Prospects for coal and clean coal technologies in Malaysia

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Abstract

Malaysia is a regular participant in world coal trade. Coal production is a modest 1 Mt/y but, as an importer, the country trades some 30 Mt/y. As one of ASEAN's most prosperous economies, the expected growth in electricity demand is inevitable. For many years the country has been dependent on gas-fired power, much of which is in the form of expensive single cycle gas turbines. However, coal-fired power has emerged as an important provider of power in a country desperate to improve its energy security. This report looks at how coal-fired power has developed, and examines the current technologies deployed in the country. It is the fourth in a series of reports by the IEA Clean Coal Centre on ASEAN countries, following Indonesia, Thailand and Vietnam.

Acronyms and abbreviations

$	US dollar
ADB	Asian Development Bank
ARA	Amsterdam/Rotterdam/Antwerp, a major coal hub for European coal imports
ASEAN	Association of Southeast Asian Nations
BAT	best available technology
bbl	barrel of crude
bcm	bank cubic metres (coal overburden) or billion cubic metres (natural gas)
boe	barrel of oil equivalent
BFG	blast furnace gas
°C	degrees Celsius(multiply by 9/5 + 32 to convert to Fahrenheit)
CCGT	combined cycle gas turbine (also known as GTCC)
CCS	carbon capture and storage
CDM	clean development mechanism
CER	certified emission credits
CHP	combined heat and power (also known as co-generation)
CIF	cost, insurance, and freight
CO_2	carbon dioxide
dwt	deadweight capacity of an ocean cargo vessel
EIA	Energy Information Administration, US Department of Energy
ESP	electrostatic precipitator (for particulate removal)
FGD	flue gas desulphurisation (for SO_2 removal)
GAD	gross air dried
GHG	greenhouse gas
GJ	gigajoule
Gt	gigatonnes (1000 million metric tonnes)
GT	gas turbine
GWe	gigawatt of electrical output capacity (1000 MWe)
GWh	gigawatt hour (1000 MWh; 10^6 kWh)
H_2	hydrogen
IC	internal combustion (typically a diesel reciprocating engine)
IEA	International Energy Agency, Paris
IEA CCC	IEA Clean Coal Centre, London, UK
IGCC	integrated gasification in combine cycle
IMF	International Monetary Fund
IPP	independent power producer/production
JI	joint implementation
kcal/kg	kilocalories per kilogramme (6000 kcal/kg = 20.9 MJ/kg)
kt	kilotonnes
kWe	kilowatt of electrical output capacity
kWh	kilowatt hour
LHV	lower heating value
LNG	liquified natural gas, a form of natural gas at -163°C temperature and 125 kPa low temperature for the purposes of long distance bulk transportation using cryogenic ocean vessels
MJ/kg	megajoules per kilogramme
MMBtu	million British thermal units
MWe	megawatt of electrical output (1000 kWe)
MWh	megawatt hour (1000 kWh)
NEB	National Electricity Board
NOx	nitrogen oxides
OECD	Organisation for Economic Cooperation and Development
O&M	operation and maintenance
OPEC	Organisation of Petroleum Exporting Countries (based in Vienna, Austria)
PF	pulverised fuel (hard coal)
R/P	reserves to production ratio, simply provides an indication of the remaining life of mineral and energy reserves
RM	Malaysian ringgit
Rp	Indonesian rupiah
SC	supercritical (typical steam pressure <22.1–25 MPa; main steam and reheat temperatures 540–580°C)
USC	ultra-supercritical (typical steam pressure >25 MPa; main steam and reheat temperatures >580°C)

SCR	selective catalytic reduction (for NOx reduction)
SO_2	sulphur dioxide
t	metric tonne or 1000kg (x 0.9844 = long ton; x 1.1025 = short ton)
t/d	tonnes per day
t/h	tonne per hour
TAGP	Trans ASEAN Gas Pipeline
TNB	Tenaga Nasional Berhad
TPES	total primary energy supply
TWh	terrawatt hour (1000 GWh, 10^6 MWh, 10^9 kWh)
UNFCCC	United Nations Framework on the Convention of Climate Change
WEC	World Energy Council
WWF	World Wildlife Fund

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1 Introduction

Key facts:

Malaysia population (2007): 27–28 million

Capital: Kuala Lumpur

Currency: Ringgit (3.4 RM: $1)

GDP (2007 current market prices): 741.9 million RM
222 billion $ (IMF data)

This report forms one of a series of reports on coal and clean coal prospects in the Association of Southeast Asian Nations (ASEAN) economies. Malaysia does not have a large resource of coal compared with countries like Indonesia, and its coal demand is currently little more than 30 Mt/y. Coal-fired power nevertheless forms an important role in the power generation sector. In recent years, coal is seen as an essential provider of power generation for many industrialising economies. The relatively secure supply chain for internationally-traded coal offers a more reliable source of energy. Malaysia is one such country which has historically been dependent on oil- and gas-fired power, both of which are expensive fuels. Renewable electricity is yet to make any impact, although conventional hydroelectricity is being pursued. One emerging possibility is biomass power, largely from palm oil waste products, but generating units are small and unlikely to replace the large gas, coal or hydro stations.

Malaysia comprises the three territories of Peninsular Malaysia, Sarawak, and Sabah (*see* Figure 1). The country stretches over 2000 km (1240 miles) from the edge of the Indian Ocean to the Northeastern end of the island of Borneo. Peninsular Malaysia is separated from Sarawak and Sabah by 1025 km (640 miles) of the South China Sea. Sarawak and Sabah occupy the northern part of Borneo, sharing borders with Indonesia's Kalimantan, and the state of Brunei. Peninsular Malaysia in the mainland borders Thailand forming a southern peninsular of the Far East.

Malaysia has an equatorial climate, and so is extremely hot and humid almost all year round. Consequently, the electricity loads for cooling in the major urban centres will continue to increase. Rainfall is highest in March to May and again in September to November; and monsoons regularly hit coastal regions.

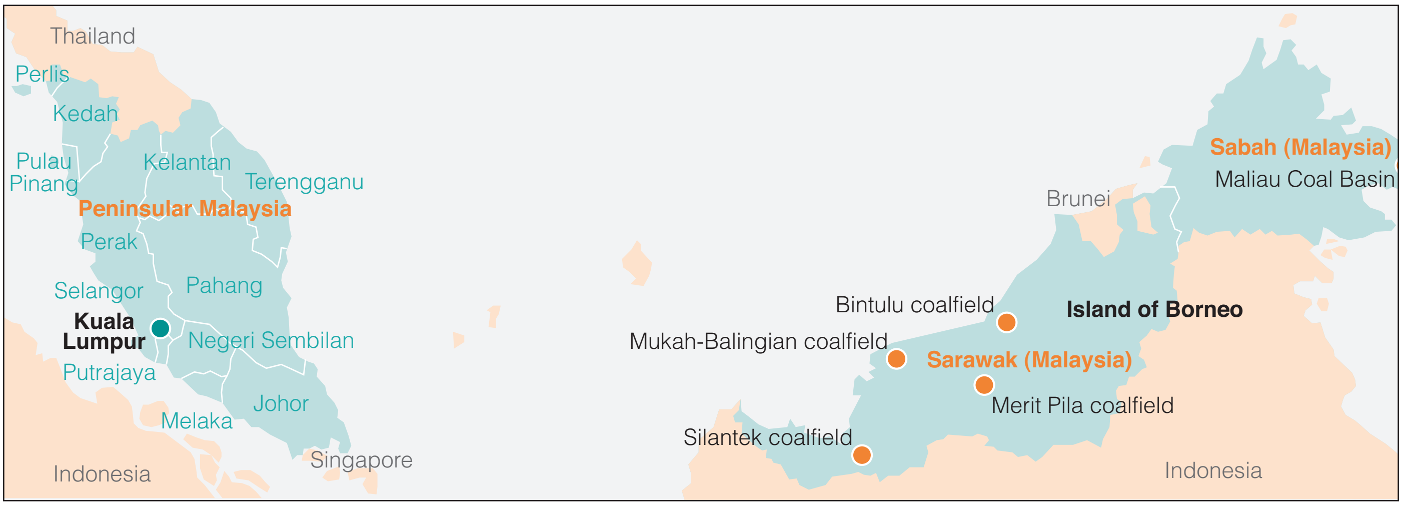

Figure 1 Map of Malaysia including major coalfields

2 Economic summary

Malaysia is one of ASEAN's most advanced economies, benefiting from decades of industrial growth and political stability. The country is a major manufacturing economy and among the world's biggest producers of computer disk drives, as well as having a large agricultural sector where palm oil, rubber, and timber industries are major export commodities.

While the economy has been relatively advanced by Asian standards, the global downturn in 2008-09 led to the government unveiling a $16 billion economic stimulus package to tackle the recession. By observing historical GDP trends over several decades, Malaysia has been hit by a downturn every 12 years or so.Yet, the country's ability to rebound from these economic events seems equally consistent.

In US dollar terms, GDP in 2008 was estimated to reach $222 billion. Throughout the 1990s GDP growth in US dollar terms reached an impressive 7.9 %/y. Starting in 1989, Malaysia achieved eight years of double digit growth, amassing an incredible 19 %/y growth in 1995. While double digit growth before the 1990s was common, the year-on-year expansion meant that between 1990 and 1996, the country's economy had more than doubled from $44 billion to $102 billion, a truly astonishing achievement. However, 1997 saw the start of the currency crisis. The short period that followed saw the economy suffer an equally astonishing contraction, falling by 27% in 1998 (accompanied by a 40% currency devaluation against the US$). Growth resumed its high rates a year later reaching 9%, but after a stutter in the 2001 tech bubble collapse, growth got back on track, reaching 19% in 2007 and 2008.

The global economic crisis in 2008-09 has dealt a blow to the world economy, and Malaysia is no exception. According to the IMF in 2009, GDP in 2009 was expected to contract by –4%, but return to growth in 2010 by approximately +4% (IMF, 2009). Growth rates of more than 8% could be seen in 2012. Whether this comes to fruition is not certain, but there is an optimistic outlook for Malaysia's economic future in GDP terms.

The historical trend suggests that Malaysia has weathered economic downturns better than most of the other ASEAN nations. The GDP downturns have been less severe, while the growth periods have been on par with the buoyancy seen in the ASEAN region as a whole. The country's growing wealth and GDP growth makes it itself a major prospect for future energy demand.

While its economy is only half the size of Indonesia, per capita GDP is more than three times that of its more populous neighbour. Malaysia is the least populated of the major ASEAN economies, at just 27 million, compared with Indonesia (222 million), and 70–90 million of the Philippines, Thailand (66 million) and Vietnam (86 million). In 2009, per capita GDP in Malaysia was $8140 per head (in purchasing power parity terms, this jumps to more than $14,000 per head), although per capita GDP was expected to fall in 2009 (in common with the rest of the ASEAN nations). Per capita GDP is the second highest in ASEAN, the highest being Brunei at $37,000 per head, and almost double that of the third highest, Thailand ($4100 per head). The average Malaysian is therefore relatively wealthy by ASEAN standards.

3 Constitutional issues

Malaysia achieved independence from British rule in 1957. The King of Malaysia (Sultan Zainal Abidin) is the Head of State and has absolute power. He takes leads from Parliament as his role is largely ceremonial, but the appointment of cabinet ministers requires his assent. He is also Head of the Armed Forces. He was installed as Malaysia's 13th King in December 2006. To spread the power, a system of rotation was devised where the position of king is rotated every five years between each of the nine hereditary state rulers.

Najib Razak obtained the post of prime minister in March 2009 when he became leader of the United Malays National Organisation, the main party in the National Front ruling coalition. The system of government in Malaysia is closely modelled on that of UK parliamentary system, a legacy of British colonial rule. Since independence, Malaysia has been governed by a multi-party coalition known as the Barisan Nasional (formerly known as the Alliance).

The population distribution is highly uneven, with some 20 million residents (out of 27 million) concentrated on the Malay Peninsula, while East Malaysia which contains the Sarawak and Sabah regions is less populated. Due to the rise in labour intensive industries, Malaysia has 10–20% foreign workers, with the uncertainty due to the large number of illegal workers. There are a million legal foreign workers and perhaps another million unauthorised foreigners. The state of Sabah alone has nearly 25% of its 2.7 million population listed as illegal foreign workers in the last census.

Malaysia is now an established technology and energy producer, although the country remains a major source of palm oil and logging. The energy sector nevertheless is a major contributor to the economy, with LNG and crude oil accounting for 9.2% of total export earnings in 2006. Although proven oil reserves have declined, Malaysia's geographical location keeps it well in the forefront of energy exports.

4 National Energy Policy

Much of this chapter is obtained from the Malaysian Energy Information Bureau which summarises the Malaysian energy policy and legislation (EIB, 2009). The Ministry of Energy Green Technology and Water (KETTHA, formerly known as Ministry of Energy Water and Communications or KTAK) outlines the energy policy for Malaysia. In 1979, the National Energy Policy was devised. Guiding this policy are three principal objectives that are instrumental for future energy sector development while considering the environmental impact of all such activity. These objectives are as follows:

The Supply Objective: To ensure the provision of adequate, secure, and cost-effective energy supplies through developing both non-renewable and renewable indigenous energy resources using the least cost options and diversification of supply sources both from within and outside the country.

The Utilisation Objective: To promote the efficient utilisation of energy and to discourage wasteful and non-productive patterns of energy consumption.

The Environmental Objective: To minimise the negative impacts of energy production, transportation, conversion, utilisation and consumption on the environment.

A number of Acts and policy initiatives were implemented to deal with managing hydrocarbon reserves, but possibly the most important policy to have an impact on coal was the *Four Fuel Policy* which was brought in 1981 which aimed to avoid over dependence on oil products, and spread the risk of energy supply across gas, hydroelectricity, coal, and oil. A subsequent revision in 2001 introduced renewable energy as the fifth fuel of choice. Interestingly, the reduction in oil dependence has been at the expense of a massive shift to gas; the country is now dependent on gas-fired power for its electricity. Nevertheless, current Government strategies at achieving national energy objectives include the following:

Secure supply – diversification of fuel type and sources, technology, maximise use of indigenous energy resources, adequate reserve capacity to cater for contingencies, adequate reserve margin for generation, upgrading transmission and distribution networks and distributed generation (islanding).

Sufficient supply – forecast demand, right energy pricing and formulate plans to meet demand.

Efficient supply – promote competition in the electricity supply industry.

Cost-effective supply – promote competition and provide indicative supply plan to meet demand based on least cost approach using power computer software such as WASP.

Sustainable supply – promote the development of renewable and co-generation as much as possible.

Quality supply (low harmonics, no surges and spikes, minimal variation in voltage) – match quality with customer demand with variable tariffs.

Efficient utilisation of energy – bench marking, auditing, financial and fiscal incentives, technology development, promotion of ESCO, energy labelling, ratings, correct pricing, energy managers.

Minimising negative environmental impacts – monitor the impacts, improve efficiency of utilisation and conversion and promote renewable.

In order to fulfil the above objectives, the following key policies guiding energy-related activities in Malaysia are listed below in chronological order:

Petroleum Development Act 1974 – established Petronas as the national oil company and vested it with the responsibility for exploration, development, refining, processing, manufacturing, marketing and distribution of petroleum products.

National Energy Policy 1979 – set the overall energy policy with broad guidelines on long-term energy objectives and strategies to ensure efficient, secure and environmentally sustainable supplies of energy.

National Depletion Policy 1980 – introduced to safeguard the exploitation of natural oil reserves because of the rapid increase in the production of crude oil.

Four Fuel Diversification Policy 1981 – designed to prevent over-dependence on oil as the main energy resource, its aim was to ensure reliability and security of the energy supply by focusing on four primary energy resources: oil, gas, hydropower and coal.

Fifth Fuel Policy (Eighth Malaysia Plan 2001-2005) – in the Eighth Malaysia Plan, Renewable Energy was announced as the fifth fuel in the energy supply mix. Renewable energy is being targeted to be a significant contributor to the country's total electricity supply. With this objective in mind, greater efforts are being undertaken to encourage the utilisation of renewable resources, such as biomass, biogas, solar and mini-hydro, for energy generation.

Energy Efficiency and Renewable Energy (Ninth Malaysia Plan 2006-2010) – The Ninth Malaysia Plan strengthens the initiatives for energy efficiency and renewable energy put forth in the Eighth Malaysia Plan that focused on better utilisation of energy resources. An emphasis to further reduce the dependency on petroleum provides for more efforts to integrate alternative fuels.

The drive to promote renewable energy has been accompanied with fiscal incentive schemes, which provide tax breaks for capital investments in renewable energies.

Under the ***Tenth Malaysia Plan 2011-15*** – in the light of the global economic turmoil, the key drive for this plan is to ensure economic growth, income generation, and social development, and so the emphasis on energy and environment seems less prominent than in previous plans, but the aims of previous plans still stand. The tenth plan merely enhances the aspirations of the government in past plans. Some of the economic reforms will also go some way to tackle sustainability issues. Fossil fuels, notable oil products and gas are underpriced. The new energy policy aims to move towards market pricing, in the case of gas this could happen by 2015. This expected withdrawal of subsidies in the Malaysian end user market would help ease the governments funding burden for fossil fuel, but also promote energy efficiency at the same time, helped by the country's own energy efficiency programme, especially in the building sector. Larger electricity users of greater than 2000 kWh per year (some 44% of users) will also face a withdrawal of subsidies. A move to greater market pricing is expected to reduce wastage and in doing so, help Malaysia in its longer-term aim of reducing carbon emissions.

New renewable investments will be enhanced by the provision of a feed-in tariff which will help finance and development. The government also aims to promote better energy efficiency across the economy, improve solid waste management (presumably through the use of biomass generators), and improve air quality emissions. In the oil and gas sector, enhancing oil recovery is becoming a major target. Where current targets are just 23%, EOR could push recovery rates to 40%. Petronas will therefore focus on improving economic wealth from existing fields rather than trying to exploit riskier new fields

The Renewable Initiative is one of the most interesting developments as it is central to the 'fifth fuel' resource under the country's *Fuel Diversification Policy* from past Plans. A target of 5% of electricity generation was set out by 2005, equivalent to 500–600 MWe of installed capacity.

In reality, Malaysia exceeded this renewable target by reaching 6% in 2005; although almost all the output was based on hydroelectric generation. This policy has been reinforced by fiscal incentives such as investment tax allowances and the *Small Renewable Energy Programme* (SREP), which encourages the connection of small renewable power generation plants to the national grid.

Projects of up to 10 MWe are able to sell their output to Tenaga Nasional Berhad (TNB) under 21-year licensing agreements. Most applications have been for biomass-fired power stations, and half of this generation capacity has been for waste biomass from the palm oil industry. In 2005, there were 28 biomass projects approved, equivalent to 194 MW of grid-connected capacity. There was also 9 MWe of landfill gas projects, and 18 mini-hydro systems capable of generating 70 MWe.

In July 2009, the Prime Minister announced the launch of a *Green Technology Policy* (PMO, 2009) . The Ministry of Energy, Water and Communication will be reformed into the Ministry of Energy, Green Technology, and Water. Terms such as 'green economy' and 'green collar jobs' were used in the Prime Minister's speech and indicate Malaysia's intent to promote sustainable practice. The National Green Technology Policy has five policy 'thrusts' that are being considered.
Thrust 1 is aimed at strengthening the institutional frameworks among Government Ministries, agencies, the private sector, and other stakeholders. The government intends to establish a Green Technology Council to co-ordinate all these stakeholders to ensure a more effective implementation of these policies.
Thrust 2 introduces economic instruments and the establishment of a financial mechanism to support the green industries. Malaysia intends to be a regional hub for renewable investments (presumably referring to non-hydro schemes such as solar and biomass).
Thrust 3 ensures that skilled, qualified, and competent human resources exist by enhancing training and education. The Ministry of Energy, Green Technology and Water, the Ministry of Education, and the Ministry of Human Resources will devise a system for grading and certifying personnel in the Green Technology field.
Thrust 4 aims to turn RD&D technologies into commercial reality with grants or assistance to public and private sectors, while establishing networks of co-operation and development amongst the centres of development.
Thrust 5 will enhance public awareness in supporting all of the above to help meet the overall objectives of greening the economy.

Clearly, this concise and simple structure for renewables development in Malaysia could be repeated for a programme to promote and develop clean coal technologies in Malaysia and the entire ASEAN region.

4.1 Climate change policy

According to national policy, Malaysia adopts a 'precautionary principle' and 'no regret' policy that allows for justified action to be taken to mitigate or adapt to climate change. Malaysia's national policy on sustainable development is based on a balanced approach such that the environment and economic development complement each other. The principle of sustainable development has been introduced in the Third Malaysia Plan (1976-1980). Some of the strategies adopted by Malaysia to address climate change are as follows:

- the energy sector has been identified as a major contributor of GHG to the atmosphere;
- to reduce the heavy dependence on oil, the Government has identified hydropower and gas, as well as oil and coal, as the primary sources to meet increasing energy demands;
- promotion of energy efficiency among industries and private sectors;
- introducing the 'Guidelines for energy efficiency in Buildings' which sets minimum standards for energy conservation in the design of new buildings;
- implementation of public awareness programmes by government agencies and non-government organisations to promote energy efficiency, recycling and use of public transport;
- maintenance of an effective forest management and conservation programme to preserve biodiversity and sinks for GHG.

According to official legislation, Malaysia has also adopted a pragmatic approach in dealing with climate change and environmental issues in line with the Rio Declaration.

There is a range of federal legislation relate relate to environmental protection, but there is currently no legislation to reduce CO_2 emissions. The list of laws that stipulate environmental protection is as follows:

- Environment Quality Act 1974;
- EQ (Clear Air) Regulation 1978;
- EQ (Prescribed Activities) (EIA) Order 1987;
- National Forestry Act 1984;
- Fisheries Act 1985;
- Fisheries Maritime Regulations, 1967;
- Fisheries (Marine Culture Systems) Regulation;

- Town and Country Planning Act 1976;
- Petroleum Mining Act 1986;
- Petroleum Development Act 1974;
- Land Conservation Act 1960;
- National Parks Act 1980.

Prime Minister Najib Razak attended the World Climate Change Summit in Copenhagen in 2009, but the debate has relatively less meaning for Malaysians than it does for larger economies, partly due to lack of awareness. According to a survey carried out in 2009, 35% of the Malaysian public were unaware or unconcerned over climate change issues (Netto, 2009) ; the figure in 2008 was 52%. Two thirds of Malaysians did however agree that a global deal was important – clearly, the role for Malaysia would not be considered a large one.

Malaysia seems to suffer less from severe drought, flooding is an annual event, and rising sea levels may not impact Malaysia in the way it will affect island nations in the Pacific and countries like Vietnam which has a great deal of deltaic land mass at sea level.

By 2009, Malaysia had not committed to binding cuts in CO_2 emissions, but an offer to cut emissions was made by Prime Minister Razak at the climate change summit in Copenhagen. Razak offered 'credible' cuts in emissions. UN data suggest that CO_2 emissions in 2006 were 186 Mt (7.2 tonnes per head), considerably lower than that of Indonesia at 2300 Mt (10 t per head). Whilst there is an obvious need to minimise and reduce emissions of CO_2 from point sources such as power stations, one sensitive issue involves that of the palm oil industry that operates in Malaysia, and the impact of deforestation. A scheme called Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (REDD) has been established, originally planned to come into place after 2012 when the Kyoto Protocol expires. Malaysia and Indonesia are the world's largest producers of palm oil, and both rejected proposals at the UN Copenhagen climate summit to halt the expansion of the industry.

According to the lobby group World Growth, based in Washington, USA, palm oil can generate returns of 3000 $/ha compared to other food crops which generate just 100 $/ha . Palm oil production in Malaysia supports 580,000 jobs. Palm oil is arguably an employer of people in some of the poorest regions in Asia. Greenpeace and Friends of the Earth, both UK-based lobby groups, argue that the peatlands destroyed by farming methods eliminates some of the largest carbon sinks in the world, particularly the activities in Indonesia.

Deforestation seems to command a greater need for urgency than the cut in CO_2 emissions. Following Copenhagen 2009, the lack of legally binding targets has meant that Malaysia would not be committed to any cut in CO_2 emission from power stations until a future agreement is reached. PM Najib stated that some $800 billion should be made available for investment in clean technologies by developed economies every year to achieve the 2°C warming, compared to the pledge to inject $10 billion funds for three years, and $100 billion per year to 2020 thereafter (Mmail, 2009).

Clearly Malaysia's climate change policy will avoid deforestation, but instead address the adoption of renewable energies. Ironically, the strategy to adopt renewables will have direct impacts, such as large hydro projects and biomass generators, many of which make use of palm oil waste. Any change in the palm oil industry could hamper the waste fuel supply for biomass plants. It is a dilemma that Malaysia could avoid by considering other waste materials and more sustainable source of biomass.

The *Clean Development Mechanism* (CDM) is one of the major schemes to spearhead renewable energies especially biomass and landfill gas projects. However, here lies one of the most sensitive issues regarding the promotion of biomass projects. Palm oil production, and the waste byproducts resulting from it, is considered an established industry. However, there must be care to ensure that the utilisation of palm oil waste for CDM projects are not linked to agricultural projects that cause habitat destruction. The palm oil industry is so lucrative, that the current national policy seems to support, or rather avoids curtailing the palm oil industry significantly. If the practice of palm oil production was overhauled such that all production was sustainable, the industry could contract, and so affect supplies of both palm oil, and waste by-products. These issues could affect the viability of many CDM if the 'price' of waste increased accordingly. A careful strategic view will therefore need to be considered by Malaysian authorities.

4.2 The Clean Development Mechanism

CDM facilitates co-operative projects between developed and developing countries for the reduction of GHG emissions, with the opportunity for additional financial and technological investment. These GHG reductions are quantified in standard units, known as Certified Emission Reductions (CER). The CDM involves the trading of emission reductions via CER that result from a specific project. Other countries then use these CER to meet their own reduction targets. In return, money is transferred to the project that actually reduces the greenhouse gases.

The following types of projects have potential for CDM in Malaysia. Two possible revenue streams exist for CDM projects: via traditional cashflows (for example electricity sales) and via environmental value of the investment (for example CER). But not all projects qualify for CDM assistance. To be eligible, projects need to demonstrate that the proposed activity is an additional benefit resulting from a normal business venture:

- renewable energy projects, including photovoltaic, hydro and biomass;
- industrial energy efficiency;
- supply and demand side energy efficiency in domestic and commercial sector;
- landfill management (flaring or landfill gas to energy);
- combined heat and power projects;
- fuel switch to less carbon intensive fuels (for example from coal to gas or biomass);
- biogas to energy (for example fruit waste or other sources);

- reduced flaring and venting in the oil and gas sector;
- land-use, land-use change and forestry projects (afforestation, reforestation, forest management, cropland management, grazing land management and revegetation)

Developers in Malaysia are already starting to utilise CDM to initiate energy projects for biogas wastewater, biomass, compost, landfill gas, and mini-hydro. Eleven energy projects will produce a total of 73 MWe of new renewable electric power. The waste sector offers tremendous potential for CDM, such as recovering emissions from methane sources. Palm oil mills using gas turbines become attractive with CDM financing, as well as small-scale power production projects using gas engines.

The real success of CDM projects depends upon the contribution they make towards national goals for sustainability. The Government takes the lead because only projects that receive national host country approval can be registered as CDM projects and generate CER.

5 Energy resources

5.1 Oil

According to the US Energy Information Administration (EIA), Malaysia's proven oil reserves have declined in recent years. According to the 2009 BP Statistical Review, Malaysia held 5.5 billion barrels at the end of 2008 (750 Mt). Based on 2009 production levels, Malaysia has roughly 20 years of oil left. Although this short R/P ratio seems like a warning, recoverable reserves have increased 17% since 1998, while production has fallen in this time.

A majority of the oil reserves are located in offshore fields and are of high quality, hence its attractiveness as an export fuel. Given OPEC crudes are generally of a 'sour' nature (higher sulphur), Malaysian 'sweet' crude (typically less than 0.5% sulphur) is a useful source for blending. More than 50% of the production comes from the Tapis field in the South China Sea, east of the Malay Peninsula.

Petroleum Nasional Berhad (Petronas) is the Malaysian national oil company, which dominates upstream and downstream activities. Petronas is the last wholly state-owned enterprise in Malaysia, and is the largest single contributor of government revenues. Any foreign or private company that operates in Malaysia must operate through a production sharing contract (PSC) with Petronas. Companies such as Exxonmobil, Shell, Chevron and BP all operate in Malaysia in production and retailing.

While Petronas is opening up new oil production units with foreign operators, exploration and production is also being initiated overseas in 29 countries by Petronas Carigali. After many years of relying on Singapore for petroleum products, Malaysia invested heavily in refinery capacity over the last 20 years and is now capable of meeting the country's need for products. Petronas runs three refineries (36 kt/d or 259 thousand bbl/d), Shell operate two (27 kt/d or 200 thousand bbl/d), and Exxonmobil have one (12 kt/d or 86 thousand bbl/d).

5.2 Natural gas

While much of the oil reserves are located offshore, east of the Malaysia Peninsula, while natural gas is generally found around the eastern Malaysian regions off the coast of Sarawak. At the end of 2008, Malaysia had 117 Mtce (82 Mtoe or 3.2 trillion cubic feet) of gas reserves. This is equivalent to an R/P ratio of 38 years.

Malaysia is a major exporter of natural gas, primarily in the form of liquefied natural gas (LNG). LNG production is concentrated in the Bintulu complex in Sarawak, which has production capacity of 25 Mt/y. Malaysia LNG is a subsidiary of Petronas. LNG is an extremely exciting prospect for world gas trade since international movements of gas no longer needs to be tied to fixed pipeline routes, which is often a cause for political and commercial sensitivity in regions such as the EU. In 2008, Malaysia was the second largest exporter of LNG in the world at 37 Mtce (29 bcm), the first being Qatar (50 Mtce). Indonesia is a close third with exports of 34 Mtce in 2008.

However, while Malaysian LNG could arrive in Europe, Malaysia LNG has secured large contracts with its Far Eastern partners, especially amongst the massive Japanese gas and electric utilities. Shikoku Electric Power, Toho Gas, Osaka Gas, and Chubu Electric Power which have signed deals lasting up to 20 years to supply 2.4 Mt/y of LNG. Other markets include South Korea, Taiwan, and to a lesser degree China. Such contracts are unheard of in the coal supply market.

While LNG forms a bulk of the gas trade, some pipeline trades are done, but the most significant development in this respect is Trans-Thailand Malaysia Gas Pipeline System, which is a step closer to realising the larger ambitions of the Trans ASEAN Gas Pipeline (TAGP).

5.3 Coal

Malaysia's coal resource is estimated to be about 1 Gt of various ranks and qualities, ranging from lignite to anthracite, although bituminous and subbituminous coals are the most commonly found.

Thaddeus (2000) of the TNB the state power utility examined the reserves in Malaysia (*see* Table 1). Some 98% of the country's coal reserves were found in the eastern Malaysian regions of Sarawak and Sabah on the island of Borneo. Just 2% of coal reserves are found in Peninsular Malaysia where most of the country's energy demand is; most of the coal fields are located inland where infrastructure is also poorly developed.

Table 1 was published in 2000 and may not reflect subsequent changes in reserves estimates. However, it does demonstrate the distribution of coal as being uneven across the country, which remains largely valid. The table shows Sarawak having almost all the measured reserves in Malaysia. Sabah has some indicated reserves, but the Peninsula has almost no coal whatsoever. Coal deposits in Sarawak can be found in four major deposits:

- Mukah-Balingian coalfield: located in a low lying plain between the rivers of the same name as the coalfield, and bounded in the south by the Sibu-Bintulu trunk road and in the north by the coast of the South China Sea;
- Merit Pila coalfield: located 75 km upstream of Kapit on the Rejang river;
- Silantek coalfield: located in the Silantek-Abok area in Sri Aman region;
- Bintulu coalfield: scattered deposits found around the rivers of Segan, Kelabat, Sera and the Spadok area.

Coal has also been identified in the Plieran valley in the far interior south of Usun Apau, the Hose Mountains, and Ulu Tubau.

Table 1 Known coal resources in Malaysia (Thaddeus, 2000)

State	Location	Measured	Indicated	Inferred	Coal types
Sarawak	Silantek	7.25	10.6	32.4	coking, semi-anthracite, anthracite
	Merit Pila	176.2	107.1	121.8	subbituminous
	Bintulu			120	
	Mukah-Balingan	43.6	8.3	98	
	Subtotal	227.05	126	372.2	
Sabah	Silimpopon	4.8	1.5	7.7	subbituminous
	Labuan			8.9	subbituminous
	Maliau			215.9	bituminous
	Malibau		17.9	25	
	SW Malibau		26		
	Subtotal	4.8	45.4	257.5	
Peninsula	Batu Arang			17	subbituminous
	Subtotal	0	0	17	
	Total	231.85	171.4	646.7	

6 Coal production

Malaysian mineral production is published online by www.malaysianminerals.com. The latest data (2009) showed national coal production for 2007 at 1 Mt/y coming from six coal operations.

According to the Government Minerals and Geosciences Department Malaysia (JMG), there were three coal mines in operation in Malaysia at the end of 2007, although five companies were listed. While there may be some confusion over the number of operations, JMG names the companies involved. These include: Global Minerals Sdn Bhd, Global Minerals Exp. Sdn Bhd, Luckyhill Coal Mining Sdn Bhd, Genesis Force Sdn Bhd, and Balingian Coalfield Sdn Bhd, which combined produced just over 1 Mt/y in 2007 (JMG, 2009) .

According to malaysianminerals.com, the coal mining employee headcount was 482, suggesting that the coal industry productivity was roughly 2100 t/man-year. In 2006, production and manning levels were slightly lower with just four coal operations; in 2006 productivity was slightly higher at 2140 t/man-year. This level of productivity is reasonable, given the size of the industry. By world standards, this is equivalent to opencast mines operating in Russia, but considerably below that of operations in Australia and Indonesia.

According to Ewart (2003), coal production in Malaysia predominantly consisted of subbituminous coal. The quantities mined are small, increasing from a meagre 0.2 Mt in 1996 to 0.4 Mt in 2001. A bulk of the production occurs in the Merit Pila coalfield in western Sarawak. Although the production capacity is around 0.7 Mt/y, output has barely changed since around 2001-02. The mine is operated by Global Minerals and PanGlobal. The Merit Pila coalfield covers an area of 260 km^2 located in the Kapit area of Sarawak. The coalfield could have more than 400 Mt of coal resource, higher than other estimates.

Due to the environmental sensitivity of many areas with coal resources, it seems unlikely the resources will be exploited. The bulk of the coal production is consumed by the 100 MWe Kuching (Sejingkat) power station located in Sarawak, while imported coal has been the main supply for the Kapar power station, as well as local industrial consumers.

The Merit Coal brand mined by PanGlobal has a low sulphur content (<1%), on par with some of the low sulphur products mined in neighbouring Kalimantan. Coal resources amount to 451 Mt, of which 132 Mt is measured, 127 Mt is indicated, and 192 Mt is inferred. The coalfield consists of 30 seams with seams ranging from 1 to 6 metres (Panglobal, 2009). Merit Coal has a calorific value of just 5300 kcal/kg, although it may range from 4500 to 6200 kcal/kg. Moisture content has a maximum 25%, keeping the coal quality well within the range of subbituminous classification.

Coal exploration in Merit Pila started in 1972. By late 1987, mining started, and the first shipments of coal exports to Japan were recorded in 1988. Merit Coal has exported to Bangladesh, Taiwan and Japan. In 1993, a contract was signed with TNB to supply domestic power stations. In 1994, another contract was signed with Sejingkat Power Corp for coal shipments due in 1997.

It is an opencast mine with the usual tasks of land clearance, overburden removal and dumping, excavation and loading onto haulage trucks. Komatsu and Hitachi supply some of the heavier machinery, while Mercedes and Nissan dump trucks are used to carry waste minerals from the mine pit to dump sites. Coal is transported by truck to preparation plants and storage areas. The preparation plants consist of primary and secondary crushers designed to produce a product up to 100 mm size at a crushing rate of 140 t/h. The storage areas have enough capacity to accommodate 100,000 t of raw coal. Coal is then loaded onto a river barge by a conveyor with a transfer rate of about 300 t/h.

Coal is then barged by river to a transshipment point at Tanjung Manis anchorage. Barges are relatively small at 2000–3500 t dwt. Coal is then transferred to ocean vessels using grabs. At high water, the estuary of the Kuala Rejang is 8.5 m. Sejingkat Power Corp, which operates the 2 x 50 MWe units at Sejingkat power station, also known as Kuching, which is also the location where coal is unloaded at the jetty by barge.

According to Lim (2007), the Mukah coalfield has a number of impacts on local communities in Sarawak. GENESIS Force Sdn Bhd (GFSB), a company incorporated in Malaysia, was granted a General Prospecting Licence (GPL) to prospect for coal in Mukah Division, Sarawak, Malaysia in 2005; and to date, GFSB has successfully identified (through their intensive exploration) proven mineable reserves of 48 Mt of coal, generally classified as subbituminous ‘B’(Lim, 2007). The said proven coalfield (known as Mukah coalfield) is located over an area of approximately 9400 hectares of secondary jungle and shifting agriculture land. The company practices the open-cut coal mining system.

Lim (2007) concludes that the economic benefits through royalties resulting in a raised standard of living have been positive for the local communities that had previously lived a more traditional lifestyle.

6.1 Malaysian coal exports – a growing trend?

Malaysia, via TNB, is a net-importer of coal. It seems unlikely that Malaysia has a future as a major coal exporter. However, there are reports of the Indian state utility Andhra Pradesh Power Generation Corporation Ltd (ApGenco) purchasing Malaysian coal. In July 2009, there were reports of 0.5 Mt of Malaysian coal being contracted for delivery to ApGenco power stations in India for the period August to

October 2009 (Reuters, 2009). ApGenco paid 112 $/t 403 (RM/t) for the coal, which at the July 2009 exchange rate with the US dollar was equivalent to 115 $/t. ApGenco had been expected to take low energy content Indonesian coal. Around 200 kt was contracted to be delivered in August, 200 kt in September and 100 kt in October. Under ApGenco's terms, the coal will be delivered direct to its power plants.

7 Primary energy supply

Fuel diversity has been one of the central tenets of the country's energy policy. In the period between 1971 and 1981, IEA data suggest that oil accounted for 64–76% of the country's primary energy supply. This dependency was clearly deemed undesirable. The four fuel policy was probably the most influential single policy to affect the fuel mix in the Malaysian economy.

Much of the shift was to occur in the power generation sector with investment in new hydro, coal, and gas CCGT capacity. Within ten years of the four fuel plan, the oil dependency had dropped to around 50%. This was still not ideal as additions in oil-fired capacity were still occurring in the power sector despite increased efforts to install non-oil generating sources.

The trend in oil products continued to increase in some sectors, such as liquefied petroleum gas (LPG) in the residential sector, and a rise in gas/diesel oil in transport and industry. While heavy fuel oil consumption across the economy fell, the trend after the 1980s was erratic. By 2007, oil product demand was higher than it was in the 1980s, albeit accounting for a smaller share of the total primary energy supply to the economy. By 2007, oil products accounted for 36% of the total primary energy supply driven mostly by transport-related demand.

In 2007, the total primary energy supply to the Malaysian economy stood at 104 Mtce (72.6 Mtoe), up 6% on 2006. The average rate of growth of primary energy since 2000 has been 5.6%/y. This is below that seen in previous decades, where growth was around 7–8%/y between 1970 and 2000.

Before 1995, growth in primary energy was fairly steady, but since 1995 there have been abrupt drops in primary energy due to a combination of one or more of the following factors:

- a fall in the demand for energy (due to economic downturns);
- a fall in energy production;
- a rise in net exports.

In all instances, these fluctuations in energy supply occurred as a result of changes in the markets for oil and gas. Figure 2 shows how the total primary energy supply in 2007 was dominated by oil and gas. As the history in Figure 3 shows, oil was the dominant fuel until 1999. By 2000, this role switched to natural gas, and has more or less remained the major fuel ever since.

In 2007, coal accounted for just 12% of the energy supply. While this share is low compared to gas and oil, its rate of growth has been high, albeit from a low starting point. Since 2000, the rise of coal in the primary energy supply has averaged more than 25%/y, increasing from less than 3 Mtce to reach 13 Mtce in 2007.

Hydroelectricity production has barely risen since the 1990s, and accounts for less than 1% of the primary energy supply. Hydroelectric potential is being pursued in Sarawak to exploit the potential from the vast network of rivers that exists in the northern parts of Borneo. Similarly, the amount of combustible renewable and waste remained fairly steady, experiencing a low growth of less than 2%/y since the 1990s. The supply of these fuels has risen nevertheless and could constitute an important future fuel resources for power generation and road fuels if government plans to boost palm oil crops for power generation and road transport fuels are realised.

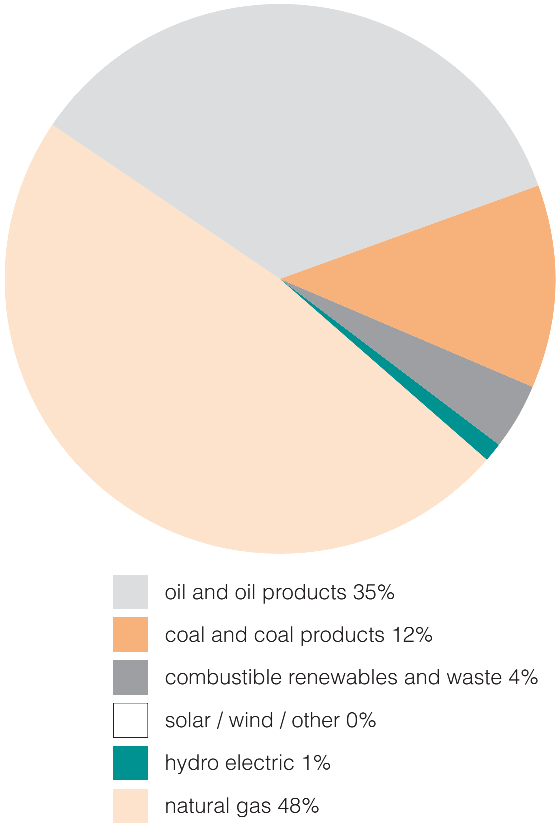

Figure 2 Primary energy split for TPES in 2007, %

Despite the modest inroads made by fuels such as coal and, to a minimal degree, renewables, the country's economy remains entirely dependent on oil and gas. While this seems highly risky, the country is a major net-exporter of both fuels, giving the country a large buffer in case of production shortages, or stock shortfalls.

Malaysia exports just under half its production of crude oil, and the same again for natural gas. While there are imports of oil and gas, these quantities are considerably less. Oil and gas trade have long been the mainstay of the energy economy. Malaysia as a net-exporter of crude oil and gas is a trend that is unlikely to alter greatly in the foreseeable future (*see* Figures 4 and 5). There has, however, been an interesting shift within the last five years with a notable increase in the imports of both fuels, for example where natural gas pipeline supplies have increased from countries such as Indonesia. According to Gas Malaysia, the supply for Peninsular Malaysia is complemented by the gas from the Indonesian West Natuna B and the PM3 fields (Commercial Allocation

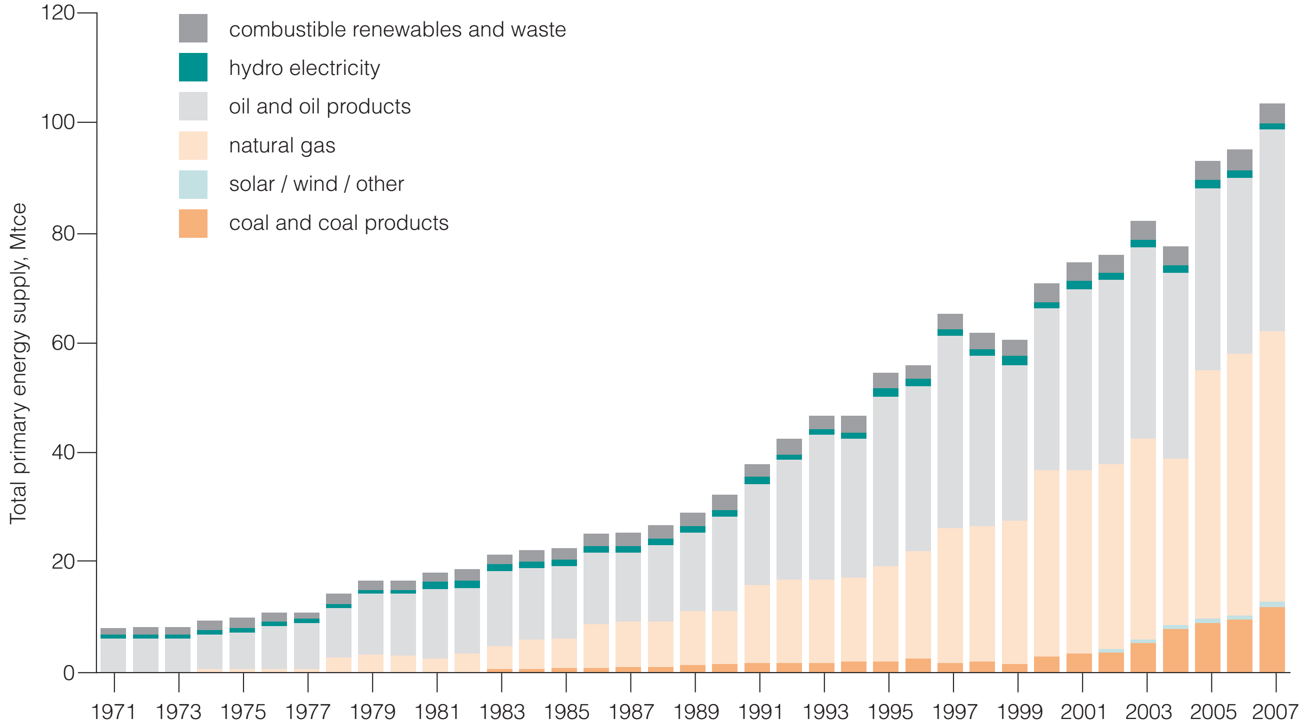

Figure 3 Long-term trend in TPES in Malaysia 1971-2007, Mtce

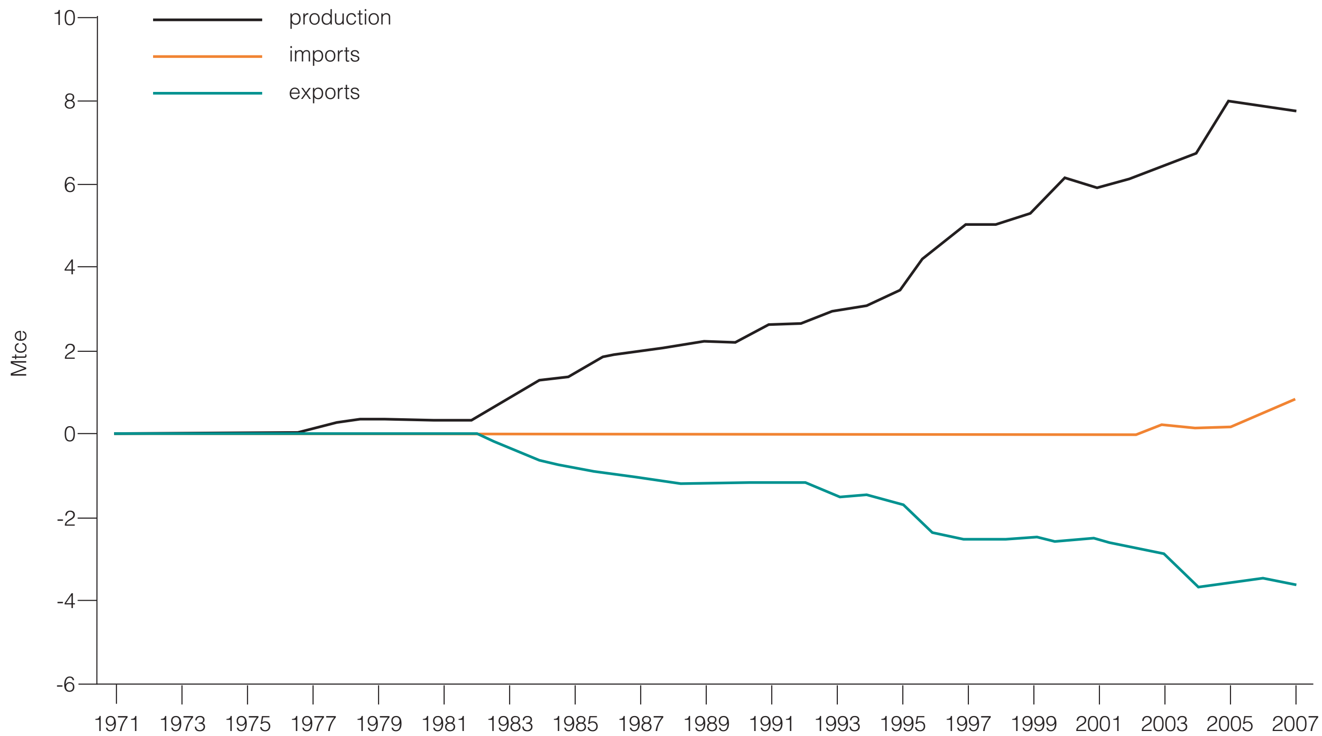

Figure 4 Natural gas trade in Mtce (IEA, 2009)

Arrangement between PETRONAS Carigali Sendirian Berhad, Talisman and PETROVIETNAM). The demand for gas in Malaysia is increasing such that the country may well turn to Australia for gas import to help feed domestic demand after 2014.

The Santos Ltd-led Gladstone LNG venture (GLNG) signed an accord to sell 2 Mt/y of the fuel to its partner Petronas for 20 years commencing 2014, with an option for an additional 1 Mt/y. The LNG was destined for the Malaysian domestic gas market. However, due to the higher cost of Australian LNG, Malaysia would need to increase domestic prices to cover the costs of these gas sources, otherwise increase subsidies (Sethuraman, 2009). According to Gas Malaysia (2009), gas prices to industry and power generation were a staggering 80% below the market price for gas in 2008. This reflects the unusually high world market prices, but demonstrates how industry and power were 'protected' from

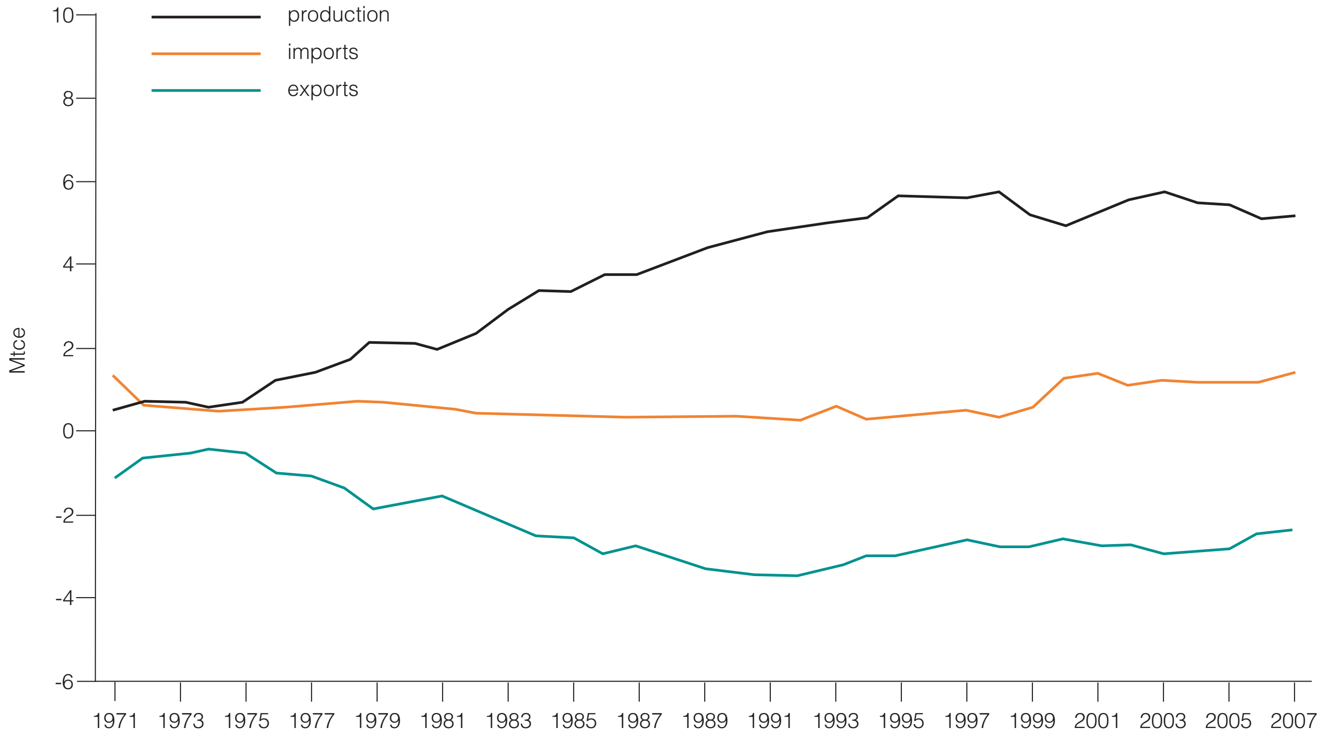

Figure 5 Crude oil trade in Mtce (IEA, 2009)

market forces. The massive subsidy that the government permits is expected to reduce over 15 years, giving TNB and other generators time to adjust to the transition.

Gas tariffs to power stations doubled in 2008-09 in accordance to Petronas demands increasing from 1.8 to 4.0 $/GJ (6.4 to 14.31 RM/million Btu). Smaller commercial end users saw an increase from 2.7 $/GJ to 7.0 $/GJ (9.4 RM/million Btu to 24.54 RM/million Btu), and larger users went from 3.2 to 10.1 $/GJ (11.32 to 32.56 RM/million Btu). This will no doubt affect inflation, but it should inject investment in efficiency measures by Malaysian industry and even promote different fuels such as biomass. Gas-fired power projects may not be as heavily affected since power tariffs to end users are also set to rise (although by a lesser amount) at around 26%. Such increased tariffs will nevertheless be a welcome boost to TNB for raising funds for investment in the transmission, distribution and generation network.

8 Electricity demand trends

Malaysian electricity demand has seen considerable growth since the 1970s, with an annual rate of increase averaging more than 9%/y between 1970 and 2007.

The production of electricity has increased over the years pro-rata to consumption since there is relatively little electricity trade. What little trade there is amounted to 2.3 TWh of electricity exports out of a total production of 90–100 TWh in 2006-07.

Figure 6 illustrates the long-term trend in electricity demand split by demand sector. The data for 1971-90 shows the residential and commercial sectors as a single group, while 2000 onwards has these sectors disaggregated. One of the striking feature of Figure 6 is the massive step jump that apparently occurred in electricity demand in 1990, seemingly driven largely by the industrial sector which grew at an average rate of 13%/y. Growth in recent years has been much lower, but nevertheless still fairly high at 5.6%/y between 2000 and 2007. Industry and commercial sectors seem to be major growth areas for demand. Malaysia's economy is one of the most advanced in the ASEAN. According to the ADP Key Indicators of the Asia Pacific (2009), industry accounted for 47% of the country's economic GDP in 2007, of which a considerable proportion is manufacturing.

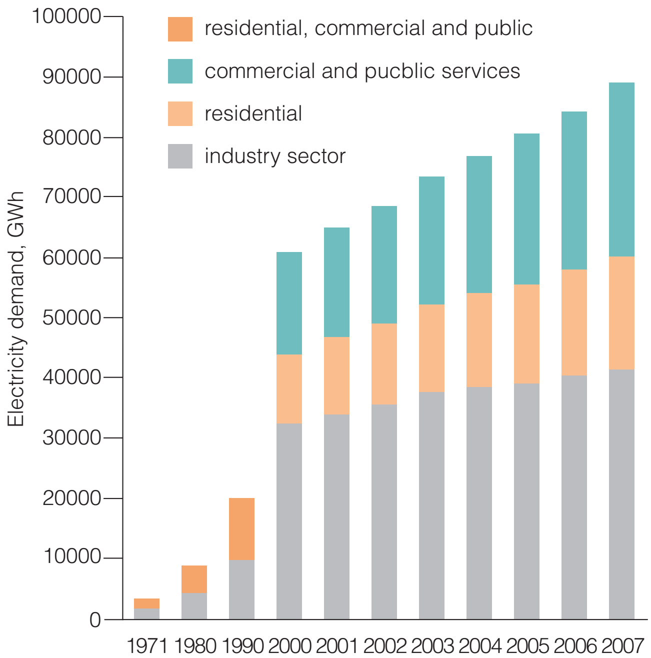

Figure 6 Electricity demand trends by sector 1971-2007 (IEA, 2009)

9 Electricity supply trends

The three major regions of Malaysia comprise the mainland (Peninsular) Malaysia, and two regions in eastern Malaysia, Sarawak and Sabah both located in the northern part of the island of Borneo. Electricity generation was introduced in varying stages due to the geographical locations.

In the Peninsula, power was first generated amongst a number of mining, industrial and public railway stations in the late 1800s. The first public electricity supply was set up in 1904 to serve 15 customers and street lighting. Later, the first Electrical Board was established in Malaya in 1921 and by 1965, The National Electricity Board (NEB) of Malaya was in control of generation, transmission, and distribution of electricity. The modern industry as seen today started in 1990 when the NEB was corporatised to form Tenaga Nasional Berhad (TNB). In May 1992, TNB was privatised and was listed on the Kuala Lumpur Stock Exchange.

In Sarawak, electricity was first generated by the timber industry powered by timber waste. Sarawak Electricity Supply Company Ltd (SESCO) was formed in 1932 and has remained unchanged since (except a change from 'Company' to 'Corporation' in 1963).

In Sabah, the North Borneo Electric Company supplied Sandakan and Jesselton. The Sabah Electricity Board (SEB) took responsibility for power supplies in 1956, and after some changes in ministerial control over electricity supply, Sabah Electricity Sendiriran Berhad (SESB) finally took over electricity supply in 1998. SESB is owned by TNB and the State Government of Sabah.

In summary, the electricity supply sector comprises of three utilities and along with a number of IPP and autogenerators. The three main utilities that control the electricity supply sector are:

- Tenaga Nasional Berhad (TNB) serving the Malaysia peninsular (shareholder ownership);
- Sabah Electricity Sdn Bhd (SESB) serving Sabah (owned by TNB and Sabah State Government);
- Sarawak Electricity Supply Corp (SESCo) (55% owned by Sarawak Government; 45% owned by Sarawak Enterprise Corporation Bhd).

Northern Utilities Resources (NUR) is a dedicated power producer serving the Kulim High Technology Park in Kedah located in the north of the mainland peninsula. The company has a generation and distribution company. NUR operates 450 MWe of generating capacity.

Independent power producers account for perhaps half of the power generating capacity in the country, and all output destined for the public grid is sold to the three utilities. According to KTKM (2002), there were roughly 20 major IPP and autoproducers operating power stations in Malaysia by the early 2000s. According to commercially sensitive data sources, by 2009, an estimated 90 IPP were recorded to be operating with unit sizes ranging from less than 1 MWe hydro and oil plants to 2000 MWe coal stations operated by IPP. On-site autogenerators range from paper and wood mills to hospitals and cement works.

9.1 Power blackouts

In past years, Malaysia's power generating and transmission grid came under severe strain when *force majeure* events, often weather related, created major problems. The 1990s saw a major series of power blackouts that could not have come at a worse period with high growth in demand. In all the cases, the transmission lines were incapable of handling and redistributing power sufficiently. In 1992, a lightening bolt struck four powerlines between Paka and Teluk Kalong in Terenggau. The result was that fifteen power stations were shutdown on the west coast as a result of an overload at just one power station, the 1000 MWe Paka plant. Even though power was restored after several hours, it demonstrated the vulnerability of the network under these unusual circumstances. Furthermore, the spare capacity in the generation system was just 10%, against the substantial spare that seems to exist today.

After this incident, TNB were almost forced to accept non-negotiable power contracts with IPP. IPP were 'compensated' by reaping lucrative $1 billion in annual take-or-pay contracts regardless of whether the power was being generated or not. The situation worsened in 1996, when a transmission line in the same region tripped, causing all power stations in the Peninsula to fail; the cascading effect put almost all the public power stations out of action.

9.2 Hydro exports from eastern Malaysia

According to the Sarawak Energy Board, the region's energy resources are potentially rich. It is the second most populous region behind the Peninsula, with a population of 2.5 million (10% of national population), and the region could produce enough energy surplus to export to the mainland Peninsula (SEB, 2008).

Although the main demand for electricity is on the Peninsula, peak demand in Sarawak could still increase from around 800 MWe in 2008 to 1400 MWe in 2020. To meet this demand as well as providing potential to export power, the Sarawak Corridor Of Renewable Energy or SCORE was set up by the Sarawak local government.

The SCORE programme considered hydroelectric schemes in eleven river basins. The programme was eventually narrowed down to 51 out of 155 potential sites. Eligible sites provided a possible 20 GWe of hydro capacity, capable of producing 87 TWh of generating capability. Based on these official figures, the hydro stations could operate at 50% utilisation, a very high figure indeed for a renewable technology. Past surveys done in 1981, with assistance from the German Agency for Technical Cooperation (GTZ), confirmed that 90% of this output could be guaranteed even in dry years. Because of the equatorial climate, hydro availability is plentiful, which is an attractive feature of exploiting hydropower in Malaysia.

Hydroelectric power is therefore considered the largest indigenous renewable energy resource, and Sarawak has 70% of the country's technically exploitable resource (SEB, 2008). While there is a wide range estimated for Sarawak's hydroelectric potential, some press reports have quoted as much as 28 GWe of potential capacity. Most of the current projects that are in the planning stages, not including Bakun and Murum, are at a very early stage of development (PiA, 2009b).

Hydropower is an important development since it would offer some buffer from the volatility of fuel prices that generally affects thermal generation. For example, Peninsular Malaysia is dominated by gas-fired power. As mentioned earlier, in 2008 Petronas raised the price of natural gas to the power sector from 1.8 to 4.0 $/GJ (6.4 to 14.31 RM/million Btu). TNB were permitted to raise electricity tariffs by just 26% in the same month. Such commodity price risks makes Sarawak hydro supplies promising on a security of supply point of view. Exports are planned for supply to Peninsular Malaysia through two phases. Phase I is the period 2013-15, with two lines stretching 1576 km that will carry 800–1000 MW via HVDC cable, and a 1600–2000 MWe overhead line. Phase II of the Sarawak to Peninsula link which was agreed in May 2008 will bring in 1000 MWe by 2017 rising to 5000 MWe by 2030.

In the smaller region of Sabah, power generation is provided mainly by diesel generation, and the rest from gas. However, coal faces opposition from lobby groups that are opposed to the potential for coal mining developments that might go ahead if a new coal-fired station is installed in the region. One solution put forward by the anti-coal lobby is a stronger transmission link with Sarawak. Sabah is not the only region that is looking to Sarawak with the prospect of exploiting hydroelectric power. Indonesia may also benefit from Sarawak hydro ambitions in the northern part of Sarawak. West Kalimantan relies almost entirely on diesel power generation which is extremely costly and heavily subsidised.

10 Electricity market projections

According to the IEA (2009), Malaysian electricity production reached 101 TWh in 2007. Generation in 2008-09 was rather subdued due to a slowdown in economic growth. The rapid growth seen in previous years saw demand rising at an average 11.6%/y in the 1990s, and then around 5.8%/y in 2000-08. The global financial crisis hit Malaysia in 2009 with a small contraction in GDP, and an estimated drop of 2.6% in electricity demand for the first eight months of the year (PiA, 2009c). Overall, 2009 growth was expected to be negative, or at most +1% based on the author's estimates.

The interruption in electricity demand in 2009 may help the Malaysian power supply industry play catch up with demand with the completion of more power stations and continuing investment in maintenance. Further to this, the expected rise in power tariffs will also help counter the rise in fuel commodity costs that have also been experienced in recent years due to changes in regulated fuel price agreements with suppliers like Petronas (gas) and special deals with Indonesian coal suppliers.

According to the IEA (2009) Base Scenario, power generation could double from the 2007 level to 216 TWh by 2030. Most of the growth probably represents the Peninsula market which accounts for a majority of the electricity generation. In 2008, Peninsular Malaysia had more than 17,000 MWe of generating capacity, a great deal of which is thermal.

Regarding future growth, the IEA projected demand to grow at such a rate that power generation would need to grow at 3.3%/y throughout the forecast period of 2007 to 2030. Other projections suggest that growth rates averaging 2.5%/y in a shorter period between 2008 and 2018 are also possible. This rise in generation will be met by a considerable growth in generating capacity, reaching 47 GWe in 2030, of which 14.6 GWe could be coal fired, double that of the coal-fired capacity in 2008-09.

Whichever growth trajectory the Malaysian energy market takes, growth may not be uniform across the various regions. While Peninsular Malaysia accounts for a large proportion of the generation and demand, TNB has been planning a capacity building programme for Sarawak based on a historical trend of demand growth of 5–7%/y (SEB, 2008). The neighbouring region of Sabah was also expected to increase by around 7%/y (Kinabalu, 2008) , again from official estimates. In terms of MW demand, Sarawak has a demand of 800 MWe (2007) and is expected to grow to around 1800 MWe in 2020. In neighbouring Sabah, the peak demand is just over 620 MW (Kinabalu, 2008) . So coming from a smaller demand base, these eastern Malaysian regions may well grow at a faster rate than the Peninsula.

Sabah has slimmer reserve margins than the Peninsula. In 2009, Sabah Electricity bought twenty 1 MWe mobile generators at a cost of $5.6 million (RM 20 million) to supplement existing capacity, including the delivery of power from western Sabah to the east coast through the east-west Sabah transmission grid (PiA, 2009b).

In 2009, the IEA in Paris published the World Energy Outlook with special reports on Far Eastern ASEAN nations. One projected outlook for Malaysia was the expected rise in generating capacity focused primarily on gas-fired power, but supplemented by some coal-fired power. By 2009, only two coal-fired stations were under construction, the largest being the 1500 MWe Jima station, and the second being the 135 MWe Mukah power station. Some small biomass plants were also going to contribute to the thermal power fleet. Interestingly, no gas-fired stations were being built at the time. Two major hydro projects were under construction in Sarawak and due for completion between 2012 and 2014. The largest of the two hydro stations is the Bakun hydro project. By 2012, the Bakun power station could be commissioned, adding 2400 MWe to the country's hydro capability. In 2014, the 900 MWe Murum hydro station will also be on line.

The projections do not yet consider a major contribution from nuclear power, if any. However, nuclear power is not being ruled out by the Malaysian authorities. Korea could well be participating in nuclear developments in Malaysia for its first nuclear reactor, at least for the pre-feasibility stage. Capital investments are more likely to be tendered openly to the world nuclear industry. According to Korean reports, nuclear is considered the lowest cost option of all the various types of power generation available to Malaysia. The unit cost of a nuclear investment is only 39 $/MWh compared to 107 $/MWh for wind, 104 $/MWh for LNG, 94 $/MWh for hydroelectric, and 41 $/MWh to 65 $/MWh for various types of coal (PiA, 2009b). Nuclear power was advantageous as it required less land than renewable energy resources such as wind, solar photovoltaic and biomass, the latter being controversial due to the link with the international palm oil industry.

11 Power generation

Much of the following section draws from two presentations given in 2008 and 2009 outlining developments and the status of the power generation sector in Malaysia (Razak and Ramli, 2008; Jaffar, 2009). In 2009, Malaysia had an estimated generating capacity of 24.8 GWe, including public and private generators (Jaffar, 2009). This more or less agrees with almost every other source of capacity data, although most sources do not specify whether the quoted capacity figure is a net or gross generation figure. The key difference is the demand offtake of the power station itself, with ancillary equipment and general running of the site drawing on the gross output before the net output is delivered to the busbar for despatch to the grid.

Figure 6 illustrates the amount of existing generating capacity by fuel type that was estimated for 2009, and the corresponding utilisations for each fleet of stations. The estimated generating capacity in GWe is represented by the vertical scale, and the average hours of utilisation on the horizontal axis. The utilisation rates presented here are based on the average utilisations calculated for the period 2000-07, and so only provides a representative overview of the Malaysian generating fleet, and may not reflect the utilisation of individual plants or more recent years.

The utilisation is calculated by dividing the annual GWh output of the fleet by the GWe capacity of the operating fleet in any given year. This results in the hours of operation which can be converted to a % by dividing again by 8760.

This despatch chart in Figure 7 was derived from IEA output data tables of GWh production by fuel types that is available from the IEA online data services (www.iea.org) and based on at least eight years of historical data where available. As verification, these utilisations and GWh data were compared with results calculated from 2008 data presented by Jaffar (2009) as shown in Figure 8 and Figure 9. These data suggested that the despatch chart is indeed a fair representation of the Malaysian fossil fuelled fleet, and are broadly in agreement.

11.1 Domination of gas-fired power

The whole fleet of power stations operating in Malaysia in 2009 was estimated to be 28–29 GWe, the largest fleet being overwhelmingly gas-fired capacity. More than 50% of this capacity comprises of CCGT plants which operate at a higher utilisation (around 60–65% according to authors estimates). Much of the CCGT is operated under IPP contracts and is likely to be operating at higher loads, perhaps 80% or more. However, in the period between 2000 and 2009, CCGT capacity more than doubled (non-CCGT increased by a modest 17%). The rise in capacity means that in any commissioning year, the newly installed capacity may well be operating at lower loads, especially if the station came online in the latter part of the year. As such, utilisations in years where there is a step rise in capacity may see a corresponding step drop in utilisation, but then rise again in a full operating year. This fluctuation in annual utilisations would be common for all power technologies.

In reality, the despatch of power stations is not carried out in such discrete blocks. On a day-to-day basis, the despatch

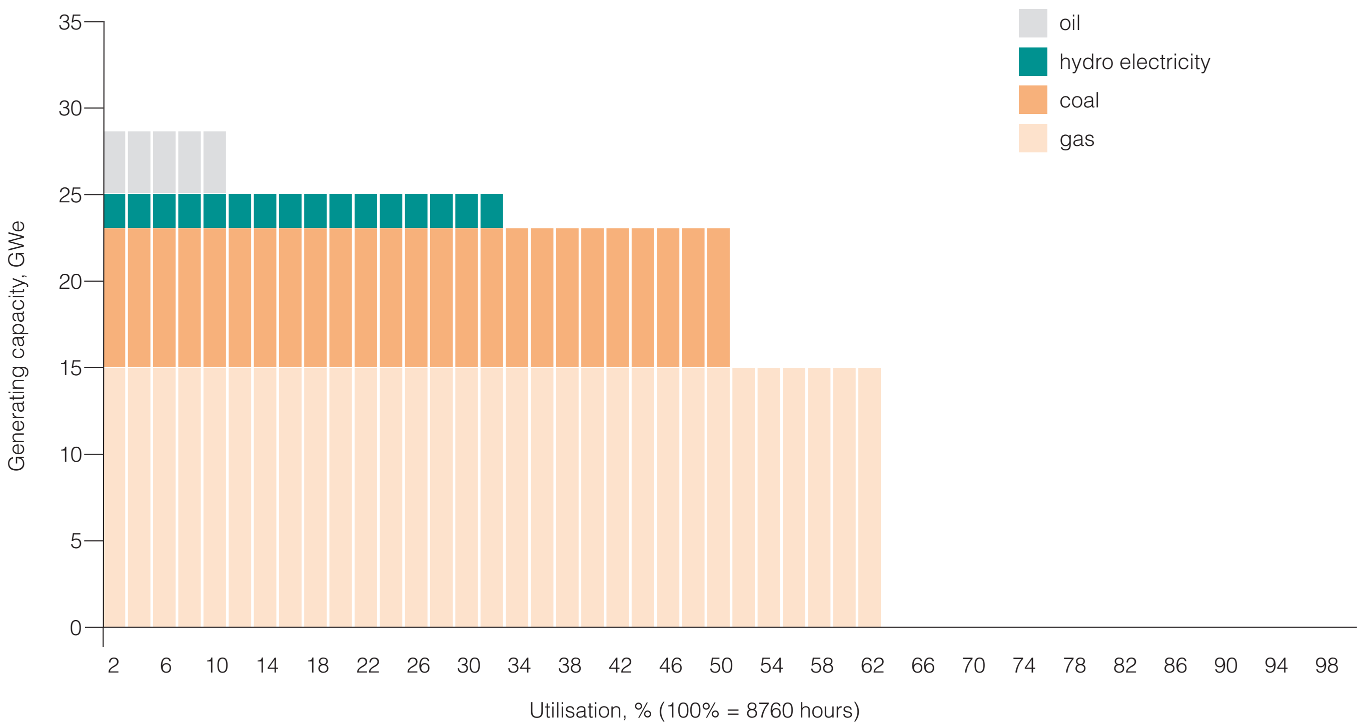

Figure 7 Representative despatch curve for Malaysia (average utilisation for 2000-07; GWe capacity for 2009)

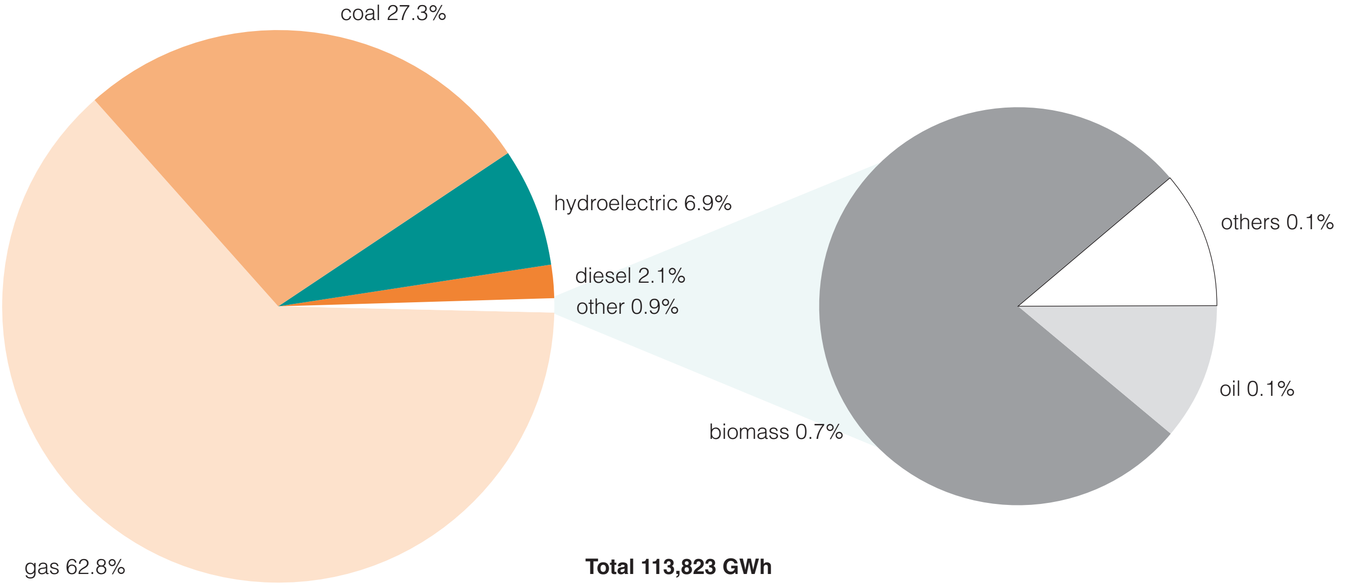

Figure 8 Estimated GWh generation mix for 2009 (Jaffar, 2009)

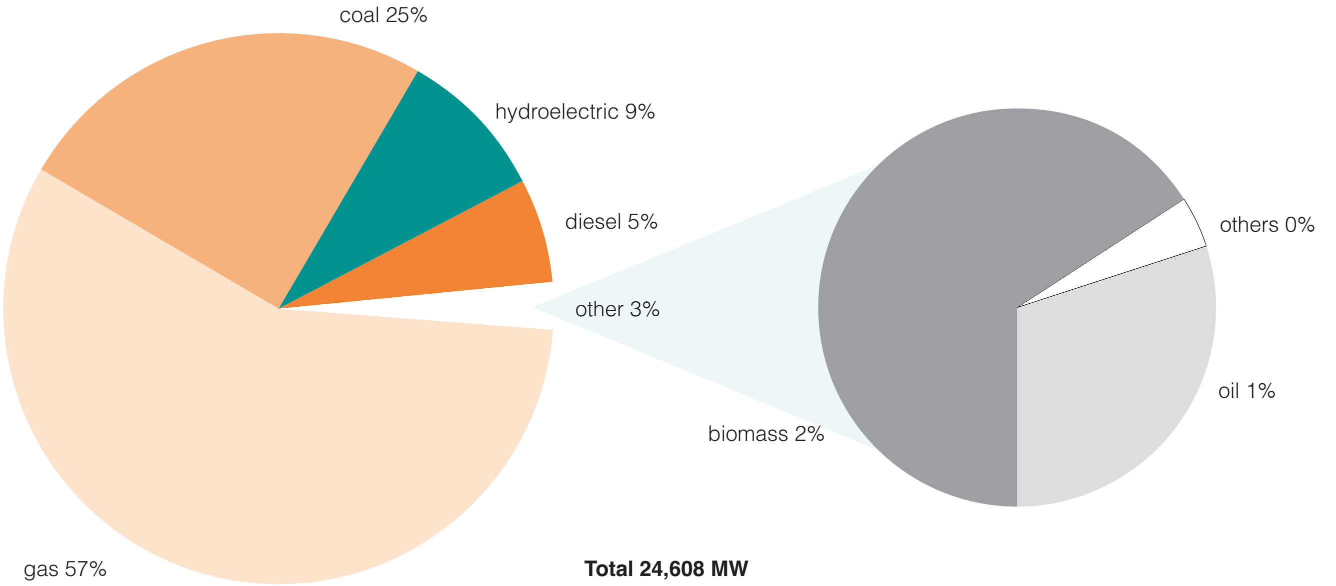

Figure 9 Installed capacity, MW in 2009 (Jaffar, 2009)

curve is smooth and the generation output from individual station units of different fuel types will be spread across the curve. Even some oil plants operating in remote areas may have utilisations that are close to base load, and not just be operating as peaking plants. Station despatch changes hourly as well as annually depending on the availability of the plant and the cost of generation. Nevertheless, the illustration provides a useful simplified picture of the way a fleet of stations operates over a typical year. None the less, the despatch chart is dominated by gas-fired power, with further bulk supplies coming from coal, hydro, and oil.

What is striking is the apparently low utilisation being achieved by the entire power station fleet. Including the overall performance of oil and hydro plants, the average utilisation of Malaysia's generating capacity between 2001 and 2009 was 53–77%, averaging some 58% (author's estimates). This is consistent with the findings by the IEA (2009) which stated that excess reserves capacity in Malaysia was at around 43%. The IEA also noted that there are plans to reduce this to 25% over the long term to help meet future demand growth.

The utilisation of the fossil fuelled fleet ranges from 50% to 70% over the year. The lack of output from much of the fleet suggests that there is considerable spare capacity in the thermal fleet and, if needed, it could be called upon – provided the cost of doing so was economic.

There is a total of 15 GWe of gas-fired capacity in the country, some 8 GW of capacity is CCGT, gas and steam turbines in a combined cycle configuration. Around 500 MWe are retrofit upgrades of single cycle gas turbines to CCGT. Non-CCGT plants therefore account for around 7 GWe of the remaining capacity. These consist of open-cycle gas turbines (OCGT) which consist primarily of a number of gas turbines that are better suited for peaking supply, but can operate at much higher loads if necessary. The average unit size of the gas fleet is 80–90 MWe, although some of the larger gas plants are around 700 MWe (mainly CCGT).

Some coal-fired stations which drive steam turbines, which might also serve load variability better than CCGT; CCGT stations are likely to operate at baseload given that they operate best in a steadier state, rather than being ramped up and down on a frequent basis which could impair the high efficiency of the station.

Industrial on-site autoproducers consist mainly of petrochemical and gas industry operators both in the public and private sectors. TNB operates just over 2 GW of the combined cycle capacity and 2.5 GW of non-CCGT capacity. Combined, this accounts for a considerable proportion of the gas generating parc. A vast majority of the CCGT, if not all, are owned and operated by private power companies. Private power producers account for roughly half the gas capacity, many of which are operators of CCGT stations. The most notable owners are Powertek, Ranhill Powertron, YTL Corp, and Malakoff BHD. Foreign equipment manufacturers have been operating in Malaysia for many years, and the most notable gas turbine suppliers are ABB, GE, Alstom, and Siemens. Alstom, Toshiba, and GE have supplied turbines and generators to coal-fired plants since the 1990s, and so foreign investment in the Malaysian power sector is commonplace.

11.2 Coal fleet – low utilisation, but essential for fuel diversity

The second biggest fleet of generators are the coal stations amounting to 8000 MWe, roughly the same size as the current fleet of CCGT stations. The technology employed in Malaysia is primarily of a subcritical design, a typical standard for the ASEAN countries. Coal-fired technology is discussed in more detail in Chapter 12. The average size of each coal-fired unit is around 440 MWe; so coal units are larger in size compared with the average gas unit.

The utilisation of the country's coal-fired plants averages 50%, suggesting there is a great deal of spare generating capacity in Malaysia today. This is likely to be a manifestation of the major power blackouts that the country experienced in 1985, 1992, and 1996. A number of minor blackouts also occurred. These painful experiences resulting from a weak transmission system meant that IPP developments with favourable take off contracts were rapidly being developed. The conditions were less good for TNB in a period when blame seemed to lie at the hands of TNB the transmission and distribution operators. Capacity building was therefore encouraged, as well as an investment in building extra transmission lines and, clearly the excess in thermal capacity is seen as a necessary buffer to help avert any future problems.

Oil-fired plants account for 3.6 GWe, comprising small units averaging 7 MWe each. The largest oil-fired units are 2 x 300 MWe located at Sultan Aziz (Units 1 & 2), the remaining four units of the complex are coal fired.

11.3 Hydroelectricity and oil – essential for eastern Malaysia

Hydroelectricity is an exception to the low utilisation rates, whereby 30–40% is not unreasonable for this form of renewable power generation. Oil is used less often since it is a common start-up fuel for gas or coal, and is also a useful peaking generator since the cost of oil products remains high compared to almost all other forms of thermal generation.

As mentioned earlier, oil-fired plants are more prevalent in some Eastern regions of Malaysia where communities are further away from gas networks, or simply the demand is too small to justify investment in large coal- and gas-fired plants. For example, oil-fired plants still deliver much of the power in parts of the eastern region of Sabah, which is a region where power shortages are a problem, but the relative remoteness to the major Peninsular grid means Sabah has to be self sufficient, in this case on higher cost oil products. Oil-fired plants are prevalent in Sarawak and Sabah, and have even been the major source of power generation in parts of these smaller eastern Malaysian states.

12 Coal-fired power generation

In 2009, Malaysia had 8000 MWe of coal-fired power generation operating (*see* Figure 9 on page 24 and Figure 10 below). The plant list consists of entirely subcritical station a technology choice seen across the whole ASEAN. However, supercritical projects are emerging as the part of the future roadmap for coal-fired technology in the region but few are in any advanced stage of planning.

Most of the stations burn bituminous coals, although subbituminous coals are commonly imported from Indonesia for blending with Australian and South African coals. Indonesian coals have recently accounted for a very large percentage of the coal blend.

The coal qualities used for major power stations range from heating values of a minimum 20.9 MJ/kg (5000 kcal/kg subbituminous) to 28.4 MJ/kg (6750 kcal/kg bituminous), and sulphur contents are always less than 1.0%. In 2004, 60% of coal supplies came from Australia, 30% from Indonesia, and 5% from China and 5% South Africa (bin Mohd Nor, 2005). Coal was procured through a mixture of long-term contracts of up to five years, and medium-term contracts of three years.

According to Jaffar (2009), coal supplies to TNB (the main importer of coal to the country) consisted mainly of Indonesian products, which accounted for 84% of import supplies, with Australia accounting for 11%, and South Africa 5%. These proportions are subject to change based on market factors, but suggest that the low sulphur properties of Indonesian coals, as well the close proximity of the coal sources make Indonesian coals more attractive, especially in times of rising shipping costs and tighter emissions standards.

The coal-fired plants in Malaysia were built less than 20 years ago and the newer ones are listed in Table 2. The earliest plant was built in 1988 by TNB. This plant is the 1600 MWe Sultan Aziz (also known as Kapar) in the state of Selangor on the west coast of Peninsular Malaysia. The first two units (of four) were built in 1988 and 1989, each being 300 MWe in capacity. The last two 500 MWe units were built later in 2000 (*see* Figure 10). Around this time, only one other coal-fired power project had been developed, the 100 MWe Sejingkat plant operated by the Sarawak Energy Group which came online in 1997-98.

The late 1990s brought little further online capacity due to the impact of the Asian economic crisis in 1997. However, as the ASEAN economies returned to growth after 2000, investor confidence improved and progress on larger power stations resumed. Since 2000, there have been three major coal-fired developments, each more than 1000 MWe, and three smaller projects of around 100 MWe (*see* Figure 10).

The largest of these is the 2100 MWe Manjung plant. The project came online some years after it was intended, following delays from the 1997-98 Asian economic crisis. Manjung fires bituminous and subbituminous coals and is located in the state of Perak on the west coast of Peninsular Malaysia. The plant is subcritical, and equipped with low NOx burners, particulate control, and seawater FGD.

The Manjung project cost $1.8 billion, and was built by Tenaga Janamanjung Sdn Bhd. The economies of scale of building 3 x 700 MWe units compared with 4 x 500 MWe units were considered beneficial, and the three units were commissioned between September 2002 and September 2003.

The plant is sited on a man-made island off the coast of Perek,

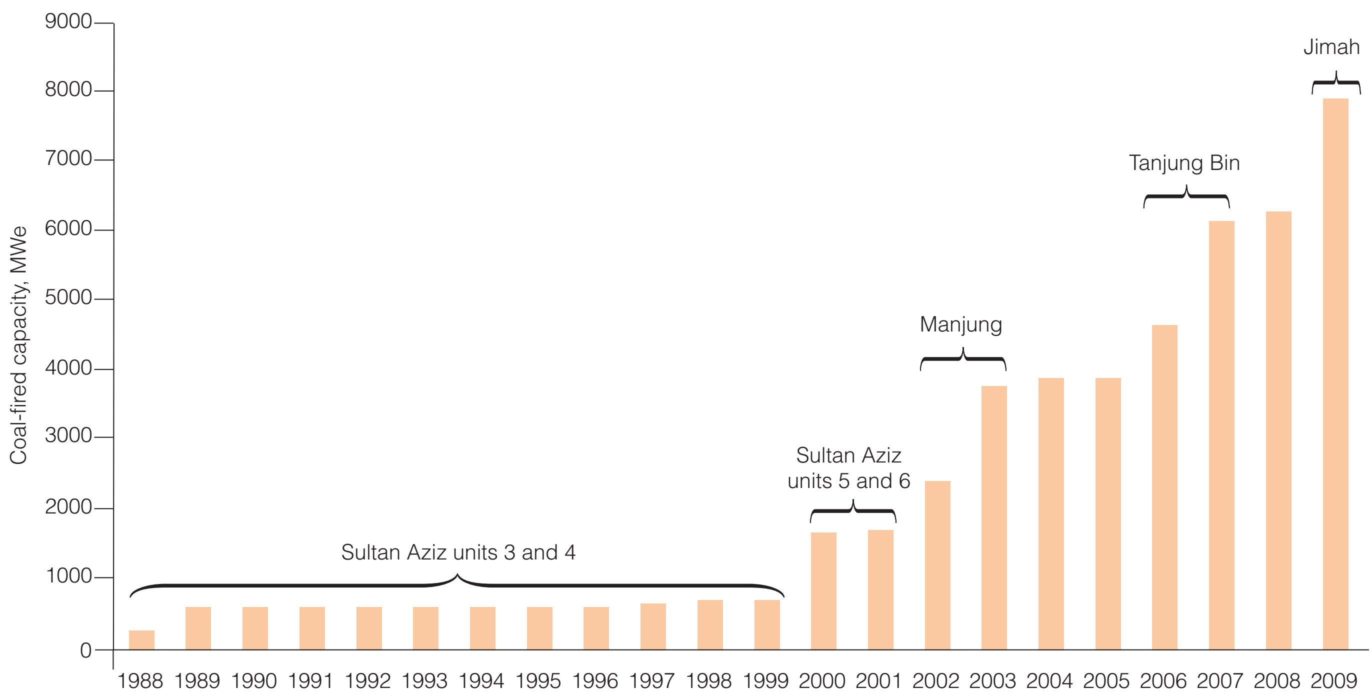

Figure 10 Cumulative growth in coal-fired capacity, GWe

Table 2 List of Malaysian coal-fired power stations

Plant (other name)	Commission-ing year	Region	Ownership	Capacity, MWe	Maximum annual consumption, Mt	Estimated GWh at 80% utilisation	Estimated efficiency at 80% utilisation
Sultan Aziz (Kapar) 3 & 4	1988	Peninsular Malaysia	TNB	600	1.5	4205	40
Sultan Aziz (Kapar) 5 & 6	1989	Peninsular Malaysia	TNB	1000	2.5	7008	40
Manjung (Janamanjung) 1-3	2002-03	Peninsular Malaysia	TNB	2100	6.0	14717	35
Tanjung Bin 1-3	2006-07	Peninsular Malaysia	IPP	2100	5.5	14717	38
Jimah 1 &2	2009	Peninsular Malaysia	IPP	1400	3.5	9811	40
Sejingkat (Kuching) 1 & 2	1998	Sarawak - East Malaysia	Sarawak State Government	100	0.5	701	23
Sejingkat (Kuching) 3 & 4	2000	Sarawak - East Malaysia	Sarawak State Government	110	0.5	771	25
Lahad Datu - 1	est 2014	Sabah - East Malaysia	TNB	160	0.5	1121	36
Lahad Datu - 2	est 2014	Sabah - East Malaysia	TNB	160	0.5	1121	36

making coal imports relatively straightforward. The island is off the coast of Lekir. The land was reclaimed between September 1997 and May 1999. The plant was built on 254 ha of the 320 ha of reclaimed land on the island. Of the 254 ha, 70 ha was for the power plant and 175 ha for the ash pond. The estimated cost for the offloading facilities was RM310 million (€93 million). The Lekir Bulk Terminal Sdn Bhd (LBT) company built a terminal to offload the 6 Mt of coal that the plant can consume each year. The jetty can handle Capesize vessels as large as 150,000 dwt.

A consortium formed by ABB Alstom Power Plants Ltd and Peremba Construction Sdn Bhd was selected as the engineering, procurement and construction (EPC) contractor for the project. ABB Alstom Power supplied the boilers, steam turbines and turbine generators along with the transmission link to the Malaysian mainland. ABB started construction in July 1999.

The Manjung plant was followed two years later by the Tanjung Bin plant in the southern peninsular state of Johor. Tanjung Bin is a 2240 MWe subbituminous plant also capable of burning bituminous coals. The plant came online in 2006-07. The plant is similar to the Manjung plant in most respects in that it has roughly the same level of environmental pollution control, albeit by different equipment manufacturers.

Tanjung Bin's first unit was online in 2006, and consists of 3 x 748 MWe units. The boiler was supplied by IHI (Japan), and the turbine and generator units were provided by Toshiba (Japan). Tanjung Bin was the first coal-fired IPP in Malaysia. The Power Purchase Agreement (PPA) with TNB was signed in Jul 2002 and the plant also secured a Coal Supply and Transportation Agreement with TNB Fuel Services.

Construction began in August 2003 and the first unit went into commercial operation some three years later in September 2006. Unit 2 entered service in February 2007. The plant was financed by Sumitomo Bank, Zelan Holdings, and Eversendai and cost $2 billion (RM7.8 billion). Malakoff Berhad holds 90% of Tanjung Bin Power, with 10% owned by Employee Provident Fund. The site is at the mouth of the Sungai Pulai River opposite Tanjung Pelepas. The power station is connected to the grid by a 53 km, 500 kV, transmission line to Bukit Batu and a 25 km, 275 kV line to the Tanjung Kupang substation.

Over the past few years, a small number of smaller coal-fired plants have been installed, with capacities of just over 110–130 MWe built by the Sarawak Energy BHD Group in the state of Sarawak. As of 2010 the last large project to be completed was located in the Peninsula. The Jimah power station was built by the Jimah Energy Ventures SDN, also 80% owners of the project, with the rest owned by TNB. This plant came online in July 2009 and is a 2 x 752 MWe subcritical station. The plant is situated in the state of Negeri Sembilin near Port Dickson on the west coast of the Peninsula. The Jimah plant is a substantial addition to the Peninsula power system, and seen as an extremely attractive investment such that bids for the station were being prepared months after commissioning, and Jimah could be under new private ownership by the end of 2010.

12.1 Dealing with emissions from coal-fired plants

Most of the country's power stations are equipped with a range of emissions control equipment to minimise air pollution resulting from SOx, NOx, and particulates. Many plants including the Manjung plant uses low sulphur coal. The resulting ash is valuable for the cement industry, and most is caught by electrostatic precipitators. Dust control is also an important feature (the conveyor belt is covered and sprinkler systems remove up to 99.9%).

The plant has a wastewater treatment facility to treat its effluent before it is released into the sea. The project even includes a plan to reinvigorate decayed mango swamps in the area. The plant will meet far higher emission standards than would be typical for an ASEAN country. It operates to particulate levels of 50 mg/m³ whilst the expected ASEAN level is 400 mg/m³ (*see* Table 3). While these limits are less stringent than limits set in the European Union, the limits fall within World Bank guidelines. The plant uses low NOx burners and FGD.

12.2 Rising opposition to coal – Case study of proposed coal plant in Sabah

Despite the adoption of air emissions controls, scepticism remains as to whether coal-fired power is an appropriate solution to the growing needs of the country's power supplies. While blackouts have seriously affected much of Malaysia in the past, parts of eastern Malaysia are struggling with less reliable electricity supplies. Sabah power demand is expected to grow at a robust 6–7%/y, but to date the generation options have been limited since a massive 60% of power generated comes from expensive diesel generation, and the rest comes from natural gas (SEB, 2008).

It was reported that 30% of the eastern coast of Sabah electricity demand is supported by generators located in the west, and that such a lopsided grid exposes the eastern coast to the risk of a serious major blackout in the event of an interconnection failure as was experienced in the Peninsula in the 1990s. As a response to these problems, in September 2009, Prime Minister Najib Razak announced the construction of a new coal-fired power plant in Felda Sahabat (Kinabalu, 2009). The 300 MWe project was considered the most viable solution to help alleviate the power shortages being experienced on the eastern coast of Sabah. The location of the proposed coal-fired power plant in Felda Sahabat had already been moved twice (first in Silam, Lahad Datu and then second was in Sungai Seguntor) following objections from various quarters due to environmental concern. The site in Felda Sahabat is remote on the Dent Peninsula and some distance from the community, which suggests that environmental issues determined the location of the power station.

Interestingly, this far eastern region of Malaysia is just north of Indonesia's coal regions of Kalimantan. It is most likely that coal will be imported from the coal rich regions of

Table 3 Malaysian air quality guidelines (Jaffar, 2009)

Pollutants	Averaging time	mg/m²	
Ozone	1 hour	0.1	200
	8 hour	0.06	120
Carbon monoxide (CO)	1 hour	30	35
	8 hour	9	10
Nitrogen dioxide (NO_2)	1 hour	0.17	320
	24 hour	0.04	10
Sulphur dioxide (SO_2)	1 hour	0.13	350
	24 hour	0.04	105
Particulate matter (PM_{10})	24 hour	–	150
	1 year	–	50
Total suspended particulate (TSP)	24 hour	–	260
	1 year	–	90
Lead	3 month	–	1.5
Dust fall	1 year	133 mg/m²/d	
		ppm	mg/m²

Emission Standards (mg/m³)

	US DOE	World Bank	Manjung
Particulates	400	50	50
SO_2	3500	750	750
NO_2	1700	650	650
Cooling water temperature rise: 8°C			

Kalimantan, Indonesia which benefits from ease of transportation, and also had low-sulphur coal with acceptable heating values and ash contents. One of the concerns is that the building of a new coal-fired plant in Sabah would lead to the mining of the coal deposit in the Maliau Basin if or when coal imports become unviable.

Thus far, the coal that would be used has been described as being subbituminous and bituminous in rank with low ash, low sulphur and low mercury contents from Indonesian coalfields in Kalimantan. Although the project is subject to a Detailed Environmental Impact Assessment, there is still a threat of the project being shelved.

The renewable energy movement has gathered momentum in Malaysia. There has been opposition to the construction of coal-fired power plant since it allegedly contradicts the objectives of The National Green Technology Policy (NGTP) according to some government parliamentary members (MTCE, 2009).

The WWF-Malaysia urged the federal and state governments to carry out the principles of the Sabah Development Corridor to ensure sustainable growth via environmental conservation (Chew, 2008). Much of the argument used by the anti-coal lobby is that the development of new, large hydro projects that are currently under construction in neighbouring Sarawak, should be exploited instead (the Bakun hydro project 2400 MWe, and the Murun 900 MWe). However, officials from TNB stated that Sabah may not benefit from the hydro projects due to the offtake being already committed to the growing demands from Sarawak and Peninsular Malaysia.

The Sarawak hydro corridor also has the potential to export power to Indonesia in west Kalimantan where diesel generation dominates, and Brunei which is dominated by gas-fired power. With Sarawak surrounded by all these parties interested in its hydro capabilities, Sabah state could be competing for Sarawak hydro resources. Given the Malaysian Peninsula is the economic centre for the country, Sabah may not be a strategic priority, so making the coal-fired power an ever more attractive prospect.

In response, TNB claimed that coal-fired power plants (in the case of the 300 MWe plant discussed earlier) is the only possible solution to the immediate power shortages faced by the State of Sabah. Consequently, Sabah Electricity appointed an independent consultant to study biomass-fired plants and the 165 MWe Liwagu and 150 MWe Upper Padas hydroelectric projects (PiA, 2009b).

Interestingly, there is little opposition to gas-fired power in parts of Sabah. However, TNB was of the view that coal-fired power was an essential component of the future energy mix. As mentioned earlier, there is a real possibility that coal-fired developments may be shelved if a strong case for environmental preservation and viable alternatives can be achieved. These alternatives almost entirely include power imports, which could add to the fragility of the Sabah system by relying on longer distance transmission lines, or adopt a greater role for biomass. Interestingly, cofiring biomass with coal did not seem to be considered by any of the stakeholders in the coal-fired projects, and so clearly not every solution has been fully considered by either TNB or WWF.

13 Coal demand trends

Coal-fired generation is discussed in previous chapters, this section briefly focuses on the trend in coal demand. The rise in coal-fired power in Malaysia in recent years has led to a steady growth in demand such that it now dominates the market for coal. Figure 11 illustrates the trend in coal consumption in the country. Before Malaysia's first major coal-fired power plant was commissioned in 1988, coal demand came entirely from the industry sector. IEA data show that coal was used almost entirely by the non-metallic mineral sector, referring mainly to the cement industry (*see* Figure 11).

Throughout the 1990s, coal-fired power became a significant proportion of the country's coal demand, accounting for an average 60% of the total demand in ktce terms. In this period coal demand was less than 2 Mtce, but by 2007, total coal demand had risen to more than 12 Mtce. Power generation is now the primary demand for coal. The cement industry has none-the-less seen considerable growth, with coal demand doubling from around 0.8 Mtce in the 1990s to 1.9 Mtce in 2007.

13.1 Coal demand in the power sector

Future growth in coal demand is almost certainly going to be dominated by the growth in the power sector. However, compared to many ASEAN countries, growth is likely to be modest. The historical trend in industrial consumption shows that the potential growth comes from cement production, but in this industry, past trends suggests a relatively low growth.

However, as the previous section suggests, spare capacity remains within the Malaysian cement production industry to either meet growing demand in the domestic sector or increase exports.

According to the Cement & Concrete Association of Malaysia (C&CA) of Malaysia, the total clinker production capacity in 2008 amounted to 18 Mt/y; cement production (grinding) capacity was just over 28 Mt/y. Cement production in 2008 was approximately 20 Mt/y, suggesting production could feasibly rise by 40% for either domestic demand or export. The potential therefore to increase the demand for coal for fuel (and palm kernel shells) could rise by 40%. Coal demand could, in principle, reach 2.8 Mt/y.

In the all-important power generation sector, Table 4 lists a number of power projects that were published in the Platt's Power in Asia Journal in 2009. In the power sector, two notable coal-fired power projects have been added to the generating fleet, these are Jimah (1500 MWe) and Mukah (270 MWe) and both came on line in the period 2008-09.

However, few coal stations are expected to come online after 2009, with the possible exception of a small 300 MW unit in Sabah which did not appear on the Platt's Power Tracker in 2009, possibly due to the uncertainty surrounding the project.

All projects that are currently under construction are hydroelectric (3344 MWe), or gas-fired (300 MWe). There are also a number of smaller hydro, gas and biomass plants that are in various stages of planning which could add a further 900 MWe between 2010 and 2015.

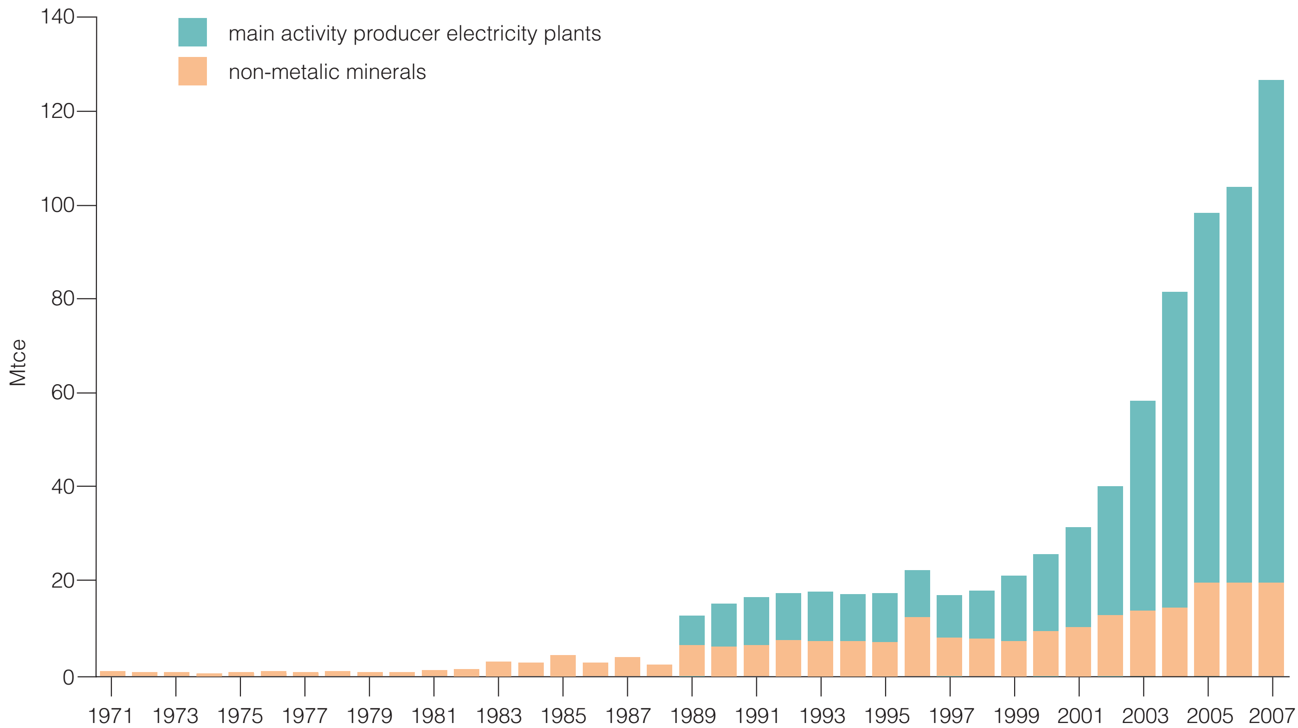

Figure 11 Malaysian coal demand trends in Mtce

Therefore, growth in the demand for coal in the power sector has been restricted to the operation of current and newly built power stations, the last being Jimah. This has been illustrated in Figure 12 which shows how each new coal-fired power station adds sequential volumes of coal to the demand. By 2010, Jimah pushes coal demand to 19 Mt/y.

However, the official projections may well be optimistic. The coal demands calculated by TNB and other official sources assume that the nation's coal-fired unit operate at high utilisation (capacity) factors. A comparison with the despatch curve in Figure 8 suggests that coal-fired units between 2000 and 2007 averaged a utilisation of just 50%. While the newer units would probably operate at higher utilisation rates, 85% being reasonable, then the weighted average utilisation of all the units as of 2010 would be approximately 60–65%.

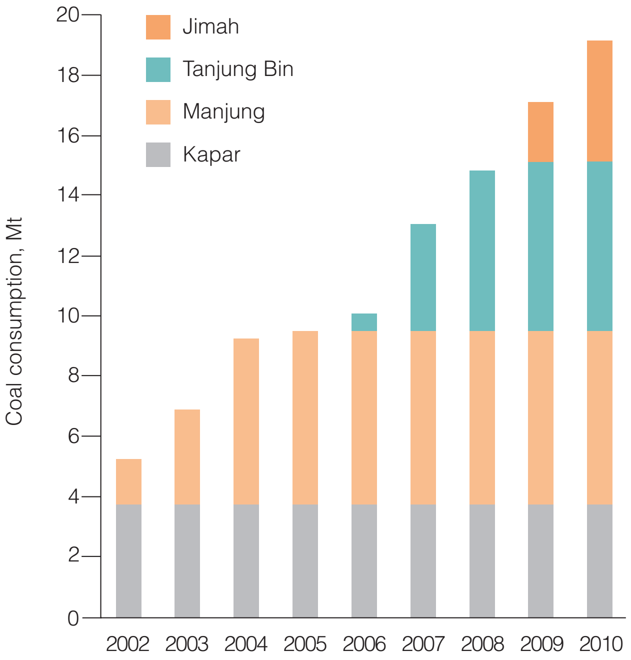

Figure 12 Official projections for coal demand growth (Jaffar, 2009)

Based on this simple assumption, the likely demand for coal would be around 15–17 Mt/y (or 14 Mtce). Further uncertainty occurs depending on the proportion of Indonesian coals that are imported, versus the proportion of Australian and South African coals, so the author's estimates are also subject to some change. When combined with the current demand for coal in the industrial sector, then total coal demand may well be around 17–19 Mt/y, close to the official estimates.

In the longer term, the projects listed in the Platt's Tracker table, and with known commissioning dates, have been incorporated into Figures 13 and 14. The growth in Malaysian electricity generation could see an increase of some 30–35% between 2008 and 2015 when some of the largest hydro projects come online in Sarawak. However, despite the modest utilisation rates of the past (averaging 35–37%), the Bakun and Murum hydro plants could push hydro output from roughly 7 TWh in 2008-09 to almost 18 TWh in 2015.

Beyond 2015, it is possible coal-fired power could grow beyond the current 8000 MWe of generating capacity. The IEA (2009) shows a possible increase to 14–15 GWe by the year 2030 (total capacity could rise to 47 GWe in this time). Coal-fired power therefore sees an increasing role in the power generation mix. The reduction in spare capacity expected over coming years, along with growth in demand will bring a need for more thermal capacity. The country's proximity to major coal suppliers in the Far East will mean Malaysia may well turn to imported coal to reduce the dependence on gas-fired power also.

Table 4 Platt's Power Tracker 2009

Project name (developer or owner)	MWe	Fuel	Status	Commissioning date
Jengka (Felda/TNB)	10	biomass	JV agreement	
Sandakan (Kina Bioenergy)	10	biomass	Operation begun	2009
Rompin (Sediaplas)	10	biomass	PPA signed	
Perak (Cahaya Mudah)	1	waste	CDM registration	
Jimah (Jimah Energy Ventures)	1500	coal		2009
Mukah Power	270	coal		2008/09
Kota Kinabalu (Petronas/YS)	300	gas	Government approval	
Tuanku Jaafar (TNB)	750	gas	Operation begun	2009
Kimanis NRG Consortium(Petronas 60%; Yayasan Sabah Group 40%)	300	gas	Ground broken for construction	2014
Bakun (Sarawak Hidro)	2400	hydro	Operation award	2011
Hulu Terengganu (TNB Hidro)	250	hydro	Size revised	
Ulu Jelai (TNB Hidro)	372	hydro	Size revised	
Murum (Sarawak Energy)	944	hydro	Finance secured	2013

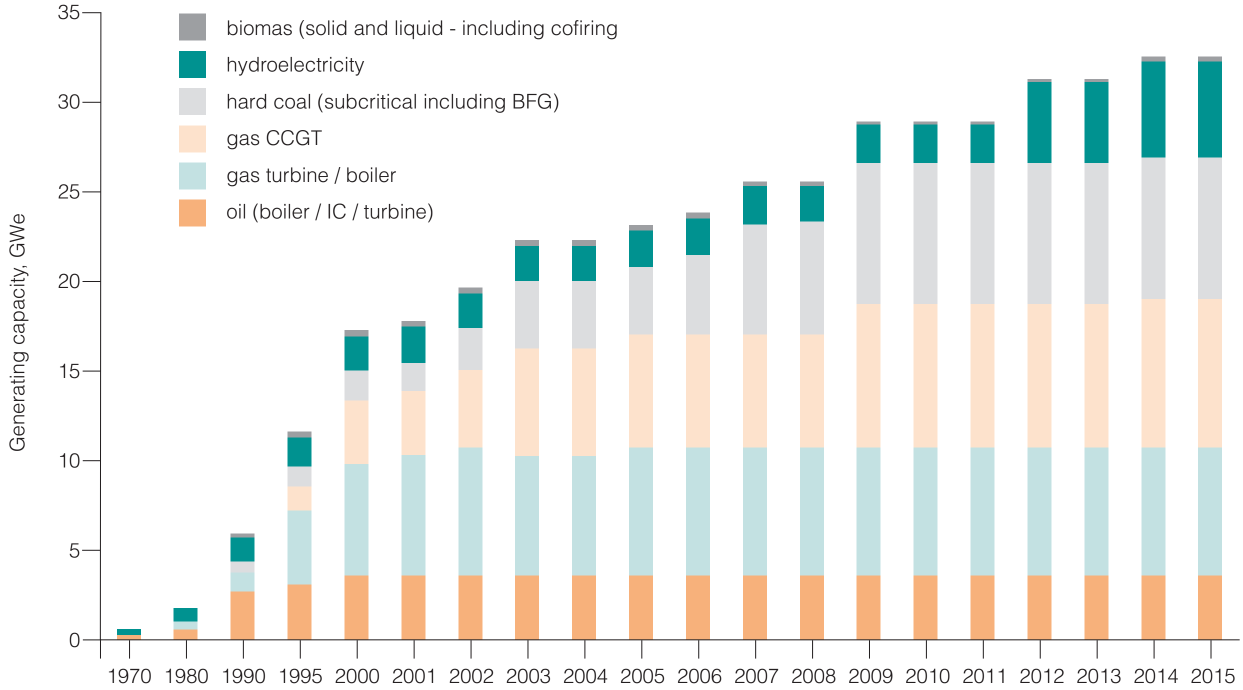

Figure 13 Outlook for Malaysia's generating capacity to 2015, GWe

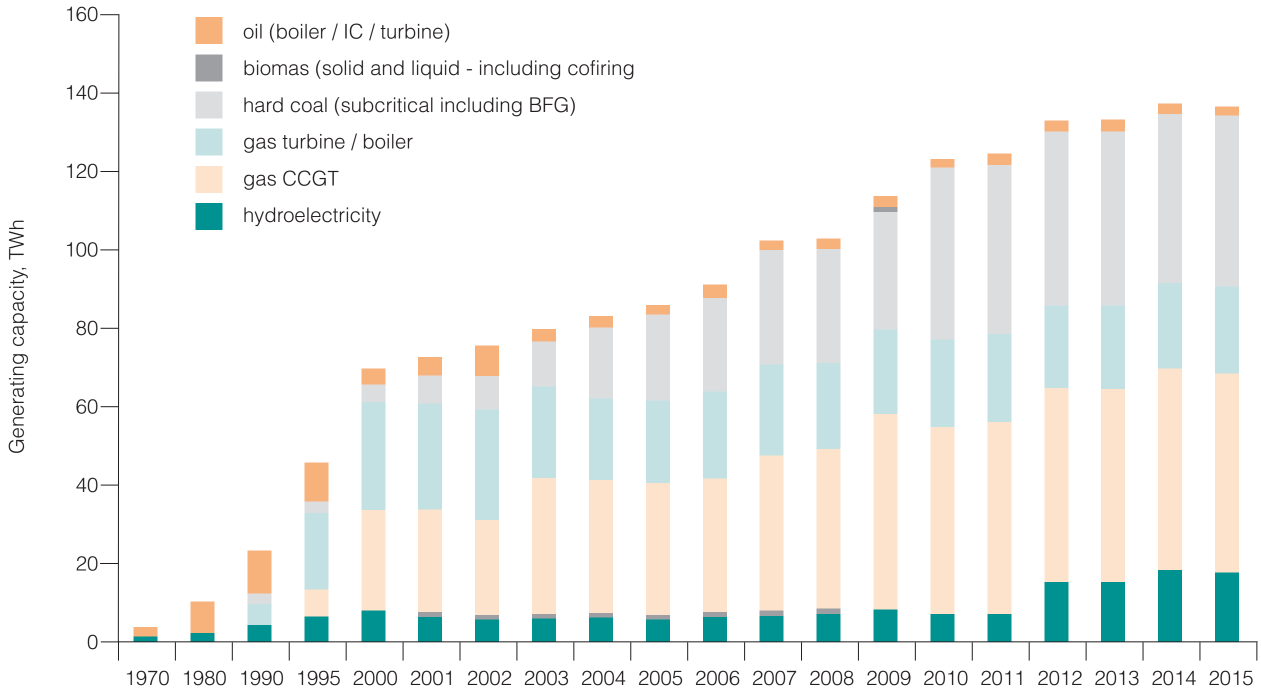

Figure 14 Outlook for Malaysia's power generation to 2015, TWh

13.2 Coal demand in the cement sector

The largest producer of cement is Lafarge Malayan Cement Bhd with three integrated cement plants and one grinding plant producing more than 40% of the country's cement output. In April 2006, Lafarge announced a CDM project which substitutes biomass for part of the fossil fuel consumption at two clinker plants. In this case, there has been a move to reduce CO2 emissions by firing biomass waste in place of coal. The project was validated by the CDM Executive Board in line with the Kyoto Protocol, and approved by the relevant Malaysian and French authorities.

The CDM project was approved for the Rawang (2.6 Mt/y cement) and Kathan (4.2 Mt/y cement) cement plants. A percentage of its (imported) coal needs would be replaced with palm kernel shells, a waste product of the palm oil industry, reducing CO_2 emissions by 60,000 tonnes every year. Palm kernel shells account for over 5% of the total energy used for heating in Lafarge's cement kilns.

14 Clean coal initiatives in Malaysia

While palm oil kernels have clearly benefited the cement industry through cofiring with coal, the prospect has not appeared to have been fully investigated in the power sector. This section looks at cofiring and the potential for CCS in Malaysia.

'Clean coal' is a term that is often interpreted differently in different regions across the world. In the case of Malaysia, clean coal refers to power stations which adopt air pollution control equipment, but rarely refers to the capture and storage of CO_2, which is how clean coal is defined in Europe and North America.

Such technologies include: FGD, ESP, use of low sulphur and low ash coals (subbituminous rank), low NOx burner, minimum 200 m chimney heights for exhaust gases. Based on all or most of these criteria, the Manjung power station is considered a clean coal technology plant.

When considering CO_2 reduction, Malaysia's role in the Climate Change Negotiations in Denmark in 2009 (COP5) was limited to supporting a cut in emissions, provided the key economies of the world including India and China could provide the means and funding to build renewable and or carbon reduction measures in Malaysia and the rest of the industrialising world.

There has been little research or study into the potential for coal-fired power in Malaysia, with specific reference to the types of coal that is burned in Malaysian power stations. However, two papers did touch on the issues of carbon capture and biomass cofiring. The first is a paper on carbon capture

Martunus and others (2008) published a paper on carbon capture in Malaysia and Indonesia. The authors concluded that based on projections for the growth in the two countries would result in a 4.1%/y rise in CO_2 emissions reaching 98 Mt in Malaysia by 2020 (171 Mt in Indonesia).

The paper discusses the various methods of carbon capture which includes:

- post-combustion capture – CO_2 separation from exhaust gas using chemical or physical solvents;
- oxyfuel combustion – CO_2 concentration for easier downstream separation;
- pre-combustion separation – H_2 production from coal gasification and so early CO_2 separation and capture.

The paper does not examine the specific issues regarding CO_2 separation or gasification of Malaysian and Indonesian coals, but rather examines the technologies separately from the needs for coal in these countries.

Elsam produced a paper in 2005 that examined the principles of cofiring biomass into a relatively large power station unit (Junker, 2005). The cofiring fuel was from two residues derived from the palm oil industry: the shell from the palm oil fruit; and empty fruit bunch (EFB) in the form of dried bales or as fibres.

The study concluded that there would be no problems cofiring coal-fired power plants with 10% fruit bunch bales and/or 5% shells. At the time, there was no experience in cofiring EFB anywhere in the world (Junker (2005). The costs of pre-processing large volumes of these fuels posed major cost considerations that grossly inflates the cost of the biomass fuel. In addition, the quality of coals assumed in 2005 (rich in Australian coal) may differ from that of coals fired in 2009 (mainly Indonesian), and so the technical issues may differ greatly.

While CCS for coal-fired plants remains a major uncertainty for Malaysia, the potential based on the existing coal-fired parc is good. Almost all the coal-fired stations are located at the coast, in order to make use of imported coal. It is therefore feasible for pipelines to be laid from these locations to offshore geological structures, whose capacities clearly require considerably more effort and funding to determine.

The current activity in CCS is based around the Bintulu LNG complex, where CO_2 will be captured and injected into an aquifer below the seabed off the coast of Sarawak. Malaysia is one of the major gas producing countries in the world, not least for its supplies of LNG into the world gas market. Typically, the feed gas for LNG contains 3–6 mol% CO_2, and is removed by gas acid removal facilities, and then released into the atmosphere after incineration of the acid componets, with little or no recovery. The CCS will capture and compress CO_2. The liquified CO_2 is transferred to the Pudina field by pipeline.

This project is also a CDM proposal, first submitted in January 2006. The project is a joint project between Mitsubishi Heavy Industry, JGC and Petronas. The annual capture rate could be 3 Mt CO_2/y with injection though 120 km pipeline into an sub-sea saline aquifer at depths of 1400 m. The project is planned to start in 2011, but is likely to face delays until the Subsidiary Body for Scientific and Technological Advice for the UNFCCC confirm the eligibility of CCS as a valid provider of CDM credits.

14.1 Biomass power, solution or problem?

In opposition to the possibility of new coal-fired plants, the WWF-Malaysia's strong support for renewable energies is not unexpected, and part of that support goes to the potential for biomass combustion. However, the source of that biomass must be sustainably produced with minimal impact on the existing environment.

WWF-Malaysia urged TNB to conduct a feasibility study on the amount of power that can be generated from the palm oil biomass available on the eastern coast of Sabah, where there are more than 60 oil palm mills. Power generation from palm oil qualifies as a Clean Development Mechanism (CDM) project where carbon credits can be sold.

As mentioned earlier, many ASEAN countries use the term clean-coal technology as technologies that reduce air pollutants such as SOx, NOx, particulates, and increasingly mercury. Since clean coal technology is yet to be proven at a commercial scale for CO_2 reduction, it is no surprise that CCS has not yet moved up the agenda in terms of climate change policy in the ASEAN region.

Biomass-fired capacity however has an important role to play regarding possible carbon neutral technologies, especially amongst foreign companies eager to exploit Malaysia's rich biomass market. Japan's Chubu Electric Power Company was involved in two biomass IPP projects. The projects were co-developed with Kina Biopower Sdn Bhd and Seguntor Bioenergy Sdn Bhd, respectively. Both projects are located at sites near Sandakan in Sabah state in eastern Malaysia. The first 10 MWe project was commissioned in January 2009, and the second 10 MWe less than three months after the first unit started operation (PiA, 2009a). Each unit uses 240,000 empty palm oil fruit bunches a year. Each project cost $24 million with the Meidensha Corporation building both plants and the local AM Bank providing debt finance.

Chubu Electric noted that the project has been registered with the United Nations as a CDM project. The company said that, in addition to earning revenues from the sale of its output to the state-owned power utility Sabah Electricity, the project plans sell around two million metric tons of carbon credits up to the end of 2012, with Chubu being responsible for deploying the certified emissions reductions.

Palm oil production has been criticised for being a major contributor of deforestation in sensitive habitats. Almost every major green lobby group has actively campaigned against both the practice and the large food corporations that use palm oil in everyday products. The subject has been ongoing for many years, and there appears to be some steps towards better protection of virgin rainforests, but much of the action has been industry-led, while the lobby groups voice concern.

14.2 Risks of capital-intensive projects

Chapter 2 described briefly how the Malaysian economy weathered downturns, most notably the currency crisis in the 1990s, and more recently the global crisis in 2009-10. One example of economic problems affecting coal-fired power projects is the effect the economy had on the Manjung plant. Some of the major risks to coal-fired projects have been twofold, exchange rates and fuel prices.

One of the major risks associated with foreign investment in IPP in the Far East has been the fluctuation in exchange rates of inward investment, and the impact it has on returns for the IPP developer. For example the Manjung plant was budgeted at $1.8 billion, an increase of 38% on the initial estimate of $1.3 billion. This steep jump in cost was largely due to the exchange rate movements that occurred resulting from the currency crisis in the 1990s. Some 30% of the financing came from equity financing, while the rest came from loans and export credit.

The fixed exchange rate was abandoned in July 2005 in favour of a managed floating system within an hour of China announcing the same move. In the same week, the ringgit strengthened a percent against various major currencies and was expected to appreciate further. In August 1999, the Perak state government announced it would take a 20% stake. TNB was happy to see this, as the company has a long-term strategy of reducing its power generation exposure to focus on transmission and distribution.

In 2009, TNB reported some major losses in net profit due to foreign exchange movements and the rise in international coal prices. TNB paid an average of 90.2 $/t, above both the 76.4 $/t average for the previous financial year and the 85 $/t cap on the amount the utility can recover under the tariff adjustment agreement effected in March 2009 (PiA, 2009c). However, the TNB group reported a 16.3% increase in total revenue for the financial year primarily because of the retail electricity tariff adjustments that became effective from 1 July 2008 and 1 March 2009. As such, the impact of rising fuel prices was slightly offset by increased tariffs.

Regarding the foreign exchange position, TNB said that 74.2% of the $350 million (RM1,177.8 million) of exchange rate losses reflected the utility's exposure to Yen loans. However, as is common in Japan, large capital project loans have very low interest rates and fixed repayment tenures sometimes lasting 30 years. In the same year, according to TNB, the company faced negative electricity demand growth, higher average coal prices which hit a peak of 113.9 $/t in the first quarter of the 2009 financial year, and additional capacity payments to the new Jimah IPP plant.

In 2008, Indonesian coal officials met with the fuel-buying arm of Malaysian utility TNB to renegotiate contracts between the utility and Indonesia's coal producers. Previously, contract prices were settled at rates well below the market level for export coal. The Indonesian Government recognised the value of coal as a commodity and the potential for maximising royalty and tax revenues. To redress the difference between the TNB contracts and the world price of coal, government auditors informed ministry officials that coal contracts should reflect index prices used by the international market. The government brought together all the stakeholders, including TNB and a number of heavyweight suppliers such as Bumi Resources, Adaro, Bayan Resources, and Kideco (Baruya, 2009).

One supplier that was not identified was believed to have had a five-year contract of 42.5 $/t on a 26.6 MJ/kg basis (6350 kcal/kg GAD). A price renegotiation is thought to have raised this by 25 $/t. PT Bayan Resources were asked to renegotiate contracts with TNB, increasing the price by 10 $/t to 100 $/t (as of the 4th quarter 2008) along with certain renegotiations of the terms and conditions of annual contracts. Reports suggested that contracts with other Asian buyers had been reopened to negotiation while European and US buyers had refused to hold discussions.

The dynamics of coal prices and the impact on their business has been calculated by TNB. When coal prices were around 60 $/t, each 1 $/t change in coal prices roughly translated to a reduction in profits of $8.4 million ($1 per RM3.45). For 2009, TNB expected to pay 85 $/t for coal supply from Indonesia, Australia, and South Africa.

While this section has focused on the effect of coal prices, Malaysia's dependence on gas-fired power should not be ignored. Peninsular Malaysia is heavily dependent on natural gas (68%) and coal (22%) for power generation, and increases in fuel prices including gas from Petronas to the power sector increased from 1.8 to 4 $/GJ throughout 2008.

TNB were restricted by tariff rises of 26% (SEB, 2008) . This constrained TNB to reduce costs elsewhere, possibly in future capital investment projects. Whether this affects future coal-fired projects is not certain. By 2009, there seemed to be little further interest in new coal-fired builds in the Peninsula. Current investment seems to be focused on the new transmission links with Sarawak's large hydro (corridor) projects, which would provide some buffer in the Peninsula against the dependence of increasingly costly gas stations.

15 Conclusions

Malaysia currently has some 8 GWe of coal-fired power capacity, most of which is owned and operated by independent power producers. The last major power station to be built was commissioned in 2009. The Jimah IPP power plant has a capacity of 1200 MWe, and could be the last coal-fired station to be completed for some years. No new plans are expected, except a possible 300 MWe plant in Sabah state which is currently facing considerable resistance by lobby groups. The state utility, TNB, retains considerable power in the downstream power supply market, but further upstream in the generating market, TNB has relinquished market share to the independent producers.

According to the IEA, coal-fired capacity could rise to 14.6 GWe, compared with the current 8 GWe. This will mean that coal will account for a larger proportion of total capacity than in the past which was previously dominated by gas-fired plants.

The current coal-fired technology consists of subcritical stations equipped with flue gas desulphurisation, particulate control and many with low NOx facilities. Carbon capture and storage is not yet on the agenda, climate change issues are being tackled through a greater role of renewable, but most of this is conventional hydroelectricity, along with a number of small biomass plants which could qualify for credits under the clean development mechanism.

Biomass cofiring has not been considered at great length, but biomass waste seems to be in abundance from the palm oil kernels. However, the link with palm oil production and deforestation is well documented and remains controversial.

The focus of new capacity turns to hydroelectricity for forthcoming years. Eastern Malaysia's hydro corridor is being developed around a number of river basins in the state of Sarawak, and will add a considerable amount of hydropower to the demand centres on the mainland Peninsula.

Gas-fired power still dominates power generation, half of which comprises of single cycle gas turbines. Gas power could retain a significant proportion of the future generation mix. While there seems relatively little interest in building new coal-fired power, the IEA World Energy Outlook expects the role of coal to increase out to 2030. The country's five fuel policy promotes fuel diversity to ensure better energy security of supply, but the emphasis appears to be on renewables.

Coal supplies will probably come from the international seaborne market. Domestic coal production is currently little more than 1 Mt/y. Coal reserves are concentrated in subbituminous-containing coalfields in Sarawak, but exploitation may be limited.

Energy prices remain under regulated forces from the government. Tariff increases are being implemented for power and gas, but coal prices have been subject to favourable and below market level agreements, even with Indonesian suppliers. However, the situation is changing. The economy is migrating to market-led forces, albeit extremely slowly. The impact on new capital intensive projects such as coal and gas-fired power is not yet determined.

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