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Journal of Advanced Research in Applied Mechanics
ISSN (online): 2289-7895 | Vol. 24, No. 1. Pages 22-38, 2016

Sustainable Power Generation Pathways in Malaysia: Development of Long-range Scenarios

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Abstract–*Power generation in Malaysia significantly depends on three major fossil fuel sources namely coal, natural gas and fuel oil. Burning of these fossil fuels emits greenhouse gases (GHG) into the atmosphere. The usage of fossil fuels for power generation also severely affects the fossil fuel reserves. In the current consumption trends, the reserve for natural gas is projected to be completely diminished by 41 years whereby crude oil by 29 years. As Malaysia is set to be a high-income nation by 2020, electricity demand would also increase furthermore. In this perspective, Malaysia is looking for alternative fuels for electricity generation to deal with the challenges and leading to a sustainable power generation sector. Malaysia is endowed with a huge amount of renewable energy resources and these could be the potential alternative for power generation. Application of renewable resources also results in several technical, financial and policy implications. Scenario building can assist policy makers to understand their implications and enable them to enact relevant measures. The purpose of this work is to develop a few power generation scenarios with various fossil and renewable resource shares for Malaysia. Three alternative scenarios, i.e. Maximum Renewable Energy Scenario, 50% renewable share by 2050 scenario, and Optimistic Energy Scenario were built based on latest information on renewable resources and energy efficiency technologies. Simulation software called Long-range Energy Alternative Planning (LEAP) system was utilized to projecting those alternative scenarios from 2015 onwards. This work found that these three alternative scenarios provide sufficient power supply and keep emissions within target limit. Policy makers can gain insights from these alternative scenarios and enact necessary policy measures to counteract the emission and fossil fuel depletion challenges.*

Keywords: Scenario, Long-range, Emission, Renewable, Energy policy

1.0 INTRODUCTION

Power generation in Malaysia significantly depends on three major fossil fuel sources namely coal, natural gas and fuel oil. These fossil fuel sources account for 89% of the total primary energy input for power generation in Malaysia [1]. Burning of these fossil fuels causes negative environmental consequences through emission of greenhouse gases (GHG) [2]. The reserves of crude oil and natural gas in Malaysia also depleting in a rapid pace and they are projected to be completely diminished by about 30 and 40 years respectively as of 2015. This country also sets to be a high-income nation by 2020 that subsequently increase electricity demands and the reserves are most likely diminished earlier than the projection periods.

The current pattern of power generation cannot be sustained in the near future because of environmental impacts and depletion of fossil fuel reserves [3]. In this perspective, Malaysia is pledging to use alternative fuels for electricity generation to counteract with the challenges and lead to a sustainable power generation sector. This country is endowed with a huge amount of renewable energy resources such as biomass, wind, solar, small hydro and ocean and these resources could be the potential alternative fuels as power generation feedstock. In 2000, Malaysia introduced a new fuel diversification strategy where renewable energy is considered as the fifth fuel after coal, oil, natural gas and hydro power [3–7]. The purpose of this new diversification policy was to encourage integration of renewable resources particularly biomass, photovoltaic, and small hydro in current fuel mixes for power generation. The new fuel strategy was also meant to reduce over dependency on conventional fossil fuel sources and reduce GHG emissions [7].

Integration of these resources could have several long-term impacts on the country's techno-economics, environments and societies through costs, emissions, reserve margins, and fuel shares. Successful integration of renewable resources into the current fuel mixes requires a serious evaluation of their long-term impacts. Several studies have assessed the potentials of renewable resources for electricity generation in Malaysia [5,8–10]. Study found that Malaysia has the potential to be one of the major contributors of renewable energy through palm oil biomass [5,11]. Khor and Lalchand (2014) recommended a number of sustainability options for addressing projected fossil fuel deficits and GHG emission challenges [3]. Petinrin and Shaaban (2015) have revealed that among all the available renewable energy resources in Malaysia, solar and biomass are the most prospective [6]. Another study found that Malaysia has a huge potential to produce large scale solar power owing to the location of Malaysia on equatorial region [12]. According to our best knowledge, however, neither of the studies evaluated renewable resources for power generation in Malaysia with long-term scenario analysis. The aim of this work is to develop four long-term scenarios with various assumptions on resource shares and technology issues. The development of these four scenarios will enable us to understand the impact of prospective renewable resource shares, demand growth rates, transmission losses, and fuel switching effects for long term periods. This study also examines how different scenarios met emission limits, increasing demands and lifespan of fossil fuel reserves. This analysis would help policy makers to enact relevant measures to achieve a sustainable power sector in Malaysia.

2.0 SUSTAINABLE POWER GENERATION SYSTEM

Sustainable power generation system can be defined as the power generation provision that meets the demands of the present without affecting the ability of the future generations to fulfill their own demands [13]. There are two key components that contribute to form sustainable power generation system; these are *renewable energy* (sources) and *energy efficiency*. These two components are sometimes referred to as the twin pillars of sustainable energy policy [14]. The term *renewable energy* are synonymous as the name implies that energy from a source that does not give impact on the depletion of the earth's resources whether obtain from a central or local source [15,16]. Renewable energy are the energy sources that are generated continuously by nature and can be obtained directly from the sun (such as photo-chemical, thermal and photo-electric) and other than the sun (such as wind, hydropower and biomass) or other natural mechanisms of the environment (such as geothermal and marine energy). Energy can also be classified as a renewable if they are derived from waste products or waste inorganic sources. Renewable energy has been described as the energy that helps us to achieve goals of reducing greenhouse gas emission, therefore bring a limit for future extreme weather and climate impacts. Renewable energy is also ensuring high reliability, timely and cost-efficient delivery of energy [10,17].

Energy efficiency comprises of efficiency in energy technologies, economics, policy, and systems. The productivity of basic energy sources can be improved by increasing energy efficiency by yielding given services with less energy resources. For instance, high energy efficient system can result in a space conditioning, lighting or mechanical power with less input of sources of power generation such as coal, solar, wind or uranium [18]. In Malaysia, *Energy Efficiency* has been addressed in the 9th Malaysia Plan in order to ensure energy sustainability for continuous economic growth [9]. In addition to efficiency in technologies, energy efficiency can also be achieved through several other provisions such as implementation of energy management, judicious energy policy, and optimization of resources.

2.1 Scenario based analysis

We will examine sustainable power system pathways in Malaysia through development of long-range scenarios that aiming to reduce the carbon dioxide emissions and the feasibility for the power system in Malaysia to fulfill the demand for various sectors. Scenario is the projection of the behaviors such as environmental, society and economy in the future. A characteristic of a scenario is determined by restrictive condition according the input data of the power system. When the input data is changed, linear equations are resolved in the model to the actual circumstances and constraints [19,20].

3.0 METHODOLOGY

3.1 Scenarios development

This research will develop four hypothetical scenarios based on assumptions in major variables on resources and technologies. These scenarios are Business-as-usual (BAU), Maximum Renewable Energy Scenario (MRES), 50% renewable share by 2050 Scenario (50-50 Scenario), and Optimistic Energy Scenario (OES). The detail descriptions of these scenarios are shown in the Table 1. The base year for the scenario development is 2015 and the first year scenario will be implemented in 2016. The scenarios will be analyzed from the base year until 2050.

Table 1: The description on each scenario

Scenarios	Description
Business-as-usual (BAU)	The future pattern of activity that there will be no significant change in people's attitudes and priorities, or no major changes in the aspect of technology, policies or economics, as a result the normal circumstances can be expected to continue unchanged [21].
Maximum renewable energy Scenario (MRES)	The usage of renewable energy sources is maximized to its potential power production with the presence of energy efficiency technologies.
Fifty percent renewable share by 2050 Scenario (50-50 Scenario)	Power generation based on renewable energy sources will be implemented 50 % share of the total power generation sources with the presence of energy efficiency technologies.
Optimistic energy Scenario (OES)	Optimistic share of renewable sources will be considered with the presence of several energy efficiency technologies.

3.2 Scenarios assumptions

3.2.1 Business as usual scenario (BAU)

In residential sector, the number of households for both urban and rural will be increased with the growth rate of 3.2%. In industrial sector, the final energy demand is increased tremendously with growth rate of 3.6% for electricity, crude oil and natural gas. For commercial sector, it is forecasted that the final energy demand is rose at annual growth rate of 2.9% and maintained until 2050. For transmission and distribution losses, it is assumed that losses in current account constants until 2050. For the installed capacity in BAU scenario, the installed capacities for fossil fuels power plants are natural gas (30 GW), coal (33 GW) and crude oil (1.8 GW). For non-fossil fuels power plants, it is forecasted that for hydro (13 GW), biomass (0.99 GW), small hydro (2.57 GW) and solar (2.43 GW). For wind and ocean energy, their installed capacities still remain same as current account, i.e. 0.0 GW. For each process of all resources, the process efficiency remains the same as in the current account until 2050.

3.2.2 Maximum renewable energy scenario (MRES)

For demand branch, the behavior of three focused sectors, i.e. residential, industrial and commercial sectors follow the BAU scenario, however it is assumed change after year 2020 where its growth rate on industrial and commercial sectors varies from 1% to 4%.

For the transformation branch, MRES are applied where there is the presence of efficiency increase in consumption by 10%, electricity transmission losses decreases by 5% by 2050 and storage technologies will be built by 2050 and about 25% of total generation is energy storage.

3.2.3 Fifty percent renewable share by 2050 Scenario (50-50 Scenario)

For demand branch, there is no changes made and it follows exactly as in BAU scenario' demand branch in the first 5 years, after that the growth rate of final energy demand for

Journal of Advanced Research in Applied Mechanics
ISSN (online): 2289-7895 | Vol. 24, No. 1. Pages 22-38, 2016

industrial and commercial sectors are assumed to vary from 1% to 4%, same as in MRES. In transformation, there is a slightly change where the assumptions for 50-50 Scenario are applied.

3.2.4 Optimistic energy Scenario (OES)

In the demand branch, the efficiency increase in consumption by 15% by energy management have been applied to all sectors involved and the energy demand growth rate for industrial and commercial sectors varies from 1% to 2%. Before 2020, the energy demand behaviors follow such in BAU scenario. For transformation branch, power generation efficiency improvement by 10% by efficient technologies is applied for each resource process and the transmission and distribution losses are reduced to 3% by 2050 by high/superconducting lines and smart grid designs. In addition, the optimum installed capacity of renewable energy by 2050 is assumed, i.e. small hydro (5 GW), biomass (0.965 GW), Solar (5GW) and wind (0.2 GW) are added in the installed capacity.

3.3 Long-Range Energy Alternative Planning (LEAP) Tool

Long range Energy Alternatives Planning System, is a software tool for energy policy analysis and climate change mitigation review developed by Stockholm Environment Institute, Sweden [22]. LEAP is an integrated modeling tool and it is technically used to analyze energy consumption production and resource extraction in all sectors of an economy. It is also being used to take into consideration for both energy sector and non-energy sector GHG emission sources and sinks. Besides from analyze of GHGs, LEAP has an important role to analyze emissions of local and regional air pollutants, which is suitable for the researches of the climate co-benefits of local air pollution reduction.

LEAP is constructed based on the concept of long-range scenario analysis. Scenario can be defined as self-consistent storylines of how an energy system pattern might evolve over time. Using this useful software, the evaluation of alternative scenarios can be compared through their energy requirements, social costs and advantages and their environmental impacts. LEAP effectively includes a Technology and Environmental Database (TED) that show information on the technical characteristics, costs and environmental impacts of various energy technologies which include existing technologies, current best practices and next generation devices. It enables analysts to access comprehensive and up-to-date data describing energy technologies.

The energy consumption in LEAP is calculated by modelling the energy demand as a function of activity and energy intensity for each technology. Activity is defined as the measure of social or economic activity for which energy is consumed (e.g. number of households, floor space, devices etc.). Energy intensity is a measure of energy use per unit of activity per year. Energy consumption is calculated for the current year and for each future year in each scenario. Mathematically,

$$D_{s,y} = \sum_{j}^{J} TA_{s,y,j} \cdot EI_{s,y,j} \tag{1}$$

Penerbit Akademia Baru

Journal of Advanced Research in Applied Mechanics
ISSN (online): 2289-7895 | Vol. 24, No. 1. Pages 22-38, 2016

where *D* is energy consumption, *TA* is total activity of a particular sector, *EI* is the energy intensity, *s* is the scenario (policy element in this work), *y* is year, and *j* is the activity type among all J activities.

LEAP dispatches the specified transformation process in electricity generation to try and meet the requirements for energy on the electricity generation branch. The dispatching process is depended on the dispatch rule chosen and this will consequently execute to different calculation algorithms area used to calculate how much each process is dispatched to its output, i.e. electricity. In this project, the used dispatch rules are Process Shares, in Proportion to Available Capacity and, Run to Full Capacity. The emissions from different technologies are determined from Eq.(2). The total GHG emissions in terms of the equivalent amount of carbon dioxide (CO_2e) from 100-year GWP (global warming potential) factors of all the individual GHG are determined as in the following Eq.(3).

$$EM_{m,y} = EC_{m,y} \cdot EF_{m,v} \cdot ED_{m,y-v} \tag{2}$$

$$EM_{CO2e} = \sum_{i}^{I} EM_i \cdot GWP_i \tag{3}$$

where *EM* is the amount of emissions, *EC* is the energy consumption, *EF* is the emission factor, *ED* is the change of emission factor due to technology degradation, CO_2e is the 100-year carbon dioxide equivalent, *m* is the technology type, *v* is the vintage (i.e. the year when the technology was added), *y* is the calendar year, *i* is the GHG type among all possible types (I), and *GWP* is the global warming potential.

All variables in electricity generation in LEAP such as planning reserve margin, system peak load shape, maximum availability, process efficiency, exogenous capacity and etc. will be fulfilled based on information provided by various references such as National Energy Balance 2014 provided by Energy Commission of Malaysia [23]. All these stated methods are applied in the current account, which is the base year of the analysis i.e. 2015.

Current account will be used as a base year and all mentioned scenarios will be based on the current account. Generally, there are 3 branches which all the data of the base year need to be specified, i.e. key assumptions, demand and transformation. Under the key assumptions is which the independent variables are created and organized that its function is to “drive” the calculations in the demand, transformation and resource analysis. Key assumptions are not calculated directly in LEAP but they are very use as intermediate variables that can be referenced in modeling calculations.

4.0 RESULTS AND DISCUSSION

Journal of Advanced Research in Applied Mechanics
ISSN (online): 2289-7895 | Vol. 24, No. 1. Pages 22-38, 2016

4.1 Final energy demand

Based on the year 2015 of social and technology development in Malaysia and also from the scenario assumptions, the forecasted final energy demands for 4 main scenarios, i.e. BAU, 50-50 Scenario, MRES and OES until 2050 are obtained as shown in Figure 1. By 2050, Final energy consumption for BAU is 342.3 TWh in 20150. The final energy demand for MRES and 50-50 Scenario would be 282.9 TWh for an industrial and commercial sectors growth rate of 3%. The OES would create 173.6 TWh and 215.2 TWh demand for growth rates of 1% and 2% respectively).

Figure 2 shows electricity demands for three major sectors under 4 scenarios from 2015 to 2050. In 2015, the electricity demands in residential, industrial and commercial sectors for all scenarios are 13.3 TWh, 55.9 TWh and 40.3 TWh respectively. By the year of 2050, the electricity demands in residential, industrial and commercial sectors for BAU scenario are 39.9 TWh, 192.7 TWh and 109.6 TWh respectively. The biggest difference of electricity demands are between OES (1% growth) and BAU scenarios.

It can be seen that the BAU has the highest final energy demand for each year from 2015 until 2050 whereas OES has the lowest in electricity consumptions. MRES and 50-50 Scenario have the same trends of each growth rate in industrial and commercial sectors after year 2020 because the pre-assumption that the efficiency increases in consumption are same in both scenarios, i.e. by 10%. The different in trends of the electricity demand in each scenario also affected by the aggressive policy in the different growth rates of energy consumption after year 2020 in MRES, 50-50 Scenario and OES.

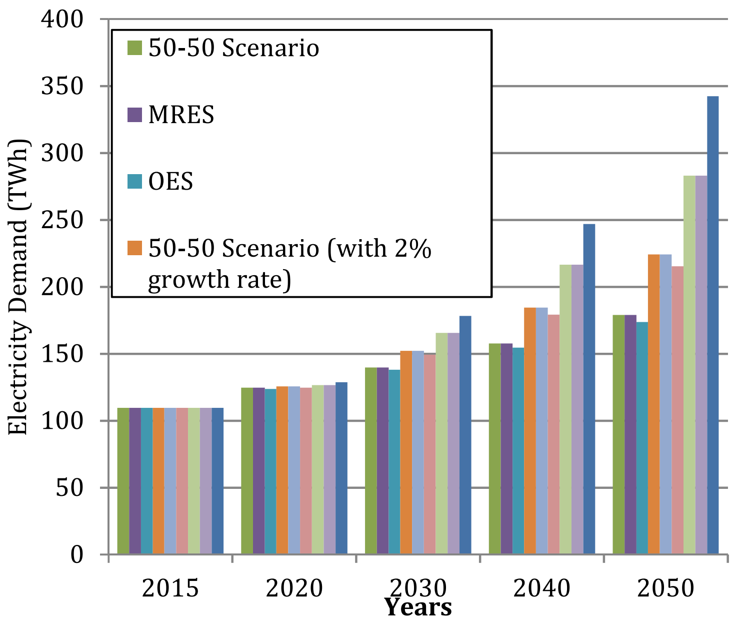

Figure 1: Final energy demand (all fuels) for 4 main scenarios from 2015 to 2050

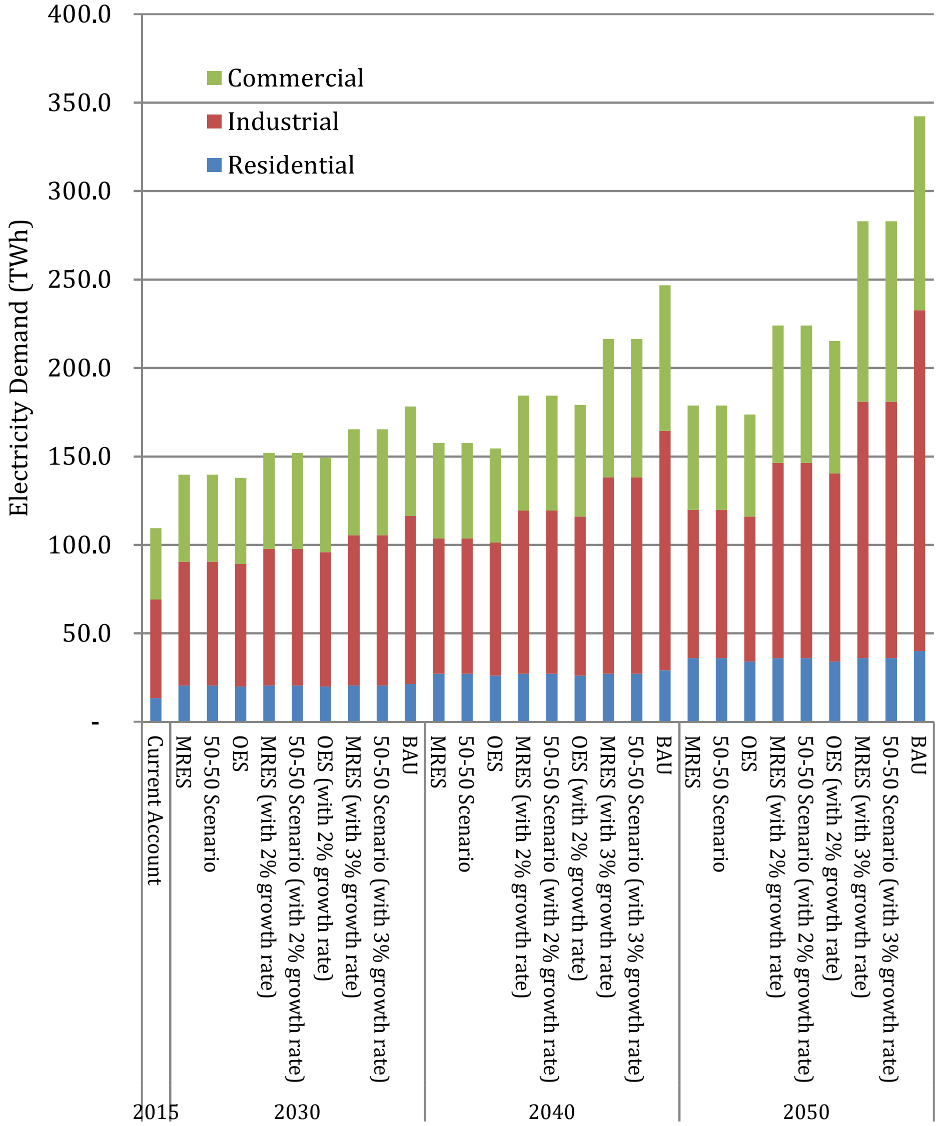

Figure 2: Electricity demand by all 3 sectors under 4 main scenarios from 2015 to 2050

4.2 Electricity Generation

Figure 3 shows the bar charts of electricity generated under 4 different scenarios to meet the growing demand for electricity. In 2015, the total electricity generated by all 4 scenarios is same, i.e. 114.7 TWh. However, by 2050, electricity generation by each scenario are varied, where BAU generates the highest electricity, which is about 361.4 TWh of electricity and OES (growth rate of 1%) is the lowest, which is about 183.6 TWh. Figure 4 shows the electricity generation shares under 4 main scenarios from 2020 to 2050. Based on the figure, the electricity

Journal of Advanced Research in Applied Mechanics
ISSN (online): 2289-7895 | Vol. 24, No. 1. Pages 22-38, 2016

generation share in 2015 is same for all scenarios, where the dominant is natural gas with 46.7%, followed by coal (41.1%), hydro (7%), diesel (3%), fuel oil (1.1%), biomass (1%) and lastly small hydro (0.1). By 2050, the share in electricity generation for BAU scenario is natural gas (49.4%), coal (27.2%), hydro (20.1%), biomass (2.6%), small hydro (0.6%) and solar (0.1%). The dependency on fossil fuels in BAU scenario is still high in 2050 where about 76.6% shares are from fossil fuels. For the 50-50 Scenario in all growth rates, 50% of electricity generation shares are from renewable energy by 2050. For the MRES in 1%, 2% and 3% growth rates, about 81.4%, 73.8% and 67.7% of electricity generation shares respectively are from renewable energy by year 2050. Meanwhile, OES scenario with growth rate of 1% and 2% have about 62.5% and 55.3% renewable energy shares respectively in electricity generation mix by 2050.

BAU produces highest electricity by 2050 is because the high energy consumption by all sectors involved. So, in order to retain the reserve margin of 30%, higher electricity supply must be achieved. However, the electricity generation from BAU emits the largest amount of GHG emissions compared to other 3 scenarios due to its highly usage of fossil fuels in electricity generation plants. Focusing to the electricity generated by MRES and OES scenarios by referring Figure 3 it is shown that the electricity generated by MRES is higher for all through 2015 to 2050 compared to the OES. Based on Figure 3, it can be summarized that all the scenarios provide the sufficient electricity to its consumers; however the major difference among each scenario is that the contribution of electricity generation plants on GHG emission to the atmosphere and the usage of fossil fuels in producing electricity.

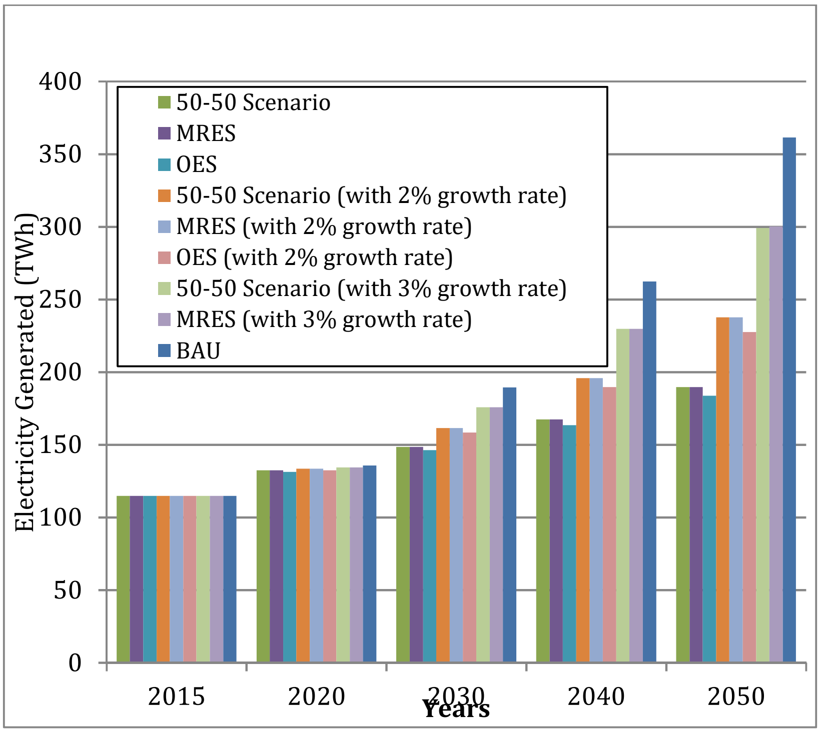

Figure 3: Electricity generated under 4 scenarios for every 10 years from 2020 until 2050

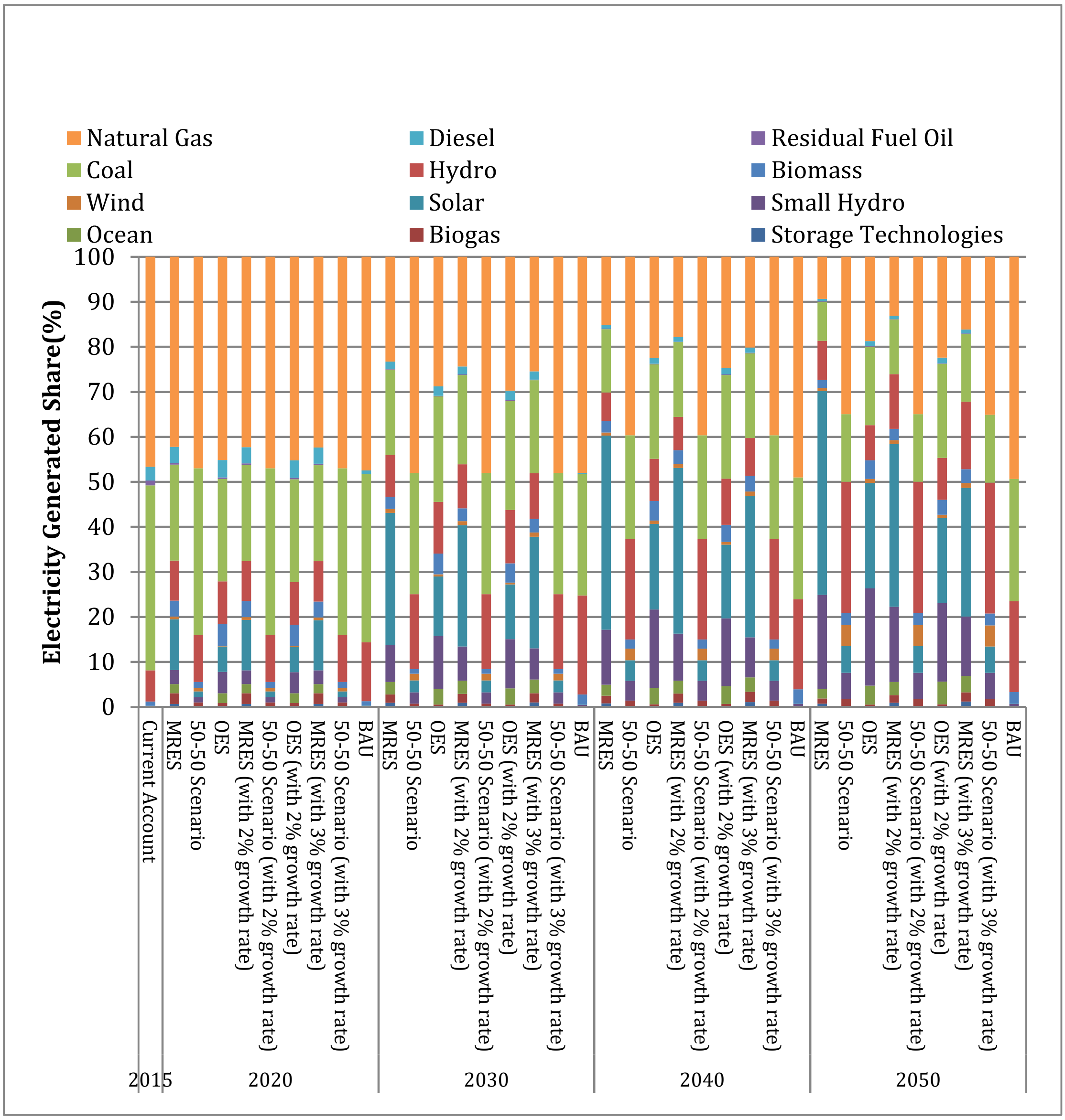

Figure 4: Electricity generation share under 4 main scenarios for every 10 years from 2020 to 2050

4.3 Emissions

The GHG emission from energy consumption and transformation process (electricity generation) under 4 scenarios from 2015 to 2050 in Malaysia is shown in Figure 5. Under the BAU scenario, GHG emission increases dramatically from 84 million tons CO_2equivalent (MtCO_2e) in 2015 up to 220.3 MtCO_2e in 2050. The increasing of GHG emission in BAU scenario can be related to the increasing in energy consumption and the high dependency on fossil fuels in order generate electricity. Under the 50-50 scenario, it appears that the highest GHG emission will be 125.9 MtCO_2e by 2050 in growth rate of 3%, which is almost 43% of GHG emission reduction compared to the BAU scenario. The reducing in the GHG emission is due to the present of 50% share of renewable energy resources in electricity power supply.

Journal of Advanced Research in Applied Mechanics
ISSN (online): 2289-7895 | Vol. 24, No. 1. Pages 22-38, 2016

For the MRES, this scenario may act as a benchmark and provide the minimum GHG emission when all the renewable energy resources are maximized to their potential in Malaysia. In MRES, the GHG emission is reduced from 84 MtCO_2e in 2015 to 43.2 MtCO_2e in MRES of growth rate of 1%, and this will be the lowest GHG emission if maximized renewable energy resources achieved. Under the OES, the trend of the GHG emission follows MRES for growth rate of 1% and GHG emission is decreased to 61.3 MtCO_2e by 2050. As comparing to the MRES at the same growth rate, OES releases more GHG emission owing to the presence of slightly fossils fuels based electricity generation. As comparing to the BAU scenario, about 72% GHG emission can be reduced if optimization of renewable energy shares in electricity generation is effectively applied (OES) and at suitable growth rate in demand for both industrial and commercial sectors.

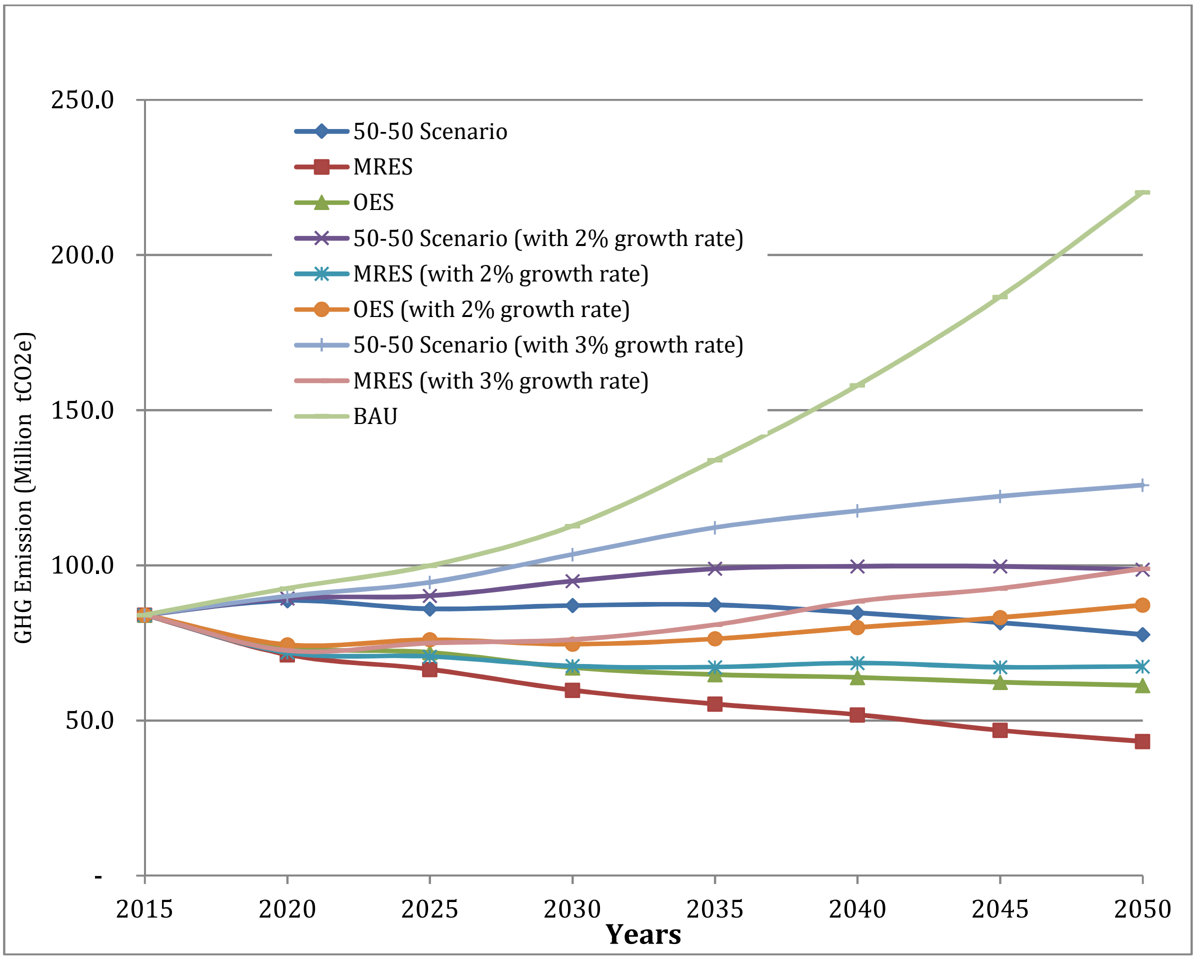

Figure 5: GHG emissions under 4 main scenarios from 2015 to 2050 in Malaysia

4.4 Per capita emission

Figure 6 shows the CO_2 emission per capita for 4 main scenarios in Malaysia from 2015 to 2050. Based on the Figure 6, it is shown that BAU scenario shows the path of increasing in

Journal of Advanced Research in Applied Mechanics
ISSN (online): 2289-7895 | Vol. 24, No. 1. Pages 22-38, 2016

CO_2 emission per capita with highest emission in 2050, which is 4.5 tCO_2/cap, increased by about 60% from CO_2 emission per capita in 2015. For the other 3 scenarios, the CO_2 emission per capita towards year 2050 is decreasing and the lowest by 2050 is MRES with growth rate of demand of 1%, where its CO_2 emission per capita is 0.9 tCO_2/cap. As compared to BAU scenario in 2050, about 80% of CO_2 emission per capita can be reduced when renewable energy resources are maximized to their potential. The lowest CO_2 emission per capita based on Figure 6 in OES is when the growth rate of industrial and commercial sectors is 1%, where CO_2 emission per capita is 1.3 tCO_2/cap by 2050. A reduction of 71% of CO_2 emission per capita is achieved compared to BAU scenario if implementation of OES assumptions is applied. In order to support 2° max Climate Strategy that the maximum CO_2 emission per capita is 3 tCO_2/cap, OES, 50-50 Scenario and MRES are the applicable solutions to achieve this strategy to reduce the global warming effect.

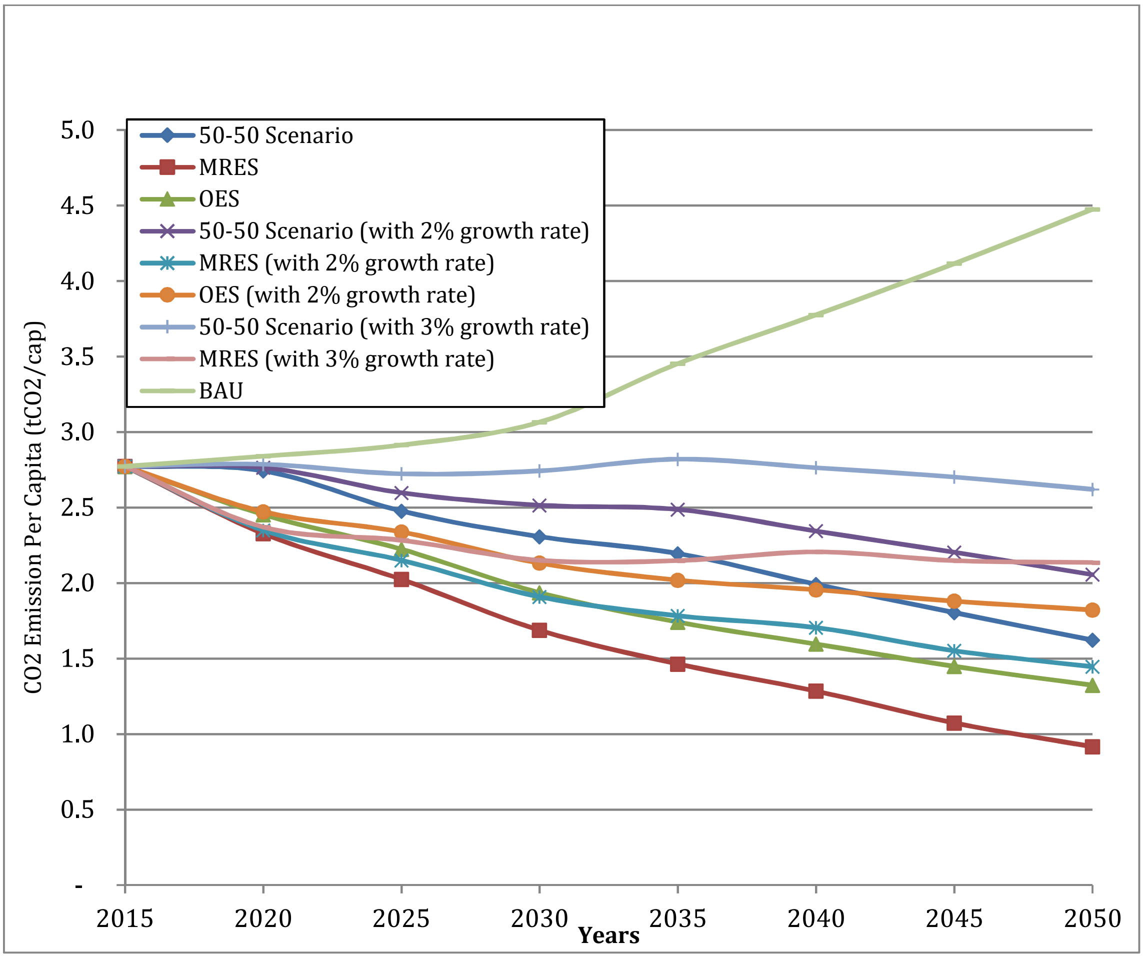

Figure 6: CO_2 emission per capita for 4 main scenarios

Journal of Advanced Research in Applied Mechanics
ISSN (online): 2289-7895 | Vol. 24, No. 1. Pages 22-38, 2016

4.5 Depletion of fossil fuel reserves

Figure 7 shows the amount of fossil fuels reserves of 4 scenarios from 2015 until 2050. The depletion of fossil fuels reserves depend on the final energy demand by all sectors including residential, industrial and commercial sectors and the amount of fossil fuels consumed by electricity power plants. Under BAU scenario based on Figure 7, the amount of fossil fuels reserves in 2015 is 51.7 thousands TWh and by 2050, it reduces to 31.4 thousands TWh, where the overall reductions of 39.3% is calculated from 2015 to 2050. For each fossil fuel in BAU scenario, it is estimated that decreasing in coal is about 38.7%, crude oil (9.4%) and natural gas (50.3%). For 50-50 Scenario, the reduction of coal reserve is 24.8%, crude oil (8.6%) and natural gas (31.3%) and the overall reductions in fossil fuels reserves are 25.2%. As for the MRES of growth rate 1%, total decreasing in fossil fuels reserves are 18.7%, where reduction in coal reserves is about 15.9%, besides crude oil reduces by 17.4% and the natural gas reserves is decreased by 20.9%. For each fossil fuel, OES contributes to reduction in coal reserves from 2015 to 2050 about 19.3%, and reductions of reserves in crude oil and natural gas are 20.3% and 23.2% respectively from 2015 to 2050.

As we can see from Figure 8**Figure** and estimation of percentage reduction in fossil fuels reserves, BAU scenario contributes to the lowest fossil fuels reserves in 2050 due to the large amount of fossil fuels share have been consumed in electricity generation mix and the high growth rate of fossil fuels demand in industrial and commercial sectors, i.e. 3.6% for industrial sector and 2.9% for commercial sector after year 2020. In MRES, it contributes to the highest amount of fossil fuels reserves by 2050 because of the highly usage of renewable energy resources in its electricity generation plants and low growth rate of final energy demand in industrial and commercial sectors. For OES, it provides higher in the amount of the fossil fuels reserves by 2050 compared to the BAU and 50-50 Scenario due to the optimized installed capacity in renewable energy based power.

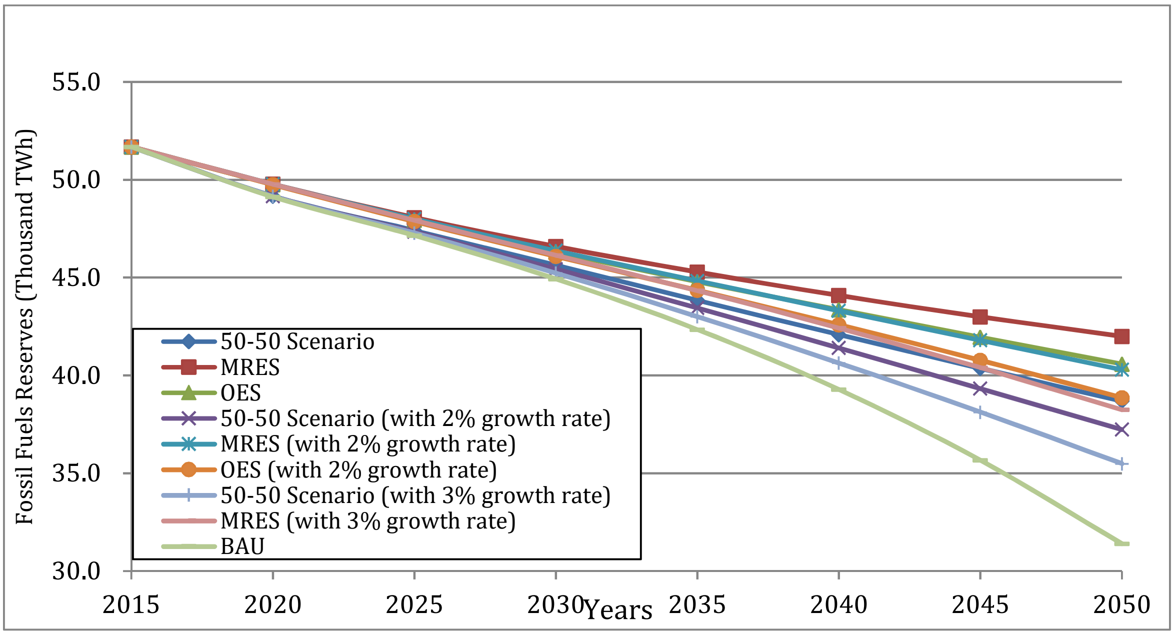

Figure 7: Fossil fuels reserves of 4 main scenarios from 2015 until 2050

Journal of Advanced Research in Applied Mechanics
ISSN (online): 2289-7895 | Vol. 24, No. 1. Pages 22-38, 2016

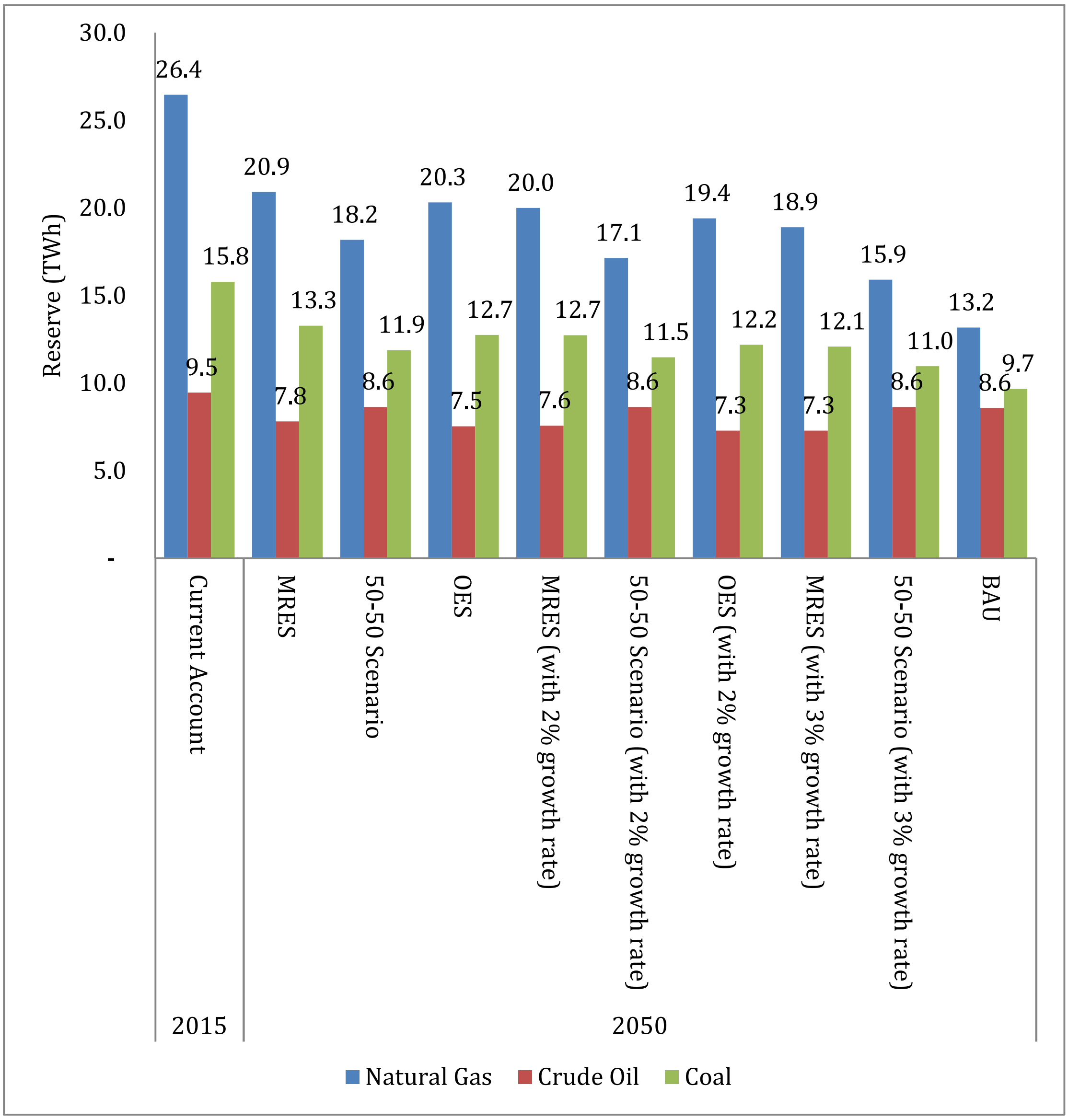

Figure 8: Amount of fossil fuels reserves on 2015 and 2050 under 4 main scenarios

5.0 CONCLUSIONS

The energy scenario modeling for Malaysia using LEAP has been conducted in order to develop long-range and sustainable power sector scenarios for Malaysia and to build emission and policy scenarios. In the model, four main scenarios have been developed include one reference scenario (BAU) and other three alternative scenarios (MRES, 50-50 Scenario and OES). The BAU scenario is based on various outlook reports provided by known local and international organizations such International Energy Agency, U.S. Energy Information Administration, Energy Commission of Malaysia and so on.

Journal of Advanced Research in Applied Mechanics
ISSN (online): 2289-7895 | Vol. 24, No. 1. Pages 22-38, 2016

For electricity demand in the three considered sectors, i.e. residential, industrial and commercial sectors for BAU scenario, it is found that BAU scenario contribute to the highest electricity demand from 2015 to 2050, while 50-50 Scenario, MRES and OES obtained much lower compared to the BAU scenario due to strategic policies such as efficiency increase in consumption. As for electricity generation, BAU scenario provides the highest electricity generation due to high in electricity demand, however most of the electricity generation shares still depends on the fossil fuels based power generation. Meanwhile, the alternative scenarios provides less fossil fuels dependency in generating electricity with MRES has the highest renewable energy shares in its electricity generation, followed by OES and 50-50 Scenario due to the strategic policies where the usage of renewable energy is improved by 2050. As a consequence due to the implementations of renewable energy along with energies efficiency technologies such as smart grid, superconducting transmission line and storage technologies, it is found these alternative scenarios provide adequate electricity to the sectors involved, the GHG emissions can be reduced, and the prolong of fossil fuels reserves is achievable. At the same time, this will ensure the reduction of GHGs and the future generations will able to fulfill their need, as well as achievement in providing the sustainable power system in Malaysia. However, it is strongly noted that an aggressive and more effective policies and technologies are needed in order to achieve the ambitious scenario with higher renewable energy shares in Malaysia.

ACKNOWLEDGMENT

The corresponding author expresses his gratitude to Universiti Teknologi Malaysia (UTM) and MOE for providing financial support through RUG (PAS) grant (01K95) to perform this research work.

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