Energy Policy for Malaysia (2013 – 2050)

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1. Introduction

Energy is essential for life, this includes electricity that plays a significant role in economic development by enhancing the productivity of capital, labor and other factor of production. Increase in the consumption of commercial energy particularly electricity signifying high economic status of a country. Many studies have shown that the energy consumption is positively correlated with economic growth. It is a norm indicator that high per capita GDP reflects the high per capita energy consumption. Nuclear energy development in Malaysia currently is being considered seriously as a result of governance acceptance and support since 2000 in order to solve energy crises. This paper took Peninsular Malaysia as a case study with regards to the fact that electricity demand is affected by the population growth concentration. Malaysia is currently working towards an industrialized nation within 10 years. The latest 10th Malaysia Plan is to diversify and expanding the resources to incorporate renewable energy and nuclear. Current and future energy status are discussed to highlight the constraints and barriers facing Malaysia towards stable energy security and greener option.

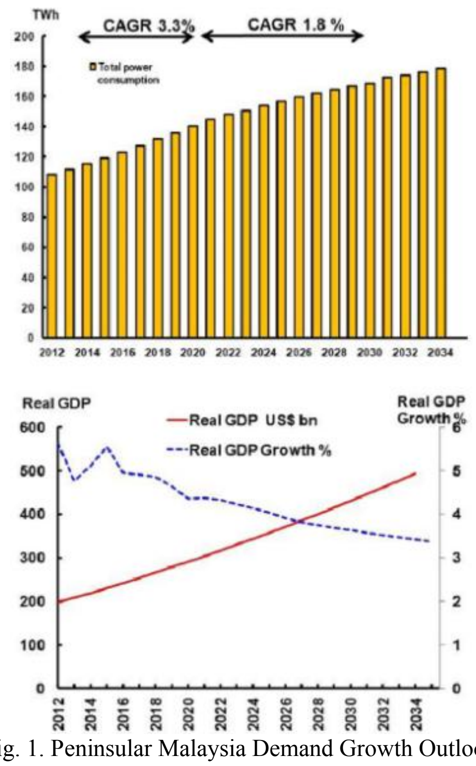

Fig. 1. Peninsular Malaysia Demand Growth Outlook.

Fig. 1 show the modest growth outlook planning by the government. Against Global Redesign GDP outlook, the demand growth assumptions appear low with the intensity ~ 0.4. Therefore, it is safe to assume that the risk on generation planning shortfall is higher as well as generation upsides. The impact of energy efficiency (EE) can be materialized in the long run as shown in Fig. 2.

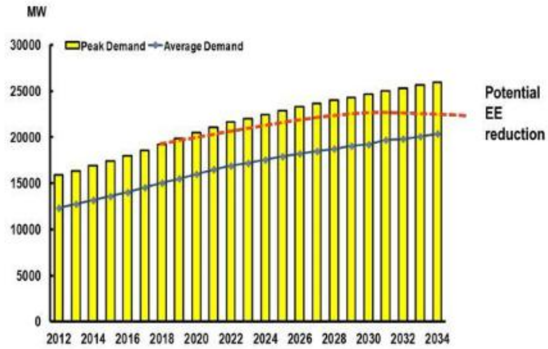

Fig. 2. Demand Assumption & Load Factor – Government Planning Scenario for Peninsular Malaysia

2. Methods and Results

2.1 Methodology

In this paper, PLEXOS is used to assess the effectiveness of renewable technology policies and forecasting market entry and assessing future technology, and fuel mixes, as well as examining the development of system adequacy. The findings will show what might be an optimum energy mix for Malaysia.

PLEXOS for power systems (PLEXOS) is an actual real life day-to-day working wholesale electricity market software tools which model schedules, dispatches and trades wholesale electricity in the single wholesale electricity market (SEM) [1]. The succinct manual for PLEXOS serves a useful introduction to PLEXOS. Modelling in PLEXOS can be carried out using deterministic or stochastic programming techniques that aim to minimize an objective function or expected value subject to the cost of electricity dispatch and other limitations such as availability and operational characteristics of generating plants, licensing environmental, fuel cost, operators and transmission constraints. PLEXOS develops quick fix by incorporate the input data operational and market constraints from the generation portfolio which take several parameter into consideration to meet demand as series of models

[2]. For this paper, the parameters that being considered are investments costs, generator offers, load duration curve – inter-temporal, generation capacity and availability, fuel constraints and contracts, merchant independent power producers (IPPs), power purchase agreement (PPA), ancillary services details also DC load flow and transmission capacity. PLEXOS will generate the solution from formulated models via solver and interprets the solution in term of tasks and results required, which later being tabulated into demographic diagram.. PLEXOS models addressed over short, medium, and long term scheduling and planning horizons for Malaysia.

2.2 The Investment Market Model

Control theory are used to model market investment dynamics. The investment market model is to optimize the objective function under a set of constraints that will define the feasible region containing all possible solutions of the problem [3]. Since the model is dynamic, current market conditions – capacity under construction, prices and their predictions are fed back to the investment block, modifying the investment behavior. The resulting investment decisions are then fed back to the pricing mechanism, hence closing the loop.

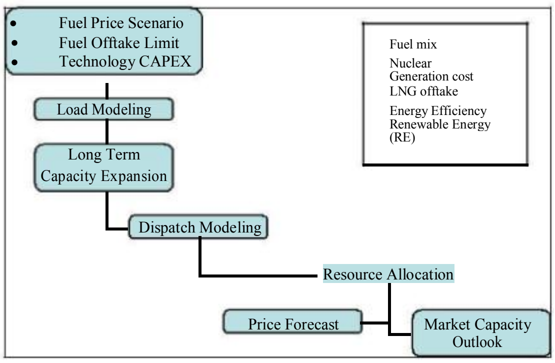

Fig. 3. The gamut consideration for Peninsular Malaysia's energy demand modeling and forecasting.

The specific features of developing countries have implications for energy demand analysis and modeling [4]. Fig. 3 shows a formulated set of elements that will be used in the rest of the paper to ensure a consistent and systematic focus on Malaysia's 12 states specific concerns. This paper utilizes model generation capacity investment as a control problem with current and future energy prices as a function of generation capacity margin acting as a feedback signal.

3. Findings

3.1 Gas & LNG

The Subsidy Rationalize Program (SRP) showed a poor performance on 2010 causing the government to renew their effort by increasing the fuel price in 2014. This also represents an effort to reduce the subsidy burden on the Malaysian economy because of declining domestic gas supply, expensive LNG imports and high demand.

Natural gas has a major role in Malaysian energy sector [5]. After the oil crisis in 1973 and 1979, Malaysian government adopted the Four Fuel Policy in 1981 that aimed to increase the fuel diversity by moving away from oil and including other sources like natural gas, coal and hydro. However in 2009, Malaysia started facing gas shortages due to declining domestic gas supply and high demand due to fast economic growth. This has increased the share of coal and oil. Therefore, in order to meet demand, Malaysia turned from a traditional LNG exporter into LNG imports.

In this section, PLEXOS is used to examine the effect of gas pricing to power sector. Fig. 4 shows that in a long-term, domestic gas supply to power sector demand is expected to taper to less than 1,500mmscfd after 2017. However, an additional supply is still required to meet the growing demand. Due to declining production from domestic gas fields, and constraints in increasing gas imports through pipelines, one of the alternative to address the shortage is to bring in, an expensive imported LNG. Lack of domestic gas supply, high gas demand, and expensive LNG imports has brought the government attention to gas price subsidies. Gas price liberalization is a way to make LNG imports economically feasible, capping the inflated gas demand due to low prices and gain from the premium consumers who are ready to pay higher gas prices.

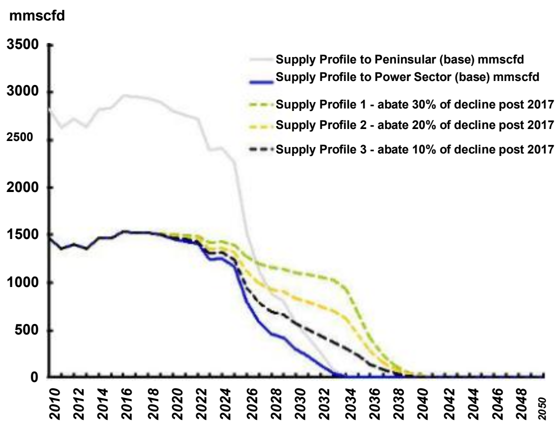

Fig. 4. Higher price domestic gas supply to power sector forecast to defer the higher price of LNG imported into Malaysia.

In such cases, PLEXOS has forecasted the wholesale price for domestic gas production by utilizing netback wellhead cost approximation. Fig. 5 shows that cost of supply is important for gas price formation so that, there will be a tradeoffs between domestic gas production to LNG. The basic pattern of the graph is an evident of increased export of natural gas lead to increase wellhead prices in all cases scenario except for the base case scenario.

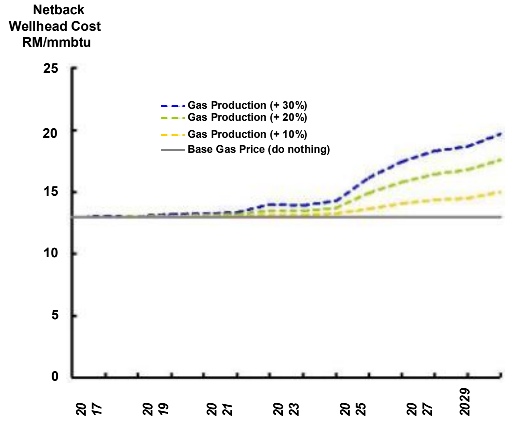

Fig. 5. Peninsular Malaysia's domestic gas wellhead cost example with different additional export levels imposed.

The huge difference between market price and domestic gas price indicates the unsustainability of the gas price subsidy regime. Without progressive gas price formation, it will be difficult for Malaysia to reduce the fiscal deficit. The way forward is to reduce the operating expenditures by reducing subsidies in a phased manner.

3.2 Nuclear

Nuclear option is closely feasible to fulfill the national energy strategy. Malaysia government have shown her willingness to add nuclear into its energy mix on her 10th Malaysia plan. They target to deploy at least two unit of nuclear reactor with total capacity 1,000 megawatts by 2022. It is an effort to introduce nuclear as a part of clean energy generation over the long term while minimizing the reliance on coal. Reducing the over-dependency on coal will eventually help the country to reduce the carbon emissions, one of the goals set by the United Nations.

Since coal is prime fossil fuel energy in Peninsular, the electric power industry becoming the top priority for a coal cap. Nuclear have high capability to fill in the gap of energy capacity after Malaysia's capping its coal power up to 60%. The price of nuclear fuel is relatively stable compared to coal price and oil. Also the production cost is comparable to the present rate [6].

Economically, experience has shown that a nuclear power plant (NPP) is high intensity capital technology [7]. Although the construction costs of NPP is generally higher compared to coal plant, NPP is more competitive compared to any other available sources due to its lower operating costs [8]. 26% of the total production costs of NPP are from the fuel, which is lower than coal, natural gas and oil which is around 80%. NPP needs to be refueled once in every 12 to 24 months while fossil sources like coal have to be added continuously.

The nuclear energy is also known as green energy because of its lower carbon emission. Since the power generation does not include burning, there are relatively no greenhouse gas (GHG) emissions from NPP [9]. Also, on a life-cycle basis the GHG emission of NPP is comparable with that available hydro and RE wind [10].

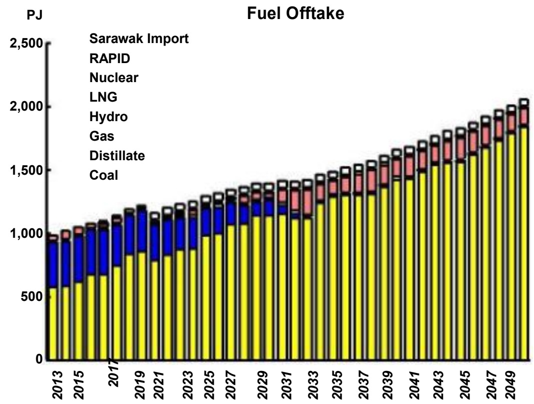

Fig. 6. Base case analysis without nuclear shows that Malaysia will have high reliance on coal in a long-term.

In this scenario, nuclear could experience a gradually growth begin from 2025 since its first being introduced like in Fig. 7 as the energy demand will also moving up at the faster rate undeterred by the overall energy intensity fell ~0.4% assumption. Nuclear power is well suited to meet the demand for continuous, reliable electricity supply on a large scale (base-load electricity). Steady, reliable, and cheaper nuclear energy will help to improve various sectors. For example, improved production and industrial sector from adequate electricity, provide more job opportunity, upgrade product quality, and hence boost the economy to a higher level.

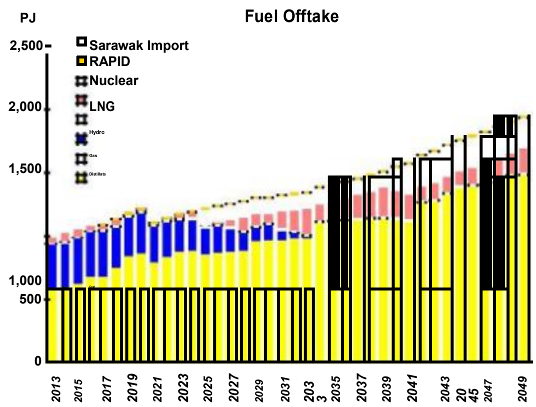

Fig. 7. Base case analysis increasing role of nuclear shows that Malaysia able to limit the coal dependency.

An optimum generation mix are described by PLEXOS using the least-cost generation electricity market investment as shown in Fig. 8. There are 3 main sources for power generation namely coal, gas and hydro that will be decreased across the years. It is expected that the gas supply to the power sector may not go beyond 2033. If there is no nuclear consideration, Malaysia may need to increase coal fired electricity generation to cover for the shortfall of gas supply which is an unattractive option considered the fact that almost 100% of the national coal supply is imported [11]. This will expose the country to interruption of CO2 control. From the timeline, Malaysia will officially launch NPP program within 5 year time from now on.

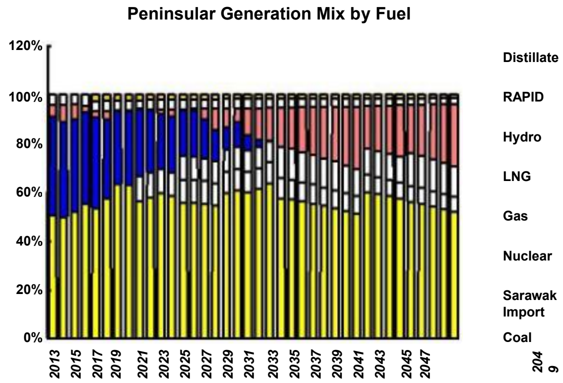

Fig. 8. West Malaysia's generation mix – including nuclear show the ability of capping coal up to 60% and succeed in sustaining energy.

It is clear that nuclear energy will help Malaysia to achieve its goal to meet 40% of carbon reduction by 2020 compared to 2005. It will also enhance the energy security and mitigate the risk of climate change caused by electricity industry (coal plant).

3.3 Renewable Energy (RE)

Renewable energy in Malaysia has shown a significant growth in recent years since implementation of feed in tariff (FIT). The uptake of renewable energy such as solar PV can result in larger requirement for system reserves. PLEXOS is used to optimize the uptake of renewables given their intermittent nature, ensure system adequacy, provision of reserves in future capacity expansion, and dispatch planning. It also will calculate the cost to the system and effect on energy prices of the additional capacity and reserve requirements with expected ancillary service price. PLEXOS helped to set dynamic reserve requirements based on generator, load or line contingencies.

Based on lessons learnt from mature markets, renewable development generally calls for a balanced, stable and predictable support system. Feed in tariffs (FIT) have proved to be the most effective system to build renewable capacity. More market driven approaches like Green Certificates mechanisms have not proved to be more cost effective as they had to compensate investors for higher market risks.

An equatorial country like Malaysia is favorable for the development of solar energy because its climate is generally hot all year long with approximately 4000-5000 Whm^(-2) daily radiation, except for monsoon season during the end of year [12]. Thus, solar photovoltaic (PV) should lead renewables capacity build-out due to the combination of good resources, high potential and local supply chain. As land availability dwindles, residential systems should lead the growth in the long term. Currently PV application is only being deployed for gardening lighting, water heating in hotels and upper-class urban houses. Also, feed in tariffs schemes has the potential to increase solar PV penetration to have its way forward in Malaysia. Malaysia's feed in tariff (FIT) system obliges Distribution Licensees (DLs) to buy from feed in approval holders (FIAHs) the electricity produced from renewable resources – solar, and sets the rate. The distribution licensees will pay for renewable energy supplied to the electricity grid for a specific duration. By guaranteeing access to the grid and setting a favorable price per unit of renewable energy, the feed in tariff mechanism would ensure that renewable energy become viable and sound long-term investment for companies industries and also for individuals.

Biomass emerges as a key contributor to Malaysia's RE generation. However, the country needs to address some of the issues that tap the development of the country's potential. Still, biomass and small-hydro installation are being seen as the most unlikely to reach the country's estimated potential due to grid access constraints. Also, importing hydropower from east Malaysia (Sarawak) is economically not viable due to technical difficulties in transferring it through South China Sea as this might be more expensive [7].

The summary of the view on Malaysia's renewable market is shown in Table. 1. This is based on the investment market model (Sec. 2.2) results. The table shows that solar PV has the highest potential among the renewables considered.

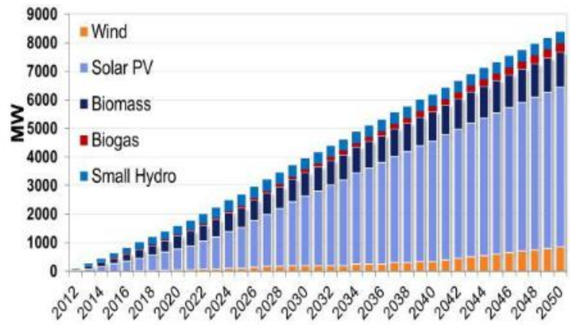

Fig. 9. Capacity forecast – residential solar PV will lead renewable capacity build-out in Malaysia, accounting for over 60% of total installation by 2030 from over 25% in 2012.

Table I: View on Malaysia's Renewable Market

	Resource Potential	**Cost**	**Capacity Factor**	**Drivers**	**Inhibitors**
Solar	Despite tropical monsoon climate, annual irradiation is relatively high at 1600-1700 kWh/m2. IHS has estimated that the country's potential is around 7 GW	• In terms of CAPEX, IHS has used US$3,000/kW. An average of South East Asia levels including medium and small commercial, residential, and off-grid installations • For OPEX IHS has used a figure of US$ 20/kW/year	IHS assumed a capacity factor figure of 13% using as a benchmark values seen in countries with similar radiation levels. This figure compares well with assumptions made by KeTTHA	• Attractive FIT rates • Regulators' support shifts away from fossil fuel based generation • Local PV manufacturing	• Capped FIT unclear for systems >5 MW • Financing hard to access for small PV systems • Controversy surrounds opaque PV quota allocations • High administrative burden to apply for quota, including a mandatory power systems study for systems >180 kW • Limits to foreign ownership in assets receiving FIT
Biomass	Estimated to be at around 1,400 MW with current production levels. Calculations made using inputs from SEDA and KeTTHA´s National Renewable Energy Policy & Action Plan	IHS has used US$1700-1900/kW for CAPEX and US$ 200/kW/year for OPEX based on historical development and installations in markets like Poland	70% based on international common practices and input from KeTTHA	• Abundance of biomass resources that could be quickly put in value • Existing experience	• Limited growth potential of available biomass due to lack of available land for new plantations as land has alternative uses • Underdeveloped grid and high connection costs mainly in rural areas
Wind	Low potential due to low yearly average wind speeds. In the absence of wind atlas for the country, IHS has estimated Malaysia's wind potential using as a benchmark wind conditions in Thailand	IHS has used US$2,300/kW for CAPEX and US$ 34/kW/year for OPEX using benchmarks from projects in Thailand and Eastern Europe	IHS assumed a capacity factor figure of 18% using Thailand as a benchmark	Despite not very good resources, wind could be deployed in some areas	• Most of the potential is located in remote areas and in natural parks what complicates site approval • Lack of a developed supply chain and scale will limit wind power development
Small Hydro	Potential in the country is important but not all the potential can be developed due to remote locations. IHS has estimated the potential to be at 400 MW	IHS has used US$2000-2500/kW for CAPEX and US$ 160-210/kW/year for OPEX using benchmarks from projects in Europe	At around 60% based on international benchmarks and input from KeTTHA	Relatively high potential and cost competitive technology	• Potential for small hydro is in remote areas. • Underdeveloped grid. Currently developer must build to substation or grid and this can be very costly.
Biogas	Estimated to be between 300 MW and 400 MW with current production levels. Calculations made using inputs from SEDA and KeTTHA´s National Renewable Energy Policy & Action Plan	IHS has used US$1700-2200/kW for CAPEX and US$ 170/kW/year for OPEX based on historical development and international benchmarks	70% based on international common practices and KeTTHA	Abundance of biomass should enable further development of biogas capacity	Issues related to gasification in the country are limiting the deployment of biogas

4. Conclusions

This paper recognizes that strong power sector governance will be required to ensure consistent policy implementation for the Malaysia's power sector. (i) Policy on power sector gas price formation is critical for optimal generation expansion planning. Domestic gas prices will trend upwards and be cost-based for domestic gas (pending TPA) and LNG-based for imports. In near time, gas allocation to power gas will depend on domestic price formations and future performance for the upstream sectors in line with potential improvements in downstream gas monetization options and economics. (ii) Coal generation share of about 60% for Peninsular delivers reasonable diversity and meets security objectives. Further development of depleting fossil resources will result in more emission of GHG and will hinder Malaysia from achieving its target of reducing carbon emission to the environment. Thus, non-hydrocarbon generation options are important. Power sector fuel mix is likely to become over dependent on single fuel (coal) which will raise concerns with regards to carbon abatement requirements. (iii) Future availability of nuclear should seriously being considered, as it's in fact the most perfect timing since many circumstances and reasons, domestically and internationally are favoring and supporting the usage of nuclear energy for peaceful purposes. Although nuclear alone is not a panacea or universal remedy but nuclear energy is one of the best alternatives that could play a vital roles in Malaysia's energy mix. (iv) Renewable development should be supported by a balanced, stable and predictable support system. In this regards, feed in tariffs (FIT) have proved to be the most effective system to build renewable capacity and it is best recommended for Malaysia. Solar PV is currently being assumed the most possible and relevant to lead renewables capacity build-out due to the combination of good resources, high potential and local supply chain. On the other hand, biomass has the potential to become a key contributor to Malaysia's renewables generation.

All in all, explicit subsidy approach is recommended to support transitional roadmap towards the introduction of market based pricing which is required to address security and supply issues in the power sector. Tariff reform can be considered in order to address energy subsidy and cross-subsidization issues as transmission infrastructure development for West Malaysia is critical. Thus, an efficient resources could be encouraged by creating access to market for fuel monetization.

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