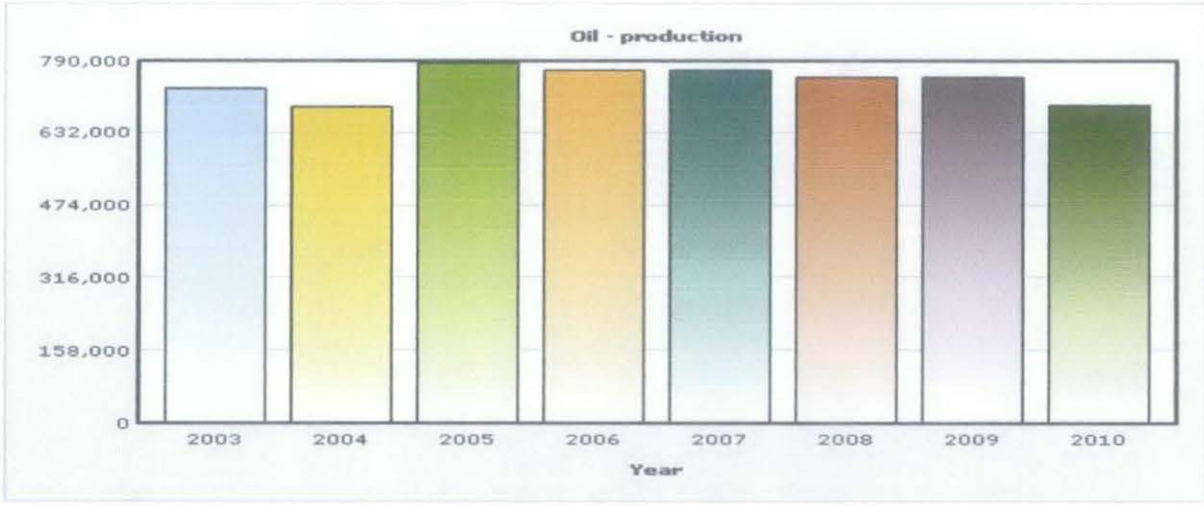


Figure 3 (source - http://www.indexmundi.com/malaysia/oil_production.html)

Year	Oil - production	Rank	Percent Change	Date of Information
2003	729,200	27		2001 est.
2004	690,000	27	-5.38 %	2003 est.
2005	785,000	22	13.77 %	2004 est.
2006	770,000	23	-1.91 %	2005 est.
2007	770,000	23	0.00 %	2005 est.
2008	753,700	25	-2.12 %	2008 est.
2009	753,700	26	0.00 %	2008 est.
2010	693,700	26	-7.96 %	2009 est.

Table 1(source - http://www.indexmundi.com/malaysia/oil_production.html)

2.3.2 OIL CONSUMPTION IN MALAYSIA

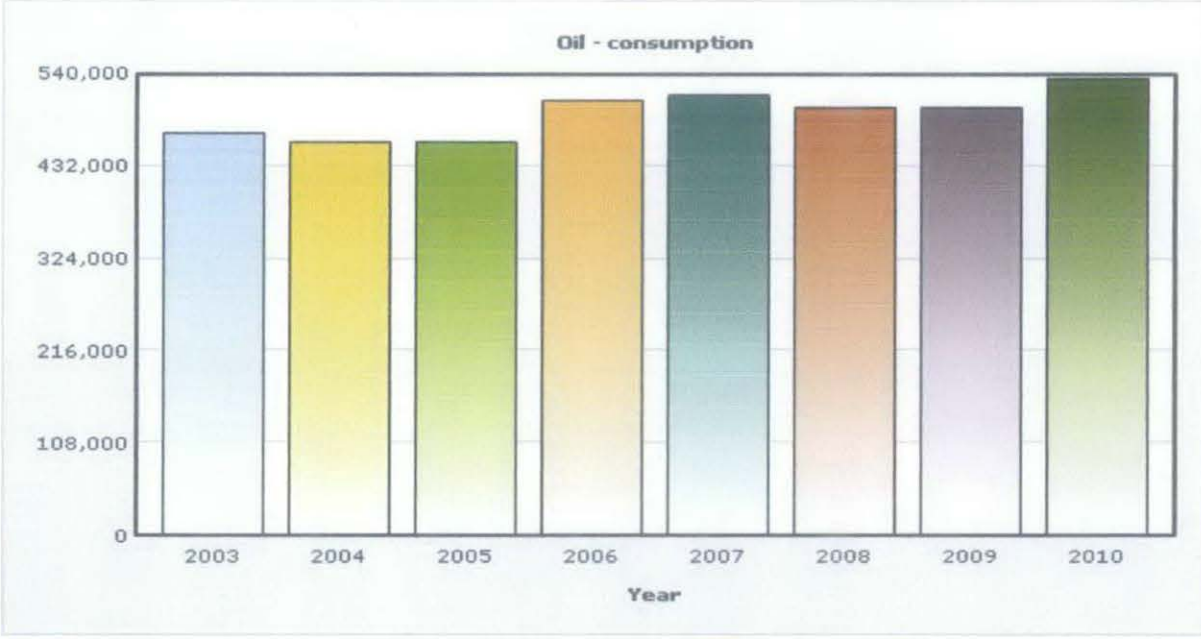


Figure 4 (source - http://www.indexmundi.com/malaysia/oil_consumption.html)

Year	Oil - consumption	Rank	Percent Change	Date of Information
2003	472,000	28		2001 est.
2004	460,000	30	-2.54 %	2003 est.
2005	460,000	28	0.00 %	2003 est.
2006	510,000	27	10.87 %	2003 est.
2007	515,000	27	0.98 %	2004 est.
2008	501,100	30	-2.70 %	2006 est.
2009	501,100	29	0.00 %	2006 est.
2010	536,000	31	6.96 %	2009 est.

Table 2 (source - http://www.indexmundi.com/malaysia/oil_consumption.html)

2.3.3 FORECAST OF MALAYSIA

The latest Malaysia Oil & Gas Report from BMI forecasts that the country will account for 1.78% of Asia Pacific regional oil demand by 2014, providing 8.50% of supply. Regional oil use of 21.42mn b/d in 2001 is set to reach a forecast 27.15mn b/d in 2010, then to rise to around 30.21mn b/d by 2014. Regional oil production was around 8.35mn b/d in 2001 and is forecast to average an estimated 8.82mn b/d in 2010. It is set to increase only slightly to 8.89mn b/d by 2014. Oil imports are growing rapidly, because demand growth is outstripping the pace of supply expansion. In 2001 the region was importing an average 13.07mn b/d. This total will rise to a projected 18.32mn b/d in 2010 and is forecast to reach 21.32mn b/d by 2014. The principal importers will be China, Japan, India and South Korea. By 2014 the only net exporter will be Malaysia.

In terms of natural gas, in 2010 the region will consume an estimated 496bcm and demand of 625bcm is targeted for 2014. Production of a forecast 415bcm in 2010 should reach 522bcm in 2014, which implies net imports rising from around 81bcm to 104bcm. This is thanks to many Asian gas producers being major exporters. Malaysia's share of gas consumption in 2010 is an estimated 6.45%, while its share of production is 16.87%. By 2014, its share of gas consumption is forecast to be 5.46%, with the country accounting for 15.33% of supply.

We continue to predict a 2010 OPEC basket oil price level of US$83.00/bbl. This equates to Brent at just under US$85.00, WTI at almost US$87.60, Urals averaging US$83.60 and Dubai at US$83.55. The 2011 OPEC assumption is US$85.00/bbl, rising to an average of around US$90.00 in 2012 and beyond. For the whole of 2010, we are currently assuming an average global jet fuel price of US$95.50/bbl, compared with around US$70.66 in 2009. The 2010 average global gasoil price, calculated by BMI, is US$92.67/bbl, against US$68.96 in 2009. The 2010 average naphtha price is estimated at US$83.09 - compared with US$59.30/bbl in 2009. For global unleaded gasoline, BMI is now forecasting an average US$95.66/bbl in 2010, up from

around US$70.17/bbl in 2009. BMI forecasts Malaysian real GDP increasing by 14.9% in 2010, with average annual growth of 4.8% forecast for 2010-2014.

State-owned PETRONAS operates in partnership with various international oil companies (IOCs) under a production sharing system that we believe will result in oil production of 755,000b/d by 2014. Consumption is forecast to rise by up to 2% per annum to 2014, implying demand of 536,000b/d. Malaysia's gas exports are set to rise from an estimated 38bcm in 2010 to 46bcm in 2014, with production climbing from an estimated 70bcm to 80bcm over the period.

Between 2010 and 2019, we are forecasting a 6.14% decrease in Malaysian oil production, with crude volumes peaking at 770,000b/d in 2011/12. Oil consumption between 2010 and 2019 is set to increase by 19.62%, with growth slowing to an assumed 1.5% per annum towards the end of the period and the country using 580,000b/d by 2019. Gas production is expected to rise from an estimated 70bcm in 2010 to a possible 100bcm by 2019. With demand growth of 20.13%, this provides an export capability reaching 61.6bcm in 2019, largely in the form of liquefied natural gas (LNG). Details of BMI's 10-year forecasts can be found later in this report, which provides regional and country-specific projections. Malaysia is ranked seventh behind the Philippines in BMI's composite Business Environment (BE) league table. Its strong showing reflects the country's fifth place in BMI's updated Upstream Business Environment rating, reflecting a strong resource position and a moderate gas output growth outlook, being offset by extensive state involvement. The country is just one point behind Papua New Guinea (PNG), but three points ahead of China. Malaysia ranks equal 13th behind Vietnam and alongside PNG in BMI's Downstream Business Environment rating, reflecting its limited refinery capacity expansion plans, sluggish oil and gas demand growth outlook and relatively high level of retail site intensity.

2.4 NUCLEAR

2.4.1 NUCLEAR ENERGY AS THE NEW ALTERNATIVE

As the world struggles to cap CO2 emissions and GHG and deal with climate change, nuclear energy is becoming more and more appealing. Fanned by climate change and dwindling fossil fuel supplies, there is now a nuclear renaissance. More and more countries are beginning to consider having nuclear reactors. In this region, Thailand, Vietnam, Indonesia and Malaysia have recently announced their nuclear plans. Nuclear energy has existed for many decades and is a popular energy source in developed countries. For instance, according to World Nuclear Association, 75% of France electricity needs are supplied by its 59 nuclear reactors and South Korea has over 20 nuclear power plants which supply 40% of its needs. Nuclear has long been considered as the only form of energy that can replace fossil fuels adequately, which currently provides 85% of the world's energy today. The burning of fossil fuels spews about 30 billion tons of CO2 into the atmosphere every year but in contrast, nuclear reactors produce almost zero CO2, according to Environmentalist of Nuclear Energy. In Malaysia, control over the use of radioactive substances began in 1968 when the government passed the Radioactive Substances Act 1968. Due to rapid development of atomic energy activities in Malaysia which requires more effective control, inspection and enforcement, the Atomic Energy Licensing Board (AELB) was established in February 1985 to act as an enforcement body and was placed under the Ministry of Science, Technology and Innovation (MOSTI) since October 1990. Non-power applications of nuclear technology have contributed to improving healthcare, generating new industrial products and processes, improving food and water security, and further development of other areas of science and technology all this while. Such nonpower applications have been the main focus of nuclear technology development in Malaysia until now.

As in many developed countries in the world, there is now a renewed interest in using nuclear energy for electricity generation in Malaysia. Recently in July 2009, the government has agreed to include nuclear as an option in the energy policy of the country, with the drafting of a new national energy policy expected to be readied by the end of the year. This is due to the realization

that the available national energy resources are inadequate to guarantee supply beyond the year 2030 and in will take 10–15 years to develop the human capital to tap into nuclear energy. Currently, electricity generation in the country is predominantly based on only three of the five fuel sources, namely, natural gas, coal and hydropower. Oil is hardly used for electricity generation, except for standby generation, and the contribution of RE to electricity generation is still insignificant and far below the target set under the 9th Malaysia Plan (2006–2010). In future, oil will no longer be a viable option for electricity generation, due to the diminishing national oil resources, and Malaysia is expected to become a net oil importer by the year 2030. Furthermore, fluctuating global oil prices do not augur well for a reliance on oil for electricity generation. As such, the priority for the use of oil should be in those sectors where it is difficult to find a substitute, especially in the transportation sector. Of the three current main sources for electricity generation, there is uncertainty over gas supply to the power sector in the peninsular beyond 2030. To cover for the shortfall in gas supply, coal-fired electricity generation may need to be increased. This is not an attractive option, given that almost 100% of the national coal supply is dependent on imports, with current total of approximately 20 million tons per year. With the increasing global demand for clean and sustainable energy, peaceful, safe and secure use of nuclear energy, further development of affordable and cost-effective small and medium sized nuclear power plants (NPP) is important.

For Malaysia, the nuclear power program can be initiated with a small nuclear power plant as a power demonstration reactor, before larger plants that are more cost-competitive can be built. This was the approach taken by Japan, which started with a Japan power demonstration reactor (JPDR) generating only 13MW of electricity from 1963 to 1982, before building 53 larger plants with capacities between 340MW and 1300MW. In view of the increasing global interest for nuclear power generation, especially among developing countries, there are concerns expressed by certain parties over the state of readiness of those countries adopting nuclear power. The main concerns have always been the nuclear waste disposal, followed by the need to decommission the NPP once it ceases operation. Both are expensive and thorny issues yet to be dealt with real effectiveness by nuclear-powered countries. If Malaysia were to pursue its nuclear future, there

are few aspects that need serious consideration. (1) Nuclear power is estimated to cost between US$0.15–0.21/ kWh whereas solar costs around US$0.20. But the costs for nuclear are rising whereas for solar, it is dropping. Solar power does not present the problems of toxic waste containment, inflated capital costs and the political and security risks associated with nuclear power. (2) Nuclear fuel is not as abundant as one might think. Uranium ore, which contains enough U-238 to make enrichment feasible, can only be found in a handful of countries. Some of these countries are politically unstable, others need the uranium for their own nuclear reactors, and some may use it as a mean of exchange (like Russia recently exchanges uranium with natural gas from Europe). Hence, the security of supply is not guaranteed.

Furthermore, usable uranium is a limited resource, just like fossil fuel, and studies even show that the peak of nuclear fuel can be expected during the coming decade, similar to the peak of oil. NPPs are designed to last around 60 years and the radioactive waste such as plutonium has a halflife of 24,400 years. The process of enriching uranium for it to be used as nuclear fuel is extremely energy intensive and produces lots of GHG. Thus, nuclear power is not as carbon neutral as many had claimed. (3) Currently, Malaysia runs at 47% over-capacity to compensate for fluctuations in demand and interruptions in supply. Such large reserves are quite adequate for years to come, and this does not even include the 2400MW Bakun dam which has yet to be commissioned. Restructuring the set up of the existing energy sector which favours IPPs at the expense of TNB seems to be a more feasible way forward. (4) It is estimated to cost US$4 billion for a 1000MW nuclear power plant (NPP), excluding other costs in running it, such as the waste disposal and other costs associated with the safety and security of the plant. Furthermore, the planning and building of an NPP normally takes 15–20 years and tends to incur cost overruns and construction complications. If the same amount of monies is pumped into solar plants which require minimal maintenance, energy can be generated almost instantly. Studies conducted by the PTM estimated that 6500MW power can be generated by using only 40% of country's house roof tops (2.5 million houses) and 5% of commercial buildings alone.

2.4.2 PROSPECT OF NUCLEAR ENERGY IN MALAYSIA

Malaysia's primary energy demand grows at an annual rate of 3.5% from 2002. Among the fossil fuels, coal usage grew at the fastest rate of 9.7% per year, followed by natural gas at 2.9% and oil at 2.7%. Coal demand will increase substantially to meet the rising electricity demand. The electricity demand in Malaysia will increase by 4.7% per year. The growth in electricity demand is heavily influenced by strong demand from the industrial sector, which increases at 5.4% annually. Electricity demand for the residential sector will also experience strong growth of 4.9% per year due to improved standards of living. Per capita electricity demand is projected to be more than double from 2002 to reach 7,571 kWh /person in 2030.

One of the main usages of atoms is electricity generation. To produce 1000MW, 2,000,000 tonnes of coals needed. But, if we replace the coals with uranium, there are only 30 tonnes of uranium needed to produce the same amount of electricity which is 1000MW.

The nice thing about nuclear energy power is that it emits practically no carbon dioxide. A small quantity of carbon dioxide is emitted in 'fuel cycle'- the mining of uranium, refining, fuel enrichment and fabrication, transportation, decommissioning and waste disposal. But it's only a minor percentage of that emitted by burning fossil fuel such as coal, oil and gas, to obtain the same amount of energy. Nuclear power's future will undoubtedly have a potential role in reducing environmental impacts because it can certainly contribute to greenhouse gases mitigation.

CHAPTER 3: METHODOLOGY

3.1 OVERVIEW OF MALAYSIA PRIMARY ENERGY

3.1.1 SUPPLY

With a projected average economic growth rate of 7.5% per year in the 2001–2005 period, resource-rich Malaysia would have to cater for the 7.8% yearly increase in final energy demand. Total primary energy supply is projected to grow at an average of 7.2% per year in the same period (Economic Planning Unit, 2001a). The main sources of commercial energy supply in 1999 amounting to 37.2 million tonnes oil equivalent (Mtoe) were derived from crude oil and petroleum products (48.5%) followed by natural gas (41.8%), coal and coke (5.2%) and hydro (4.5%). In the 1990–1999 period, the share of crude oil and petroleum products in the total primary energy supply declined while that of natural gas increased indicating a successful reduction from the overall dependence on crude oil and petroleum products (Ministry of Energy, Communications and Multimedia, Malaysia, 1999, 2000). Total oil reserves stood at 3.42 billion barrels in 1999. With sustained domestic production of oil and maturity of existing fields, domestic crude oil reserves are expected to last at least another ten years. Malaysia is expected to be a net crude oil importer by 2008 (Economic Planning Unit, 2001b) unless efforts in domestic oil exploration result in discoveries of substantial new oil reserves. Natural gas can be classified into two types viz. associated and non-associated gas. As at 1999, total natural reserves amounted to 84.4 trillion standard cubic feet of which 16% was associated gas and the remaining 84% was non-associated gas (Ministry of Energy, Communications and Multimedia, Malaysia, 2000). To ensure adequate gas supply, the country will supplement domestic gas supply with gas from the Malaysia–Thai Joint Development Area (MTJDA), West Natuna and South Sumatra. The gas pipeline interconnections will form part of the Trans-ASEAN gas pipeline network. The country's known coal reserves in 2000, mainly in Sarawak and Sabah, were estimated at 1050 million tonnes. Although coal quality ranges from lignite to anthracite, bituminous and sub bituminous coal form the main share of the total coal reserves. Based on the forecast coal production at 0.75 million tonnes per year, a recent report highlighted that 95% of the total coal

requirement by the year 2005 still needs to be imported (Ambun, 2000). The lack of economies of scale and competition from bigger coal producing countries are reasons why development of domestic coal resources has not been aggressively pursued.

3.1.2 DEMAND

The expansion of industrial and transport sectors were main contributors to the increase of final demand for commercial energy, which collectively grew at an average annual growth rate of 7.5%, from 11.3 Mtoe in 1990 to 21.7 Mtoe in 1999. the industrial and transport sectors were the largest energy consumers in the 1990–1999 period. In 1999, share of transport and industrial sectors in the total final energy use were 42% and 38%, respectively. The decrease in the share of oil and petroleum products in energy mix reflects the success of the Four Fuel Diversification Strategy and the National Depletion Policy introduced in the early 1980s. The share of petroleum products in final commercial energy consumption declined from 75% in 1990 to 69% in 1999. Although the electricity sector has successfully decoupled from oil dependency, the transport sector still relies heavily on petroleum products. The increase in private and commercial vehicles and the expansion of road networks have contributed to the high energy demand growth in the transport sector. The trend toward greater urbanization accelerated the transition to electricity where higher income per capita made desirable electrical goods more affordable. Success of the rural electrification programme introduced by the Government also contributed to an increase in electricity demand. As of 2000, 93% of rural households in Malaysia were served with electricity. As shown in Fig. 3, share of electricity in final energy consumption increased from 13% to 18% in 1990 and 1999 respectively.

3.1.3 OIL

- Escalating global oil prices;
- Depleting national oil reserves, with new exploration moving to deeper seas & Malaysia expected to revert to being a net oil importer by the year 2011;
- Need to reserve for future generations & other sectors, such as transportation, where it is difficult to replace oil as fuel;
- Oil already decoupled from power sector.

3.1.4 NATURAL GAS

- Cap on gas utilization for power generation, with no new gas-fired power plants allowed;
- Deregulation of natural gas prices, with price increase from RM 6.40 per MMBTU to RM 14.31 per MMBTU for power sector;
- Current gas fields to be depleted by 2027 with new fields of higher carbon dioxide;
- Competing petrochemical industry demand;
- Committed exports of liquefied natural gas.

3.1.5 COAL

- Over 90% dependence on coal imports;
- Supply constraints amongst exporters, e.g. port facilities in Newcastle, Australia, unable to cope with coal export demand;
- Escalating coal prices, especially within the region;
- Limited high quality indigenous coal deposits, with mostly sub-bitumeneous & lignitic coal.

3.1.6 HYDRO POWER

- Limit to availability of Sarawak hydro resources for supply to Peninsular Malaysia;
- Geographical supply & demand mismatch for hydropower resources, between Peninsular Malaysia & Sarawak, with 670 km. of South China Sea in between. but only to around the year 2020, with maximum transmission of only around 5,000 MWe to Peninsular Malaysia, including Bakun hydropower project;

3.1.7 NUCLEAR POWER

- With need for good, advanced preparation, national capacity-building & public acceptance, supported by current increasing renewed interest.

3.2 ENERGY PROSPECTS IN MALAYSIA

Malaysia in the 21st century faces many challenges as it sails through the uncharted path of globalization. Although the 1997–1998 economic downturns was cushioned by the adoption of strategic measures, another bout of economic slowdown is expected to bring about a certain degree of uncertainty to the energy sector. In the quest to achieve 'Developed Nation' status as embodied in its Vision 2020 goal, sustainable development of the energy sector will become the pivotal factor for economic competitiveness and progress.

Electricity peak demand in Peninsular Malaysia alone has grown from 3447MW in 1990 to 9948MW in July 2001. Peak demand is projected to increase by almost 55% to 15,380MW by 2005 (Economic Planning Unit, 2001a). Based on recent reports, a huge capital investment of approximately RM30 billion will be allocated for new power plants in the next ten years. Savings accrued from energy efficiency are viewed as a unique domestic energy resource. It is hoped that energy efficiency programs will also reduce the need to allocate huge power plant capital investments. Energy efficiency efforts facilitated by the Government not only reduce the overall requirements for energy but are also expected to improve the profit margins of organizations, generate new businesses and decrease foreign exchange loss by reducing the need to build new power plants and recurring fuel imports

3.3 STUDY METHOD : SCENARIO DEVELOPMENT

3.3.1 BUSINESS AS USUAL (BAU) SCENARIO

The Business As Usual (BAU) scenario represents the energy pathway that follows the continuation of current trends by using official state-level forecasts and plans. Consumption trends in residential, commercial and public services, and industrial sectors, as well as steady growth in population and GDP characterize the BAU pathway. This scenario will also take into account current and anticipated government policy related to the power sector and how these policies actually shape the direction of the sector in the coming two decades.

The aim of this scenario is to show the future through the prism of current policies and strategies, and delineate the relationship of the power sector with political, economic and the environmental institutions. The growth of electricity demand in residential, industrial, and commercial sectors is assumed to follow the normal one

3.3.2 GREEN FUTURE (GF) SCENARIO

The (Green Future) GF scenario is a fairly aggressive promotion and implementation of renewable energy technologies in the overall energy mix. It explores how the country can diversify its energy source in the light of the uncertain international energy market and for the benefit of greater energy independence. Given the country's heavy reliance on natural gas, of which about 25% is imported, reducing dependence on gas becomes a key energy security concern. Hence, not only does renewable energy symbolize real environmental commitment but it also becomes a strategic resource for negotiating future electricity generation beyond fossil fuels.

3.4 KEY FACTOR OF NUCLEAR OPTION IN ENERGY SUPPLY SECURIITY

3.4.1 NATIONAL ENERGY SITUATION

- Lack of available competitive, sustainable alternative commercial energy sources for the long-term, especially beyond 2020.
- Need to enhance national energy security due to depleting indigenous resources.

3.4.2 GLOBAL ENVIRONMENT SITUATION

- Need to reduce GHG emissions, subject to future national obligation under the post-Kyoto Protocol regime to the UN Framework Convention on Climate Change (UNFCCC).

3.4.3 NATIONAL STATE OF PREPARDNESS

- Increasing level of confidence that national economic & industrial capabilities well-developed for nuclear power.
- Power grid in Peninsular Malaysia with 900 km 500kV backbone large & robust enough for nuclear power plants.
- Privatization of power generation industry led to more innovative & enterprising industry.

3.4.4 NUCLEAR PLANT TECHNOLOGICAL ADVANCEMENT

- Extension of design life of modern plants from 25 to 40 years for past generation to 60 years for current generation plants.
- Shortening of plant construction periods from 10 to 15 years to 3 to 6 years.
- Improved plant safety, with plant standardization, robust designs, and modular construction techniques.

3.4.5 NUCLEAR FUEL TECHNOLOGY IMPROVEMENT

- Improvement in nuclear fuel design & technology with extension of refueling cycle from 12 to 18 months to up to 24 months, resulting in improved plant load factors.

3.4.6 NUCLEAR POWER PROJECT RISK REDUCTION

- Improved nuclear power plant licensing and regulatory process due to standardization of modern nuclear plant designs;
- Minimized susceptibility to nuclear plant project cost overruns due to escalation in interest-during-construction (IDC), with shorter construction periods.

3.4.7 IMPROVED NUCLEAR POWER ECONOMIC

- Improvements in nuclear plant technology, nuclear fuel design, reduction in construction & project lead time, and extension of plant operating life, leads to improved nuclear power economics.

Type of Power Plant	Fuel for 1,000 MWe for 1 year
Nuclear (fission)	30 Tonnes of uranium
Natural Gas (Combined Cycle)	87.6 Billion SCF of gas
Fuel Oil	1.96 Billion Gallons of oil
Coal	2 Million Tonnes of coal
Thermonuclear (fusion)	0.6 Tonne of tritium/hydrogen
Bioalcohol	16,100 KM2 of corn
Biomass	30,000 KM2 of plantation area
Wind	3,000 Wind Turbines of 1 MWe
Solar	100 KM2 area
Biogas	800 Million chicken

Table 3

3.5 PROJECT FLOW CHART

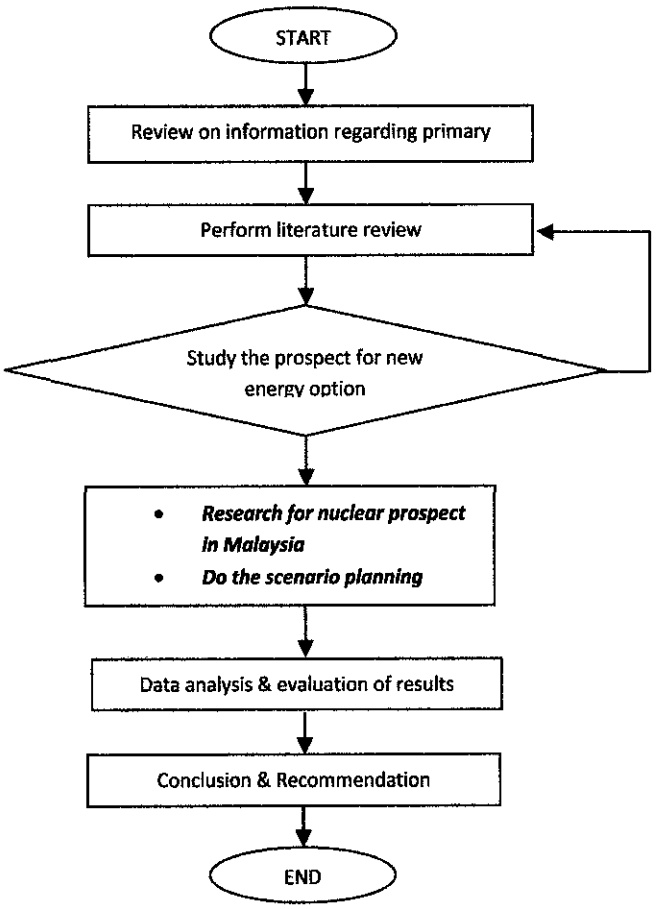


Figure 5

3.6 GANTT CHART

WEEK / ACTIVITES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Make the Progress Report															
Submission the Progress Report															
Design the Poster															
Poster Presentation															
Make the Technical Report															
Submission the Technical Report															
Make the Dissertation															
Submision the Dissertation															
Submission the Hardbound Copy															
Oral Presentation															

Table 4 - Gantt-chart of the Project

CHAPTER 4: RESULT AND DISCUSSION

4.1 RESULT OF SCENARIO PLANNING

All the tables below are showing about what happen to the demand of primary energy in Malaysia in year 2020 after Malaysia develop the nuclear energy as one of the energy source.

Natural Gas (KTOE)	
Total demand (2020)	53,151
Demand for electricity sector (2020)	18,402
New demand Forecast (2020) = Total demand (2020) - demand for electricity sector (2020)	34,749
53151 - 18402 = 34749	
Percentage of demand reduction	34.62%
18402 / 53151 * 100 = 34.62%	

Table 5

Coal (KTOE)	
Total demand (2020)	14,408
Demand for electricity sector (2020)	11,253
New demand Forecast (2020) = Total demand (2020) - demand for electricity sector (2020)	3,155
14408 - 11253 = 3155	
Percentage of demand reduction	78.10%
11253 / 14408 * 100 = 78.10%	

Table 6

Nuclear (KTOE)	
Total demand = New natural gas demand forecast (2020) + New coal demand forecast (2020)	29,655
18402 + 11253 = 29655	

Table 7

BAU Scenario Planning Energy Production Supply Forecast (2020) in ktoe								
Year	2009	2010	2011	2012	2013	2014	2015	2020
Natural gas production forecast (2020)	54,826	55,211	55,902	56,604	56,801	57,002	57,500	60,906
Crude oil production forecast (2020)	33,726	32,551	32,704	32,704	32,960	33,215	33,215	32,449
Coal production forecast (2020)	586	589	592	595	598	601	604	620

Table 8

GF Scenario Planning Energy Production Forecast (2020) in ktoe								
Year	2009	2010	2011	2012	2013	2014	2015	2020
Natural gas production forecast	54,826	55,211	55,902	56,604	56,801	57,002	57,500	34,749
Crude oil production forecast	33,726	32,551	32,704	32,704	32,960	33,215	33,215	32,449
Coal production forecast	586	589	592	595	598	601	604	620

Table 9

4.2 BAU SCENARIO RESULT

4.2.1 OIL, NATURAL GAS AND COAL PRODUCTION FORECAST

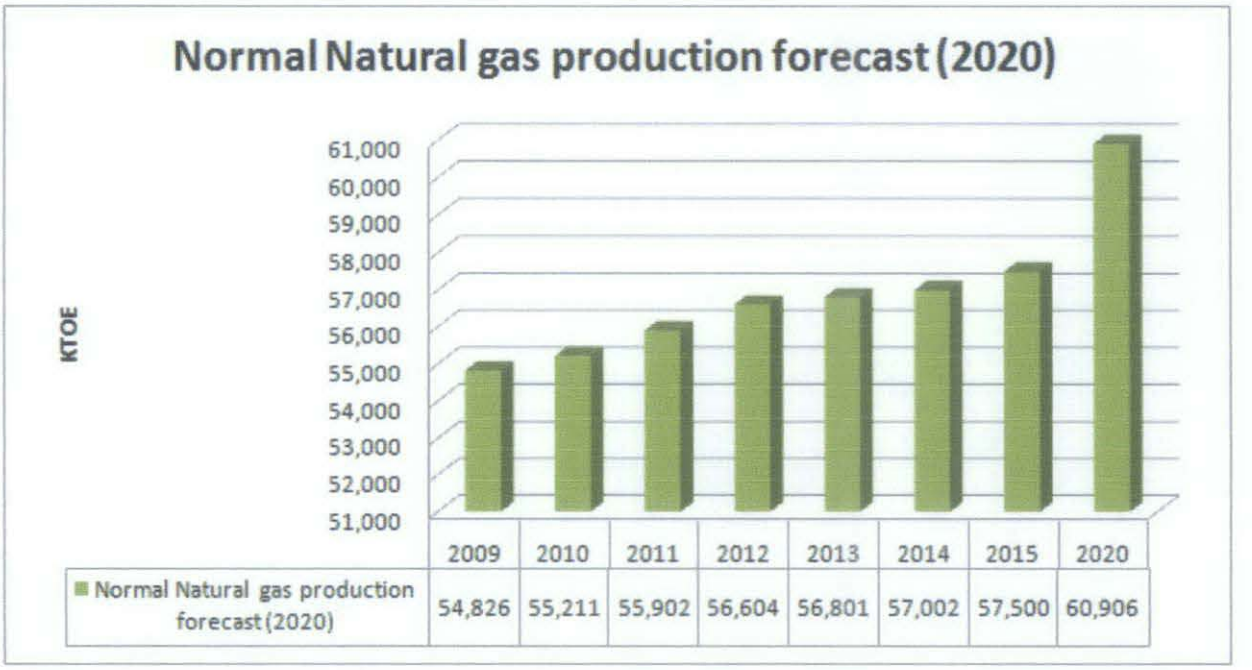


Figure 6

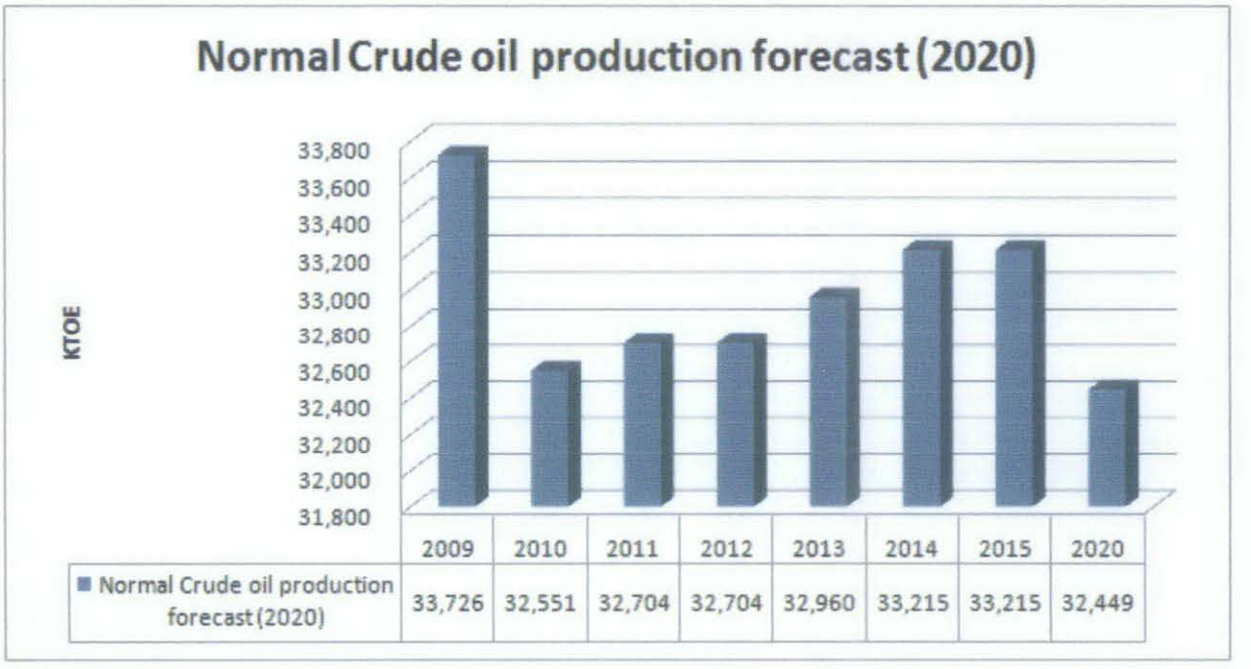


Figure 7

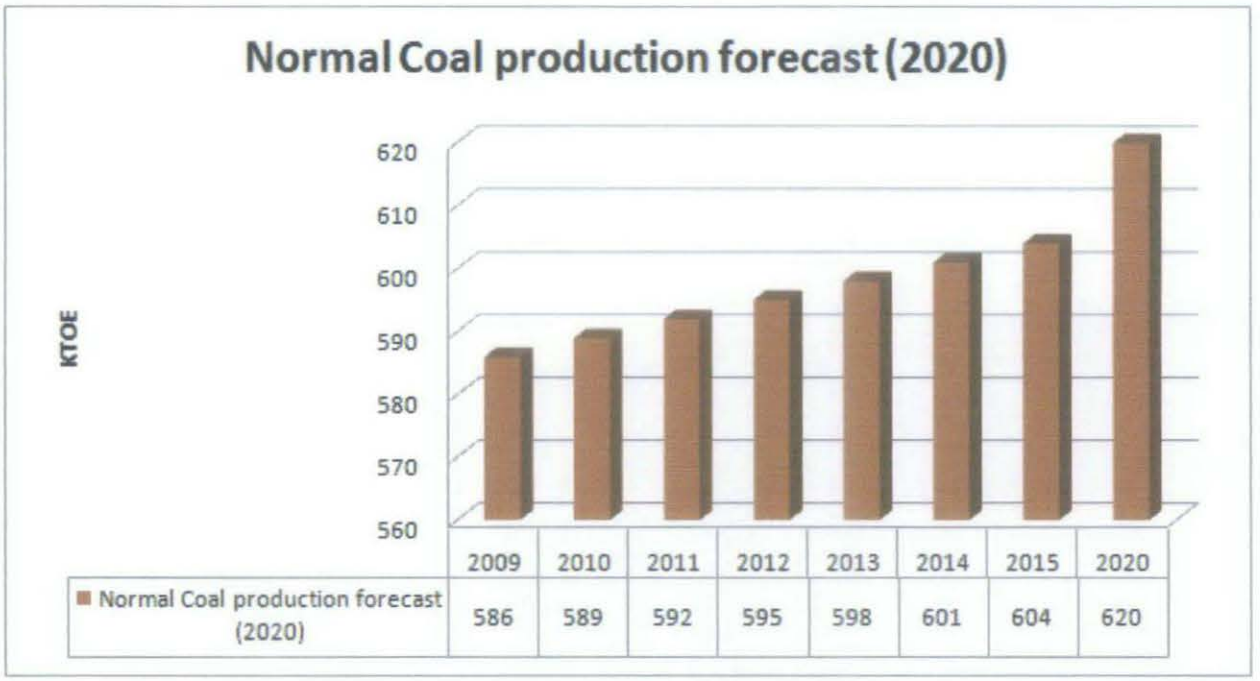


Figure 8

This is the forecast of production of natural gas in year 2020. Basically, we forecast that the production of natural gas and coal will be increased because to fulfill the increasing of demand. For crude oil, we forecast that the production will be decreased because our reserves are depleted.

4.2.2 OIL, NATURAL GAS AND COAL DEMAND FORECAST

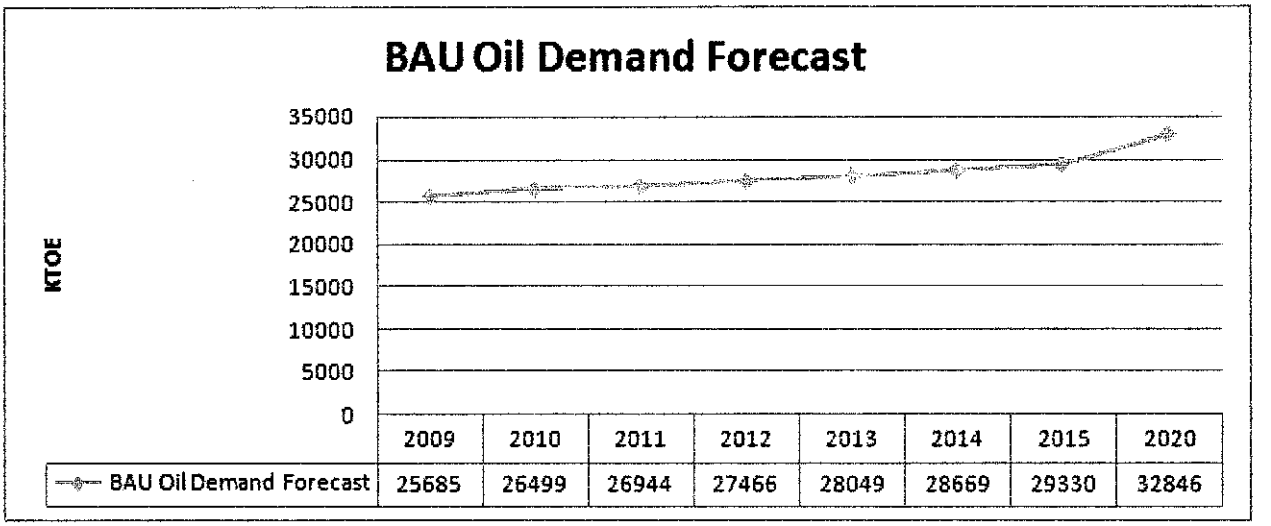


Figure 9

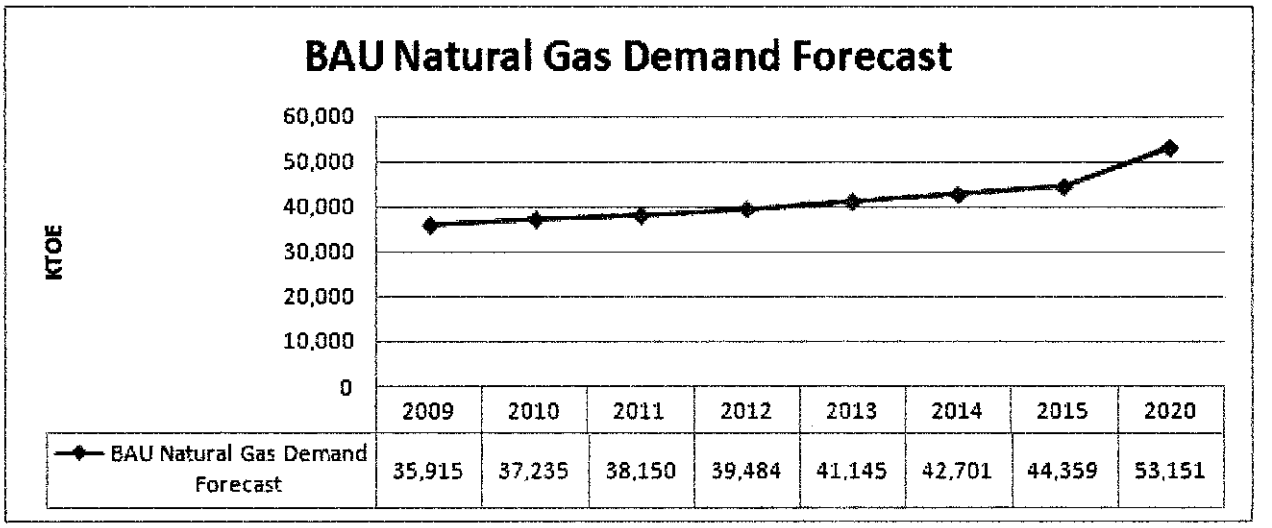


Figure 10

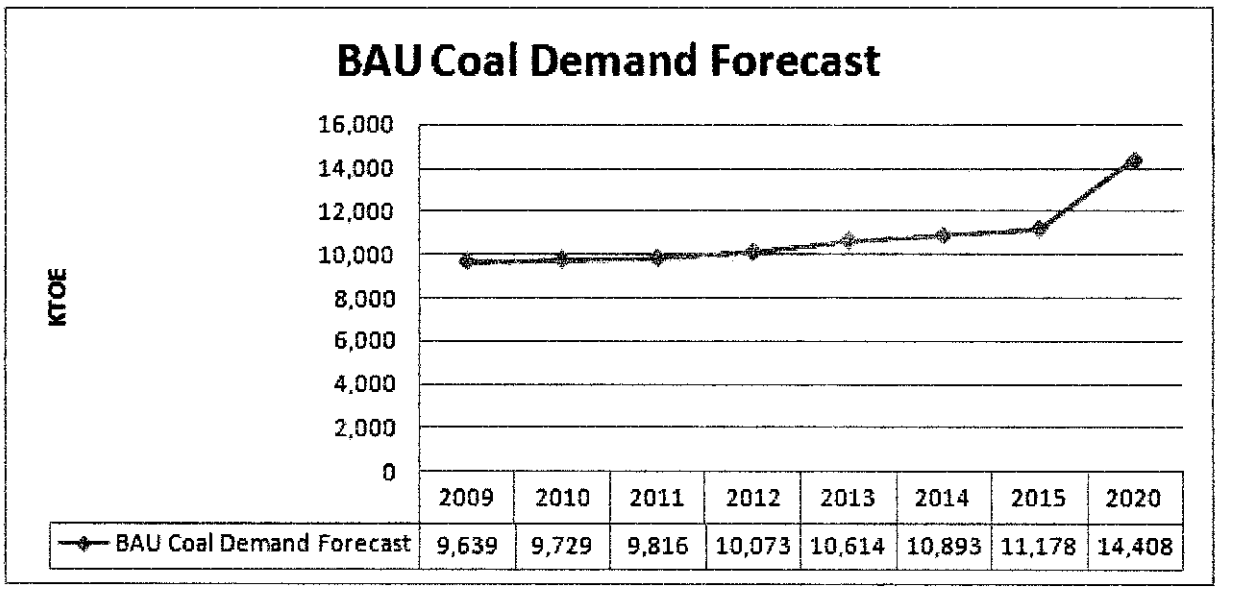

BAU Coal Demand Forecast
KTOE
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
2009 2010 2011 2012 2013 2014 2015 2020
BAU Coal Demand Forecast 9,639 9,729 9,816 10,073 10,614 10,893 11,178 14,408

Figure 11

4.2.3 ELECTRICITY SECTOR FORECAST

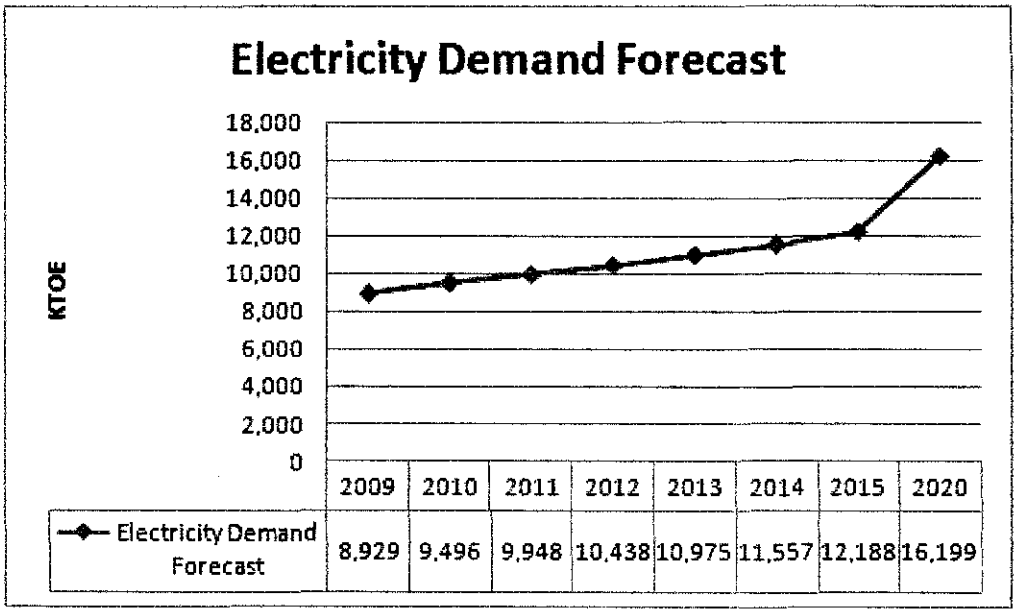


Figure 12

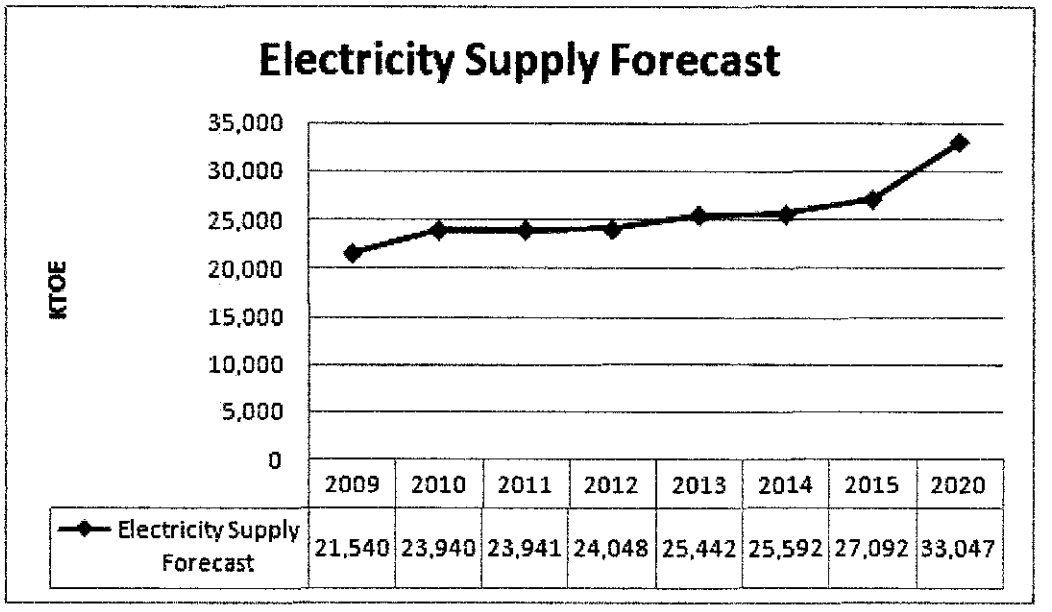


Figure 13

The forecast of natural gas and coal in electricity sector until year 2020

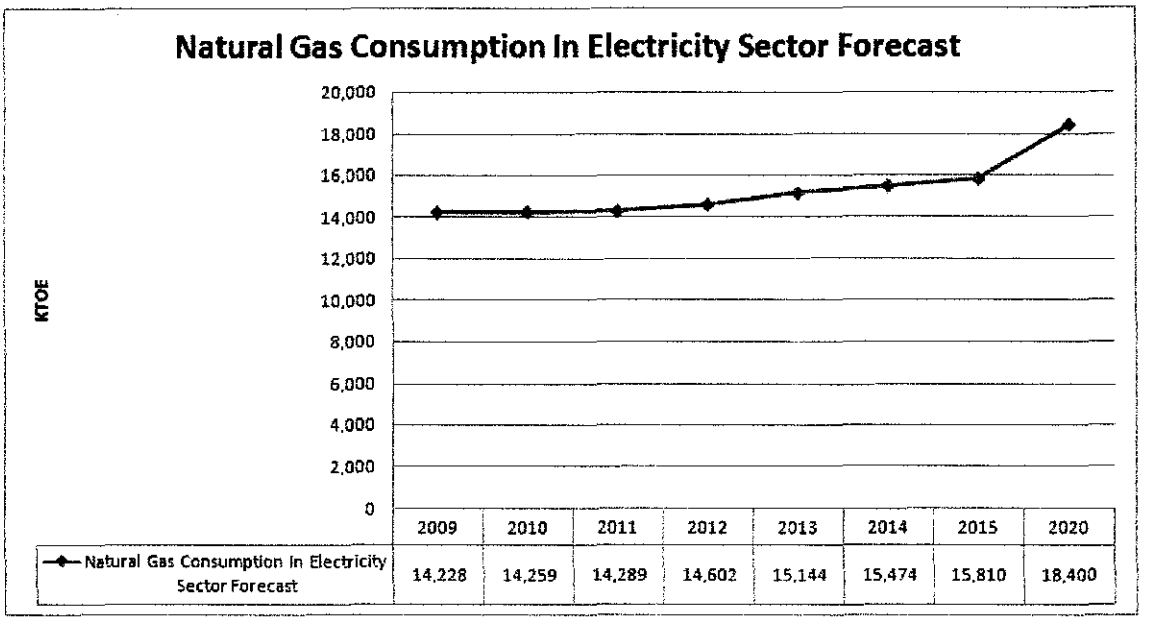


Figure 14

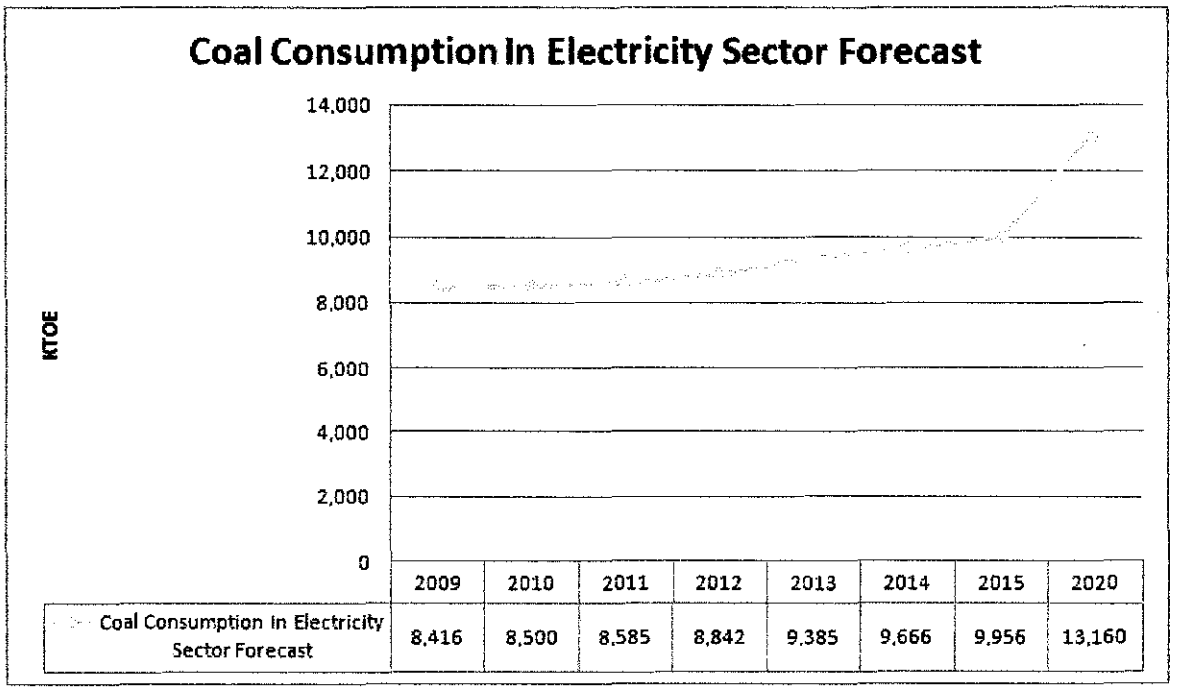


Figure 15

4.2.4 BAU SCENARIO OVERALL FORECAST IN 2020

This is the normal forecast of primary energy in Malaysia in year 2020. For this one, we just have 4 primary energy which are crude oil, natural gas, coal and hydropower.

Normal Energy Demand Forecast In Malaysia in 2020 (KTOE)	
Natural Gas	53,151
Crude Oil	32,846
Coal	14,408
Hydro Power	1,700
Total	102,105

Table 10

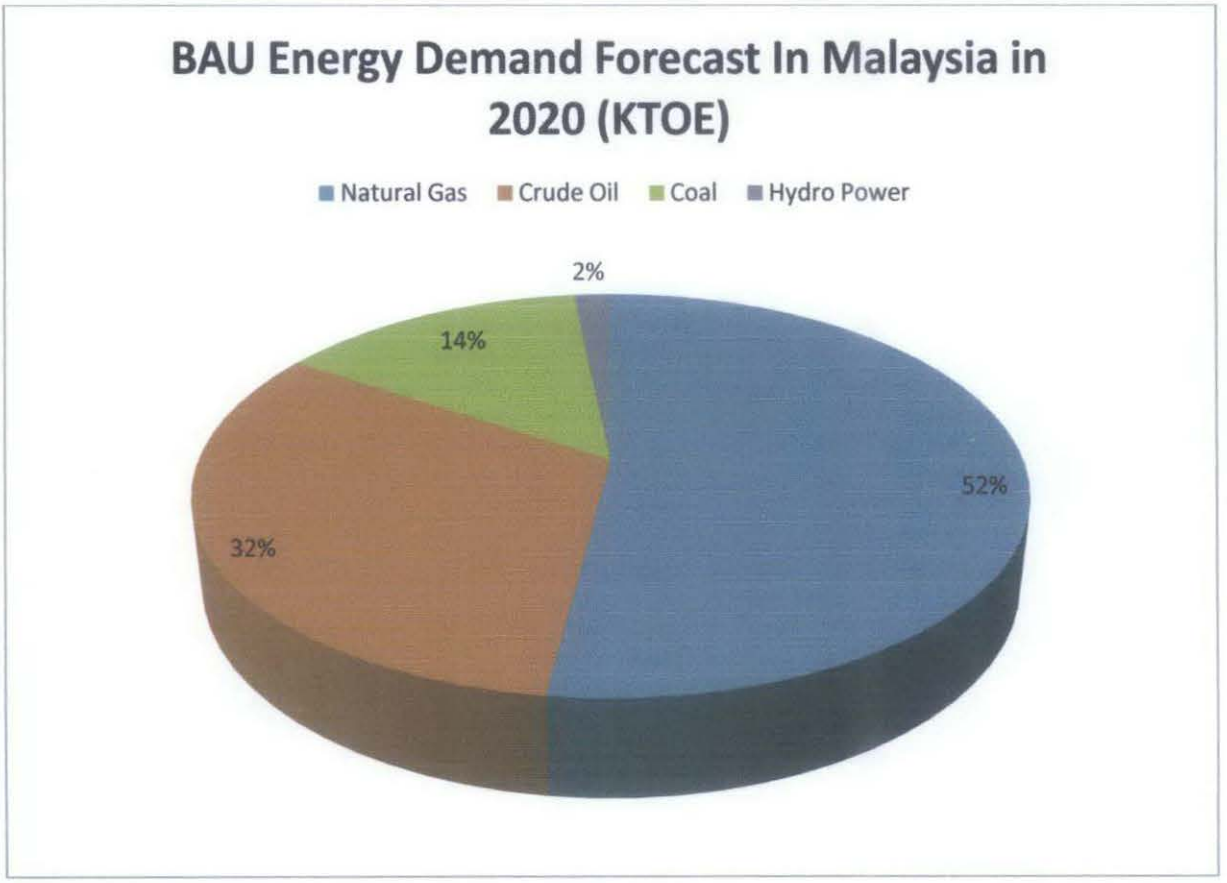


Figure 16

4.3 GF SCENARIO RESULT

4.3.1 OIL, NATURAL GAS AND COAL PRODUCTION FORECAST

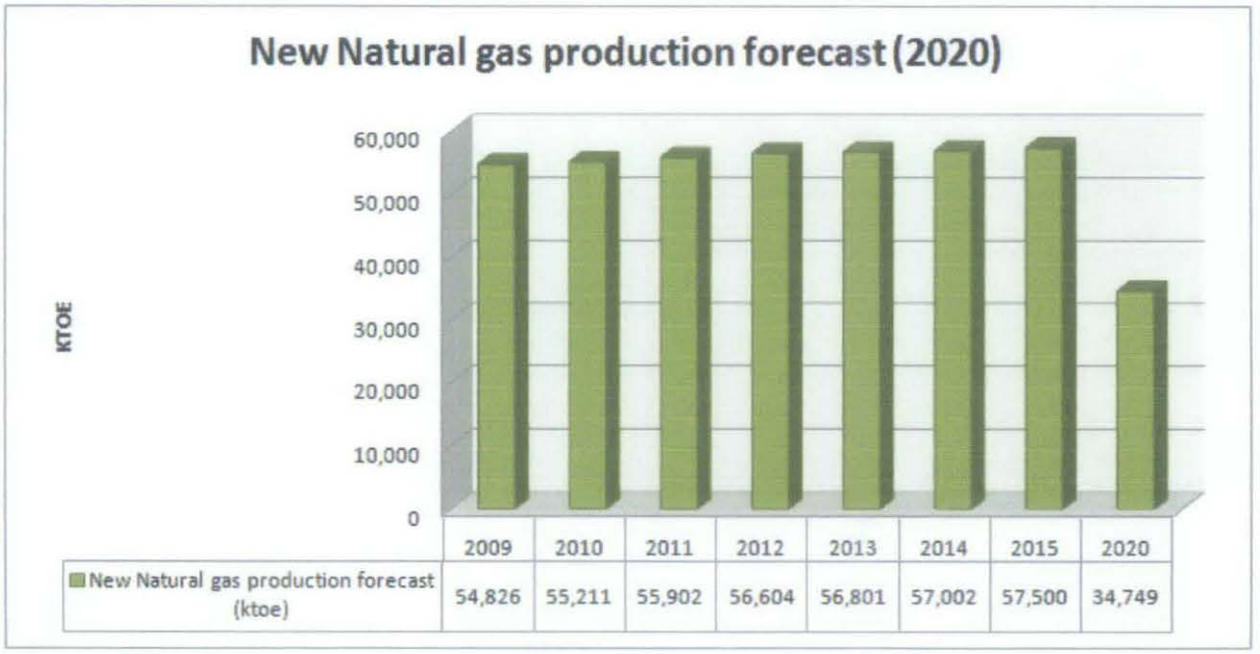


Figure 17

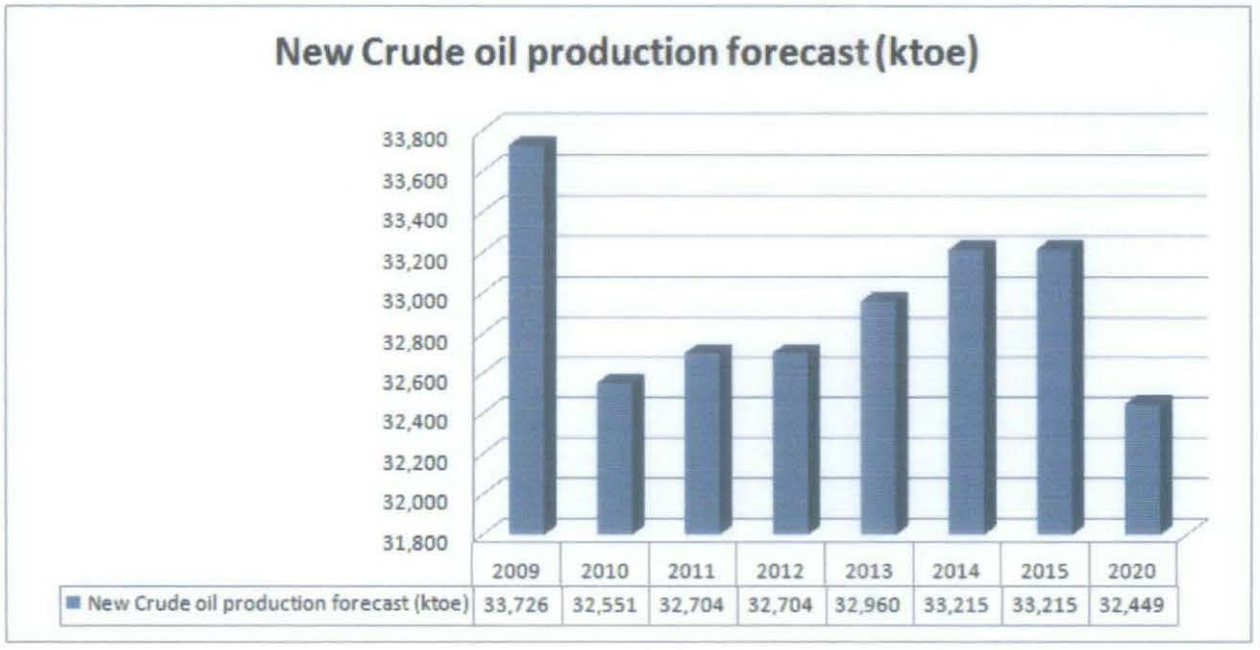


Figure 18

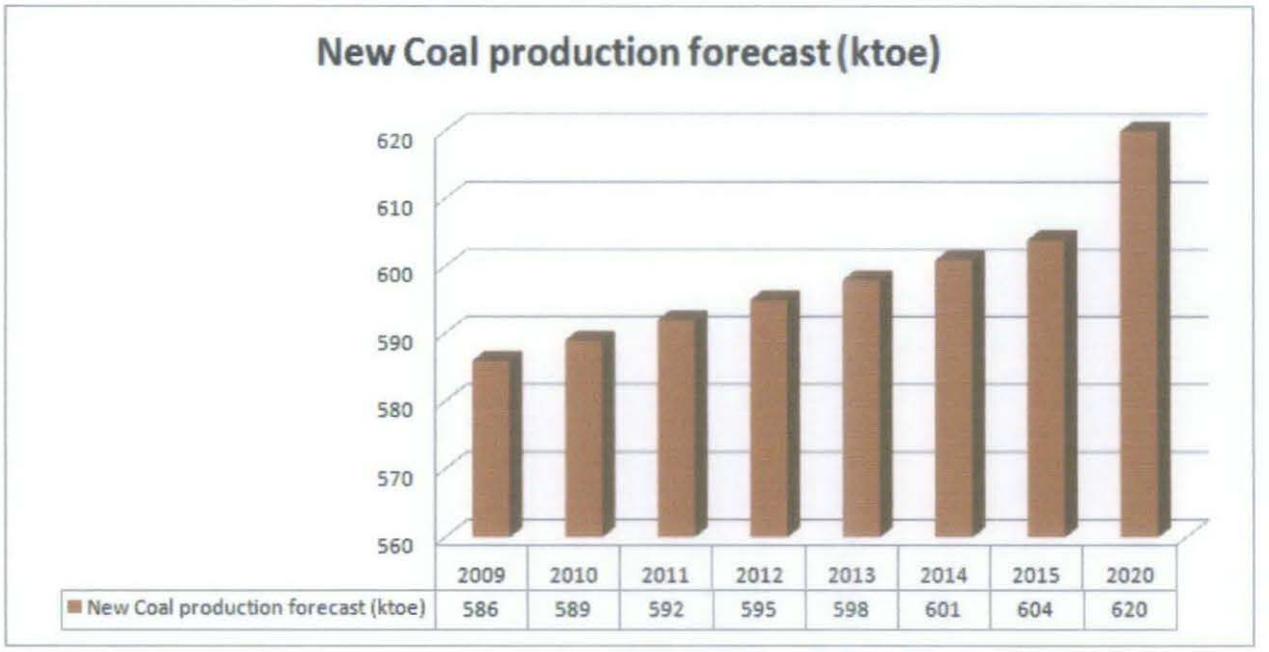

New Coal production forecast (ktoe)
620
610
600
590
580
570
560
2009
2010
2011
2012
2013
2014
2015
2020
New Coal production forecast (ktoe)
586
589
592
595
598
601
604
620

Figure 19

4.3.2 OIL, NATURAL GAS AND COAL DEMAND FORECAST

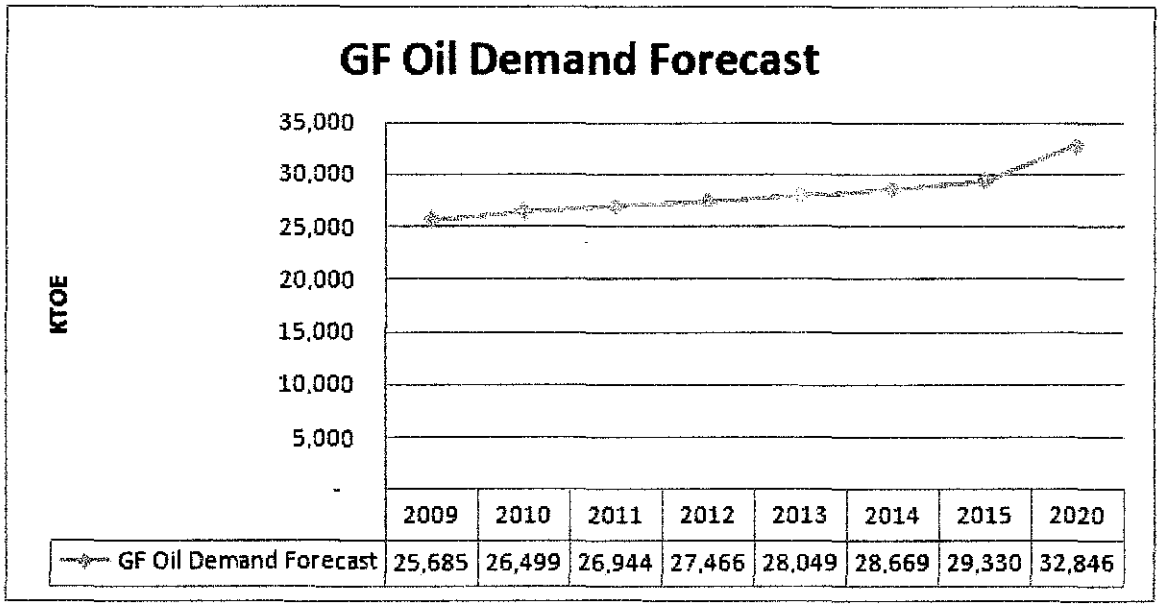


Figure 20

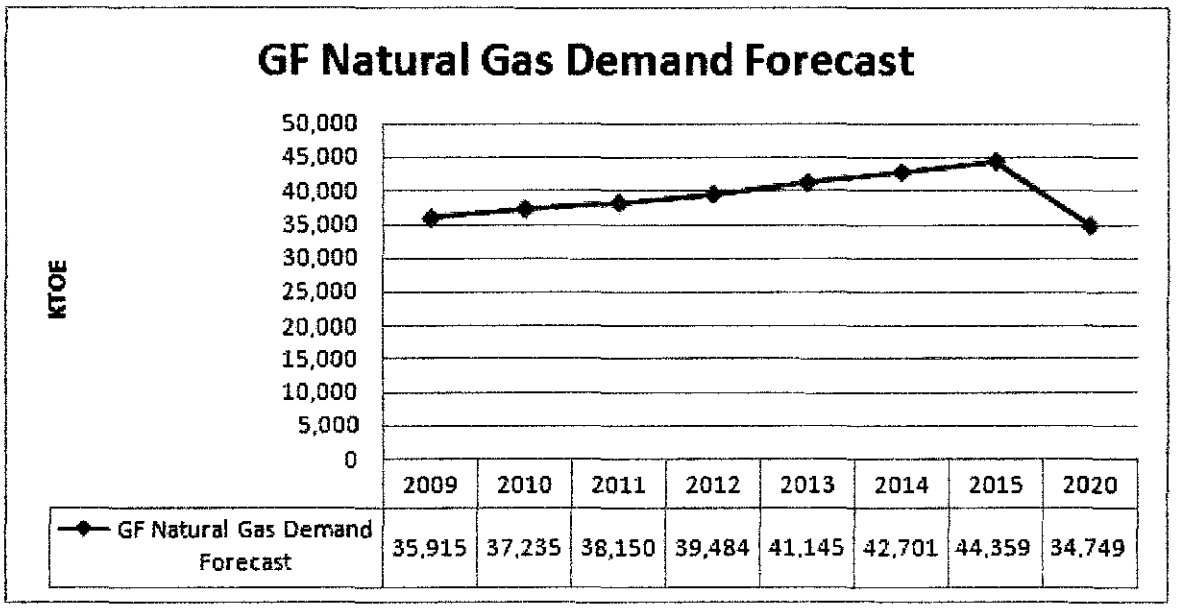


Figure 21

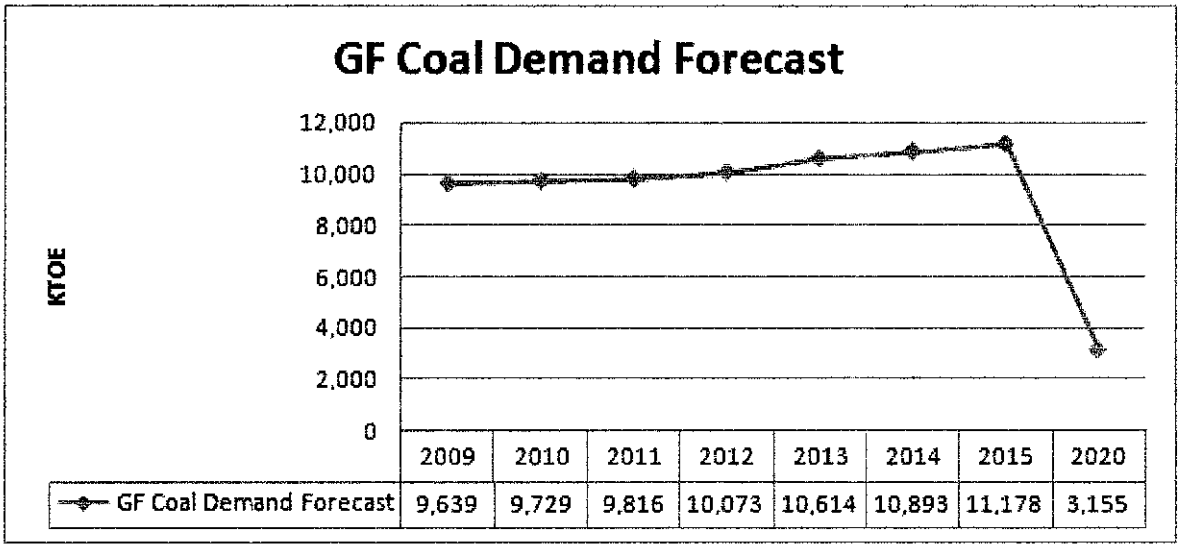

GF Coal Demand Forecast
KTOE
12,000
10,000
8,000
6,000
4,000
2,000
0
2009 2010 2011 2012 2013 2014 2015 2020
GF Coal Demand Forecast 9,639 9,729 9,816 10,073 10,614 10,893 11,178 3,155

Figure 22

4.3.3 ELECTRICITY SECTOR FORECAST

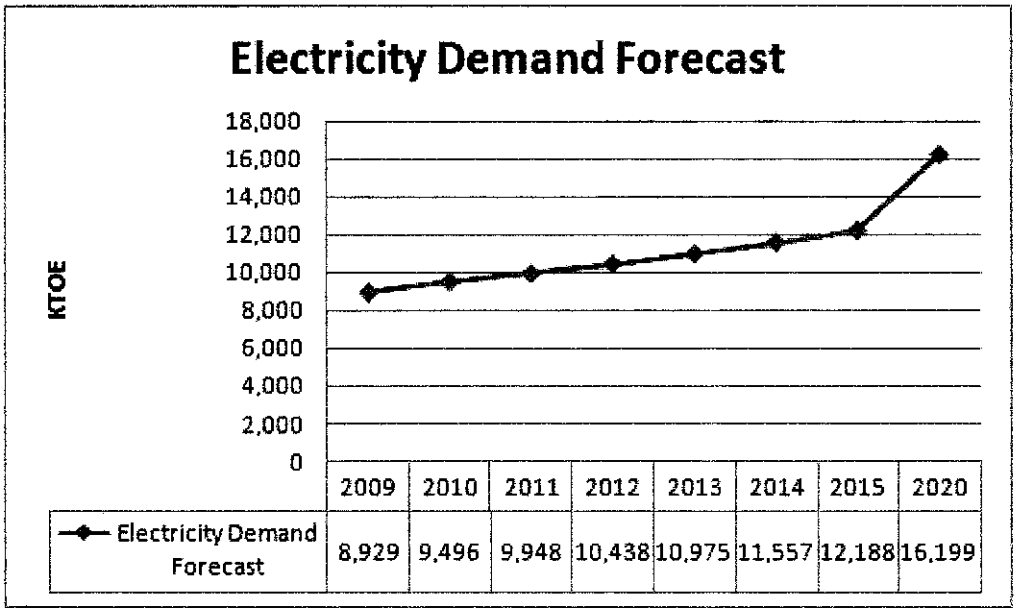


Figure 23

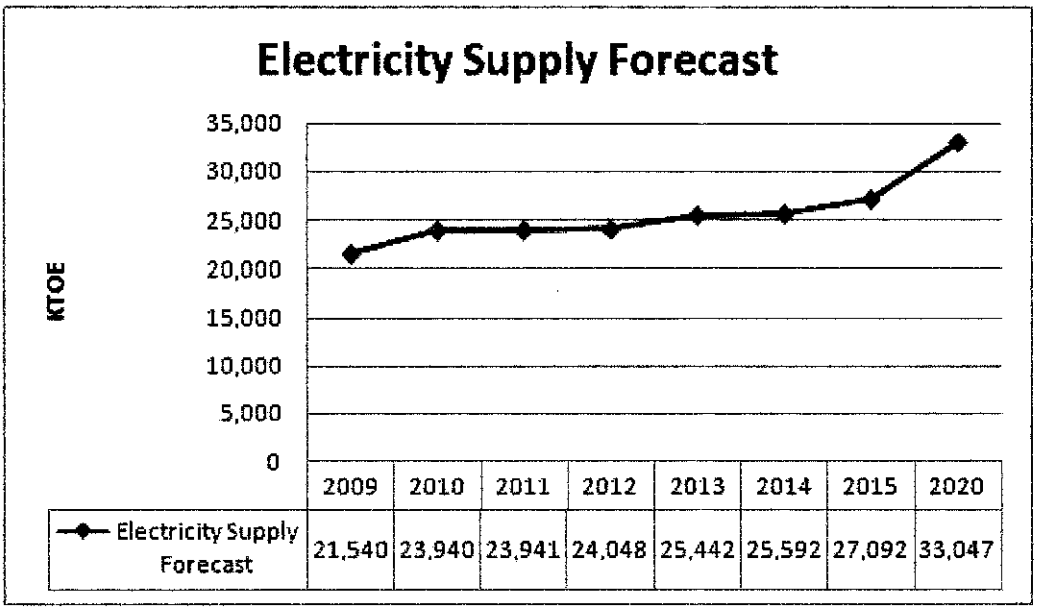


Figure 24

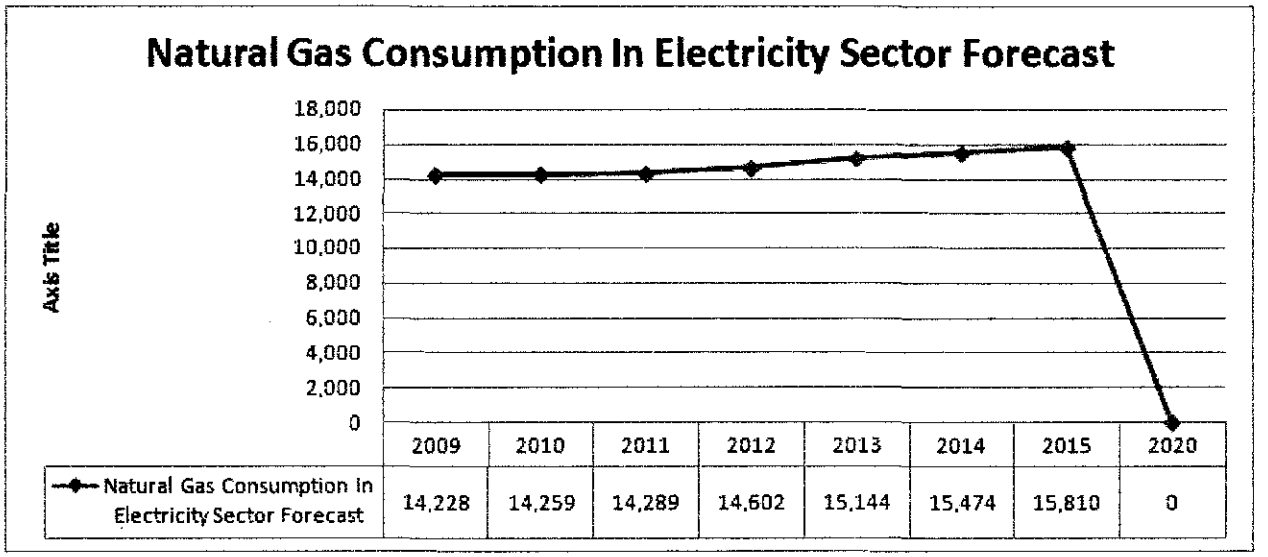


Figure 25

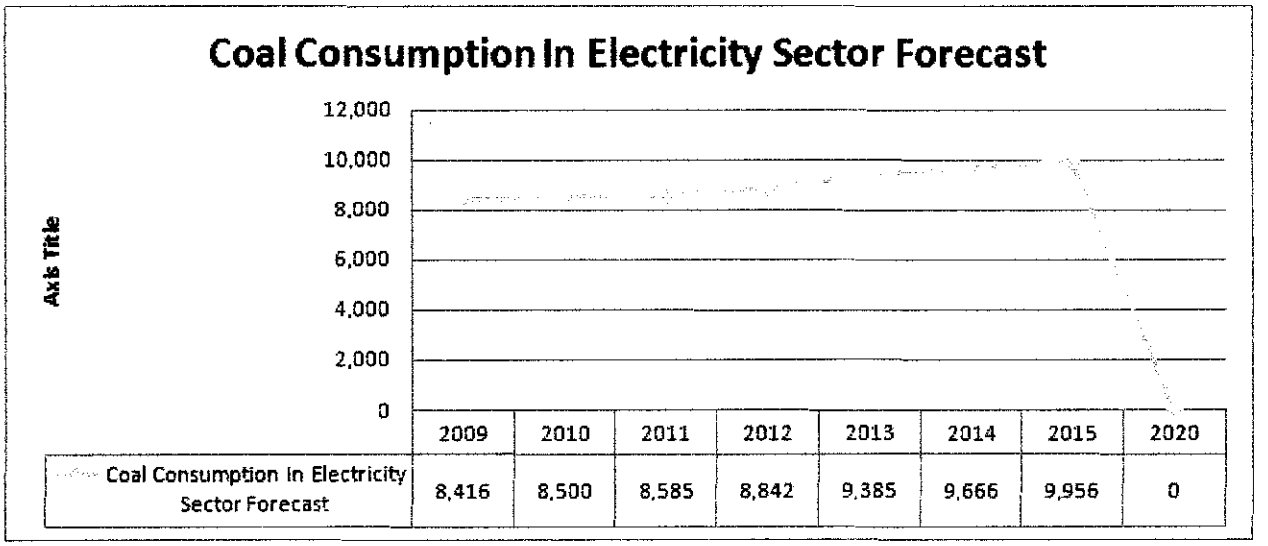


Figure 26

We forecast that the demand for natural gas and coal will be zero in year 2020.

4.3.4 GF OVERALL FORECAST IN 2020

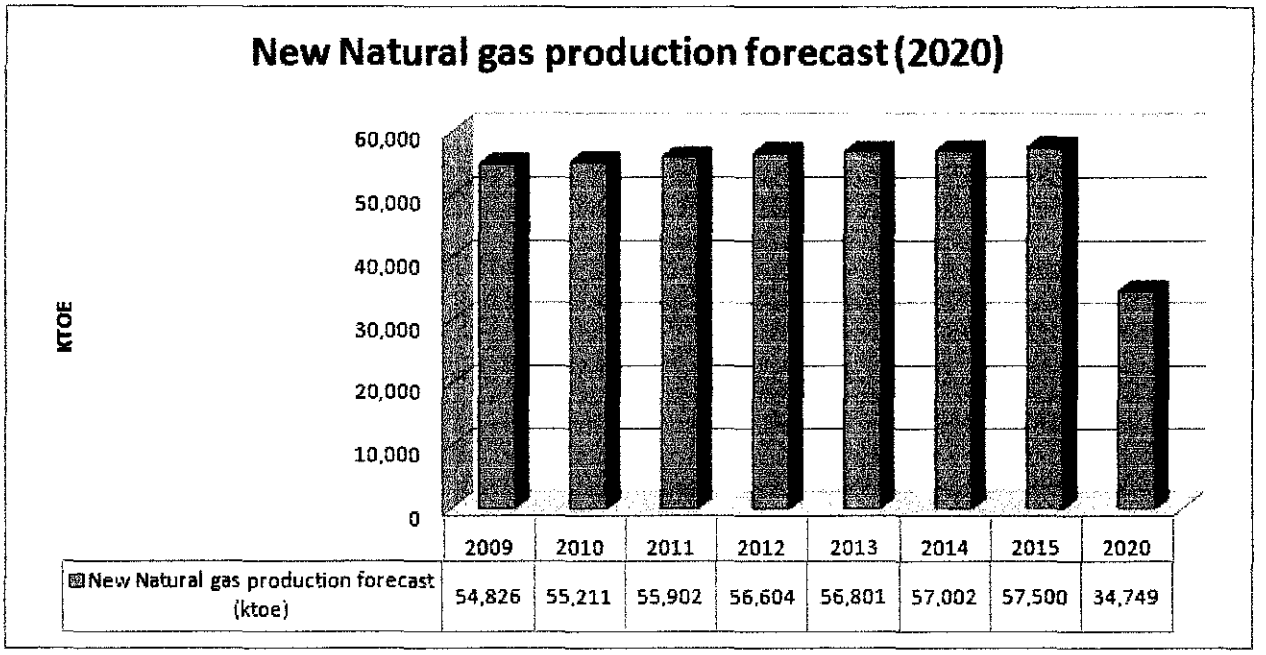


Figure 27

This is the forecast of production of natural gas in year 2020. Basically, we forecast that the production of natural gas will be decline because some of its usage will be covered by nuclear energy. But, for the production of crude oil and coal, it will be the same either if we have or not have nuclear plant because crude oil are not affected so much by the existence of nuclear energy while for the coal, we are still depend too much on the import and not from our own production.

New Energy Demand Forecast In Malaysia in 2020 (KTOE)	
Natural Gas	34749
Crude Oil	32846
Coal	3155
Hydro Power	1,700
Nuclear	29655
Total	102105

Table 11

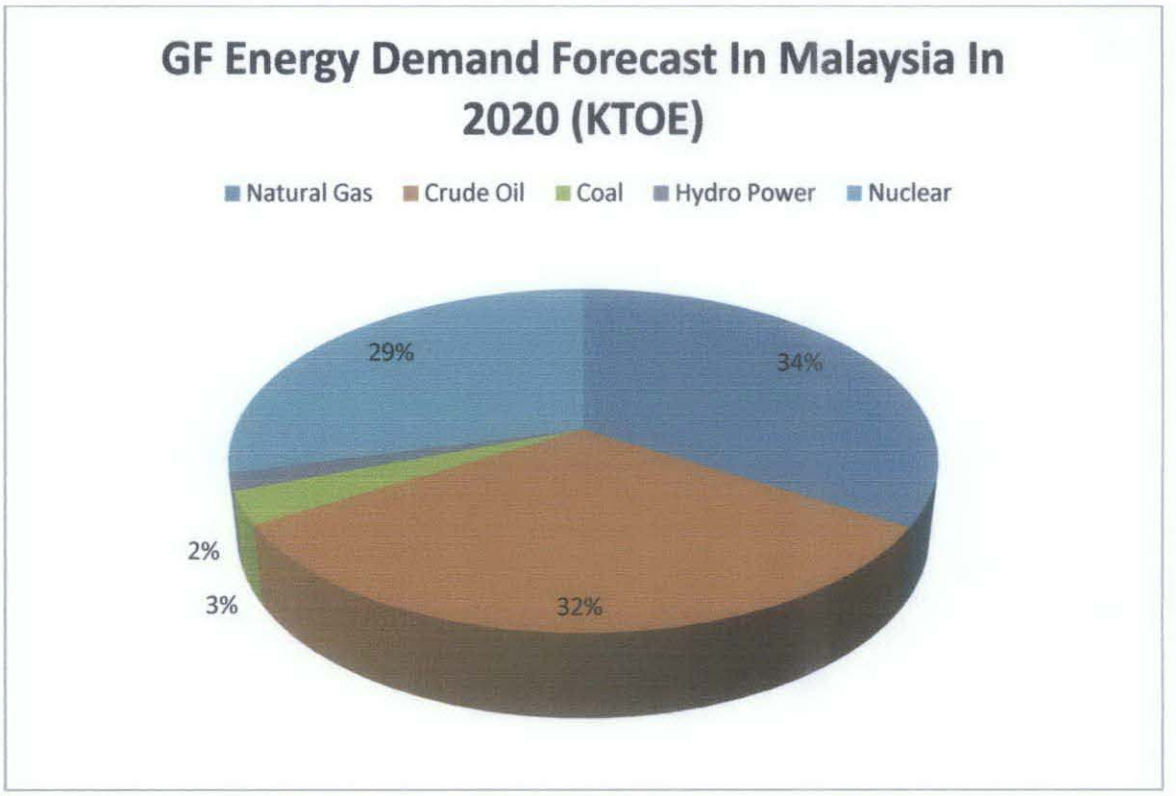


Figure 28

This is the forecast of primary energy in Malaysia including nuclear energy. As we can see here, if there are the developments of nuclear plant in Malaysia, the consumption of natural gas and coal can be reduced at high value. Nuclear basically can replace the usage of natural gas and coal in electricity sector. So that, we can save natural gas energy for the other purpose.

4.5 DISCUSSION

4.5.1 NUCLEAR PLANT NEEDED

Details For GF Scenario	
Capacity of 1 nuclear reactor (mwe)	1,000
Energy needed (ktoe)	29,655
Energy needed (mwh)	344,887,650
Power needed (mwe)	39,370
Total nuclear reactor needed (unit)	40

Table 12

4.5.2 CO_2 EMISSION REDUCTION

Type of energy	Total emission (kg CO2)	Equivalent to (kg carbon)
Natural gas	39,637,738,160	10,821,102,517
Coal	37,919,224,000	10,351,948,152
Total	77,556,962,160	21,173,050,669

Table 13

4.5.3 CONCLUSION OF RESULT

- The development of nuclear reactor still cannot solve the problem regarding the depletion of oil.
- To cover the usage of natural gas and coal in the electricity sector, we need at least 40 units of nuclear reactor.
- The emission of carbon can be reduced up to 21,173,050,669 kg per year

CHAPTER 5: CONCLUSION AND RECOMMENDATION

One of the oil–nuclear competitions is indirect: nuclear electricity versus oil products at the level of end-use. It involves many factors including economics, productivity, convenience, regulation, availability, product quality, and social preferences. These factors limit the room for competition between electricity and oil products (and vice versa) in the residential, commercial, industrial, feedstock and transportation markets.

Here the characteristics of fuels and associated conversion technologies can be an advantage or disadvantage in meeting a particular energy service demand. As we have witnessed over recent decades, transportation services have remained the domain of oil. Likewise, many energy services are exclusively a domain of electricity (information/communication, lighting, control, etc.) where oil products are essentially excluded. Electricity is an end-use energy technology without any emissions, highly efficient, versatile, and convenient to use. No wonder then that it has been the fastest growing end-use energy carrier worldwide. Oil use outside the transportation and chemical sectors (feedstock) and non-energy use has declined in the residential, commercial, and industrial sectors of the OECD countries (1973: 707 Mtoe; 2002: 403 Mtoe) in large part as a result of increased use of electricity and natural gas. In developing countries, oil use in these sectors has been increasing from 124 Mtoe to 354 Mtoe over the 1973–2002 period (IEA, 2004). Globally, however, oil use in these sectors has declined from 960 Mtoe to 811 Mtoe over this period.

Another, to some extent related form of indirect linkage is the substitution by nuclear of other energy sources for electricity generation that can then be used to substitute oil in other market segments. In particular, nuclear may replace natural gas in power generation and this would then free natural gas that could replace oil in the transportation sector or heat market. In as far as the indirect competition between nuclear electricity and oil products is concerned, it is useful to analyze the market share of electricity in total final energy as a function of nuclear electricity generation in different countries. In short, at a first glance there is little evidence that suggests a

strong influence of the level of nuclear presence in electricity generation on the electricity market share in final energy and hence a significant indirect competition between nuclear power and oil.

In summary, since 1973 nuclear power expanded its market share in electricity generation essentially at the cost of oil. In absolute terms, however, oil sales to power generation did not decline—rather increased slightly. The decline in oil product use in the non-transport end-use sectors is hardly attributable to nuclear power. There are some exceptions and special cases like Sweden where nuclear-generated electricity replaced oil in residential heating and to some extent even in district heating. By and large, however, numerous factors have contributed to the relative decline of oil use in the OECD region with OPEC geopolitics and pricing being the largest ones.

CHAPTER 6: REFERENCES

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