AKADEMI SAINS MALAYSIA

Sustainable Energy Options for Electric Power Generation in Peninsular Malaysia to 2030

CONTENTS

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Foreword

I would like to convey my congratulations to the ASM Energy Committee for producing this Advisory Report, aptly entitled *Sustainable Energy Options for Electric Power Generation in Malaysia to 2030*. We believe that this Advisory Report is most timely to ensure security of supply of all related primary energy resources for future national economic development.

This paper is consistent with the Rt Honorable Prime Minister of Malaysia's pledge of a conditional voluntary target of 40% reduction in the CO_2 emissions intensity per unit of Malaysian GDP by 2020 against a 2005 baseline, as announced at the *15th Conference of the Parties (COP 15)* to the United Nations Framework on Climate Change Convention (UNFCCC) in Copenhagen, Denmark. This Report sets out to analyze the effectiveness of the various energy policies and initiatives that Malaysia has adopted, and how they have affected the reliability and security of energy supply. This Report considers the various options from a technical perspective for energy security consistent with other existing energy policies currently in place.

The publication of this Advisory Report is in fulfillment of the Academy's many functions, among which are to provide independent advice to the Government through dissemination of ideas and suggestions amongst decision- and policy-makers, scientists, engineers and technologists through identifying where the innovative use of science, engineering and technology can provide solutions to particular national problems towards sustained national development.

Tan Sri Dr Ahmad Tajuddin Ali, FASc
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Preface

In Malaysia, the demand for electricity is growing in tandem with its GDP growth. The growth forecasted for electricity has shown an increase of 3.7% in 2012 compared to 3.2% in 2011, driven by strong demand from the commercial and domestic sectors. For the period until 2020, the average projected demand for electricity is expected to grow at 3.2%. Based on this forecast, the country is going to need even more electrical energy as it strives to achieve the high-income economy status. With depleting local gas and petroleum reserves and the need to adhere to stricter environmental regulations whilst still having to meet the requirement for growing electricity demand, there is a need to reconsider new options in the future generation fuel mix. This fuel mix is important to ensure security of supply through sustainability, adequacy and diversity of fuel supply and affordable prices.

Malaysia's energy mix, comprising petroleum, natural gas, coal, hydroelectric power, and renewable energy, has proven to be reliable in meeting energy needs thus far. But the situation is expected to change as Malaysia is projected to become a net energy importer by the end of the 2030s, unless new energy sources of indigenous origin are found and successfully developed. This paper recommends strategies for the roles of renewable energy as well as energy efficiency and conservation practices, besides enhancing the supply security of coal, as electricity generation options to the year 2030 and beyond. Nonetheless, successfully employing the proposed strategies require reducing the government's subsidies on gas prices and electricity tariffs in tandem with a common regulatory framework overseeing efforts by all relevant entities involved.

This Advisory Report is the final product arising from a series of meetings among the members of the Academy of Sciences Malaysia's Energy Committee, energy experts, energy players, relevant government agencies, non-governmental organizations, and other key stakeholders.

Finally, I am grateful to all the Committee members for providing open and often blunt opinions and ideas, all of which have helped to develop a deeper understanding of the challenges before us and the potential solutions expressed in this Advisory Report.

Academician Datuk Ir (Dr) Ahmad Zaidee Laidin, FASc
Chairman
ASM Energy Committee

Executive Summary

Energy is a critical component for the growth and prosperity of a developing country such as Malaysia. This paper focuses on energy for grid-connected electricity generation mainly for Peninsular Malaysia based on anticipated demand growth and known planting up program combined with the need for adequate reserve margin for supply reliability.

A number of sustainable energy generation options are considered and the most optimum ones are recommended to meet the projected energy needs in Malaysia up to the year 2030, consistent with the desire to adopt low-carbon systems and technologies. The latter is in direct response to an announcement by the Rt Honorable Prime Minister of Malaysia on a conditional voluntary target of 40% reduction in the emissions intensity per unit of GDP by 2020 from a 2005 baseline at the *COP15 Meeting* in Copenhagen.

ASM recommends alternative strategies that promote enhanced roles for renewable energy (RE) as well as energy efficiency and conservation (EE&C) practices. A greater contribution of RE from biomass, biogas, hydroelectric power, and solar photovoltaic is proposed compared to the present less than 1%, in concert with more widespread promotion for the adoption of concerted EE&C initiatives, in anticipation of the planned EE&C Act. ASM to further recommend that the thorium-based nuclear option should be considered and supported with detailed studies on prior public engagement, modern 5th Generation (or later) designs as a viable alternative to coal-based CO_2-emitting plants.

The Report addresses proposals to ensure security of supply of all related primary energy resources for future national economic development. Strategies are also advocated to improve coal supply reliability and security. On top of these measures, ASM urges the government to moderate gas and electricity subsidies while enforcing a common energy regulatory framework that involve all the relevant agencies and parties.

Abbreviations

CCT	clean coal technologies
EE&C	energy efficiency and conservation
EPU	Economic Planning Unit
ETP	Economic Transformation Programme of Malaysia
GDP	gross domestic product
GW	gigawatt (unit for power)
GWh	gigawatt hour (unit for power)
HEP	hydroelectric power
KeTTHA	Ministry of Energy, Green Technology and Water
mmscf/d	million standard cubic feet per day
MP	Malaysia Plan
NG	natural gas
NP	nuclear power
NPP	nuclear power plant
PV	Photovoltaic
RE	renewable energy
SREP	Small Renewable Energy Power program
ST	Energy Commission of Malaysia (Suruhanjaya Tenaga)
TNB	Tenaga Nasional Berhad
Tscf	trillion standard cubic feet
UNFCCC	United Nations Framework on Climate Change Convention

INTRODUCTION

As a developing country, Malaysia is highly dependent on energy for its economic growth. As such, the availability of adequate, reliable, and affordable energy is not only critical to drive the country's industrial and commercial developments; energy also serves as a basic utility of social needs in ensuring a desirable quality of life for the nation's people. Hence, the evolution of Malaysia's energy sector has followed the route of providing secure, reliable, and cost-effective energy supply besides promoting efficient utilization, advocating supply diversification, and discouraging wastage.

Guided by future power demands, there have been calls for use of nuclear energy and increased use of coal in sustaining Malaysia's energy supply. Added to that dimension is the Rt. Honorable Prime Minister of Malaysia's pledge of a conditional voluntary target of 40% reduction in the CO_2 emissions intensity per unit of Malaysian GDP by 2020 against a 2005 baseline, as announced at the 15th Conference of the Parties (COP 15) to the United Nations Framework on Climate Change Convention in Copenhagen, Denmark. This Report sets out to analyze the effectiveness of the various energy policies and initiatives that Malaysia has adopted, and how they have affected the reliability and security of energy supply. The foregoing analysis then sets the premise to support the main thrust of the Report of advocating an energy mix made up of a greater contribution from renewable energy (RE) and more widespread adoption of energy efficiency and conservation measures as alternatives to coal or nuclear energy in balancing Malaysia's future energy supply and demand. The Report concludes by recommending several strategies to realize the proposed optimum energy mix.

POLICY DRIVERS AND LEGISLATIVE FRAMEWORK

The major thrusts of Malaysia's energy policies have been sustainability, efficient resource utilization, environmental safeguarding, and delivery of high quality services to its stakeholders. The various initiatives undertaken by the government reflect these approaches as expounded through the policies and plans explained next (Chua & Oh 2010).

The National Energy Policy 1979 was formulated with three objectives:

1. To supply adequate energy cost-effectively from indigenous non-renewable and renewable resources, yet securely by diversifying the sources
2. To utilize energy efficiently and productively; and
3. To minimize negative environmental impacts in the energy supply chain.

This Policy was timely in view of the global oil crises in 1973 and 1978, in which economic growth worldwide was severely affected by the dramatic escalation of oil prices. Malaysia was not spared of these effects since it relied mainly on oil as its main energy source. It is arguable that this policy set forth the consequence of reducing our energy mix dependence on oil.

The National Depletion Policy 1980 was aimed at safeguarding the country's finite and non-renewable petroleum resources from over-exploitation. Production control was enforced on major oilfields of over 400 million barrels of oil initially in place (OIIP) to a conservative 1.75% of OIIP that subsequently was revised to 3% in 1985 (IEA Clean Coal Centre 2011b; U.S. Energy Information Administration 2012). As a consequence, crude oil production was regulated to an average of 630,000 barrels per day (bpd) while natural gas to 2000 million standard cubic feet per day (mmscfd) (Energy Commission/Suruhanjaya Tenaga (ST) Malaysia 2010; Mohamed 2009) as strategies to prolong the reserves' lifespan for future supply security and stability.

Complementing the National Depletion Policy is the Four-Fuel Diversification Policy 1981 that was designed to reduce over-dependence on oil as the main energy source. As the name indicates, the Policy called for a four-fuel supply mix consisting of oil, gas, hydro-electric, and coal for electricity generation. To the extent possible, local sources of these fuels are used to enhance supply security. This aspiration led to the National Mineral Policy 1998 that prescribes guidelines to promote more efficient utilization of locally sourced coal through improved underground mining methods, larger equipment in surface mining operations, and computerization of mine maintenance and administrative activities.

It was only in 2000 that RE was included in the country's energy mix for grid connected power generation through the Five-Fuel Diversification Policy 2000, under the Eighth Malaysia Plan (8MP, 2001–2005) and the Third Outline Perspective Plan (OPP3, 2001–2010). The Policy recognizes the role of RE by placing it as the fifth fuel on par with oil, gas, hydro-electric, and coal for grid-connected electricity generation. In line with these efforts is the implementation of the Small Renewable Energy Power (SREP) programme in 2001 to further develop RE resources for utilization in power generation. SREP developers sign a Renewable Energy Power Purchase Agreement (REPPA) with utilities purchasing RE-generated electricity from them, particularly Tenaga Nasional Berhad (TNB), the national power utility company. SREP licensees are allowed to generate power from renewable sources, chiefly biomass and biogas from palm oil mill wastes, solar photovoltaic (PV), and biogas from municipal landfills, besides mini-hydroelectric, wind, and biofuels from municipal waste. A maximum of 10 MW power may be exported by a small RE plant (although the plant's overall capacity may be larger) for sale to TNB via the national grid for up to 21 years (Jamaludin 2004; UNDP/BioGen 2007).

However, the outcome of the SREP program has been poor as less than 14 MW was achieved compared to the 9MP target of 350 MW of RE (Hasan 2009a; Chin 2008). The major obstacles identified were:

- High subsidies for fossil fuels in contrast to the low incentives for RE-based projects

- High capital expenditure with long payback period and low tariff causing financial institutions and investors to shy away from RE projects (Ali et al., 2008; UNDP/BioGen, 2007)
- Long negotiations involved in REPPA with stringent conditions; and
- Uncertain biomass price and availability as fuel for the long term.

Despite its low uptake, SREP has served to reaffirm the government's commitment towards developing RE as the fifth fuel. At the same time, it reasserted the objectives of OPP3, which called for "… better management, utilization as well as seeking out new sources of renewable energy."

The National Green Technology Policy 2009 takes cognizance of the need for better and more efficient use of technologies that are benign to the environment such as adoption of biomass-based cogeneration technology and use of RE for power generation as well as manufacture and use of green products for diverse applications. The Policy also provided a roadmap for the transition towards a low carbon economy by striking a balance between EE&C and environmental protection. Moreover, the so-called green market opens up vast business opportunities in the form of green buildings, environmentally-benign water and waste management practices, manufacturing processes with low carbon footprints, and transportation with low carbon emissions.

The New Energy Policy 2010, as embedded in 10MP (2011–2015) (EPU 2010), expands the energy horizon to include economic efficiency, environmental, and social considerations while enhancing security through alternative resources. The current concerns are reflected in its five strategic pillars, namely:

1. Initiatives to secure and manage reliable energy supply
2. Measures to encourage EE
3. Adoption of market-based energy pricing
4. Stronger governance; and
5. Managing change.

The Policy once again emphasized EE&C and use of RE for power generation.

More recently, the *Renewable Energy Act 2011* has been enacted that establishes and implements the Feed-in-Tariff (FiT) system for RE-generated electricity (Government of Malaysia 2011). *Table 1* summarizes the sequence and thrusts of the various energy policies and strategies implemented in Malaysia.

TABLE 1. SEQUENCE AND THRUSTS OR OBJECTIVES OF ENERGY POLICIES AND INITIATIVES IN MALAYSIA

Year	Policy/Plan	Thrust/Objective
1975	National Petroleum Policy	Ensure optimal use of petroleum resources via regulation of ownership and management of the industry including related economic, social, and environmental safeguards.
1979	National Energy Policy	Achieve supply and utilization of energy resources with environmental considerations.
1980	National Depletion Policy	Guard against over-exploitation and hence dependency on crude oil and natural gas.
1981	Four-Fuel Diversification Policy	Strategize generation mix as based on oil, gas, coal, and hydro.
1998	National Mineral Policy	Utilize locally sourced coal.
2001	Five-Fuel Diversification Policy	Recognize renewables as fifth fuel in generation mix.
2001	Small Renewable Energy Power (SREP) program	Encourage small private power generation projects using renewables.
2009	National Green Technology Policy	Use green technologies and promote cogeneration and renewables in power generation.
2010	New Energy Policy	Enhance energy security to include economic, environmental, and social considerations.
2011	Renewable Energy Act	Enforce Feed-in-Tariff (FIT) scheme for RE.
2011	National Biomass Strategy 2020	Recognize use of biomass waste for biofuels.

NATIONAL DEVELOPMENT PLANS

Malaysia's economic developments have been centrally planned according to the five-year Malaysia Plans (MP) for integrated national development by the Economic Planning Unit (2010). The plans include infrastructure development covering energy policies, strategies, and initiatives to support the national economic development objectives as well as rural electrification to extend the basic amenity to the deprived segments of the society.

Until the two oil supply shocks of the 1970s, imported petroleum products were the predominant sources of primary energy for Malaysia's electricity generation, supplemented by hydroelectric power plants, with biomass-powered cogeneration plants for the palm oil and timber industries for the owners' use. Following the oil shocks, Malaysia formulated the National Energy Policy on electricity generation in 1979. The Policy was subsequently complemented with other energy-related policies. The latter policies included the National Depletion Policy to optimize the extraction and use of indigenous oil and gas resources, and later the Four-Fuel Policy to diversify primary energy sources by incorporating local and imported coal for power generation.

Growing concerns over the finite fossil fuel resources and a desire to preserve the environment culminated in the formulation of the Five-Fuel Policy in 2000 to utilize biomass from palm oil mills (POM) and biogas waste from POM effluent (POME) for power generation. The policy was designed to achieve the dual objectives of eliminating the accumulating POM waste, which caused air and water pollution, by way of using them to generate grid-connected electricity; thus converting the polluting waste to a valuable commodity. Development of about 600 MW of grid-connected RE power generation capacity was envisaged by the end of 8MP in meeting about 5% of the total energy demand by 2005.

To encourage adoption of the Five-Fuel Policy, it was supported with the SREP program that offered reasonable RE tariffs to promote financially viable investments for prospective developers. The government also granted fiscal incentives in the form of pioneer status and investment tax allowances besides import duty and sales tax waivers to facilitate development of RE projects. These initiatives were promoted with the implementation of UNDP□GEF-supported projects such as the Biomass-based Power Generation & Co-generation in the Malaysian Palm Oil Industry (BioGen) project (2002–2010) and the Malaysia Building Integrated Photovoltaic (MBIPV) (2005–2011) project.

The ongoing 10MP (2011–2015) envisages the implementation of the New Energy Policy, in addition to continual developments of EE and RE. Figure 1 lists the chronological sequence of energy initiatives taken by Malaysia beginning from the 4MP (1980–1985) through to the current 10MP (2011–2015).

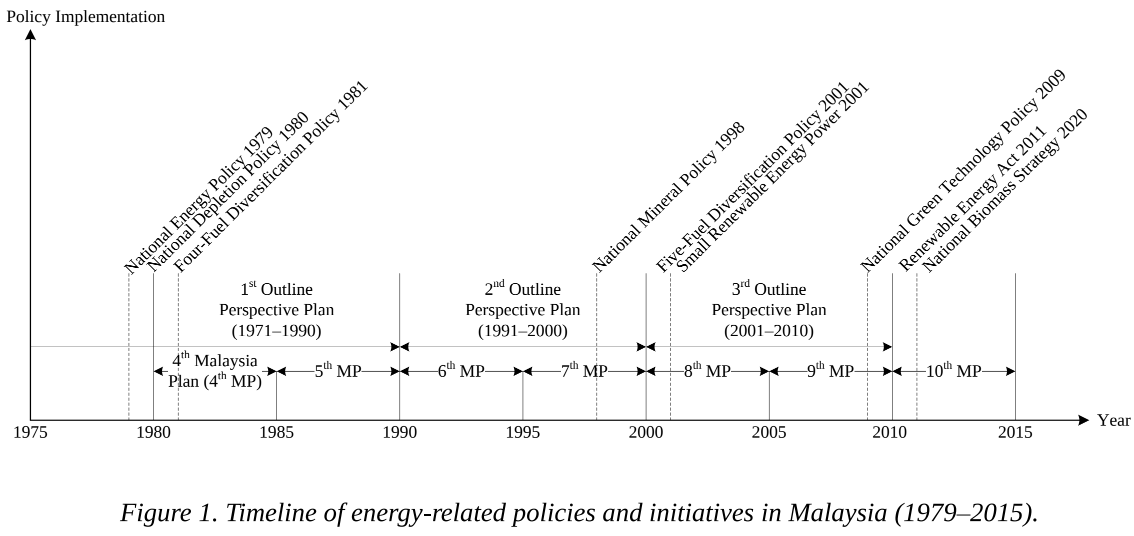

Figure 1. Timeline of energy-related policies and initiatives in Malaysia (1979–2015).

It is necessary to determine the projected demand that needs to be met for the time horizon concerned, i.e. up to 2030 (and the available supply capacities) in order to consider the possible primary energy options for the future energy mix, consistent with the basic criteria for the current policies in place.

ENERGY RESOURCES AND RESERVES FOR ELECTRICITY PRODUCTION

Malaysia's current energy mix of primary energy supply consists of oil, gas, coal, hydroelectric, and RE (non-hydroelectric) resources as delineated in *Table 2*. However, escalating prices of oil and gas, coupled with their finite reserves, will see coal, hydroelectric, and RE gaining increased importance for electricity generation.

As such, this section sets out to review Malaysia's major energy resources for electricity production with Table 3 providing data on reserves and production capacity according to energy sources (Ong *et al.* 2011; Oh *et al.* 2010).

TABLE 2. PRIMARY COMMERCIAL ENERGY SUPPLY BY SOURCE IN MALAYSIA (1980–2010)

	Energy supply (%)				
Energy source	1980	1990	2000	2005	2010
Crude oil & petroleum products	86.2–87.9	71.4	45.5–49.3	46.8	44.7
Natural gas[†]	7.5	15.7	42.2–45.3	41.3	41.6
Coal & coke	0.5–2.2	7.6	5.2–5.6	9.1	11.2
Hydroelectric	4.1	5.3	3.3–3.6	2.8	2.5
Renewables	0	0	0	0	<1.0
Nuclear	0	0	0	0	0
Total (petajoule (PJ))	n.a.[*]	n.a.[*]	2003.1	2526.1	3127.7

[†]Excludes flared gas, re-injected gas, and exported liquefied gas
[*]n.a.: not available
Source: EPU (2010), p. 395, *Table 19–3*; Mohamed & Lee 2006.

TABLE 3. RESERVES AND PRODUCTION CAPACITY OF VARIOUS ENERGY SOURCES IN MALAYSIA

Energy source	Reserves (Potential)	Production
Oil and condensates	5.46 billion barrels	550,000 barrels/day
Gas	88.00 tscf/d[a]	5700 mmscf/d
Coal	1843 million ton	383,000 ton
Hydroelectric	20,000–22,000 MW	4000 MW
Mini-hydroelectric	500 MW	30.3 MW[b]
Biomass	1340 MW (by 2030)	39 MW[b]
Biogas	410 MW (by 2028)	4.45 MW[b]

Municipal solid waste	360–400 MW (by 2022)	5.5 MW[c]
Solar PV	(unlimited)	7.1 MW[*]
Low wind speed	(not reported)	0.2 MW[d,*]

[a]Trillion standard cubic feet/day[b]capacity under construction as of July 2009.
[c]Commissioned on 1 August 2009.
[d]Refers to TNB's wind turbine facility in Pulau Perhentian Kecil, which is collaboration with Terengganu state government and Ministry of Regional and Rural Development (Ibrahim, 2010).
Source: Hasan (2009a).

Crude Oil and Natural Gas

As of 2010, Malaysia is a net energy exporter backed by proven oil reserves of 4.00 billion barrels with a reserves-to-production (R/P) ratio of 19.8 years (U.S. Energy Information Administration 2012). However, the oil reserves pale in comparison to that of Saudi Arabia (260 billion barrels), Iran (138 billion barrels), and Iraq (115 billion barrels) (Hasan 2009a). Over the years, the geological structures associated with crude oil production have matured and likewise, the majority of the oilfields discovered either had been developed or have been in production for more than 30 years. Pending new discoveries, the remaining fields are generally lower in quality due to high carbon dioxide contents, smaller in sizes, and scattered in distribution—factors that make development of these fields costly.

On the other hand, Malaysia's natural gas reserves of 83 trillion standard cubic feet (tscf) (as of 2010) have an R/P ratio of 38.2 years (U.S. Energy Information Administration (EIA), 2012). Similar to oil, the reserves are inferior compared to that of Russia (1680 tscf), Iran (1046 tscf), and Qatar (900 tscf) (Hasan, 2009a). Although Malaysia is still a net gas exporter, production has been declining at about 10% per annum because the gas fields are scattered in their distribution, thereby escalating their extraction cost while some may not be economically feasible.

The fast depleting of oil and gas reserves has prompted a need to reaffirm the sustainability of their supplies. Appraisal wells will continue to be drilled in small fields offshore and in deepwater areas. Under the Economic Transformation Programme (ETP), efforts are underway to attract international oil companies for exploration activities, particularly in waters deeper than 200 metres and in ultra-deep waters greater than 1 kilometre in depth, as well as efforts to drill deeper into matured fields to increase domestic petroleum and gas production (PEMANDU 2010a). Thus, it is conceivable that for the medium and long terms, even maintaining the present level of oil production at 630,000 bpd and gas at 2000 mmscfd can prove to be challenging.

Coal

Malaysia's coal reserves of 1938 million tonnes have an R/P ratio of 285 years (U.S. Energy Information Administration (EIA 2012). The coal fields are located mainly in Sarawak and Sabah with a small portion in Peninsular Malaysia. Only a small proportion of local coal is mined for use in coal-fired power and cement plants to supplement the sizeable amount (90%) of imported coal from Indonesia (84%), Australia (11%), and South Africa (5%). Current annual coal production in Malaysia stands at about 383,000 ton, a significant increase from the 65,000 ton produced in 1991. Together with the imported coal, this constitutes about 27.3% of the total power generation mix. Importantly, the contribution of coal to the energy mix in the medium and longer terms is expected to grow in view of increases in both energy demands and costs of other fossil fuel types (Mohamed & Lee 2006; Jaffar 2009).

Although the National Mineral Policy 1998 was implemented to promote improved extraction and utilization of locally sourced coal, the production rate has yet to respond fully to the initiatives. Recently, Suruhanjaya Tenaga (ST) had awarded new licenses for two 1,000-GW units of supercritical coal-fired power plants at Tanjung Bin and Manjung. More licenses have been proposed by independent power producers (IPP) beyond 2015 in view of coal's relative ease of supply in the international market and its lower cost compared to other fossil fuel types. ST has also called for bids for new coal- or gas-fired power plants in view of the expected expiry of some of the original IPP licenses from 2015 onwards, although ST is still renegotiating the existing IPP power purchase agreements for possible extension of 5 to 10 years.

Hydroelectric Power

Malaysia possesses substantial hydroelectric resources; however, developing a hydroelectric power (HEP) plant is capital intensive and overwhelmingly complex, because it not only involves the design, construction, and operation of dams but also entails substantial environmental, social, and political considerations. Nevertheless, the advantages are numerous as hydroelectric is renewable, and the power generated is less affected by fluctuation in fuel prices. Hydroelectric is by far the largest renewable energy source in Malaysia. Large hydroelectric dams have been in operation in Peninsular Malaysia such as in Temenggor and Kenyir. Moreover, the ASEAN Power Grid provides a potential ready platform for harnessing use of HEP (Mohamed 2009; Hasan 2009a).

Renewable Energy

Sources of non-hydroelectric RE in Malaysia include biomass, biogas, solar, wind, geothermal, as well as waste-to-energy sources. They provide alternative supply options in the overall energy mix without restriction to only a few finite energy sources. Energy generated from renewable sources is generally considered to be 'green' and environmental friendly, with potential for minimizing GHG emissions that obviates costs for CO_2 emission abatement, which are otherwise necessary for fossil fuels. Besides, RE eliminates pollution from agricultural wastes because a significant proportion of RE resources are from such materials.

In view of abundant agriculture residue, sunshine, and precipitation (rainfall), the most significant sources of RE in Malaysia are biomass and biogas, solar, and small- and mini-HEP, respectively. Each of these sources involves several applications; for example, biomass includes direct combustion of plant matters to produce biofuels and syngas while solar energy includes PV conversion to electricity. In addition, wind energy contributes 0.2 MW off-grid electricity. Other RE sources that have been identified for the country include geothermal and ocean tidal energy (Hasan 2009a; Diesendorf 2012). *Table 4* summarizes the objectives and reported status for the three major initiatives providing support and promotion mechanisms for developing RE in the country.

TABLE 4. SUPPORT AND PROMOTION MECHANISMS FOR RENEWABLE ENERGY DEVELOPMENT PROGRAMS IN MALAYSIA

Program	Objective	Status
SREP (2001–2010)	To encourage RE-produced grid-connected electricity by small power generators (up to maximum 10 MW capacity) and allow its sale to TNB for up to 21 years	• 30 MW grid-connected power from biomass • 2 MW grid-connected power from biogas
BioGen (2002–2010)	To demonstrate biomass and biogas grid-connected power generation projects	• 13 MW (with 10 MW for export) and 500 kW (FELDA Serting) power plants are grid-connected and commissioned in July 2009 • 447 MW off-grid electricity produced by private palm oil millers
MBIPV (2005–2011)	To reduce unit cost of solar PV by 20% and increase capacity by 330% via applications in buildings	• 1.5 MW of cumulative grid-connected PV installations • PV system unit cost has dropped by about 60% (average) from 2005 to 2011.

Source: Hasan 2009a; 2009b; Haris 2010b

Currently, the installed capacity of RE stands at less than 1% (55 MW) of total power generation capacity nationwide (Haris 2010b). Nevertheless, RE is expected to grow with the implementation of the FIT scheme, in which individuals can sell the power generated to utility companies such as TNB and Sabah Electricity Sendirian Berhad (SESB) at a fixed premium rate for specific period (Haris 2010a). Such efforts support policies for minimizing a need for additional fossil-fuelled power plants while reducing carbon emissions at the same time.

Nuclear Energy

To face the challenges posed by global warming and climate change, the government has proposed use of nuclear energy to reduce CO_2 emissions from power generation. Malaysia is reportedly one of the countries with the fastest growing rate of CO_2 emissions in the world (PEMANDU 2010a). Nonetheless, the use of nuclear power for electricity generation has remained a contentious issue, with numerous arguments for and against its use. The controversy is compounded by the March 2011 Japanese earthquake and tsunami resulting in the Fukushima Daiichi nuclear plant explosion with radiation leakage, which paints a sobering picture against nuclear energy. This is not to mention the persisting unease in the public memory concerning the high profile nuclear plant accidents in Three Mile Island, USA (1979) and Chernobyl, Ukraine (1986) although the NPP designs used then were old.

Major arguments against nuclear energy include the limited raw material supply particularly uranium. The technology entails massive technical hurdles with a need for specially-trained engineers, inspectors, and personnel. This requirement is on top of the long lead time to plan, approve, build, and start-up a new reactor. The proposed development of a twin unit 1-GW nuclear power plant (NPP) by PEMANDU (2010a) under ETP is expected for commissioning in 2021 for the first unit (and the second in 2022–2023), indicating a projection of at least 11 to 12 years from pre-project stages to operation.

Furthermore, nuclear plants are costly to build. The planned 2-GW NPP for Malaysia would require a total investment of RM21.3 billion (PEMANDU 2010a). Additionally, cost over-runs are frequently associated with its construction: over-runs of 25% have been reported for similar projects in South Korea and Japan while a figure of 90% has been incurred in Finland. There are also lingering issues concerning the need for massive security to safeguard against nuclear terrorism, the potential leakage of radioactive materials, the absence of safe disposal methods for radioactive wastes that are otherwise costly, the non-guarantee of safe storage and final disposal, and the often-polarizing public opinions (ElBaradei 2007; Mohamed, 2009; Greenhalgh & Azapagic 2009).

On the other hand, supporters of nuclear plants advocate that it is a stable and reliable source of energy. The power generated is cleaner because it emits significantly less carbon waste into the environment as compared to coal- and gas-driven generators. Moreover, Malaysia has experience in running a nuclear reactor. The Malaysian Nuclear Agency or Nuclear Malaysia for short (formerly known as Malaysian Institute of Nuclear Technology Research (MINT) has been operating the TRIGA PUSPATI nuclear reactor since 1982. Besides, countries such as USA (104 nuclear plants), France (50), and South Korea (20) have been using nuclear power to generate electricity and can therefore be sources for experience sharing (Academy of Sciences Malaysia 2009). Furthermore, thorium is now being considered as a fuel source and the thorium-based NPP are considered much safer. Malaysia has its own source of thorium from locally-occurring monazite minerals.

ENERGY FOR POWER GENERATION

Peninsular Malaysia's maximum demand for electric power for 2010 is estimated at 15,072 MW with a fuel mix comprising natural gas (62.6%), coal (20.9%), HEP (9.5%), and petroleum products (7.0%). In relation to that, Malaysia has undertaken efforts to reduce a high dependence on gas in its generation fuel mix by turning more to coal, as evidenced in a decline of gas share in the total mix from 77.0% (in 2000) to 55.9% (2010) while that of coal increased from 8.8% to 36.5% over the same period, with similar trends projected to 2030 (*Table 5*).

TABLE 5. FUEL MIX FOR POWER GENERATION IN MALAYSIA FOR 2000–2030)

Fuel type	Electricity mix (%)													
	1980	1990	2000	2001	2003	2005	2006	2007	2009	2010	2015†	2020†	2025†	2030†
Natural gas	7.5	15.7	77.0	71.8	71.0	70.2	62.6	56.6	62.8	55.9	25.0	21.0	20.0	25.0
Coal	0.5	7.6	8.8	13.7	11.9	21.8	20.9	34.2	27.3	36.5	45.0	49.0	47.0	43.0
Hydro	4.1	5.3	10.0	10.1	10.0	5.5	9.5	6.9	6.9	5.5	26.0	25.0	26.0	23.0
Oil/Petroleum products[a]	87.9	71.4	4.2	4.4	6.0	2.2	7.0	2.3	2.1	0.2	1.0	1.0	<1.0	<1.0
Renewables (non-hydro)	0	0	0	<1.0	1.1	0.3	<1.0	<1.0	0.9[b]	1.8	3.0	4.0	3.0	3.0
Nuclear	0	0	0	0	0	0	0	0	0	0	0	0	4.0	6.0

†Projections are taken from Mohamed (2009).
[a]Mainly refers to diesel.
[b]Detailed composition is reported to be biomass (0.7%), bio-oil (0.1%), and others (0.1%).
Source: Yob *et al.* (2011); EPU (2010); Jaffar (2009); Mohamed (2009); DoESREC (2007); Mohamed & Lee (2006); ASM (2010).

In terms of electric power use, the industrial sector is the main user accounting for 44.47% of total electricity consumption, as reported in *Figure 2*. This is followed by (in decreasing order) commercial, domestic (or residential), public lighting, agriculture, and mining sectors (*Figure 2*). Demand for energy by the industrial sector is expected to be more pronounced in view of its envisaged rapid expansion under the New Economic Model (NEM) and its operative ETP in propelling Malaysia towards becoming a high income nation by 2020 (PEMANDU 2010a).

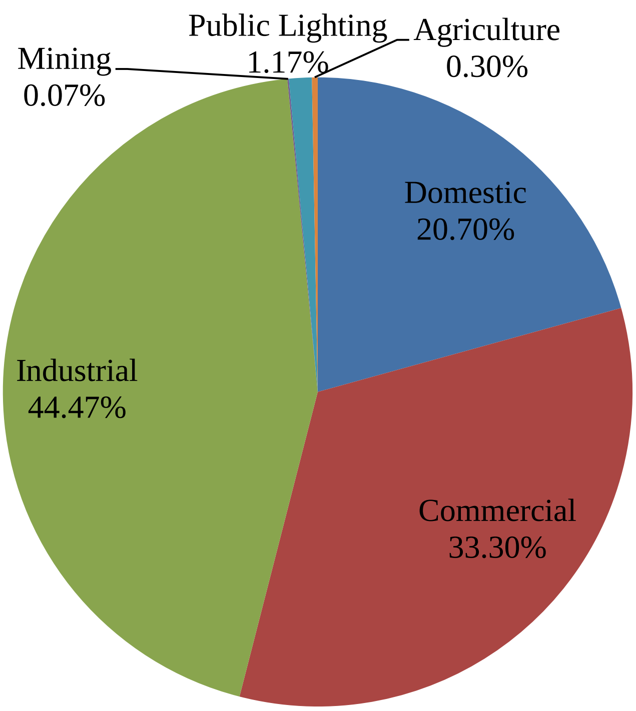

Figure 2. Electricity distribution by sector in Malaysia based on electricity sales of TNB, SESB, Sarawak Electricity Supply Corporation, and Northern Utility Resources Sdn. Bhd. in January–June 2010 (Suruhanjaya Tenaga, 2010).

WAY FORWARD

Power Generation Capacity

The maximum demand of electricity in Peninsular Malaysia was 15,700 MW in 2010, while the current generation capacity is about 22,100 MW. Recent developments have seen the ST publicising a request for bids for a total of about 7,300 MW of power generating capacity. Licenses for two coal-fired power plants of 1,000 MW each have been awarded to date: one to TNB and the other to Tanjung Bin for commissioning around 2015 to 2017. In addition, ST has successfully negotiated and extended the IPP licenses for 2,253 MW. Of this, 1,978 MW is extended for 10 years while 275 MW for 5 years. ST has also awarded TNB the license to develop a 1,071 MW combined-cycle gas turbine (CCGT) power plant at Prai.

It is assumed that the 7,300 MW above includes the 3,071 MW (i.e., 1,000 + 1,000 + 1,071 MW) already awarded and scheduled for commissioning by 2020. It is also assumed that this capacity does not include the proposed NPP, in which the first unit is scheduled to be commissioned in 2021 (i.e. after 2020). Under this assumption, the total power generating capacity for the duration up to 2030 could be of the order as projected by the two scenarios A and B in *Table 6*. Scenario A assumes that the first generation licensees' plants are retired before 2020 while scenario B assumes that the first generation licenses are extended for 10 years and that the ST's additional 5,300 MW bids are implemented between 2020 and 2025. These initiatives have been stated to be necessary to replace the decommissioning of some of the first generation IPPs (totalling about 4,100 MW of capacity) whose original licenses were due to expire by 2020. However, these figures exclude consideration of any existing plant that are scheduled to be decommissioned during the period up to 2025.

TABLE 6. PROJECTION OF POWER GENERATION CAPACITY (MW) EXCLUDING RENEWABLE ENERGY FOR 2010–2030

Year	2011	2015	2020	2025	2030
Scenario A	22,100	22,100	20,000	25,300	25,300
Scenario B	22,100	22,100	24,100	29,400	25,300

KeTTHA has taken advantage of the UNDP/GEF-supported MBIPV (Malaysia Building Integrated Photovoltaic) project (2006–2011) to pursue the formulation of the Renewable Energy Policy and Action Plan (REPAP) and enactment of the *Renewable Energy Act 2011*, which was passed in April 2011. This included the FiT mechanism as well as the *Sustainable Energy Development Authority Act 2011* to establish a dedicated agency to implement the *Renewable Energy Act* and its FiT mechanism.

Implementation of the *Renewable Energy Act* to accelerate the development of RE power generation in Malaysia commenced on 1 December 2011. The RE capacity development under the *Renewable Energy Act* and the FiT mechanism is expected to add substantial power generating capacity to the electricity supply network in Peninsular Malaysia during this period. However, it may not be able to achieve its original targets due to the time lag in implementation and possible impact of other extraneous developments.

The actual RE capacity development may not match the initial projections particularly as the plantation waste feedstock has now become a valuable commodity that is too costly to burn for power generation compared to its alternative uses as promoted in the National Biomass Strategy 2020 (Agensi Inovasi Malaysia 2011). Hence, a conservative and more realistic forecast is considered in this Report for comparison purpose. The projected capacities are presented in *Table 7* with the revised grid-connected power generation capacity moderated as shown in *Table 8*.

TABLE 7. PROJECTION OF POWER GENERATION CAPACITY (MW) FROM RENEWABLE ENERGY FOR 2010–2030

Year	2011	2015	2020	2025	2030
Including PVPP*	154	1,275	3,140	4,643	7,068
Excluding PVPP*	134	980	2,080	2,888	3,993
This Report's estimate excluding PVPP*	70	500	1,400	2,400	3,400

*PVPP stands for photovoltaic power plant
Source: Haris (2011)

Table 8. Revised projection of power generation capacity (MW) including renewable energy for 2010–2030

Year	2011	2015	2020	2025	2030
Scenario A	22,100	22,600	21,400	27,700	28,700
Scenario B	22,100	22,600	25,500	27,700	28,700

Energy Efficiency & Conservation

KeTTHA has formulated a National Energy Efficiency Master Plan (NEEMP), which has been peer-reviewed by a team of industry experts from the Asia Pacific Economic Co-operation. KeTTHA is currently in the process of formulating an Energy Efficiency and Conservation Act to accelerate the adoption of EE in Malaysia. As well, KeTTHA has implemented the Sustainability Achieved Via Energy Efficiency or SAVE program from July 2011 as a part of the ETP's Entry Point Project (EPP) 9 to catalyze the adoption of EE through the purchase of EE appliances such as 5-star refrigerators and energy-efficient air conditioners.

The government's plans for the NPP have also been incorporated in the ETP under EPP 11. As indicated above the first unit of 1,000 MW is scheduled to be commissioned in 2021. However, the development of an NPP is now a more controversial issue than it was initially, following the incident at Japan's Fukushima Daiichi NPP in March 2011. Hence the potential capacities of the proposed NPP units (2,000 MW) are not considered for this discussion.

A comparison of the required and anticipated power generation capacities in Malaysia to satisfy power demand under an EE&C scenario is shown in *Table 9*. Even if the scepticism can be overturned, there would still be some doubt as to how much impact can EE&C have on national power demand. *Figure 3* indicates a potential demand saving of about 826 MW by 2020 at a conservative demand saving rate of about 0.5% per annum. Such a demand reduction magnitude (826 MW), together with a reserve margin of 25%, equal to a generation capacity need of about 1,030 MW or a considerably significant saving of about RM3 billion in capital investment.

TABLE 9. PROJECTION OF POWER SUPPLY AND DEMAND BALANCE FOR 2010–2030 UNDER AN EE&C SCENARIO

Year	2010	2015	2020	2025	2030
Maximum demand (MW) (EE&C scenario)	15,072	17,378	19826	22,604	25,752
Generation capacity (MW) (EE&C scenario) (a)	22,100	22,600	25,500	27,700	28,700
Generation capacity needed (assuming 25% reserve margin) (b)	18,840	21,723	24,783	28,225	32,190
Generation capacity shortfall (MW) (b – a)	Nil	Nil	Nil	525	3,490

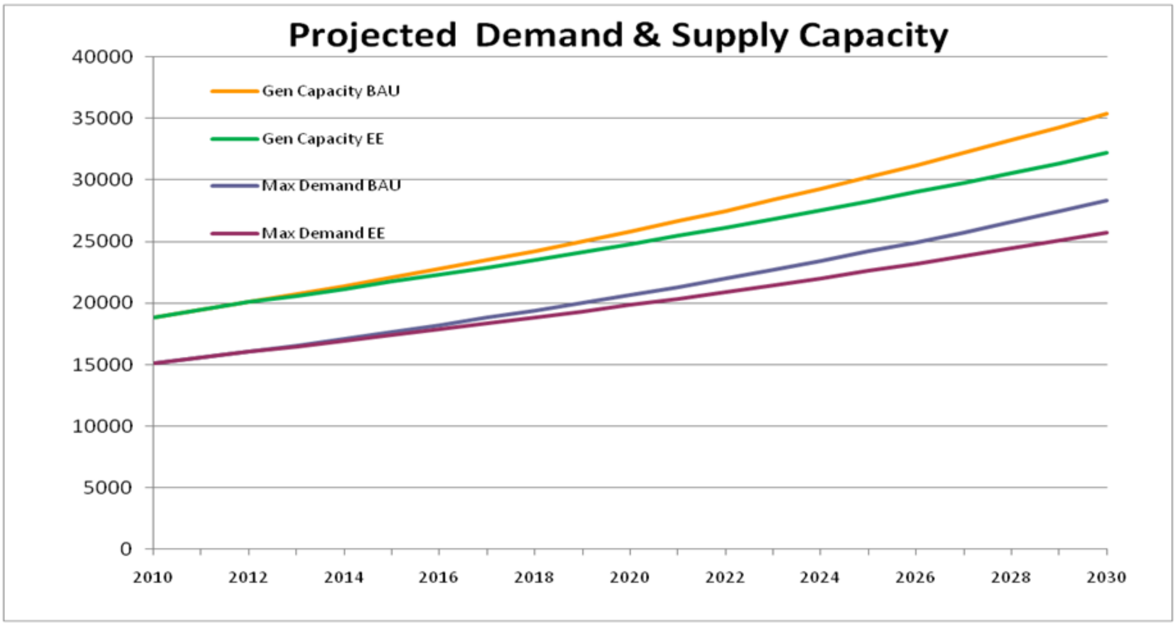

Figure 3. Projected electricity demand under a business-as-usual scenario (3.2% per annum growth rate).

There are several EE initiatives that can be exploited by all categories of consumers, even without any legislation for EE&C. A few simple and easy initiatives include the following:

- Replacement of incandescent lamps with compact fluorescent lamps: KeTTHA has mandated the phasing out of incandescent lamps by 2014. This can be supplemented by the promotion of LEDs which are now becoming cost-effective;
- Similarly, tubular T-8 fluorescent lamps, which are commonly used for commercial and residential use, can be replaced by the more efficient T-5 tubes which give the same lighting level with about a one-third reduction in the energy used. These too can include the use of LED alternatives;
- Continued promotion of 5-star EE refrigerators, as promoted by KeTTHA from the middle of 2011 under its SAVE program;
- Replacement of typical window or split type air-conditioners with the 5-star or inverter type equivalent models;
- Roof insulation, which is still not widely used in Malaysia and can help to reduce the cooling power demand. Similarly, better quality window with higher insulation performance supplements cooling load energy use reduction; and
- Anecdotal evidence indicates that rain in the Klang Valley reduces power demand by about 3% for Peninsular Malaysia. This is equal to a demand reduction of about 450 MW on a maximum power demand of about 15,000 MW. Again, only a part (about 50% or 225 MW) of this reduction may be achieved with enhanced roof, wall and window insulation.

Most commercial and some industrial users have significant air-conditioning cooling loads, using large centralized chillers. Technology improvement over the years makes new centralised chillers significantly efficient than older plants. Chiller efficiency improvement itself may warrant their replacement on economic grounds in view of current electricity tariffs and their anticipated increase in line with the government's declaration to remove fuel subsidies gradually.

Experience from energy audits for some commercial consumers show their air-conditioning energy use share at 50%–60% and lighting energy use share at up to 30%. The share of air-conditioning and lighting energy use for industries are not as well known but, on a conservative basis, they may be of the order of about 10% of their respective total consumption.

This is more so since such consumers can avail tax benefits (Investment Tax Allowance) that the government has provided for the adoption of EE&C initiatives by companies. Replacing every ton of refrigeration of centralised chiller plant with newer more efficient plant can provide energy cost savings of the order of RM300 per annum (based on an average operation of 10 hours a day) for typical users such as offices, shopping malls, and hospitals.

So how much additional electricity demand savings are possible if these consumers change their older chillers? Statistics for 2010 show industrial and commercial use to be 29,872 GWh (1 GWh equals 1 billion kWh) and 40,071 GWh respectively (Suruhanjaya Tenaga 2010). Thus, a very conservative energy saving estimate of only 10% for the cooling load equates to about 1,494 GWh saving for commercial users and 400 GWh saving for industrial consumers, making a total saving of about 1,894 GWh per annum. This energy saving would imply a demand saving of about 309 MW, hence avoiding a need for power generation capacity of about 380 MW. (Actual savings from replacing old chillers with state-of-the-art EE chillers can be as much as 25%, without sacrificing the cooling capability required).

Similarly, energy efficient lighting for commercial and industrial users would provide additional savings. Based on conservative shares of energy used (20% for commercial and 10% for industrial users) and conservative prospective saving to be achieved (only 20% compared with known saving of about 30% for T-5 fluorescent tubes against the current standard T-8 tubes, and up to 50% with LEDs but at a much higher cost), the savings from changing existing lighting to the more efficient alternatives can be about 1,996 GWh a year. This energy saving would equate to a demand saving of about 326 MW, implying a reduction in power generation capacity required of about 407 MW.

The total potential energy savings from using EE lighting and replacing existing older centralised chillers with new more efficient units can be as much as 3,890 GWh which would equate to a demand reduction of 635 MW. Allowing for a 25% reserve margin, this would equal to a reduction in required power generation capacity of 787 MW. Thus, the total demand reduction from the various initiatives would be as reported in *Table 10*.

TABLE 10. DEMAND REDUCTION FROM VARIOUS EE&C INITIATIVES

Initiative	Saving (GWh)	Maximum demand (MW) reduction	
		Minimum	Maximum
EE refrigerators	1,380–1,821	225	297
EE air-conditioners	1,380–3,678	225	600
Rain (insulation)	1,380	225	
EE chillers replacement	1,894	309	
EE lighting	1,996	326	
Total*	8,030–16,769	1,310*	1,757*

The total saving from these initiatives will experience some fluctuation in the demands, so the actual demand reduction will be less than the estimated figures in *TABLE 10*. The effect of fluctuation may moderate the demand reduction to 70%–80% of the total saving estimated. A conservative reduction of 70% translates to a potential saving of 917 MW –

1,230 MW. Allowing for a nominal 25% reserve margin results in the generation capacity required to meet such a load to be reduced by 1,146 MW – 1,538 MW.

Nuclear Energy

Does Malaysia need 5,000 MW of NPP as projected by KeTTHA, or even the 2,000 MW as planned by PEMANDU, with the first 1,000 MW unit to be commissioned by 2021 under EPP 11 of the ETP? *TABLE 9* again shows that the NPP capacity would not be needed until at least 2025. Even a need beyond 2025 is debatable as discussed next in light of the aforementioned potential contribution of EE and RE on generation capacity.

Licenses for a total of 2,253 MW of IPP generating capacity, which are due to expire between 2015 and 2020, have been extended by up to 10 years. The power plants in question are capable of operating satisfactorily during the proposed extension period. Besides extension of their operating licenses, these power plants can be judicially re-powered with new power generating units at the current sites where the gas supply may still be available beyond the present license periods.

The combined cycle (CC) gas turbine (or CCGT) plants that are to be retired have an average operating efficiency of 40%–45% while the units being manufactured now claim a design efficiency of the order of 60%. The new CC plants may thus be able to operate at an average efficiency of 50%–55%, i.e., about 10% higher than the existing plants. This means that new CC power plants can generate up to 20% higher output than the plants they replace using the same amount of gas supply. In addition, the existing open cycle (OC) gas turbine (or OCGT) plants can be converted to CC mode that will increase their output by about 50% compared with the current OC operating mode.

Briefly, current maximum demand for electricity in Peninsular Malaysia is about 15,400 MW and is predicted to grow to an estimated 20,700 MW in 2020 (Mohamed 2009). Meanwhile current total electricity generation capacity stands at approximately 21,800 MW. As aforementioned, about 4,200 GW of IPP plants will be decommissioned from 2015 to 2020, but ST has been seeking bids for about 7,300 MW for commissioning over the same period besides renegotiating possibility of extending the IPP licenses beyond the current expiry dates. In addition, the *Renewable Energy Act* with its associated FiT regime is expected to add 2,100 MW – 3,200 MW by 2020 (which is separate from the capacity that ST has put up for bids). On top of that, the ETP under Entry Point Project 9 for EE envisages a demand reduction of 10–15% on a business-as-usual growth (PEMANDU 2010b). Assuming conservative achievement of EE and RE at 70% of their target lower-ends, demand and generating capacity are estimated to be 19,300 MW and 26,300 MW respectively, by 2020.

Thus, we would still maintain a reserve margin of the order of 36%, which is well above a recommended 25% target. If EE and RE achievements are better than the conservative 70% assumption, the reserve margin would be close to 46%–50%. With all the developments taken together, it warrants the consideration of whether Malaysia needs the proposed 2,000 MW of NPP in early 2020s.

On the other hand, the generation mix is expected to involve a greater share of coal, whose consumption is projected to grow at a faster rate of 9.8% per annum compared to the slower rate of oil and natural gas at 2.7% and 3% per annum, respectively. As such, Malaysia's energy infrastructure needs to be developed continuously to meet the projected demand. This will impose significant pressure on sustaining the present energy mix, especially the finite fossil fuel resources, which cannot be extended on a long-term basis into the future at current consumption rate.

Hence, there have been calls to further develop RE resources particularly in view of Malaysia's depleting fossil fuel resources. It is forecast that Malaysia will become a net energy importer starting from 2017 (assuming business-as-usual) or 2019 (assuming adoption of EE&C measures and development of RE power projects) (Mohamed 2009). Being a net energy importer does not mean that the country's reserves are completely drained or that Malaysia does not produce any more oil, natural gas, or coal for its own use or for export. It implies that the value of imported fossil fuels is much higher than what is exported. However, recent offshore discoveries, development, and production have improved oil and gas reserves by 2% and 3% respectively, thus possibly delaying the transition to a net importer.

Although RE has been anticipated to assume a higher profile in the country's electricity generation mix with the implementation of the SREP program, RE's contribution hitherto has been dismal at less than 1% despite the financial incentives granted (Mustapha 2008). To boost RE's contribution to generation mix, the recent *Renewable Energy Act* incorporates a generous FiT scheme that allows companies and individuals to sell electricity generated from renewables to public utility companies. As such, RE's contribution is expected to increase to 9% (about 11 TWh) by 2020 and up to 12% (17 TWh) by 2030 (Haris 2010b). The targets may seem optimistic, but they are achievable and show that RE has the potential to be a major source in the nation's future power generation equation.

Clearly, Malaysia has to consider alternative approaches to sustain its reserves and meet its energy needs for desired economic development, besides re-examining its energy mix. Potential proactive measures include adopting EE&C practices and demand side management in general. There is also a need to reassess the available electricity generation options, as discussed next.

Nevertheless, notwithstanding the above, the nuclear option should not be disregarded completely as there are safer options, and therefore with much less security concerns as for uranium-based fuels. A modern alternative, such as utilizing a thorium-based nuclear fuel in a 5th Generation (or later), could be considered as a viable alternative. This is also one way where CO_2 emissions from coal-based power plants can be reduced.

If the nuclear option is to be considered for implementation by the government, it should initially undertake an intensive and extensive public engagement exercise to convince the public of the need for the NPP, capability and competence of the personnel managing the NPP design and the decommissioning of the plant, among other matters. It should also begin to send highly-qualified engineering and science graduates overseas to undertake post-doctorate programs in NPP management.

RECOMMENDATIONS

This section presents our recommendations on strategies for sustainable electricity generation alternatives and measures to year 2030 for Peninsular Malaysia.

Enhancing Coal Supply Security

Owing to its favourable price structure compared to oil and natural gas, coal will continue to be a major component of Malaysia's energy mix and is expected to constitute over 40%–45% of future energy mix. Hence it is important to have control over such a vital natural resource.

Since local coal-fired power stations are not designed to run on local coal alone (blended form is possible), a strategy is to consider acquiring coal mines abroad especially in the U.S., Australia, South Africa, and Indonesia, although one such acquisition in Kalimantan, Indonesia, had run into difficulties later and was sold off in 2007. Countries including China, India, and Japan have undertaken such measures to supplement their coal supply. Currently, there are available for sale coal mines in Australia (e.g. pits owned by Peabody Energy Corporation) and in the U.S. (e.g. Massey Energy Corporation). A Malaysian public-listed company, Jotech Holdings Berhad, has taken a stake in a coal mine in Kalimantan, Indonesia (Syed Jalal & Bodger 2009).

Acquisition of coal mines abroad not only ensures supply security and reliability, but it also does not incur any additional training cost since these mines are already in full operation. Therefore, the supply is instantaneous once the acquisition is complete. Moreover, despite increasing environmental constraints imposed on its production, coal asset prices are projected to increase in the future due to rising demand by energy-hungry industrialized and newly-industrialized countries. Thus a quick decision can only serve to put one in an advantageous position. With such developments in place, coal stands to be an important component for Malaysia's future generation mix.

Supporting Renewable Energy

Feasible RE resources in Malaysia primarily include biomass, biogas, mini-hydroelectric, and solar PV. Some measures of success have been demonstrated by the SREP program (2001–2010) and the two UNDP–GEF-supported projects, namely BioGen (2002–2009) and MBIPV (2005–2011). While their overall achievement resulted in only 45.9 MW connected to the national grid compared to the 350 MW target for RE by 2010 (Haris 2010b; Hasan 2009a), the enactment of the *Renewable Energy Act 2011* with its FiT mechanism shows a much enhanced rate of RE capacity development.

Under SREP, RE generated from biomass and biogas was paid RM0.21/kWh and that from mini-hydroelectric at RM0.17/kWh, whereas energy from PV was based on net metering with residential installation at up to RM0.44/kWh and commercial at up to RM0.39/kWh. In rough comparison, the prices payable for power generated from RE, except for PV, are competitive against the average rates payable for power generated from conventional fossil fuels with subsidized natural gas.

However, there is a low uptake of RE due to uncertain biomass supply besides the high capital expenditures with long payback periods involved. Such situations have caused financial institutions and investors to be apprehensive about investing in RE projects (Sovacool & Drupady 2011). Fortunately, the recent passing of the *Renewable Energy Act 2011* has brought about some much welcome boost. First, it has incorporated the generous FiT system for power generation in the RE industries to fast track its growth (Haris 2010a; 2010b). Second, the legislative enactment has established a regulatory framework with clearly defined roles for the regulators and power producers. Moreover, dedicated funding is available to top-up the FiT rates for renewable power producers. With FiT in place, the situation augurs favorably in achieving the 5.5% national target from RE in the generation mix as stipulated in the 10th MP (2011–2015). Moving forward, Haris (2010b) projected the contribution of RE to the generation capacity mix to increase progressively to a high of 17% (4 GW) by 2030.

Adopting Energy Efficiency and Conservation Measures

Significant energy losses occur due to inefficiencies in the transmission and distribution of electric power; losses amounting to about 12% of power generated have been reported for Malaysia. As such, there avail opportunities for Malaysia to improve on its utilization through widespread adoption of EE&C measures, for example, through cogeneration and tri-generation of power and heating and cooling duties (APEC 2011).

On a wider cross-sectoral scale, Malaysia possesses largely untapped potential for savings through EE&C measures. This condition is partly because of the marginal incentive attainable due to low electricity prices resulting from high government subsidy. Fortunately, EE&C is poised to be given a higher profile under ETP as subsidies on fossil fuels will be progressively removed. As it is, there already are many good reasons for adopting EE&C: the measures are undertaken locally, thereby enabling local participation and ensuring community resilience. They offer the low-hanging fruits for which relatively little investment is required for the substantial benefits achievable. EE&C actions also entail use of less energy and consequently, serve as a means to reduce GHG emissions and air pollution.

Similar views on the benefits of EE&C have been expressed in a McKinsey (2008) Report which postulated that projected global energy demand growth to 2020 could be reduced significantly by enhanced EE&C. Thus, it is fair to assert that EE&C is a potent way of riding the sustainable development wave. EE&C has been touted even as the best "energy resource". All in all, broader adoptions of EE&C are bound to provide major economic and social dividends, besides environmental benefits, often with rapid return. In this regard, the Malaysia government has played an important role by taking the lead in making its own buildings (at its Putrajaya administrative capital) and practices more energy efficient.

EE&C activities are not new in Malaysia, dating back to as early as the middle of 1980s. The 7th MP (1996–2000) promoted EE&C at the national level for the first time. The initiatives were progressively enhanced in 8th MP (2001–2005) through provision of fiscal incentives, and they have been explicitly encouraged in the 9th MP (2006–2010) via both public and private sectors' participation. As a result, numerous EE&C measures are already adopted in Malaysia, with ongoing efforts that include electrical equipment labeling program (started in 2005), energy efficiency awareness campaigns, green building rating tools, and incandescent bulb phasing out (by 2014), culminating with the National Energy Efficiency Master Plan (NEEMP) (Yob *et al.* 2011). Consequently, ETP envisages EE&C measures to reduce the nation's energy bill by 10%–15% by 2020 as compared to a business-as-usual scenario (PEMANDU 2010b). By a similar basis, NEEMP targets a 10% reduction in Malaysia's electricity consumption in 2020 (Asia-Pacific Economic Cooperation 2011). Thus, it is envisaged that proper policy implementation, political leadership, and capacity building are requisites in ensuring significant contribution from EE&C initiatives.

Moderating Gas Subsidies

The Malaysian energy market is somewhat distorted: prices of petroleum products and natural gas prices as well as electricity tariffs are highly regulated by the government through subsidies. Although part of the aim is to attract foreign direct investments, subsidies have in turn led to non-efficient energy use as well as suboptimal resource allocation. As such, the Report advocates a need for policy-driven leadership to moderate energy subsidies in the country.

Reviewing Nuclear Energy Development

Constructing an NPP is highly capital intensive. But as revealed by the analysis in this Report is a high-cost NPP necessary or even warranted for Malaysia, especially in the wake of the Fukushima tragedy? The NPP would also inevitably raise concerns over health and safety issues generally associated with its construction, operation, and decommission as well as disposal of residual radioactive wastes. Of course, the Fukushima incident was due more to the design of the plant (and an earlier design was utilized) as well as the tsunami that followed the earthquake. In Peninsular Malaysia, the risk of an equivalent tsunami and earthquake is low as the tectonics in this country completely different.

Nevertheless, notwithstanding the above, the nuclear option should not be disregarded completely as safer, and therefore with much less security concerns as for uranium-based fuels, and modern alternatives to uranium fuel source, such as a thorium fuel source, could be considered as a viable alternative. If the nuclear option is to be considered for implementation by the government, it should initially undertake an intensive and extensive public engagement exercise to convince the public of the need for the NPP, capability and competence of the personnel managing the NPP (and possibly by now utilizing the thorium-based nuclear fuel in a 5th Generation (or later) NPP design and the decommissioning of the plant, among other matters. It should also begin to send highly-qualified engineering and other graduates overseas to undertake post-doctorate programs in NPP management.

Enforcing a Common Regulatory Framework

Energy issues in Malaysia currently come under the purview of several government entities, namely the Ministry of Energy, Green Technology and Water (KeTTHA), the Energy Commission/*Suruhanjaya Tenaga*, the Economic Planning Unit, and the Prime Minister's Office (PMO) (with PMO primarily concerned with petroleum-based resources as vested under PETRONAS). This has resulted in issues that include: possible fragmentation of the present system concerning energy planning particularly on the supply side; energy prices not reflecting the actual costs; low energy intensity leading to loss of competitiveness; and problems with coordination and priority setting as regards decisions on EE&C practices and RE initiatives.

A regulatory framework can be effective for coordinating energy-related undertakings to drive convergence of energy requirements for the industrial, agricultural, commercial, services, and residential sectors as well as to promote use of RE, encourage EE&C practices, and minimize energy wastages. Enforcing a regulatory framework will send a strong signal to the market about the government's commitment to the energy sector. The framework will also act as a foundation on which governance principles and mechanisms are enforced to support the systematic growth of the energy and its affiliated industries. In addition, the regulatory framework will spur a critical mass to enhance use of RE and stimulate an EE&C culture.

CONCLUDING REMARKS

Malaysia has, and still experiences, an unusually high reserve margin of the order of 40% in its electricity generation system in Peninsular Malaysia, while the demand growth has moderated over the recent decades from over 8% per annum to about 3.2% per annum (TNB 2010). Nevertheless, it is necessary to ensure supply adequacy and reliability for the future needs of unrestrained economic development. This Report has considered the many alternative options available for Peninsular Malaysia to develop a power generation system using a variety of primary energy resources to ensure supply security while meeting the national commitment to reduce its carbon intensity by 40% from the levels in 2005 by 2020. Briefly, these options include the following key elements:

- Accelerate the promotion and adoption of EE&C initiatives and practices among all categories of users so as to reduce the growth of demand in relation to GDP growth;
- Continue to develop available RE power generation using the FiT mechanism as provided for under the *Renewable Energy Act 2011*;
- Minimize the use of oil and constrain the use of natural gas mainly to combined cycle and co-generation facilities to maximise the benefits from this valuable fuel resource;
- Increase the use of indigenous coal and ensure the security of imported coal supplies through options such as purchase of foreign coal mine ownership or operations;
- Exploit the remaining hydropower resources that satisfy system load demand profiles, whether as peaking plants or as re plants;
- Prepare for the possible exploitation of thorium nuclear energy in the future by developing human capacity in technology and the necessary regulatory framework, but plan in advance on massive intensive and extensive public engagement exercise to prepare for a time when more benign sources are inadequate to meet the forecast power demand; and
- Ensure that the power generation capacity is developed in accordance with the forecast

demand growth with particular attention to maintaining adequate (about 25%) but not excess (as the current 40%) reserve margin for the overall system.

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